Surprising Efficacy of 'Sipping' DNAPL with Low-Flow Piston Pumps

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DNAPL Remediation -- So Many Issues

- **Tough to pump: High viscosity, chemically aggressive**
- **Past practice: Indiscriminant pumping**
  - High percentages of groundwater to product
  - Product and water emulsified
  - Difficult to treat
- **Result: Expensive, diluted, emulsified effluent**
  - Disturbs the formation
  - Product typically separated before transport -- costly
  - Years to reduce the plume
- **"Is it worth the effort?"**

Sites Find Success – Another Way

A counterintuitive approach: Little sips

- Small piston pumps
- Low, low flow, fewer strokes

Advantages

- Less formation disturbance
- Fine-tune flows to formation tolerance
- Higher percentages of product to groundwater
- Lower costs to purchase, operate, transport & treat
- Controlled plume reduction

Why Piston Pumps? Positive Displacement

Pistons:

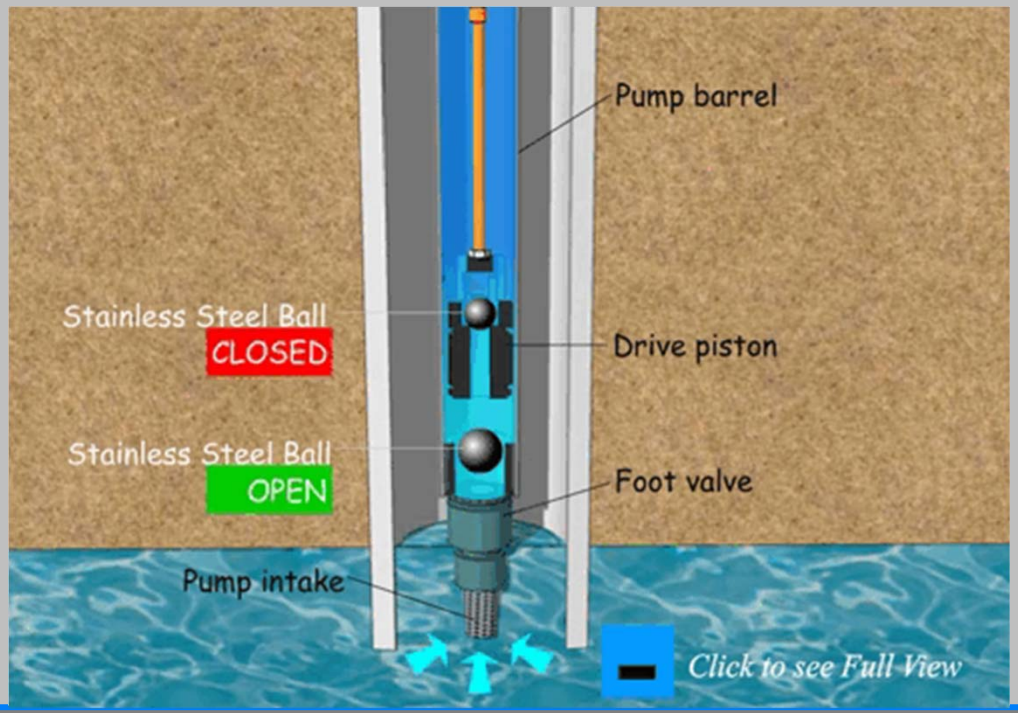
- **Pump anything flowable**
- **Pump at constant flow rate**
- **Pump to bottom of well or sump**
- **Unaffected by + or - changes in pressure**
- **Pump dry without harm**

Why Piston Pumps?

