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Comparison of Screening Values from Selected Hydrocarbon Screening Instruments





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Comparison of Screening Values from Selected Hydrocarbon Screening Instruments

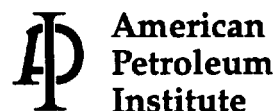
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ABSTRACT

Fugitive emissions from leaking equipment are being monitored by refineries, chemical plants, petroleum marketing terminals and oil and gas production operations. Different instruments, each capable of measuring the fugitive hydrocarbon emissions, or screening values, are being utilized by different studies. The measurement distance to hold the screening instrument from the point of maximum leak also differs for different facilities.

This study evaluated the differences in screening values for the following four different screening instruments^{*}:

- Foxboro Organic Vapor Analyzer (OVA) 108;
- Bacharach Threshold Limit Value Sniffer (TLV Sniffer®);
- HNU® PI-101; and
- Foxboro Total Vapor Analyzer (TVA) 1000, both flame ionization detector (FID) and photo ionization detector (PID).

This study showed that there were differences in screening values for a particular component based on using the different screening instruments. Adjustment factors, or correlation equations, were developed to allow screening values from the TLV Sniffer®, and the TVA FID to be converted to comparable OVA screening values. Adjustment factors were not developed relating HNU® or TVA PID screening values to OVA screening values because inadequate correlations were found between these screening values.

This study also evaluated the differences in screening values for these screening instruments based on screening as close as possible to the surface of a component at the point of maximum leak versus screening 1 cm away from the component at the point of maximum leak. This study showed that there are differences in screening values if the screening instrument is held at 1 cm away compared to holding the instrument as close as possible to the surface. An adjustment factor, or correlation equation, was developed to convert screening values from the OVA screening instrument using a 1 cm spacer basis to an "at the surface" basis.

^{*} Please note that other screening instruments, not studied in this report, may be available.

A 1979 study on screening distance effects and screening instrument effects was compared to the results of this study. Both studies show comparable differences between the OVA and TLV Sniffer® screening values; however, the screening distance differences were more pronounced in the 1979 study than in this study. The reason for the differences in screening distance results is unknown. These differences could be due to screening techniques, in ambient conditions, or in differences in instrument sensitivities.

An analysis was performed to determine other factors that may affect the relationship between screening values. Insignificant, or minimally significant effects were observed for windspeed, component type and service type.

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EXECUTIVE SUMMARY

Fugitive emissions from leaking equipment are being monitored by refineries, chemical companies, and petroleum marketing terminals. Several different instruments, each capable of measuring the fugitive hydrocarbon emissions, or screening values, are being utilized by these facilities. Furthermore, the distance that the screening instrument is held from the surface of the component at the point where the primary leak is measured can vary depending on local practices, the potential for probe-tip contamination, and/or the presence of rotating parts. To investigate these differences, the Western States Petroleum Association (WSPA) and the American Petroleum Institute (API) commissioned this study.

Specifically, this study's objectives were to:

- Develop a correlation equation for converting screening instrument measurements from other analyzers' to the Foxboro Organic Vapor Analyzer (OVA) 108 measurements by collecting side by side screening measurements from four different screening instruments:
 - Foxboro OVA 108,
 - Bacharach Threshold Limit Value Sniffer (TLV Sniffer®),
 - HNU® PI-101, and
 - Foxboro Total Vapor Analyzer (TVA) 1000, both flame ionization detector (FID) and photo ionization detector (PID).
- Develop a correlation equation converting screening measurements made at a distance of 1 cm to screening done as close as possible to the surface.

These correlation equations enable facilities that collect data with different instruments and different screening distances to convert their data to screening values that can be applied to mass emission correlation equations (i.e., that relate the mass in lb/hr to a particular screening value). However, other comparisons between instruments and screening distances may also prove beneficial to facilities monitoring fugitive emissions. Some of these additional comparisons were also evaluated in this study.

- Please note that other screening instruments, not studied in this report, may be available.

For this study, equipment leaks screening data were collected from two refineries, one located in southern California and one in northern California. The testing at one refinery occurred in December, 1993. The testing at the second refinery took place in January, 1994. Of the approximately 400,000 valves and connectors available in both refineries, less than 300 components were selected for this intercomparison. The statistical sampling used was designed to provide information on the sensitivity of various portable instruments throughout the range of potential screening values. Therefore, the hydrocarbon concentrations measured when screening these components are not representative of routine data collected during leak detection and repair programs at petroleum refineries. Although not every component selected for this study was screened with each of the four portable instruments, all components were screened at least with the OVA 108. Fewer measurements were made with the other instruments because of instrument difficulties. Screening took place over a one week period at each of the two refineries.

Of the 271 components tested, 227 were valves and 44 were connectors. The majority of the components to screen were identified by refinery inspection and maintenance (I/M) teams as part of their routine I/M program. The remainder were found by Radian field staff. Because of the deliberate focus on higher leaking components identified by the I/M teams, the screening value distribution of the data is certainly biased toward higher percentages of high screening value components than would be found with a random screening program at either refinery.

RESULTS FROM DIFFERENT SCREENING INSTRUMENTS

The four instruments use three unique methods to detect the hydrocarbon concentration. The OVA 108 and the TVA 1000 (FID) are both flame ionization detectors. The HNU[®] and the TVA 1000 (PID) are both photo ionization detectors. The TLV Sniffer[®] uses a combustion gas detector. The different hydrocarbon detection systems are believed to be the primary reason for the different results between instruments. The two FID instrument results and the two PID instrument results were much more comparable to each other than to instruments using different detection systems (FID vs. PID vs. combustion gas).

Recently completed studies by WSPA and API for refineries, petroleum marketing terminals and the oil and gas production industry have all used the OVA 108 as the screening instrument. For facilities that use other screening instruments that would like to apply results

of these recent studies to their facilities, an adjustment factor needs to be applied. A set of adjustment factors, or correlation equations, have been developed as part of this study to convert screening values from the TLV Sniffer[®] and TVA FID instruments to screening values measured with an OVA. These correlation equations are shown on Table ES-1. Plots showing the data comparing the different instrument results to each other are found in Section 3 of this report.

Table ES-1. Equations Relating Screening Values From Different Instruments^a

Variables Correlated	Screening Distance	Number of Data Pairs	Correlation Equation	Correlation Coefficient
OVA versus TLV Sniffer [®]	@ Surface	174	$OVA@ = (6.09 \times 10^{-1}) \times (TLV@)^{1.216}$	0.85
	1 cm	164	$OVA1 = (4.58 \times 10^{-1}) \times (TLV1)^{1.222}$	0.75
OVA versus TVA FID	@ Surface	54	$OVA@ = (1.54) \times (TVAF@)^{0.935}$	0.90
	1 cm	52	$OVA1 = (1.02) \times (TVAF1)^{1.013}$	0.83

^a For maximum sustainable screening values.

