

Protocolo Modificado para la Toma de Muestras de Vapores de Lixiviados y Condensados Vertedero de Chiquita Canyon

Vertedero de Chiquita Canyon
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Castaic, California 91384

SCS ENGINEERS

01204123.21 Tarea 22 | Junio de 2026

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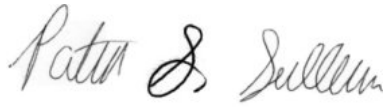
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Este Protocolo Modificado para la Toma de Muestras de Vapores de Lixiviados y Condensados (VSP) para el Vertedero de Chiquita Canyon, ubicado en 29201 Henry Mayo Drive, Castaic, California, fue elaborado y revisado por las siguientes personas:

A handwritten signature in black ink, appearing to read "Patrick S. Sullivan".

Patrick S. Sullivan, REPA, CPP, BCES
Vicepresidente Sénior
SCS ENGINEERS

1.0 INTRODUCCIÓN Y ANTECEDENTES

1.1 INTRODUCCIÓN

Este documento sirve como Protocolo Modificado para la Toma de Muestras de Vapores de Lixiviados y Condensados (VSP) para el Vertedero de Chiquita Canyon, LLC (el Vertedero o el Sitio), elaborado por SCS Engineers (SCS) en colaboración con Chiquita Canyon, LLC (CCL) y en cumplimiento con la Condición 72 de la Orden de Depuración Estipulada (SOFA) Modificada emitida a Chiquita por el Distrito de Gestión de la Calidad del Aire de la Costa Sur (SCAQMD) el 24 de abril de 2024, más recientemente modificada el 3 de junio de 2026.

El objetivo de este VSP es proporcionar detalles sobre los lugares de toma de muestra, los métodos para la toma de muestra, la frecuencia de los muestreos, los métodos analíticos a ser utilizados y los requerimientos para elaborar informes sobre los datos, como se especifica en la Condición 72(a) y (b). Este VSP será revisado con el tiempo, en base a la identificación de otros lugares de toma de muestra, la verificación en el campo de los lugares de toma de muestra y las posibles modificaciones en el método de toma de muestras para mejorar la toma de muestras, según la necesidad.

1.2 ANTECEDENTES

A continuación se indica la Condición 72(a)–(b) de la SOFA:

72. El demandado deberá tomar muestras y analizar, probar, instalar y monitorear la toma de lixiviados y condensados de biogás, el almacenamiento y el sistema de tratamiento, como se especifica a continuación:

- a. Por lo menos cada seis meses, realizar pruebas para tomar muestras y analizar el flujo de vapor en las tuberías utilizadas para ventilar los tanques de almacenamiento/tratamiento de lixiviados y los tanques de almacenamiento/tratamiento de condensado de biogás y dirigir los vapores al sistema de control de biogás y las líneas de los cabezales de biogás que alimentan las antorchas/los oxidantes térmicos. Las pruebas deberán incluir por lo menos los siguientes puntos y los resultados de estas pruebas deben proporcionarse en el informe mensual, en cumplimiento con la Condición No. 8:*
 - i. índice de flujo de vapores de tanques de lixiviados ventilados,*
 - ii. índice de flujo de vapores de tanques de condensados ventilados,*
 - iii. temperatura del vapor,*
 - iv. concentraciones de orgánicos especiados (incluyen, de forma enunciativa más no limitativa, Contaminantes del Aire Carcinogénicos y Tóxicos de la Tabla 1 de la Regla 1150.1),*
 - v. los compuestos de azufre total como H₂S y compuestos de azufre especiado y*
 - vi. analizar en cada uno de los lugares indicados a continuación:*
 - 1. Las ventilaciones o los colectores de los tanques que sean representativos de un set de tanques;*