- **Pump rate can be tuned to yield of formation**
- **No electric power or pneumatic air enters well**
- **Top-head drive: Easy service, low maintenance**
- **Can pump 90° vertical to horizontal axis**

Downhole Pump: Positive Displacement

- **Simple, two-valve downhole**
  - Standing valve & traveling valve
- **Traveling-valve reciprocation cleans barrel w/each stroke**



How Piston Pumps Work

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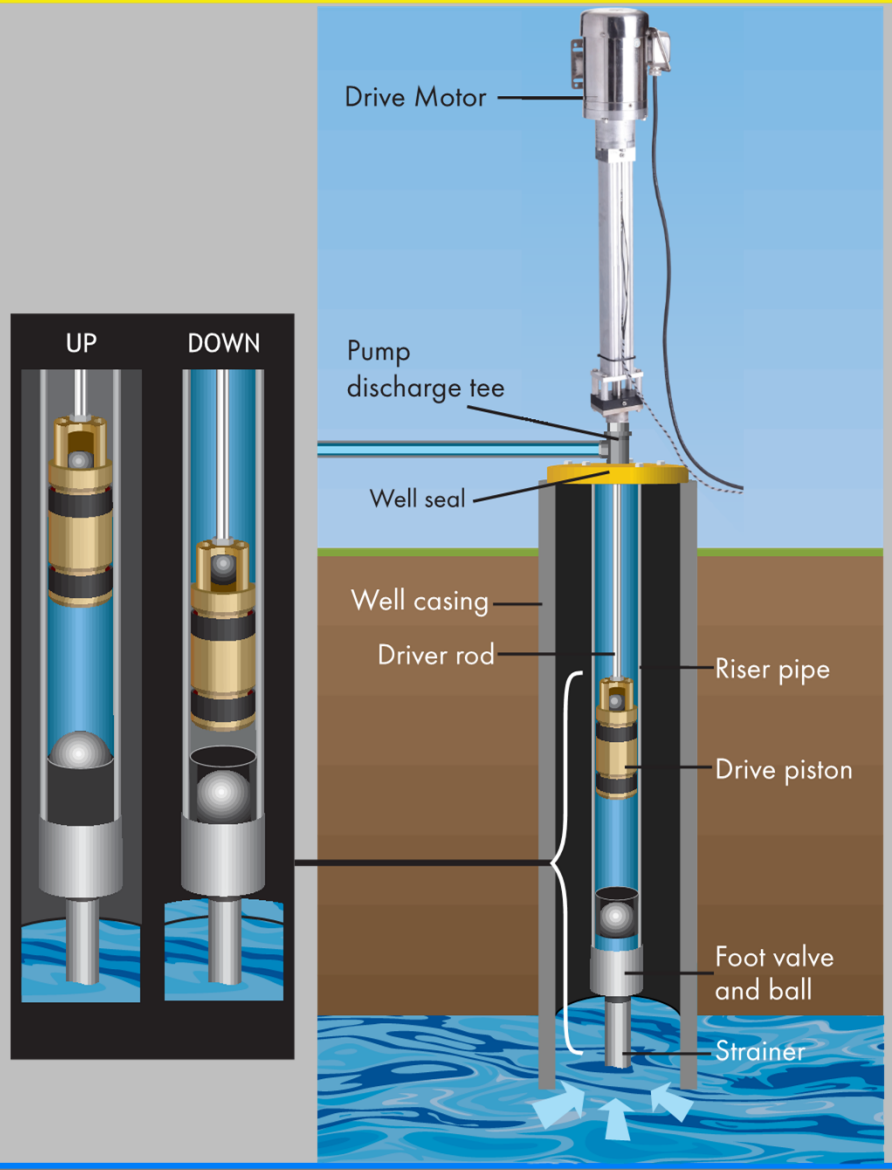


Top-Head-Drive Piston Technology

- **All power & maintenance above ground & wellhead**
- **No pneumatic air or electric power enters the well -- ever**
- **Air never in contact with liquid being pumped**

Blackhawk Features

Low-Flow Piston Pumps

- **7 gpm or less**
- **TDH to 800 ft.**
- **Low maintenance; quick & easy servicing**
- **No air/O_2 in discharge; no exhaust emissions**
- **Safer for workers**
- **All weather**
- **Customize materials for conditions & liquids**