Key

OVA@ = OVA screening value at the surface of a component.
 OVA1 = OVA screening value obtained with a 1 cm spacer.
 TLV@ = TLV Sniffer[®] screening value at the surface of a component.
 TLV1 = TLV Sniffer[®] screening value obtained with a 1 cm spacer.
 TVAF@ = TVA screening value at the surface of a component.
 TVAF1 = TVA screening value obtained with a 1 cm spacer.

No correlations were developed to relate HNU[®] or TVA PID screening values to OVA screening values because an adequate correlation was not found between these screening values. Therefore, it is not advisable to use mass emission correlation equations that were developed with an OVA when HNU[®] or TVA PID screening measurements are obtained.

Study results indicate that the differences between peak screening values (i.e., the highest observed screening value) and the maximum sustainable screening values (i.e., the maximum screening value observed for two to three seconds or which was repeated multiple times in 30–60 seconds) were not statistically significant.

RESULTS FROM DIFFERENT SCREENING DISTANCES

Most facilities that routinely screen for fugitive emissions from leaking equipment screen as close to the surface as possible but not so closely that it causes hydrocarbon contamination of

the probe tip, thereby causing erroneous screening measurements. The instrument probe is normally held from the point of the highest leak on the component and the probe distance from the surface can vary from less than 1 mm to as much as 1 cm. If a 1 cm standoff basis is used, a spacer that maintains this distance can be applied to the end of the probe tip. In other cases, the inspector uses his or her experience and judgment to maintain this distance of approximately 1 cm.

For testing purposes in this study, a 1 cm spacer was applied to the probe tip to maintain a standardized distance for the 1 cm measurements. The surface measurements were made as closely as possible to the surface, recognizing that because of the instrument probe dimensions and component geometry, the actual probe distance from the surface could vary from one component type to another. The actual probe distance from the surface of the component could be some immeasurable distance which is less than 1 cm.

The recent refinery and petroleum marketing terminals studies were performed by screening components as close as possible to the surface. For facilities that use a 1 cm spacer that would like to apply results of these recent studies to their facilities, an adjustment factor needs to be applied. The adjustment factor for an OVA at the surface (OVA@) versus an OVA at 1 cm (OVA1) is given in the equation below:

$$\text{OVA@} = (3.60) \times (\text{OVA1})^{0.962} \quad (\text{Equation ES-1})$$

The recommended approach for converting screening values from the TLV Sniffer® and the TVA FID, when these instruments use a 1 cm spacer, to comparable OVA screening values at the surface is to first convert to comparable OVA values at 1 cm by using the correlations in Table ES-1 and then apply the above equation. Because of the lack of correlation for the HNU® and TVA PID to OVA screening values it is not recommended to convert any screening values from these instruments to OVA screening values.

Each of the instruments had screening values compared with that instrument at the surface to those with that same instrument at 1 cm. The effects of screening at the surface versus screening at 1 cm appears to have roughly the same impact for each instrument type. The screening values are two to three times lower, on the average, when obtained at a 1 cm

screening distance. Plots showing the data comparing results for the different instruments are found in Section 3 of this report.

COMPARISON OF STUDY RESULTS TO EARLIER STUDY

A previous study, entitled *Valve Screening Study at Six San Francisco Bay Area Petroleum Refineries*, or the "1979 Screening Study," reported on results for similar analysis of the TLV Sniffer[®] and the OVA 108. The current study, or "1994 Screening Study", evaluated more components, included connectors in the analysis, included additional screening instruments, and looked at additional factors that could influence test results such as windspeed, component type and service type.

Both studies show comparable differences between OVA vs. TLV Sniffer[®] screening values; however, the screening distance differences were more pronounced in the 1979 Screening Study than in the 1994 Screening Study. The reason for the differences in screening distance results is unknown. These differences could be due to differences in screening techniques, in ambient conditions, or in instrument sensitivities.

COMPARISON OF OTHER FACTORS THAT MAY AFFECT THE CORRELATION EQUATIONS

An analysis was performed to determine other factors that may affect the relationship between screening values. Windspeed was found to have a statistically significant effect for some of the inter-instrument comparison correlation equations. However, the impact of windspeed on the correlation equations was minor. Only marginal improvements in the correlation coefficients were found by including windspeed in the equations for which windspeed was significant. For example, the correlation coefficient for the OVA at the surface versus OVA at 1 cm correlation equation improves from 0.929 to only 0.930 by including windspeed.

Component type and service type were shown to have a significant effect for a few of the screening value correlations developed; however, these may either be anomalous occurrences or questionable due to limited data for a specific factor. Investigations to determine any other reasons for the significant effects are beyond the scope of this project. Future research might investigate whether or not different component types with different geometries could effect the

actual distance the instrument probe is away from the surface and quantify the variation effect on screening values. In addition, future research could investigate whether service type (low vapor pressure, high vapor pressure, low viscosity liquid, high viscosity liquid, etc.) could have a similar effect on measured screening values.

ES-6

Section 1

INTRODUCTION

Fugitive emissions from leaking equipment such as valves and connectors are being monitored by refineries, chemical companies, and petroleum marketing terminals. Several different instruments, each capable of measuring the fugitive hydrocarbon emissions, called "screening values," are being utilized by these facilities. Furthermore, the distance that the screening instrument is held from the surface of the component at the point where the primary leak is measured can vary depending on local practices, the potential for probe-tip contamination, and/or the presence of rotating parts. To investigate these differences, the Western States Petroleum Association (WSPA) and the American Petroleum Institute (API) commissioned this study, entitled "Comparison of Screening Values from Selected Hydrocarbon Screening Instruments and Different Screening Distances" and is referred to here as the "1994 Screening Study."

STUDY OBJECTIVES

This study's objectives were to:

- Develop a correlation equation for converting screening instrument measurements from other analyzers to the Foxboro Organic Vapor Analyzer (OVA) 108 measurements by collecting side by side screening measurements from four different screening instruments* including:
 - Foxboro OVA 108,
 - Bacharach Threshold Limit Value Sniffer (TLV Sniffer®),
 - HNU® PI-101, and
 - Foxboro Total Vapor Analyzer (TVA) 1000, both flame ionization detector (FID) and photo ionization detector (PID).
- Develop a correlation equation converting screening measurements made at a distance of 1 cm to screening done as close as possible to the surface.

* Please note that other screening instruments, not studied in this report, may be available.

