**From:** Batra, Roger [rbatra@TRCSOLUTIONS.com]
**Sent:** Friday, March 18, 2005 10:12 AM
**To:** Hwang, Don, Env. Health
**Cc:** Thomas.H.Kosel@conocophillips.com; Shelby.S.Lathrop@conocophillips.com
**Subject:** RE: 76 Stations 0746 (3943 Broadway), 3135 (6535 San Leandro Street), and 5043 (449 Hegenberger Road), Oakland, California

**Attachments:** 2887_001.pdf

2887_001.pdf (302 KB)

Don,

Here is a generic SOP that we follow for conducting MTS events at UST sites.

Thanks,

Roger Batra
Senior Project Manager
TRC

-----Original Message-----
From: Hwang, Don, Env. Health [mailto:don.hwang@acgov.org]
Sent: Thursday, March 17, 2005 2:08 PM
To: Batra, Roger
Subject: RE: 76 Stations 0746 (3943 Broadway), 3135 (6535 San Leandro Street), and 5043 (449 Hegenberger Road), Oakland, California

Roger, I looked at the website. Still, the information regarding MTS is about its capabilities. Do you have Standard Operating Procedures which describes how the MTS will be operated? Thanks, Don

-----Original Message-----
From: Batra, Roger [mailto:rbatra@TRCSOLUTIONS.com]
Sent: Thursday, March 17, 2005 10:17 AM
To: Hwang, Don, Env. Health
Cc: Thomas.H.Kosel@conocophillips.com; Shelby.S.Lathrop@conocophillips.com
Subject: RE: 76 Stations 0746 (3943 Broadway), 3135 (6535 San Leandro Street), and 5043 (449 Hegenberger Road), Oakland, California

Don,

TRC has a website, www.trcmts.com, and a lot of information regarding MTS is available on that site. Hope that will help.

Thanks,

Roger Batra
Senior Project Manager
TRC

-----Original Message-----
From: Hwang, Don, Env. Health [mailto:don.hwang@acgov.org]
Sent: Tuesday, March 15, 2005 5:40 PM
To: Batra, Roger
Subject: RE: 76 Stations 0746 (3943 Broadway), 3135 (6535 San Leandro

Street), and 5043 (449 Hegenberger Road), Oakland, California

Roger, Do you have an SOP for the MTS? Thanks, Don

-----Original Message-----
From: Batra, Roger [mailto:rbatra@TRCSOLUTIONS.com]
Sent: Tuesday, March 15, 2005 8:59 AM
To: Hwang, Don, Env. Health
Cc: Thomas.H.Kosel@conocophillips.com;
Shelby.S.Lathrop@conocophillips.com
Subject: FW: 76 Stations 0746 (3943 Broadway), 3135 (6535 San Leandro Street), and 5043 (449 Hegenberger Road), Oakland, California

Don,

Here is the response to your question for each site.

Thanks,

Roger Batra
TRC

-----Original Message-----
From: Trevor, Mark
Sent: Monday, March 14, 2005 11:12 AM
To: Batra, Roger
Subject: RE: 76 Stations 0746 (3943 Broadway), 3135 (6535 San Leandro Street), and 5043 (449 Hegenberger Road), Oakland, California

Here is a short paragraph on DPVE application at each site.

3135:
Dissolved-phase hydrocarbon concentrations in the target well (MW-6) have been 1,000 to 8,000 ug/L during the last 4 monitoring events. Prior to that, concentrations were in the 10,000 to 30,000 ug/L range. Depth to groundwater is approximately 6 fbg and the soil in the vadose zone consists of well graded sand. The high concenrations in a localized area, combined with shallow groundwater and permeable soil make this location a good candidate for short-term dual-phase extraction. It is anticipated that vapor-phase hydrocarbons will be removed from the vadose zone and possibly from the saturated zone if water levels can be lowered. In addition, hydrocarbon-impacted groundwater will be removed from the subsurface. Dissolved-phase hydrocarbon concentrations may be lowered significantly at relatively little expense using this technology.

0746:
Dissolved-phase hydrocarbon concentrations in the target wells (MW-3, MW-5 and RW-1) have been on the order of several thousand ug/L with free-product in MW-5. Benzene and MTBE have also been detected in MW-3 and RW-1. Depth to groundwater is approximately 10 fbg and the soil in the vadose zone consists of fine to medium grained fill or clay. The soil in the water bearing zone is coarse-grained gravel and sands. The high concenrations in a localized area, combined with shallow groundwater and a coarse-grained water-bearing zone make this site a potentially good candidate for short-term dual-phase extraction. It is anticipated that dissolved- and vapor-phase hydrocarbons will be removed from the saturated zone and to a lesser extent from the fine-grained vadose zone soils. In addition, hydrocarbon-impacted groundwater will likely be removed from the subsurface.