Pump Choices

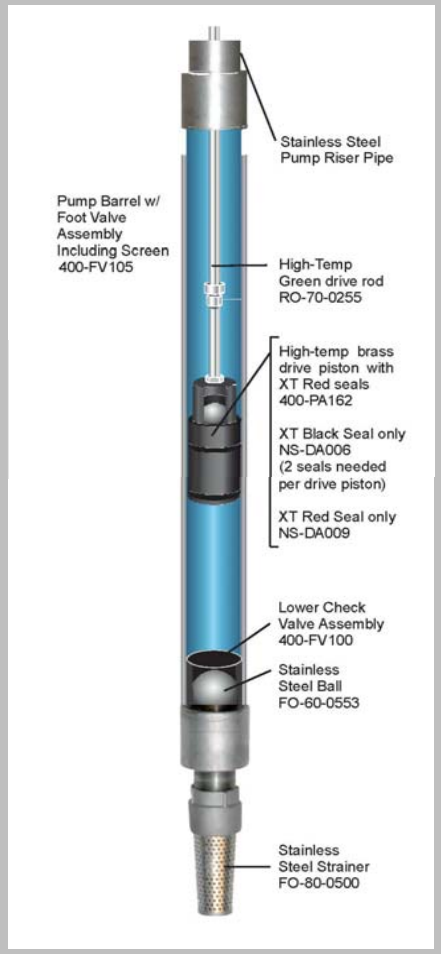
3 Power Options

Pneumatic

Electric

Solar

3 Downhole Options



Customizable by size & materials of construction

304, 316 super-deluxe stainless steel, bronze, Delrin, PEEK, Teflon, Ceramic

Models
101
102
103

Case Studies

1. **Midwest U.S. municipal park: Electric plant coal tar**

2. **Lake Superior: Mixed-source Superfund site**

3. **Australian steel-plant works: Coke industry**

Municipal Park: Electric-Plant Coal Tar

- **Bedrock depression, 50 ft. under park, across river**
- **Weight forcing tar into fissures, groundwater threat**
- **Tar 'pond' covered by water contaminated with light oil**
- **4-acre-site recovery goals:**
  - Remove coal tar and oil . . .
  - . . . But not the water
  - . . . Without disturbing formation

Municipal Park Solution

- **Multi-month test**
- **Pressure transducers in tar & upper groundwater**
- **Basin dewatered @6 gpm w/electric submersibles**

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- **2 small pneu pumps for tar**
  - 1 cup (8 oz.) per stroke each
  - 2 strokes per hour
- **Tar pumped into drums, hauled away**

Edge Pneumatic Piston Pump

Municipal Park Results

- **After 3 months:**
  - Approx. 550 gal of tar removed
  - Formation remained calm
  - Pumping tar, not water
  - Pumps ‘working reliably & without problems; doing what we wanted them to do.’

    -- Site engineer

Edge Pneumatic Piston Pump

Mixed-Source Superfund Site

Ashland, WI -- Lake Superior

- Toxic mix of tar, wood waste, oil, demolition debris
  -- PAHs, VOCs, heavy metals
- Air-lift pumps underperforming in extraction wells
- Engineers test single high-efficiency electric piston pump beginning Apr 2011
- 3 mo later, air-lifts removed for 2 more electric piston pumps and one electric submersible

Ashland WI Superfund Site Results

18 months: 09/30/10 to 03/31/12

1,556.2 gal **Free-product recovery**

2.85 gal/day **Average rate per day, increased 40%+**

392,800 gal **Effluent discharged**

5,036 gal **Per week discharge**

1) Increased flows forced replacement of treatment-system transfer pump 02/08/12 to 1.5 gpm

2) DNAPL transfer pump also reset higher, to 4 gpm

3) System reduced VOC levels to less than compound detection limits, to max 6.7 ug/L

4) Blackhawk pumps customized for Copper Fall Formation groundwater

Anchor Electric Piston Pump

Source: Wisconsin Dept. of Natural Resources Report, 04/03/12

Ashland Superfund Site Today

11 units -- pumping product 24/7

- .5 gal/min -- (.05 gal x 10 strokes/min)
- 30 gal/hour
- 720 gal/day
- 21,600 gal/mo