The correlation equations convert screening values from one instrument to those with an OVA. The reason that the reference point was an OVA was because that was the basis for the recently completed studies from WSPA and API for refineries (API, 1994) and petroleum marketing terminals (API, 1993). Another desired product of the study was an adjustment factor, or correlation equation, that could convert screening values for an OVA at one screening distance to comparable values at a different screening distance, since in the two API studies, components were screened as close to the surface as possible.

A previous study, entitled *Valve Screening Study at Six San Francisco Bay Area Petroleum Refineries* (Radian, 1979), referred to as the "1979 Screening Study" in this report, reported on results for similar analysis of the TLV Sniffer® and the OVA 108. The 1994 Screening Study evaluated more components, included connectors in the analysis, included additional screening instruments, and looked at additional factors that could influence test results (windspeed, component type and service type). The 1994 Screening Study results have been compared to the 1979 Screening Study results in this report.

PROJECT DESCRIPTION

For this study, equipment leaks screening data were collected from two refineries, one located in southern California and one in northern California. The testing at one refinery occurred in December, 1993. The testing at the second refinery took place in January, 1994. A total of 271 components were screened. Although not every component was screened with each of the four screening instruments, all components were screened at least with the OVA 108. Instrument difficulties resulted in fewer measurements with the other instruments. Screening took place over a one week period at each of the two refineries. A total of 227 valves and 44 connectors (9 flanged connectors and 35 non-flange connectors) were screened. The majority of the components to screen were identified by refinery inspection and maintenance (I/M) teams as part of their routine I/M program. The remainder were found by Radian field staff. Because of the deliberate focus on higher leaking components identified by the I/M teams, the screening value distribution of the data is biased toward higher percentages of high screening value components than would be found with a random screening program at either refinery.

REPORT ORGANIZATION

This report is organized as follows:

- Section 2 documents the test procedures including a description of the equipment, QA/QC, and sampling procedures;
- Section 3 discusses the data analysis, including comparison of the screening instrument screening values, comparison of screening values as a function of screening distance, comparison of 1994 Screening Study results to 1979 Screening Study results, and analysis of other factors that may affect the correlation equations;
- Section 4 presents the conclusions and recommendations; and
- Section 5 includes the references.

Section 2

TEST PROCEDURES

This section describes the test procedures, including a description of the equipment, quality assurance/quality control (QA/QC), and sampling procedures.

EQUIPMENT

Four different screening instruments were used in this study:

- Foxboro Organic Vapor Analyzer (OVA) 108;
- Bacharach Threshold Limit Value (TLV) Sniffer®;
- HNU® PI-101; and
- Foxboro Total Vapor Analyzer (TVA) 1000, both flame ionization detector (FID) and photo ionization detector (PID).

The first three instruments have been heavily used in past studies and in I/M programs. The final instrument is new and represents a potentially popular instrument for future studies and I/M. Please note that other screening instruments, not studied in this report, may be available. Each of the four screening instruments is briefly described:

OVA 108

The Foxboro OVA 108 was used for screening every component in this study. The OVA 108 is a portable FID, powered by a refillable hydrogen tank. The OVA 108 internal vacuum pump is powered by a rechargeable battery. The pump continuously draws sampled hydrocarbons and air from the probe tip to the analyzer at a flow rate of approximately one liter per minute. The hydrocarbons are analyzed by the FID. The detector output is read on a hand-held logarithmic meter scale which is graduated from 1 to 10,000 ppmv. The OVA 108 was calibrated with methane. Hydrocarbon concentrations greater than 10,000 ppmv can be measured by use of a dilution probe. The dilution probe mixes charcoal scrubbed ambient air with the sample. The charcoal was used in an attempt to remove hydrocarbons from the background dilution air. In general, a dilution ratio of 10:1 was used in this study, allowing hydrocarbon concentrations up to 100,000 ppmv to be measured.

TLV Sniffer®

The Bacharach TLV Sniffer® is a portable hydrocarbon detector that uses a catalytic combustion cell to determine hydrocarbon concentrations. A rechargeable battery provides the power for the internal sample pump which draws the sample through the detector chamber at a flow rate of approximately two liters per minute. The detector element catalytically oxidizes the hydrocarbon in the sample in order to determine the heat of combustion. This heat of combustion is expressed as an equivalent concentration. The TLV Sniffer® was calibrated with hexane. The TLV Sniffer® measures hydrocarbons from 1 to 10,000 ppmv. A dilution probe can extend the range of the TLV Sniffer® to 100,000 ppmv. However, a dilution probe was not used in this particular study for the TLV Sniffer®.

HNU®

The HNU® Systems Inc. PI-101 detector (HNU®) used was a 10.2 eV lamp PID. Similar to the previously mentioned instruments, the HNU® uses a rechargeable battery to power the internal sample pump to draw the sample through the detector chamber at a flow rate of approximately 0.10–0.18 liters per minute. The PID ionizes the sample by an ultraviolet (UV) light. The detector output is displayed on a scale with three settings: 0-20 ppmv, 0-200 ppmv, and 0-2000 ppmv. The HNU® was calibrated with isobutylene. The PID measures halogenated hydrocarbons, aldehydes, ketones, aromatics, and any other compound with an ionization potential of 10.2 eV or less, including several that cannot be measured by an FID. The PID, however, does not respond well to many alkanes, particularly in the lower carbon number ranges. There are dilution probes available for many PID instruments, but none was available for use on this study.

TVA 1000

Foxboro has recently introduced into the market an instrument that has both FID and PID capabilities, called the TVA 1000. The FID operates in nearly exactly the same manner as the OVA 108 FID. The PID operates with the same basic principles as the HNU® PID. The TVA PID uses a 10.6 eV lamp, which is relatively close to the 10.2 eV used in the HNU®. The flow rate into the PID and FID combined is approximately one liter per minute. The sample stream is split into two paths within the TVA 1000 to allow for simultaneous analysis by the FID and PID. The TVA 1000 FID was calibrated with methane. The PID was calibrated with

isobutylene. The range of the TVA 1000 without the dilution probe is from 1 to 50,000 ppmv for the FID and from 1 to 2,000 ppmv for the PID. A dilution probe can be attached to the TVA 1000 to extend the range. A dilution probe was used in this study to extend the range by approximately a factor of 10. The hydrocarbon concentrations were displayed in digital readouts on the hand-held sample probe and also on the body of the analyzer. The TVA 1000 also allows data to be logged internally for data collection purposes; however, this feature was not used for this study.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Each screening instrument was calibrated at least once each day. If batteries needed to be replaced, the instrument was recalibrated.