2. *El cabezal/colector de cada parque de tanques de lixiviados o colector que incluye el Parque de Tanques No. 7, el Parque de Tanques No. 9, el Colector del Perímetro Norte, el Colector del Perímetro Noreste, el Colector LC, los tanques de almacenamiento de condensado de biogás y cualquier otro futuro parque de tanques o colectores, realizando las pruebas flujo arriba de la conexión de la tubería al Sistema de Recolección y Transporte de LFG donde el biogás pueda afectar los resultados; y*
3. *La entrada de antorchas/oxidantes térmicos antes de la combustión.*
4. *Las líneas de los cabezales de biogás hacia las antorchas/los oxidantes térmicos (flujo arriba de la mezcla de vapores de lixiviados/condensados)*

vii. clasificación del calor de los gases (BTU/scf)

viii. Índice de flujo de vapores de biogás

- b. *Deberá presentarse un protocolo de pruebas de origen modificado al AQMD de la Costa Sur antes del 30 de junio de 2026, a menos que el AQMD de la Costa Sur apruebe otra cosa por escrito. Las pruebas deberán realizarse dentro de los 45 días desde que el AQMD de la Costa Sur recibe la aprobación escrita del protocolo de prueba de origen y deberán presentarse los resultados finales en un formato de informe de prueba de origen dentro de los 30 días desde que se realizan las pruebas, a menos que el AQMD de la Costa Sur apruebe otra cosa por escrito.*

2.0 MÉTODOS PARA LOS MUESTREOS Y PARÁMETROS PARA LOS ANÁLISIS

La Condición 72(a) requiere que se midan y/o analicen los siguientes parámetros del sistema de recolección de vapores de lixiviados y condensados en varias ubicaciones dentro de la red de tuberías de los tanques de líquidos que se dirigen al sistema de biogás (LFG) y antes de su inyección a las antorchas de LFG:

- Índice de Flujo de Vapores de Tanques de Lixiviados Ventilados, Según Corresponda
- Índice de Flujo de Vapores de Tanques de Condensados Ventilados, Según Corresponda
- Temperatura del Vapor
- Análisis de Orgánicos Especiados, como se Identifican en la Regla 1150.1, Tabla 1, Contaminantes del Aire Carcinogénicos y Tóxicos
- Compuestos de Azufre Total como Ácido Sulfhídrico (H₂S) y compuestos de azufre especiados
- Clasificación de Calor del Gas ((Unidades Térmicas Británicas por pie cúbico estándar (BTU/scf))
- Índice de Flujo de Vapores de LFG.

Se instalarán puertos de muestreo en cada una de las ubicaciones de toma de muestras descritas en la Sección 3.0 para que las muestras puedan tomarse sin fugas. La toma de muestra inicial se realizará dentro de los 45 días desde la aprobación escrita del SCAQMD de este FSP y después semestralmente todos los años.

2.1 MEDICIONES DEL ÍNDICE DE FLUJO DE VAPORES DE LFG, LIXIVIADOS Y CONDENSADOS

A menos que se hayan instalado medidores de flujo permanentes en las ubicaciones de toma de muestras, el flujo en cada punto de toma de muestras se medirá mediante el uso de un anemómetro térmico de sondas articuladas TSI (Apéndice B). El anemómetro será utilizado para medir la velocidad del aire en unidades de pies por segundo. Todos los sistemas de transporte estarán utilizando conductos redondos, por lo tanto se utilizarán las siguientes ecuaciones para calcular el índice de flujo en cada lugar de prueba, en base a la velocidad medida del aire. La velocidad medida del aire se calculará como el promedio de cinco (5) puntos de cruce de conductos.

r = Radio en pulgadas

A = Área en pies²

$A = (3.14 * r^2) / 144$

V = Velocidad Medida en pies/seg.

$F = \text{pies}^3/\text{seg.} = V * A$

Todos los datos se tomarán en el campo y serán específicos del punto de toma de muestras.

2.2 MEDICIONES DE LAS TEMPERATURAS DE LOS VAPORES

También se realizarán mediciones de las temperaturas de los vapores en cada punto de toma de muestras. Se utilizará el mismo anemómetro térmico de sondas articuladas TSI para tomar las mediciones de las temperaturas de los vapores. Todos los datos se tomarán en el campo y serán específicos del punto de toma de muestras.