4 units -- thick product 6 hr/day

- .5 gal/min -- (.05 gal x 10 strokes/min)
- 30 gal/hour
- 180 gal/day
- 5,400 gal/mo

Anchor Electric pumping in Ashland residential neighborhood

Australian Steel Works – Coke Industry

- **2015 -- Tar found in enviro monitor bore**
- **2-ft. diam. well installed, 12 ft. deep**
- **Modified, extended V-2 Pneumatic Piston Pump**
- **Discharge to dumpster, vacuumed out**
- **Continuous ops begin Feb. 2016**

Aussie Tar Recovery – 10,000 Liters

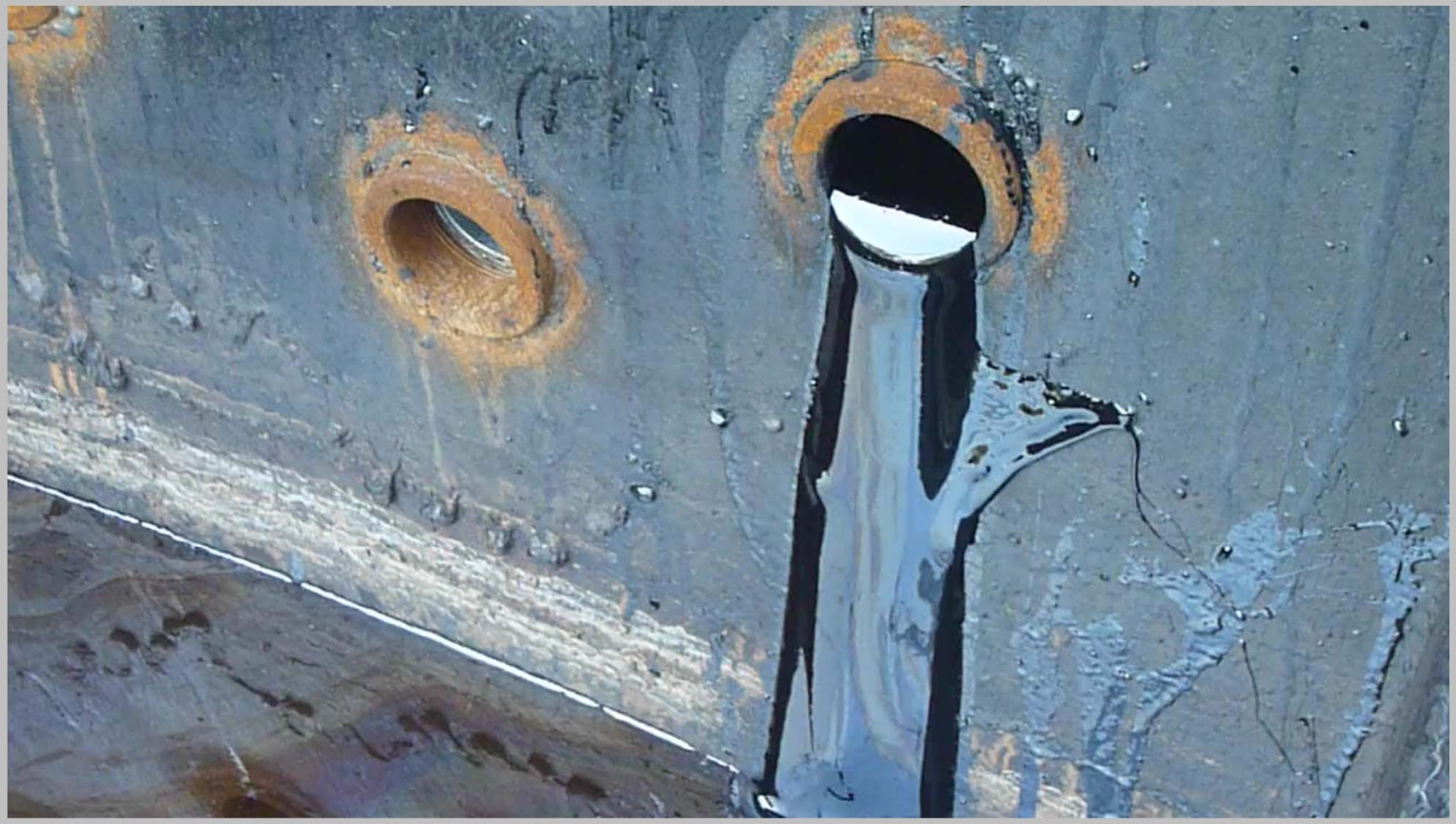
Four Months' Results

- **10,000 liters = 2,500+ gallons**
  - Ave. 600+ gal/mo, 150 gal/wk, 20+ gal/day
- **Onsite damage to Delrin cartridge seal**
  - Cylinder rod crusts w/dried tar residue
  - Rod running through road without cleaning
  - Engineer: 'Our lube was lacking'
  - Solution: Auto lube -- rod oiler

'The pump has performed exactly as we had hoped'