5043:
Dissolved-phase hydrocarbon concentrations in the target well (MW-6)

have been 71,000 to 110,000 µg/L during the last 4 monitoring events. Concentrations have been consistent with this for the past 4 years. Depth to groundwater is approximately 2 fbg and the soil in the upper 7 feet consists of sandy clayey fill. The high concenrations in a localized area, combined with shallow groundwater and semi-permeable soil make this location a good candidate for short-term dual-phase extraction. A DPVE event conducted in 1999 on MW-6 removed approximately 300 pounds of vapor-phase hydrocarbons and appeared successful at removing the recurring free-product in MW-6. It is anticipated that vapor-phase hydrocarbons will be removed from the vadose zone and possibly from the saturated zone if water levels can be lowered.

-----Original Message-----
From: Batra, Roger
Sent: Friday, March 11, 2005 11:50 AM
To: Trevor, Mark
Subject: FW: 76 Stations 0746 (3943 Broadway), 3135 (6535 San Leandro Street), and 5043 (449 Hegenberger Road), Oakland, California

Mark,

Please see me regarding a response to Don Hwang at Alameda County. I would like to get a response to him by Monday.

Thanks,

Roger
-----Original Message-----
From: Hwang, Don, Env. Health [mailto:don.hwang@acgov.org]
Sent: Friday, March 11, 2005 11:12 AM
To: Batra, Roger
Subject: RE: 76 Stations 0746 (3943 Broadway), 3135 (6535 San Leandro Street), and 5043 (449 Hegenberger Road), Oakland, California

Roger,

I've reviewed Work Plans for Dual Phase Vacuum Extraction Pilot Test for 0746 (3943 Broadway) and 5043 (449 Hegenberger Road), but can't find 3135 (6535 San Leandro Street) because we have it listed under a different address, do you have another address and which address should be used? The Work Plans are similar, specs for the MTS are given & which well will be used. For each site, please state how your proposals have a reasonable expectation to be effective.

Don

-----Original Message-----
From: Batra, Roger [mailto:rbatra@TRCSOLUTIONS.com]
Sent: Tuesday, March 08, 2005 3:17 PM
To: Hwang, Don, Env. Health
Subject: FW: 76 Stations 0746 (3943 Broadway), 3135 (6535 San Leandro Street), and 5043 (449 Hegenberger Road), Oakland, California

Don,

Here it is. I did not have the period between your first and last name. Thanks.

Roger Batra
TRC
925-688-2466

> -----Original Message-----
> From: Batra, Roger
> Sent: Tuesday, March 08, 2005 2:37 PM
> To: 'donhwang@acgov.org'
> Cc: 'Thomas.H.Kosel@conocophillips.com';
'Shelby.S.Lathrop@conocophillips.com'
> Subject: 76 Stations 0746 (3943 Broadway), 3135 (6535 San
Leandro Street), and 5043 (449 Hegenberger Road), Oakland, California
>
>
> Don,
>
> TRC on behalf of ConocoPhillps Company (ConocoPhillips) had submitted
the following documents for the subject sites to Alameda County Health
Services in September/October 2004.
>
> 76 Station No. 0746, 3943 Broadway, Oakland, California
>
> Work Plan for Dual Phase Vacuum Extraction Pilot Test dated September
23, 2004.
>
> 76 Station No. 3135, 6535 San Leandro Street, Oakland, California
>
> Work Plan for Dual Phase Vacuum Extraction Pilot Test dated September
23, 2004.
>
> 76 Station No. 5043, 449 Hegenberger Road, Oakland, California
>
> Work Plan for Dual Phase Vacuum Extraction pilot Test dated October
> 11, 2004
>
> TRC has scheduled the pilot tests at these sites to take place in late
March/early April 2005. The pilot tests will be conducted using TRC's
Mobile Treatment System, a truck-mounted, dual-phase soil-vapor and
liquid extraction system. In addition, prior to commencement of onsite
work, TRC will notify the Bay Area Air Quality Management District of
the proposed activities.
>
> No comments have been received from Alameda County Health Services
> since the submittal of the Work Plans for the subject sites. In
> accordance with 60-day rule (CCR Title 23, Division 3, Chapter 16,
> Article 11, Section 2722, 2e), TRC on behalf of ConocoPhillips can
> proceed with the dual-phase vacuum extraction pilot tests at the
> subject sites. If we do not hear back from you by March 18, 2005 we
> will assume you have no objections to the implementation of the
> aforementioned Work Plans
>
> Please call me should you have any questions or need additional
information.
>
> Thanks,
>
> Roger Batra
> Senior Project Manager
> TRC
> 1590 Solano Way, Suite A
> Concord, California 94520
> 925-688-2466 (Direct)
> 925-260-6405 (Cell)
>