2.3 TOMA DE MUESTRAS DE ORGÁNICOS ESPECIADOS

Se espera que los puntos de muestreo de toma de vapores estén bajo vacío de aproximadamente 5 pulgadas de agua (en H₂O). Las muestras se tomarán en depósitos SUMMA de 5 litros con tuberías de acero inoxidable conectadas al puerto de muestreo. No habrá necesidad de usar reductores o controladores del caudal de flujo. Se seguirán los siguientes pasos al tomar la muestra:

- 1) Retire la tapa de la parte de arriba de la válvula de prueba;
- 2) Mientras la válvula de prueba está cerrada, conecte el medidor de presión de vacío a la entrada del depósito. Abra la válvula y registre el vacío inicial del depósito. Cierre la válvula. Retire el medidor de presión;
- 3) Conecte los tubos de prueba inoxidables desde el puerto de prueba hasta la entrada del depósito;
- 4) Abra la válvula de prueba y deje que se llene el depósito con la presión de la línea (Aproximadamente 1 minuto);
- 5) Cierre la válvula de prueba, retire la conexión de tubos inoxidables, tape el puerto de prueba y vuelva a tapar el depósito SUMMA; y
- 6) Registre los siguientes parámetros del muestreo en el formulario a presentar: fecha y hora de toma de muestra, ubicación de la muestra y No. de depósito.

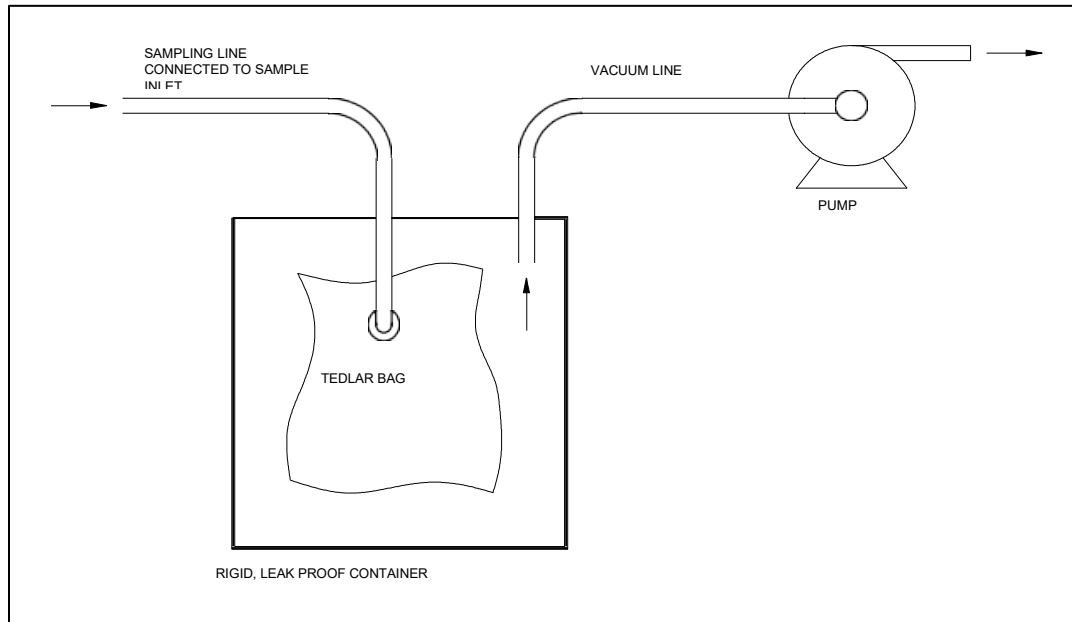
2.4 TOMA DE MUESTRAS DE COMPUESTOS DE AZUFRE REDUCIDO TOTAL Y DE AZUFRE ESPECIADO

Se tomarán muestras de azufre de los mismos puertos de muestreo identificados durante el detalle del estudio de campo de la Sección 3.0. Las muestras se toman utilizando un sistema de muestreo de desplazamiento del aire, también conocido como "sonda de muestreo tipo pulmón". Este método se utilizó para eliminar cualquier influencia que pueda haber tenido una bomba de aire en la muestra tomada. La Figura 1 es un diagrama esquemático de cómo funciona la pipeta de desplazamiento de aire. Se coloca la bolsa con la muestra en la pipeta tipo pulmón sellada y se conecta a través de un adaptador de alimentación al colector de muestras. Se coloca un segundo adaptador en la pared de la pipeta tipo pulmón que se conecta a una bomba de vacío. Después se cierra y se sella el contenedor. A medida que la bomba va extrayendo aire del contenedor sellado, se va extrayendo un volumen equivalente del aire de muestra en la bolsa de la muestra, sin tomar contacto con la bomba. Esto se complica cuando el punto de toma de muestras está bajo vacío leve, ya que la bolsa no comienza a llenarse hasta que el vacío de la pipeta tipo pulmón es mayor en la pipeta. Actualmente prevemos utilizar una bomba de prueba que opere a 10 litros por minuto (lpm) para tomar la muestra durante un período de toma de muestras de 1.5 minutos. Podrá tener que ajustarse el período de prueba en base a la presión del tubo.