The OVA 108 was calibrated using a 100 ppm methane standard (certified at plus or minus 2%). To ensure that the OVA 108 was responding adequately over the entire range of hydrocarbon concentrations, the OVA 108's response was also checked with a certified zero air standard and with 10 ppm, 1000 ppm, and 10,000 ppm methane in zero air standards (each hydrocarbon standard certified at plus or minus 2%). The OVA 108 response to all of the hydrocarbon concentrations was checked by a linear regression. A correlation coefficient (r) of 0.995 or greater was required or the instrument was repaired. The OVA 108 dilution probe was set to a dilution ratio of approximately 10:1 based on using the 10,000 ppm methane standard. The reading of the OVA 108 with the dilution probe at 26,900 ppm was also checked and recorded.

The TLV Sniffer[®] was calibrated with a 500 ppm hexane standard and a 4000 ppm hexane standard. The HNU[®] was calibrated with a 95 ppm isobutylene standard at the first refinery and with a 102 ppm isobutylene standard at the second refinery. The TVA 1000 FID was calibrated in the same manner as the OVA 108 with the exception that the automatic calibrating mode was generally used for the TVA 1000. The automatic calibrating mode of the TVA 1000 allows for the instrument to calibrate itself when a known concentration of a calibration gas is examined. The TVA 1000 PID was calibrated in the same manner as the HNU[®] with the same exception that the automatic calibrating mode was generally used for the TVA 1000.

Calibration gases were carried into the field in Tedlar™ bags during all field testing. Each instrument was checked for accuracy after approximately every five samples. If an instrument failed this QA/QC check then the previous readings until the last verified QA/QC check were excluded or retested with a recalibrated instrument. In practice, very few samples needed to be excluded. The excluded samples, along with all of the raw sampling data, are shown in Appendix A.

SAMPLING PROCEDURES

In general, the screening measurements were made in accordance with the latest version of the United States Environmental Protection Agency's (U.S. EPA) Reference Method 21. U.S. EPA Method 21 instrument specifications are summarized in Table 2-1. The requirements that were followed in this study exceeded the requirements of U.S. EPA Method 21. Table 2-2 outlines the general screening procedures that were followed for all four of the screening instruments.

Table 2-1. Summary of EPA Method 21 Requirements

Determination of Volatile Organic Compound Leaks	
1. Analyzer response factor <10	
2. Analyzer response time ≤30 seconds	
3. Calibration precision ≤10% of calibration gas	
4. Internal pump capable of pulling 0.1 to 3.0 L/min	
5. Intrinsically safe	
6. Single hole probe with maximum ¼-inch OD	
7. Linear and measuring ranges must include leak definition value (may include dilution probe)	
8. Instrument readable to ±2.5% of leak definition	
9. No detectable emissions (NDE) value defined as ±2.5% of leak definition (i.e., ±500 ppm)	

Data collected from screening were recorded on forms like the one shown as Figure 2-1. Five different readings were made with each screening instrument for each component. The first reading was a background reading measured in an area close to the component. Once the point of maximum leakage was found on the component as close as possible to the component's surface, then the maximum sustainable leak rate and the peak leak rate were recorded. The maximum sustainable leak rate was the screening value that stabilized for two

to three seconds, or was repeated multiple times in 30-60 seconds. The peak leak rate was the highest observed screening value on the instrument, even if the screening value were only a fleeting spike.

Table 2-2. Summary of Screening Procedures

General Screening Procedures
1. Prepare analyzer for sampling. 2. Calibrate analyzer. 3. Check analyzer for leaks. 4. Without fouling the tip, and without restricting flow into the analyzer probe, place probe as close as possible and approximately perpendicular to the component surface or seam where leakage could occur. 5. Move the probe slowly along the line of potential leakage to obtain the maximum reading. 6. Leave the probe tip at the maximum reading location for approximately two times the instrument response time. 7. Record the maximum sustainable screening value and the peak screening value on the data form. 8. If the reading exceeds full scale, use the dilution probe, if the instrument has a dilution probe. 9. Add 1 cm spacer to the probe tip. 10. Repeat steps 5 through 8. 11. Repeat steps 1 through 10 for the remaining screening instruments.

The next two readings (maximum sustainable and peak) were taken at a 1 cm standoff from the surface of the component. The readings at 1 cm were generally, but not always, 1 cm away from the point of highest leak at the surface of the component. The component was always rescreened to determine, independent of the surface readings, where the point of highest leak at 1 cm was found. A 1 cm spacer, supplied by Foxboro, was provided for screening at 1 cm with the OVA 108 and the TVA 1000. A different 1 cm spacer was constructed for use with the TLV Sniffer® and the HNU®.

Valves screened for this study were usually identified by the refinery inspection and maintenance (I/M) teams. The remaining valves were found by Radian staff when insufficient numbers of valves for Radian to test were located by the I/M teams on the day of Radian's testing, or if there was a need to obtain more diversity in screening values tested. In order to strengthen the statistical significance of the desired correlations, Radian attempted to obtain screening values from the whole leak range from 1 ppmv to 100,000 ppmv for the OVA 108,

from 1ppmv to 10,000 ppmv for the TLV Sniffer®, from 1 to 2000 ppmv for the HNU® and from 1 to over 500,000 ppmv for the TVA 1000. Components that tested beyond the range of the analyzers (pegged components) were also screened with the pegged value recorded.

The majority of the connectors that were tested for this study were located by Radian. This was primarily because these connectors were not tagged and locating leaking connectors from the records of the I/M team was significantly more difficult than searching for these leaks independently. Furthermore, fewer leaking connectors than valves, at least on a percentage basis, are found in these refineries.

After the screening values were all recorded for a particular component, then the ambient temperature was recorded from a digital thermometer and the windspeed was recorded from an anemometer. The temperature and the windspeed were measured as close as possible to the highest leaking point on the component. As shown in Figure 2-1, also recorded was the component tag ID, the component subtype (i.e. gate, glove, plug or other type of valve), the component actuation if a valve (either control or manual), the size of the component, and the service category (light liquid, heavy liquid or gas). For this study, light liquids are defined as any liquid with vapor pressure greater than kerosene.

Duplicate measurements were taken, on the average, for every twentieth component screened. For the duplicate tests, all instrument readings were retaken exactly as on the first measurement, both for the different instruments and the different screening distances.