3/18/05

**Draft Multi-phase Extraction Standard Operating Procedure**

This document provides guidance to remediation contractors operating multi-phase extraction (MPE) systems. Emphasis is placed on current remediation objectives of the mobile MPE trailers which focus on product removal or dissolved hot-spot cleanup through short-term (30-60 day) operation. Many of the operating decisions described herein will be applicable to longer-term MPE remediation systems, although monitoring schedule and scope may be significantly altered. This is a working document, subject to change and improvement as needed. The purpose is to establish a standardized methodology for performing MPE remediation, and thereby improve system flexibility, efficiency, effectiveness, and cost reduction.

## I. Multi-phase Extraction Objectives and Overview

UST gasoline release volume is often sufficient for non-aqueous phase liquid hydrocarbon (NAPL) to migrate to the water table, forming a non-wetting phase in soils of the upper saturated zone. Modern multi-phase flow theory recognizes this zone as an area of intimate contact between NAPL and water, representing a long-term source for dissolved phase contamination. Since NAPL displaces the wetting phase (water) it is mobile only so long as saturations are sufficient to maintain fluid pressures exceeding the pore entry pressures of adjacent soil pores. As seasonal water table fluctuations occur, NAPL is distributed vertically through an increasingly larger soil volume, causing a reduction in saturation throughout the NAPL plume. As saturations decline, the majority of the NAPL mass eventually becomes trapped as discontinuous ganglia within a "smear zone"[1]. Since saturations are low within the smear zone, little NAPL can be removed through drainage. Multi-phase extraction (MPE) systems are designed to dewater smear zone soils, induce air flow, and remove NAPL through volatilization.

MPE systems have two primary configurations. The first is dual-phase extraction (DPE), utilizing separate mechanical systems for pumping groundwater and extracting soil vapor. The second is two-phase extraction (TPE), where a single vacuum pump is used to extract both water and soil vapor through small diameter piping inserted in recovery wells. The most cost-effective MPE configuration is determined by aquifer permeability and corresponding well yield of both water and air (Figure 1). MPE systems are designed to operate at moderate to high vacuums (12-25" Hg), which create an inward radial pressure gradient in the vicinity of extraction wells. Subsurface vacuum enhances gravity-driven hydraulic gradient, which increases water yield to extraction wells and can generate a much broader cone of depression than would be possible under atmospheric pressure conditions. Since the objective of MPE remediation is to dewater the smear zone and volatilize NAPL, primary operational metrics are based on aquifer drawdown and vacuum distribution. Maximizing drawdown and annular vacuum in extraction wells optimizes both.

## II. Dual-Phase Extraction Systems

DPE systems typically include an air compressor and pneumatic downhole pumps for groundwater extraction, and a rotary lobe vacuum pump for concurrent vapor extraction at moderate vacuum. Vapor effluent may be treated with a thermal oxidizer, or may be discharged direct to the atmosphere where permitted. Extracted groundwater is processed through an oil/water separator, surge tank, air stripper, and final carbon polish (if necessary) prior to discharge to a POTW or surface drainage through NPDES permit.

[1] Monitoring wells in the center of the smear zone may contain ephemeral thicknesses of locally mobile NAPL, although the plume as a whole is immobile.

DPE system performance monitoring data include:

- ✓ Groundwater extraction pump depth
- ✓ Groundwater extraction rate (on an individual well basis)
- ✓ System operating vacuum
- ✓ System air flow rate
- ✓ System VOC concentration
- ✓ Wellhead operating vacuum
- ✓ Wellhead air flow rate
- ✓ Wellhead air flow control valve setting
- ✓ Wellhead VOC concentration
- ✓ Vacuum in adjacent monitoring wells
- ✓ Drawdown in adjacent monitoring wells

These data allow well-specific system adjustments based on degree of drawdown, yields of water and air, and mass removal rate.