Aussie Pneumatic Pump in Action

Coal Tar Flowing

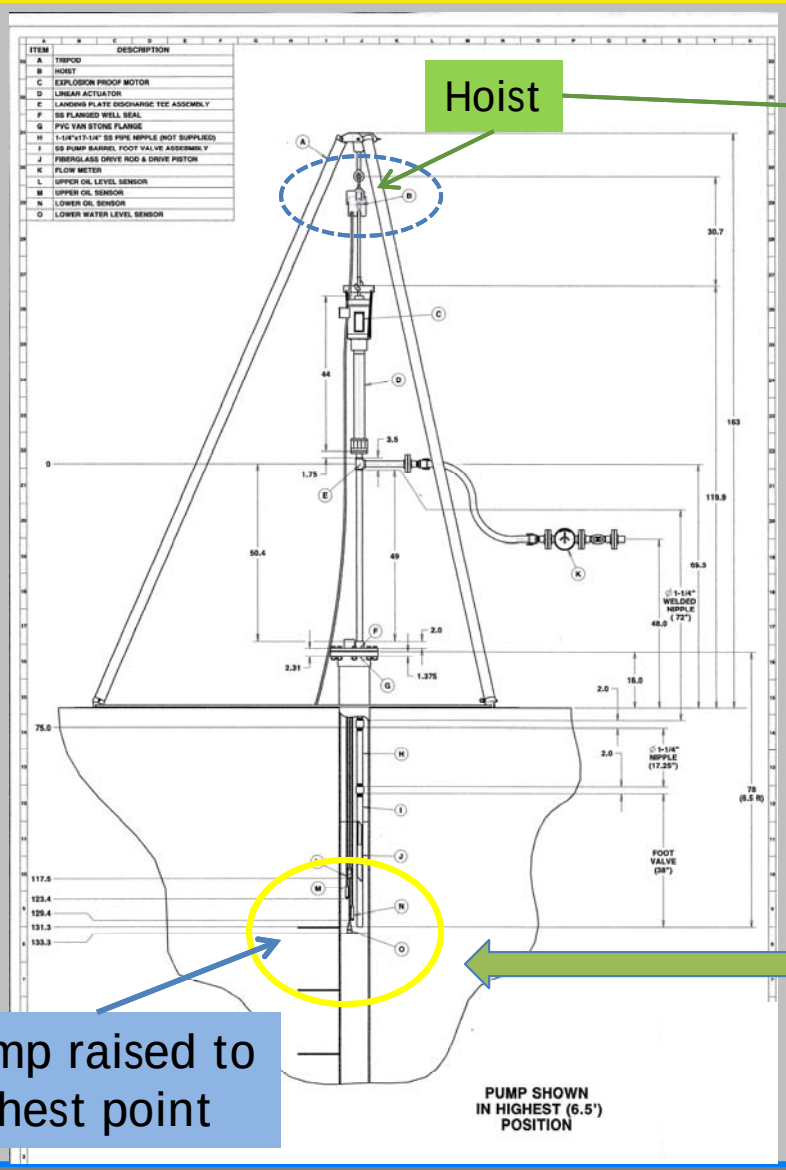


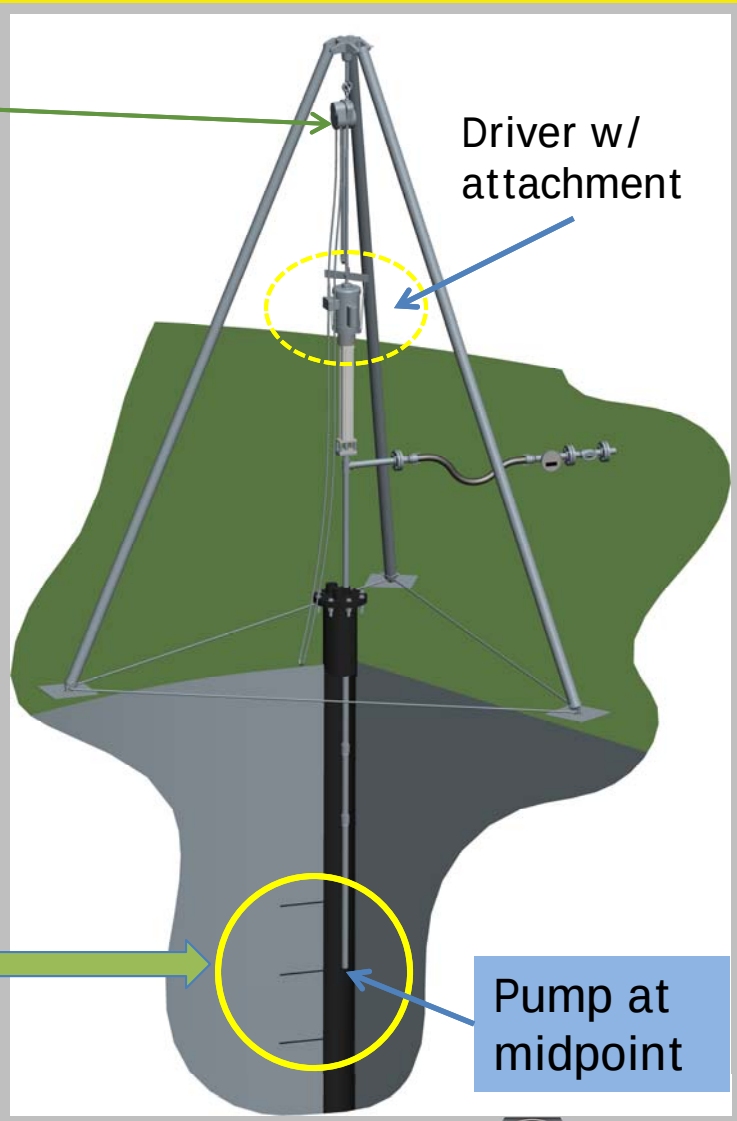
Oil Refinery

Recovering heavy hydrocarbons

- **Issue:**
  - Removing product from fluctuating water table
- **Data:**
  - Well diameter: 8 in.
  - Well depth: 20 ft.
  - Depth to product: 4 ft. from surface
  - Product thickness: 9 ft.
  - Water level: 14 ft.
  - Water table fluctuation: 2 ft.
- **Solution through customer collaboration:**
  - Raise and lower entire pump as needed
  - Constructed tripod with hoist
  - Simple, effective