Plant ID: _____ Date: _____ Screening Team: _____
 Unit: _____ Page: _____ of _____ Instrument ID: (OVA 100) (TLV Swifter) (HNE) (TVA 1000)

Seq #	Component ID	Type	Sub Cat	Act.	Size (in.)	Service	Amb. Temp.	Amb. Wind	Instrument Type	Background	Maximum Detectable Screening at Surface	Peak Screening at Surface	Maximum Detectable Screening at 1 cm	Peak Screening at 1 cm	Comments
									OVA 100						
									TLV Swifter ^a						
									40%						
									TVA 1000 (PID)						
									TVA 1000 (PID)						
									OVA 100						
									TLV Swifter ^a						
									40%						
									TVA 1000 (PID)						
									TVA 1000 (PID)						
									OVA 100						
									TLV Swifter ^a						
									40%						
									TVA 1000 (PID)						
									TVA 1000 (PID)						
									OVA 100						
									TLV Swifter ^a						
									40%						
									TVA 1000 (PID)						
									TVA 1000 (PID)						
									OVA 100						
									TLV Swifter ^a						
									40%						
									TVA 1000 (PID)						
									TVA 1000 (PID)						

QC Check Time _____ ppm
 Standard _____ ppm
 OVA 100 _____ ppm
 TLV Swifter^a _____ ppm
 HNE _____ ppm
 TVA 1000 (PID) _____ ppm
 TVA 1000 (PID) _____ ppm

Type: valve, con-fl (connection-flange), con-non (connection-nonflange)
 valves: gas, globe, plug, ball, b-fly (butterfly), bellows, other
 connections: flange, screw (screwed connection), union, other
 H (heavy liquid), L (light liquid), G (gas)
 Act: (only for valves): M (manual actuation), C (control valve)
 Amb Temp.: Ambient temperature in °F
 Amb. Wind: Ambient wind velocity in mph.

Figure 2-1 Screening Value Data Collection Sheet

Section 3

DATA ANALYSIS

Throughout this section the following notation will be used to refer to the screening instrument and distance:

- OVA@/OVA1 — Screening values obtained using the OVA at the surface and at 1 cm, respectively;
- TLV@/TLVA1 — Screening values obtained using the TLV Sniffer® at the surface and at 1 cm, respectively;
- HNU@/HNU1 — Screening values obtained using the HNU® at the surface and at 1 cm, respectively;
- TVAF@/TVAF1 — Screening values obtained using the TVA FID at the surface and at 1 cm, respectively; and
- TVAP@/TVAP1 — Screening values obtained using the TVA PID at the surface and at 1 cm, respectively.

In general, no appreciable differences were noted between the maximum sustainable screening values versus the peak screening values. Plots of both types of screening value measurements are included in this section. Correlation equations were developed using only the maximum sustainable screening value measurements, however, because it is believed that this is the type of screening value measurement typically collected by refineries.

Pegged values were obtained during the 1994 Screening Study; however, these pegged values were not included in any of the emission correlation equations and were therefore excluded from any of the statistical analysis in this report.

Statistical analyses were performed on the screening data to examine the following:

- Correlation between screening values obtained from different instrument types (OVA, TLV Sniffer®, HNU®, and TVA);
- Correlation between screening values at different screening distances (screening at the surface versus a 1 cm screening distance) for a given instrument;

- Differences between the 1979 Valve Screening Study (1979 Screening Study) results and the current 1994 Screening Study results; and
- Other variables that may affect screening results (e.g., component type, component service, windspeed).

The analyses performed for each of the aforementioned areas are discussed in detail and briefly summarized in the following sections.

The factor which could potentially cause the largest differences between the measured screening values is the type of screening instrument used. Two sets of the instruments tested during this study employ similar analytical methods in determining a screening value. The OVA and the TVA FID are both flame ionization detectors (FIDs); and the HNU® and the TVA PID are both photo ionization detectors (PID). The TLV Sniffer® instrument is neither an FID nor a PID, but uses a combustible gas detector to determine hydrocarbon concentrations. Although screening values from similar instrument types tended to be highly correlated, screening values from non-similar instrument types tended to show very low correlations. In fact, screening measurements from the OVA and TVA FID, and from the HNU® and TVA PID provided virtually a one-to-one correlation; whereas for dissimilar instrument types (i.e., the OVA and HNU®, and the OVA and the TVA PID) the correlation between screening value measurements was virtually zero in some instances (i.e., the correlation coefficient was very small and not statistically different from zero). When comparing OVA screening values to the TLV Sniffer® screening values, the differences between screening measurements tended to increase as the screening values increased. Thus, for example, an OVA screening value at 100 ppm may differ from a TLV Sniffer® screening value by only a factor of 1.5 to 2.0, whereas an OVA screening value at 10,000 ppm may differ from a TLV Sniffer® screening value by a factor of 4 to 7.

For every instrument type, screening distance (at the surface versus 1 cm) was found to have a significant effect on the measured screening value. In general, screening values obtained at a 1 cm screening distance were found to be about 2 to 3 times smaller than screening values obtained at the surface for every instrument type. This factor of 2 to 3 was found to be fairly consistent throughout the range of screening values obtained. For example, on the average,

an OVA screening value of 3 ppm obtained at the surface would screen at roughly 1 ppm when screened at 1 cm screening distance; and an OVA screening value of 30,000 ppm at the surface would screen at roughly 10,000 ppm when screened at 1 cm screening distance.

Screening measurements obtained using the OVA and TLV Sniffer® screening instruments were compared to the same types of screening measurements obtained during the 1979 Screening Study. During the 1979 Screening Study a number of valves were screened using both an OVA and a TLV Sniffer® instrument. Measurements were collected at the component surface and at a 1 cm screening distance. When comparing the OVA screening values at the surface versus the TLV Sniffer® screening values at the surface, and the OVA screening values at 1 cm versus the TLV Sniffer® screening values at 1 cm, no statistically significant differences were found between the correlation equations obtained using the 1979 Screening Study data and the 1994 Screening Study data. However, when comparing the OVA screening values at the surface versus the OVA screening values at 1 cm, and the TLV Sniffer® screening values at the surface versus the TLV Sniffer® screening values at 1 cm, statistically significant differences were found between the correlation equations obtained using the 1979 Screening Study data and the 1994 Screening Study data. In summary, both studies show comparable results between OVA vs. TLV Sniffer® screening values; however, the screening distance differences are more pronounced in the 1979 Screening Study than in the 1994 Screening Study. The cause of these significant effects is unknown. However, they could be due to differences in screening techniques used during the two studies, in ambient conditions, or in instrument sensitivities.