IIA. DPE Groundwater Extraction System Setup:

Groundwater extraction pumps should be placed at a depth such that the pump intake allows maximum well dewatering. This may not be practical at sites with excessive yields where wells may not be completely dewatered to the pump intakes. Excessive yields are generally greater than 6-7 GPM/well for 2" diameter wells, and 12-14 GPM/well for 4" diameter wells. If either individual well yield is too great for pump capacity, or combined yield is too large for the groundwater treatment system, pumps should be raised to reduce dewatering and lower flow rates. In such cases, pumps should be set at a depth corresponding to an interpreted base of the smear zone[2], or generally as deep as water treatment or pump capacity will permit. Preferred pump types will utilize internal level controllers (e.g., clean environment, QED), since these controller designs do not require external pressure reference to casing vacuum, generally use less air/cycle, pump only water, and are reliable. Individual pump rates should be determined with cycle meters located within the remediation trailer, and should be converted to GPM values and recorded at each site visit.

IIB. DPE Drawdown measurement:

Prior to startup of the DPE system, a round of liquid elevations should be collected from all extraction wells and site monitoring wells as a baseline for calculation of induced drawdown. Once DPE has begun, liquid levels need not be collected from extraction wells, which are presumed to be dewatered to the pump intake, but should be collected from monitoring wells. Liquid levels should be collected at each site visit until stabilized drawdown can be demonstrated. If system configuration is altered, drawdown levels should again be verified until a steady-state condition can be verified.

IIC. DPE Wellhead air flow rates and vacuum monitoring:

Refer to Figure 2A for an example schematic of a typical DPE wellhead configuration. Although solid SVE piping can be utilized at the wellhead, a hose connection between underground SVE piping and casing is recommended to facilitate air flow measurement and provide flexibility for installation of valves and fittings within the well vault. Air flow can be measured with a rotameter attached to a double length of hose with camlock fittings at either end. In this manner, a single rotameter can be used to measure flow from all wells. Likewise, a quick-connect fitting is recommended for monitoring wellhead vacuum as a single gauge can be used on all extraction wells (although dedicated vacuum gauges are also acceptable).

[2] Since smear zone soils contain residual NAPL, headspace screening of soil samples collected during well installation can be used to distinguish between smear zone soils, and soils within the dissolved plume only.

IID. DPE Wellhead VOC monitoring:

VOC sampling should be performed under operating conditions, requiring a sample pump capable of defeating casing vacuum of 20" Hg (recommended). Although a variety of sample pump configurations are possible, the use of vacuum chamber/Tedlar bag combination allows positive visual evidence that the air sample is undiluted by leakage within the pump or fittings. Vapor samples should be screened in the field with a portable gas analyzer (FID preferred). VOC concentration (ppmv) should be converted to mass removal rate (Lb./day) utilizing an assumed molecular weight of 86.2 Lb./Lb.-mole (Hexane)[3].

IIE. DPE System VOC monitoring:

A pitot tube, venturi gauge, orifice plate, or other appropriate differential pressure flow measurement device should be installed on the discharge side of the vacuum blower. A hose barb or quick-connect fitting should also be installed at this location for vapor sampling upstream of effluent treatment (Thermox, if required). A matching flow measurement device should be installed to allow measurement of ambient air flow introduced to the system at the blow intake manifold. System air flow rate, VOC concentration as measured with a portable gas analyzer, mass removal rate (per method describe above), and bleed air flow rate (if any) should be recorded at each site visit. A confirmation laboratory analytical vapor sample should be collected concurrent with field screening sample to validate the portable gas analyzer readings. A Suma canister should be used for this purpose and submitted for analysis of BTEX and MTBE (if present) by Method 8020, and GOR through Method 8015, TO3, or suitable alternate. A laboratory VOC sample should be collected at least once during each 10 days of operation.

IIF. Optimizing DPE mass removal:

DPE systems allow broad flexibility and control in optimizing smear zone dewatering and remediation. The operational objective should be to maximize mass removal rate, initially for the system as a whole, and secondly from individual wells. Mass removal rate optimization approach emphasizes both air flow rate and VOC concentrations from individual wells, and considers initial limitations on mass removal which may be imposed by effluent treatment requirements. This approach is especially important in light of the short time frame of most DPE remediations (30-60 days).

All DPE wells should experience high mass removal rates at the beginning of remediation, especially if product removal is the remediation objective. If so, air flow control valves should be set 100% open initially, and baseline mass removal rates should be established for each well during the first week of operation. If a thermal oxidizer is required, air flow adjustments from individual wells should generally be deferred until no ambient bleed air is required (i.e., the BTU fuel value of the vapor effluent is less than Thermox treatment capacity). If maximum system vacuum operation is possible (i.e., no bleed air), individual air flow adjustments should be considered in the context of air flow rate comparisons between wells, and total air flow to the blower. Air flow rate adjustment decisions should be based on the following criteria:

1) If combined air flow rates from all wells are high relative to the maximum flow capacity of the blower, system vacuum should be within the mid- to lower portion of the performance curve (Figure 3). Under these operating conditions, flow and mass removal rate comparisons should be made between individual wells to evaluate whether air flow from certain wells should be restricted.