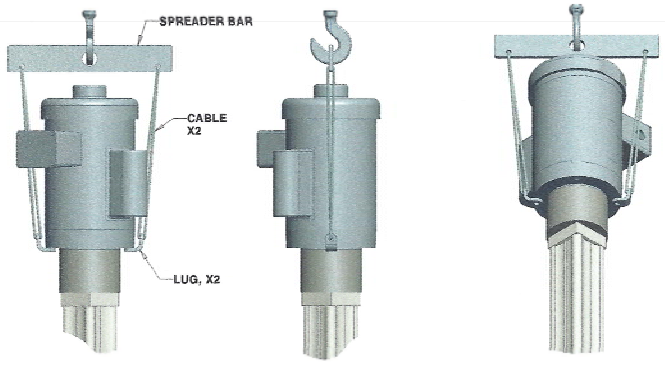
Refinery Tripod



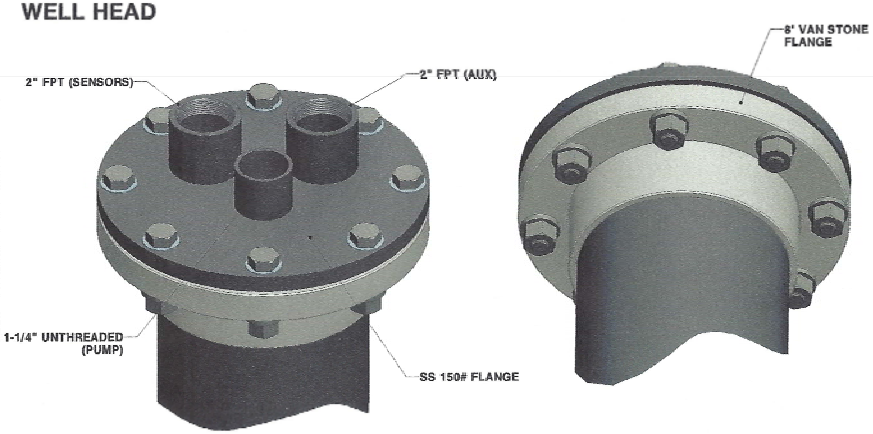


Tripod Components

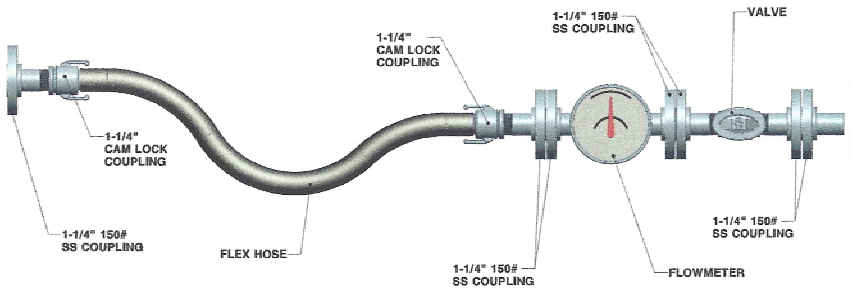
PUMP ATTACHMENT



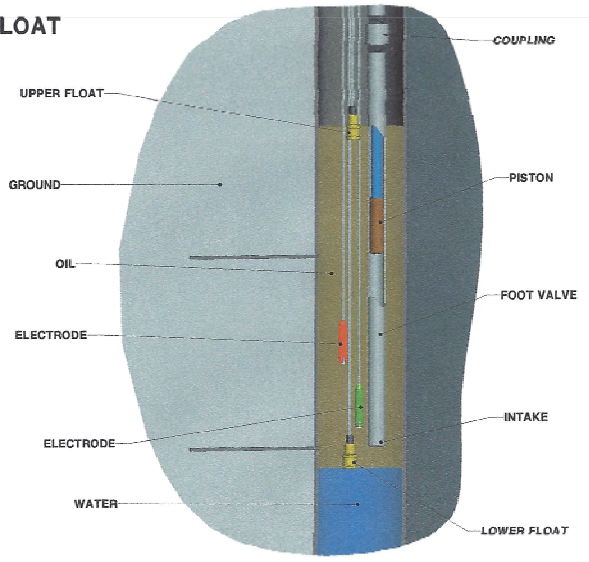
WELL HEAD



OUTLET



SENSORS/FLOAT



Refinery Results

Results . . . .

- Working as planned
- Pump can be raised 3 ft.
- Product pumped dry: Timer reset based on recharge rate
- Site is satisfied

Vertical – Side Slope - Horizontal

BLACKHAWK TECHNOLOGY COMPANY

Thank You

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