Lastly, an analysis was performed to determine other factors that may affect the relationship between screening values. The results of this analysis showed that windspeed had a statistically significant effect on the OVA@ to OVA1 equation (that is, windspeed accounted for a significant portion of the variability in the OVA@ to OVA1 equation). Windspeed was also found to have a significant effect on the OVA@ versus TVAF@ correlation equation, the TVAP@ versus HNU®@ correlation equation, and the TVAP1 versus HNU®1 correlation equation. Investigations to determine the degree of variability of measured screening values as a function of windspeed is beyond the scope of this project. Future research might investigate the degree of screening value variability as a function of windspeed, instrument probe

sampling velocity, and equipment component emission velocity. The impact of windspeed on the correlation equations, however, is minor. For example, the correlation coefficient for the OVA at the surface versus OVA at 1 cm correlation equation improves from 0.929 to only 0.930 by including windspeed. Windspeed was not found to have a significant effect on the other correlation equations developed. Component type and service type were shown to have a significant effect for a few of the screening value correlation equations developed; however, these were thought to be either anomalous occurrences or questionable due to limited data for a specific factor.

COMPARISON OF SCREENING INSTRUMENT SCREENING VALUES AT MAXIMUM SUSTAINABLE RATE AND PEAK RATE

Comparisons were performed between the OVA instrument screening values and screening values obtained using the other three instrument types. Recently published emission correlation equations (e.g., marketing terminals study and 1993 Refinery Study) were developed using an OVA instrument. Thus, it was of primary interest to compare the OVA screening values to screening values from every other instrument type rather than comparing screening values from every combination of instrument types. However, screening value measurements obtained from the HNU® and the TVA PID were also compared, because these are similar instrument types (both are photo ionization detectors). In summary, screening values from the following instruments were compared:

- OVA versus the TLV Sniffer®;
- OVA versus the HNU®;
- OVA versus the TVA FID;
- OVA versus the TVA PID; and
- HNU® versus the TVA PID.

Screening measurements collected at the component surface as well as screening measurements collected at 1 cm from the component surface were compared for different instrument types. In addition, the maximum sustainable screening values and the peak screening values were compared for different instrument types, resulting in a total of four sets of correlation equations that were evaluated for each inter-instrument comparison. Figures 3-1 through 3-5 show the comparisons that were performed for each of the five inter-instrument categories listed above. The upper left corner of each of these figures (labeled "a")

shows a plot of the maximum sustainable screening values at the surface. The upper right corner of each of these figures (labeled "b") show plots of the peak screening values at the surface. The lower left corner of each of these figures (labeled "c") show plots of the maximum sustainable screening values at 1 cm and the lower right corner of each of these figures (labeled "d") show plots of the peak screening values at 1 cm. Each of the figures shows the corrected screening data (after subtracting the background screening value).

Correlation equations were developed using measurement error methods in which the errors in x were assumed to be equal to the errors in y, as discussed in Appendix B. Predictive correlation equations are presented only for the following inter-instrument comparisons:

- OVA versus the TLV Sniffer®;
- OVA versus the TVA FID; and
- HNU® versus the TVA PID.

Although there was a positive correlation between the OVA and the HNU®, and the OVA and the TVA PID, there was not a strong correlation. The models evaluated for these two inter-instrument relationships were not sufficiently adequate for predictive purposes. Therefore, no predictive correlation equations were developed for these two inter-instrument comparisons.

The primary objective of this study was to develop correlation equations between screening values collected using instruments other than an OVA screening instrument (e.g., a TLV Sniffer®, an HNU®, etc.) to those with an OVA instrument to use in emission correlation equations that relate lbs/hr emission rates to OVA screening values. OVA screening values were found to be highly correlated to TLV Sniffer® screening values and TVA FID screening values. Equations or adjustment factors were developed for these sets of correlation equations. OVA screening values were found to not be highly correlated with HNU® screening values or TVA PID screening values. Thus, using HNU® or TVA PID screening values to predict mass emissions based on emission correlation equations developed for OVA screening instruments is questionable.

Table 3-1 gives the correlation equations that were developed relating screening values from the different instrument types. As stated previously, correlation equations are only given for the maximum sustainable screening values (instead of the peak screening values).

Table 3-1. Equations Relating Screening Values From Different Instruments^a

Variables Correlated	Screening Distance	Number of Data Pairs	Correlation Equation	Correlation Coefficient
OVA versus TLV Sniffer®	@ Surface	174	$OVA@ = (6.09 \times 10^{-1}) \times (TLV@)^{1.216}$	0.85
	1 cm	164	$OVA1 = (4.58 \times 10^{-1}) \times (TLV1)^{1.222}$	0.75
OVA versus TVA FID	@ Surface	54	$OVA@ = (1.54) \times (TVAF@)^{0.935}$	0.90
	1 cm	52	$OVA1 = (1.02) \times (TVAF1)^{1.013}$	0.83
TVA PID versus HNU®	@ Surface	21	$TVAP@ = (5.88 \times 10^{-1}) \times (HNU@)^{0.950}$	0.88
	1 cm	21	$TVAP1 = (1.69 \times 10^{-1}) \times (HNU1)^{1.186}$	0.59

^a For maximum sustainable screening values.

Key

OVA@	=	OVA screening value at the surface of a component.
OVA1	=	OVA screening value obtained with a 1 cm spacer.
TLV@	=	TLV Sniffer® screening value at the surface of a component.
TLV1	=	TLV Sniffer® screening value obtained with a 1 cm spacer.
TVAF@	=	TVA FID screening value at the surface of a component.
TVAF1	=	TVA FID screening value obtained with a 1 cm spacer.
HNU@	=	HNU® screening value at the surface of a component.
HNU1	=	HNU® screening value obtained with a 1 cm spacer.
TVAP@	=	TVA PID screening value at the surface of a component.
TVAP1	=	TVA PID screening value obtained with a 1 cm spacer.

Figure 3-1 shows the correlation equations that were developed between the OVA and the TLV Sniffer®. Currently, all published emission correlation equations (i.e., relating mass emissions to screening value measurements) were developed using either an OVA or a TLV Sniffer® instrument. As shown by the predictive correlation equation in the figure, for low screening value ranges the OVA and TLV Sniffer® show similar screening value measurements, on the average. The difference between screening value measurements increases, however, as the magnitude of the screening values increases, with the OVA resulting in consistently higher screening value measurements. Thus, for example, on the average, an OVA screening value at 100 ppm may differ from a TLV Sniffer® screening value by only a factor of 1.5 to 2.0, whereas an OVA screening value at 10,000 ppm may differ from a TLV Sniffer® screening value by a factor of 4 to 7.

Figure 3-2 shows plots of the OVA screening value data versus the HNU® screening value data. As shown in the plots there is a lot of scatter in the data and the correlation coefficient is less than 0.40 for every type of correlation equation evaluated (i.e., for the maximum sustainable screening value at the surface and at 1 cm; and peak screening value at the surface and at 1 cm). In addition, the OVA screening instrument provides screening values that are typically an order of magnitude higher than the HNU® screening values. As discussed, however, the OVA and HNU® are different types of analytical instruments (the OVA is a flame ionization detector and the HNU® is a photo ionization detector).