---

[3] (ppmv/1,000,000) * SCFM * 1440 min/day * 379 ft.$^3$ air/mole * 86.2 Lb./Lb.-mole = Lb./day

Figure 4 illustrates a two well DPE scenario in which one well is completed in higher permeability soils than the other. The high permeability well (high K) will receive the majority of air flow if flow control valves for both wells are set at 100% open, or if the system is balanced on wellhead vacuum (left illustration). Overall air flow rates are high and system vacuum low under these conditions (Figure 3). However, if the flow control valve is partially closed for the high K well, the system can be balanced on flow rather than vacuum (right illustration). System air flow rate is lowered and system vacuum increases. Casing vacuum increases in the low K well, and decreases in the High K well. Changing casing vacuum may affect drawdown which, in turn, may affect flow rate, requiring further flow valve adjustment to obtain balance. Balancing the system on air flow places emphasis on low permeability wells where remediation of NAPL through volatilization will occur less rapidly than high permeability wells, thus increasing the probably that all wells in the remediation system will be adequately treated within the preferred operational period of 30-60 days.

2) Balancing on flow rate criteria alone may not be optimal if low permeability wells also have low mass removal rates, especially when dissolved phase hot-spot reduction is the remediation goal. Empirical data suggest certain smear zone soils will experience mass removal limitations (diffusion-limited SVE performance), which is usually associated with low permeability. If flow balancing does not significantly improve mass removal rate from these wells, it may be optimal to shut them down and thereby increase flow to other extraction wells in the system. In any case, where dissolved hot-spot cleanup is the remediation objective, decisions to eliminate low permeability extraction wells from the system based on mass removal rate should be shared between the remediation contractor, Chevron project manager, and CRTC support personnel.

3) Extraction wells with high air flow rate and low mass removal rate should be considered for exclusion from the DPE system. These conditions are more likely to develop when dissolved phase hot-spot reduction is the remediation goal. High flow/low mass removal rate wells lower the operating vacuum of the system, and contribute little to overall system performance. It is important to note that high flow/low mass removal rate wells may be experiencing short-circuiting, especially if VOC concentrations drop markedly within the first few day of operation. A study of over 70 SVE pilot tests (Peargin and Mohr, 1994) noted short-circuiting occurred in about 20% of these tests. Since the pilot tests were performed at vacuums ranging between 2.1"- 4.6" Hg, short circuiting may be more prevalent at the high vacuums typical of MPE operation. Short circuiting may be more likely where well screen and filter pack intervals extend to within about 3 ft. of the surface. If monitoring wells are completed in this manner due to a shallow water table, DPE may not be feasible.

4) If combined air flow rates from all wells are relatively low, the blower should be operating in the high vacuum end of the performance curve (Figure 3). In this case, restricting air flow from individual wells will have little effect on system vacuum, and should result in little change in flow from other wells. No air flow adjustments are necessary.

✓ IIG. DPE System Monitoring Schedule:

Monitoring should be performed frequently at startup, and less frequently as the system performance pattern is established. A minimum frequency of 3 site visits is recommended during the first week of operation. Two site visits are recommended during the second week, followed by a single visit per week until the end of remediation. This should be considered a minimum frequency, and can be increased for Metro Atlanta, or other site locations where travel time and accessibility permit.

NA

## II. Two-Phase Extraction Systems

TPE systems use a single vacuum pump to extract both water and soil vapor through small diameter piping inserted in recovery wells. A generic system schemaic is shown in figure ____. Chevron mobile systems are equipped with either a 15 or 20 h.p. Travaini oil-sealed liquid ring vacuum pump. The liquid ring pump is connected to an air/liquid seperation tank which is under high vacuum. The tank is equipped with level controls and a Moyno progressive cavity pump to transfer liquids (and any entrained sediment) from the tank to an oil/water separator, or, settling tank, if required. Vapor effluent treatment has not been required for these systems to date. However, if necessary, vapor could be readily treated through use of a thermal oxidizer, or with vapor phase carbon following filtration for entrained sealant oil droplets. Extracted groundwater and NAPL (if present) is processed through the oil/water separator, followed by surge tank, air stripper, and final carbon polish (if necessary) prior to discharge to a POTW or surface drainage through NPDES permit.