Plots of the OVA screening values versus the TVA FID screening values are given in Figure 3-3. Note that the predictive correlation equation shows virtually a one-to-one correspondence between the OVA screening values and the TVA FID screening values for every type of screening measurement collected (i.e., maximum sustainable screening values and peak screening values at the surface and at 1 cm). That is, there appears to be no bias, but there is scatter about the regression line. As shown in the figures, the correlation equations form almost a perfect 45° line from (1,1) to (100000,100000).

Figure 3-4 shows plots of the OVA screening value data versus the TVA PID screening value data which look very similar to the plots obtained for the OVA versus the HNU® screening values. The correlation coefficients between screening values from the OVA and the TVA PID are very low (usually less than 0.40), and for figures (a) and (c) the correlation coefficients were not statistically different from zero ($\alpha = 0.05$).

Because the HNU® and the TVA PID are similar instrument types (i.e., both are photo ionization detectors) it was of interest to compare the screening measurements from these two instruments. In practice, an equation relating these two instrument types would probably be of little use because none of the published emission correlation equations (i.e., relating mass emissions to screening values) were developed using an HNU® or TVA PID instrument. As would be expected, however, screening value measurements from these two instruments are highly correlated. Figure 3-5 shows plots of the data and the predictive correlation that would be obtained based on the limited data available for these two instruments. Although both of these instruments are capable of measuring concentrations greater than 2,000 ppm with the

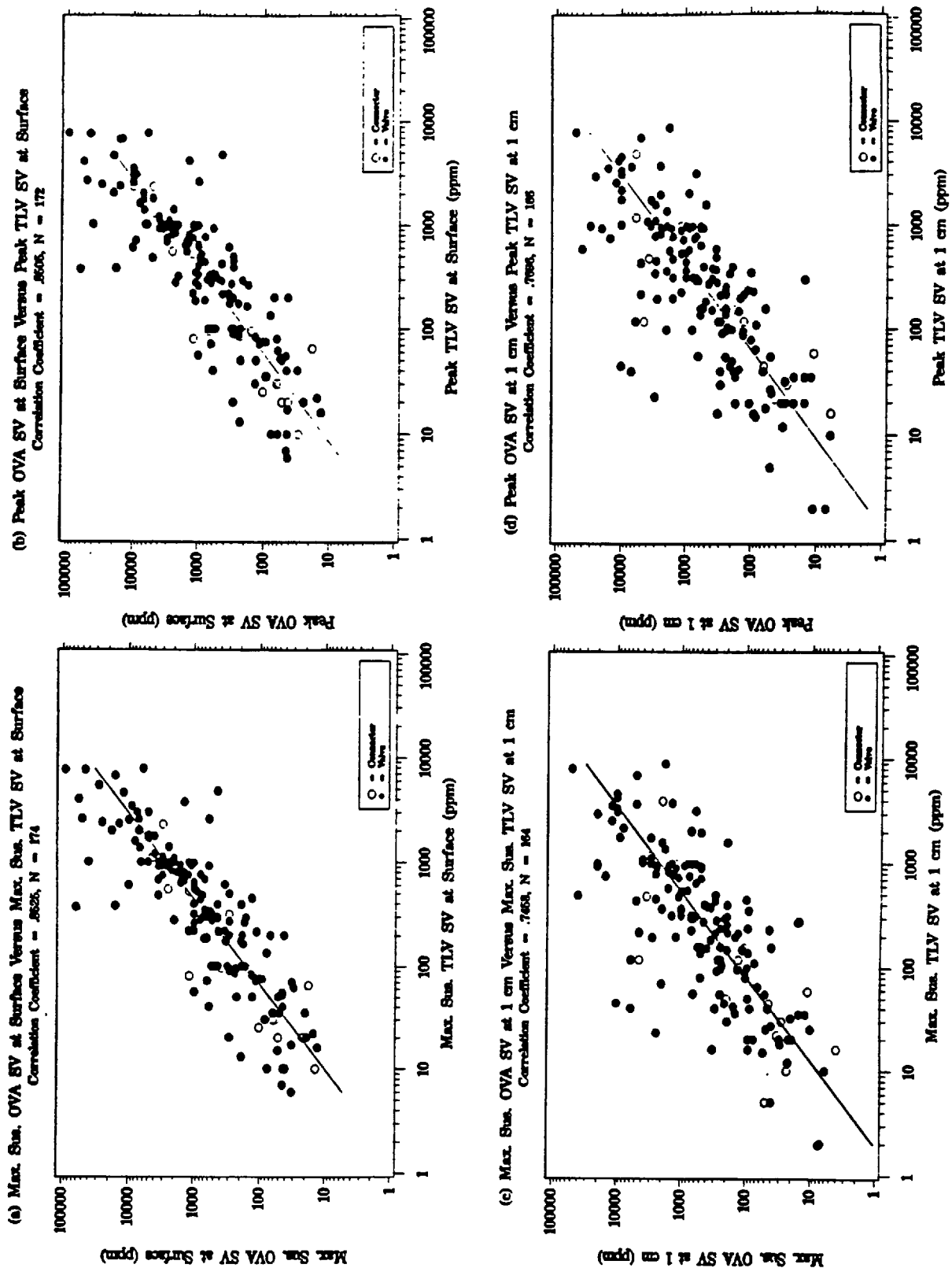


Figure 3-1 OVA vs. TLV Sniffer® Screening Instrument

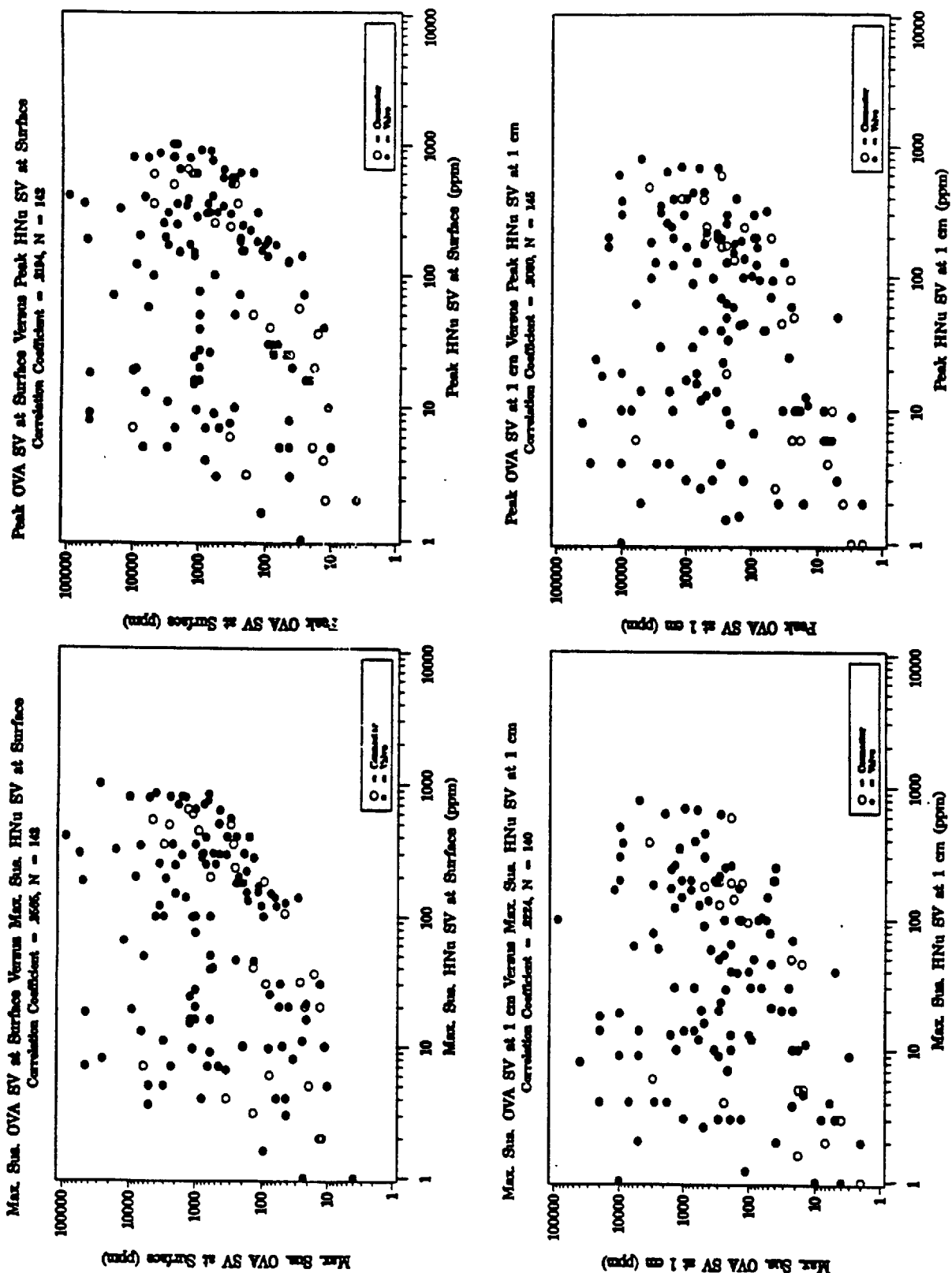


Figure 3-2 OVA vs. HNU® Screening Instrument

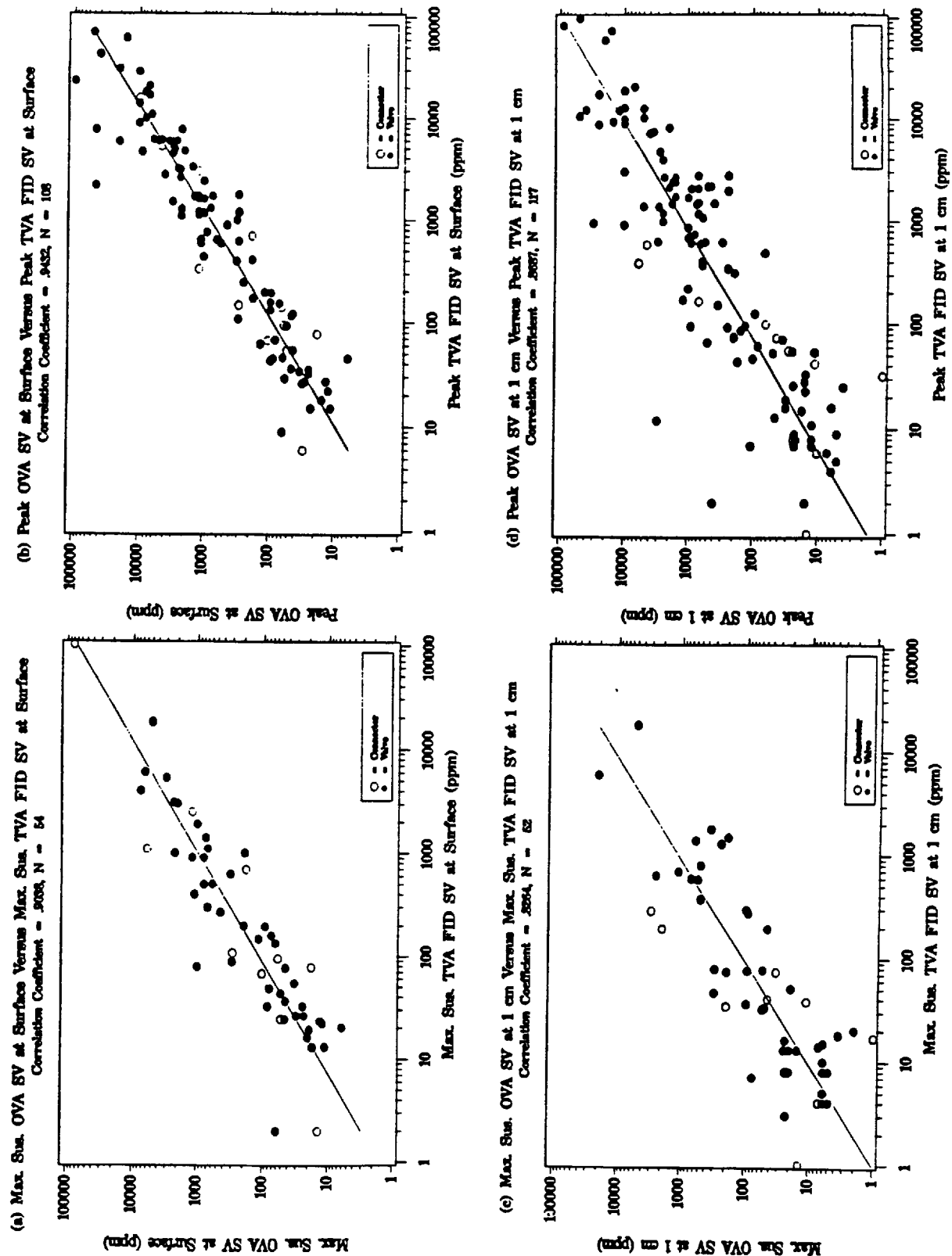


Figure 3-3 OVA vs. TVA FID Screening Instrument

3-10