TPE system performance monitoring is more limited than DPE systems since both vapor and liquids are extracted through a single piping system. TPE performance data include:

- ✓ Groundwater extraction rate (on a system basis)
- ✓ System operating vacuum
- ✓ System air flow rate
- ✓ System VOC concentration
- ✓ Wellhead drop tube operating vacuum
- ✓ Wellhead casing operating vacuum
- ✓ Wellhead flow control valve setting
- ✓ Wellhead bleed valve setting
- ✓ Vacuum in adjacent monitoring wells
- ✓ Drawdown in adjacent monitoring wells

These data allow for limited well-specific system adjustments, and may indicate the need to modify system piping sizes, connections, and operating practice.

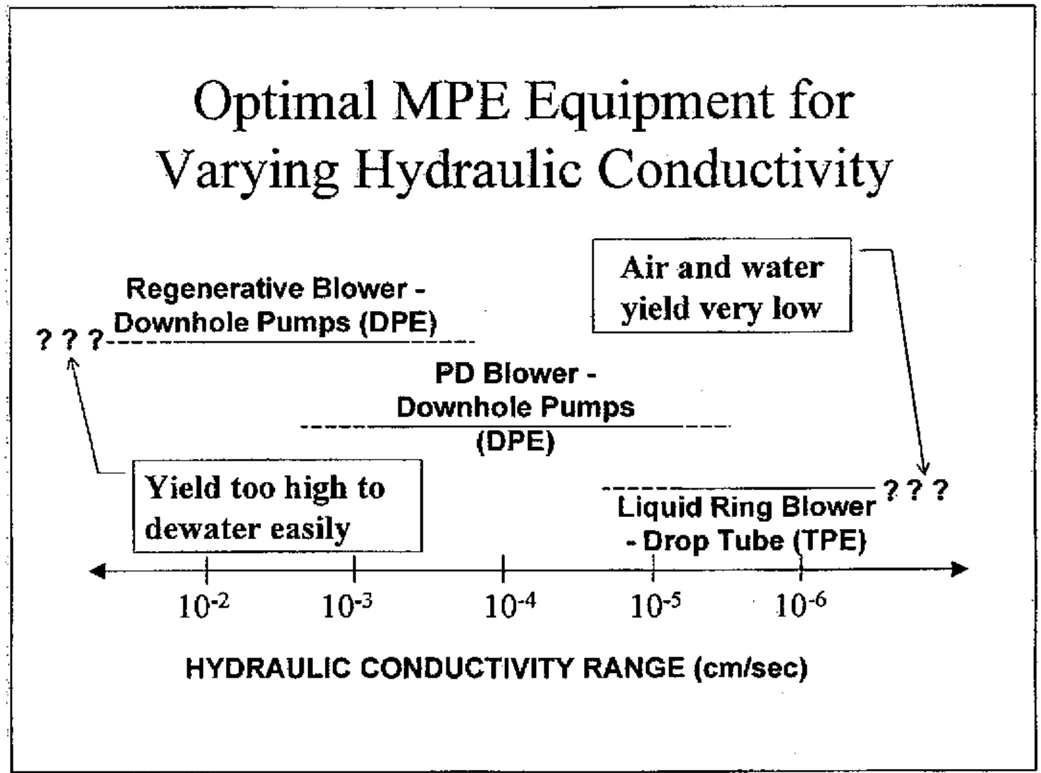


**Figure 1. MPE Application Permeability Range**

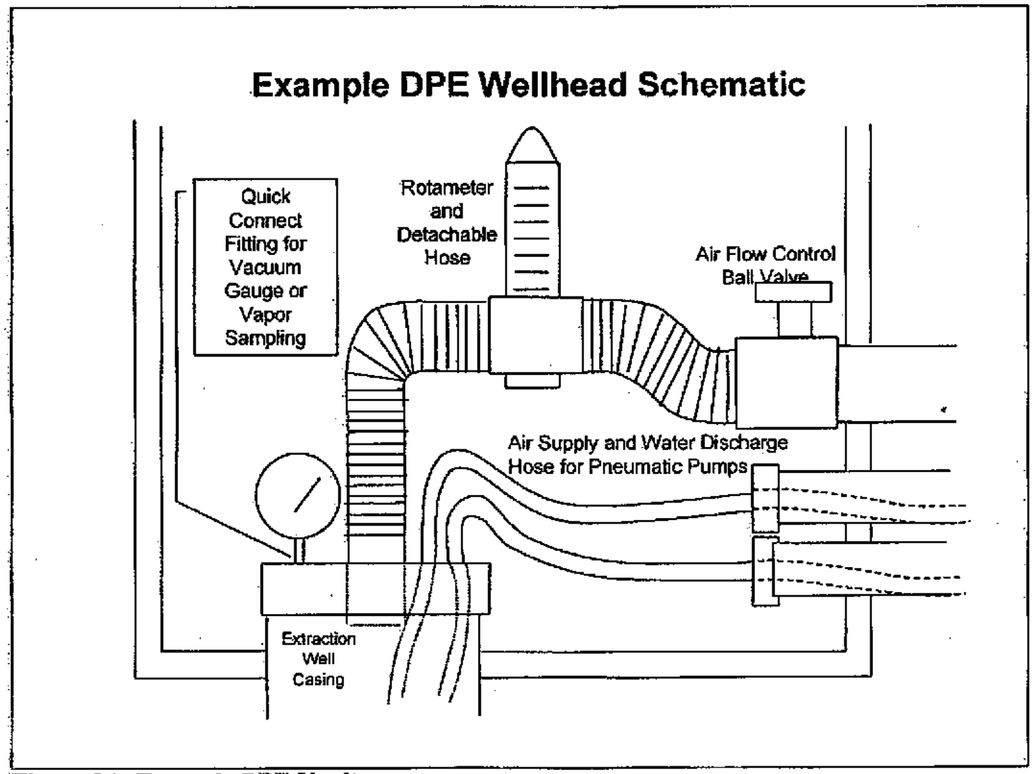


**Figure 2A. Example DPE Vault**

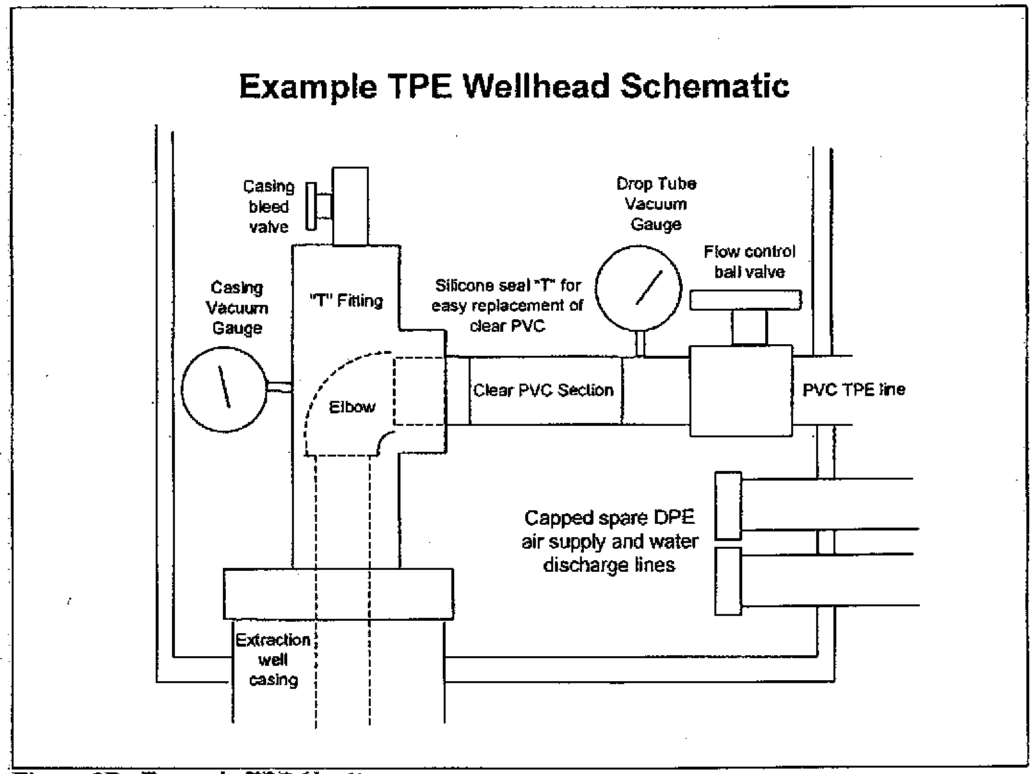


**Figure 2B. Example TPE Vault**

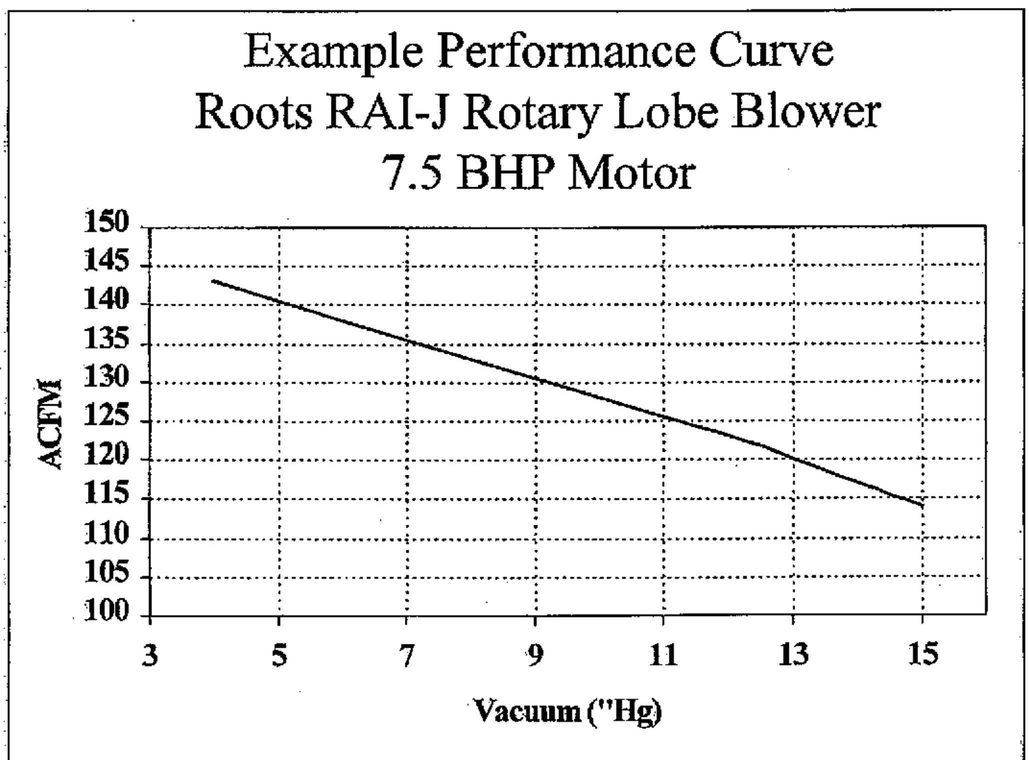


**Figure 3. Example Rotary Lobe Blower Performance Curve**

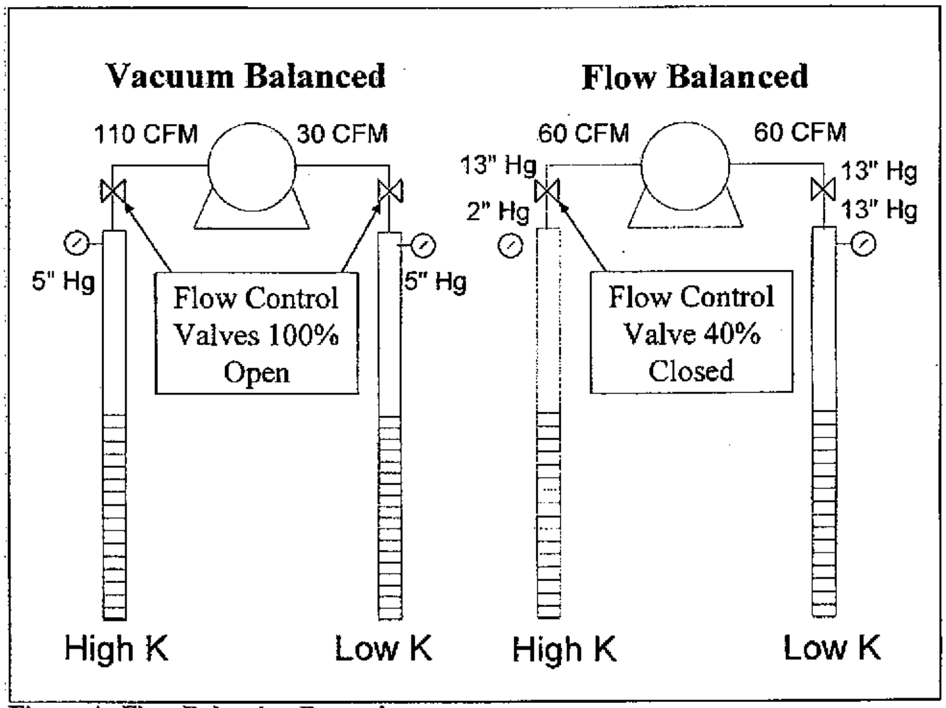


**Figure 4. Flow Balancing Example**