2.5 CLASIFICACIÓN DEL CALOR DE LOS GASES

La clasificación del calor de los gases se determinará analizando cada muestra tomada como se indica arriba para orgánicos especiados también para el contenido de metano, utilizando el Método D-1946 de la Sociedad Estadounidense para Pruebas y Materiales (ASTM). La clasificación del calor de los gases se calculará multiplicando el contenido de metano en porcentaje por el poder calorífico del metano de 1012 BTU/scf.

Figure 1: Air Displacement Sampler Diagram



3.0 LUGARES DE TOMA DE MUESTRAS

La Condición 72 indica que las muestras de vapores de lixiviados y condensados deben tomarse en los siguientes lugares:

- Las ventilaciones o los colectores de los tanques que sean representativos de un set de tanques;
- El cabezal/colector de cada parque de tanques de lixiviados o colector que incluye el Parque de Tanques No. 7, el Parque de Tanques No. 9, el Colector del Perímetro Norte, el Colector del Perímetro Noreste, el Colector LC, los tanques de almacenamiento de condensado de biogás y cualquier otro futuro parque de tanques o colectores, realizando las pruebas flujo arriba de la conexión de la tubería al Sistema de Recolección y Transporte de LFG donde el LFG pueda afectar los resultados;
- La entrada de antorchas o unidades de oxidantes térmicos (TOx) antes de la combustión; y
- Las líneas de los cabezales de biogás hacia las antorchas/unidades TOx (flujo arriba de la mezcla de vapores de lixiviados/condensados).

El **Apéndice A** muestra los planos "De Obra" actuales del sistema de recolección de vapores de lixiviados y condensados. Antes de realizar el siguiente evento de toma de muestras, SCS realizará un estudio de campo para identificar los mejores lugares para la toma de muestras que cumplan con los requerimientos de la condición. Además, SCS instalará puertos de toma de muestras en cada punto de toma de muestras que se identifique. Los informes de las pruebas del origen incluirán las coordenadas de GPS de cada lugar de toma de muestras.

4.0 MÉTODOS ANALÍTICOS

Después de tomar las muestras, las muestras serán enviadas a un laboratorio externo para su análisis.

Los métodos analíticos incluirán el Método TO-15 de la Agencia de Protección Ambiental (EPA) de los Estados Unidos y para azufres, se utilizará el Método 307.91 del SCAQMD. Los analitos orgánicos de 1150.1 indicados en la Tabla 1 a continuación se cubrirán con los análisis de TO-15 junto a otros productos químicos de la lista del estándar de TO-15. El H₂S se cubrirá utilizando el Método 307-91. El Metano se cubrirá con el Método D-1946 de ASTM.

Tabla 1: Lista de Contaminantes Tóxicos del Aire de la Regla 1150.1 del SCAQMD

Constituyentes de la Tabla 1 de la Regla 1150.1 del SCAQMD			
Benceno	1,1-Dicloroetano	Tetracloroetano	Triclorometano
Cloruro de bencilo	1,2-Dicloroetano	Tetraclorometano	Cloruro de vinilo
Clorobenceno	1,1-Dicloroetano	Tolueno	Xilenos
1,2-Dibromoetano	Diclorometano	1,1,1-Tricloroetano	
Diclorobenceno	Ácido Sulfhídrico	Tricloroetano	

5.0 ELABORACIÓN DE INFORMES DE DATOS

Dentro de los 30 días desde que se completan las pruebas, se le proporcionará un informe al SCAQMD que contendrá los siguientes elementos:

I. Introducción – En esta sección se presentará la información de referencia relacionada con los análisis:

- A. Requerimientos de la Condición 72.
- B. Fechas de los análisis.
- C. Breve descripción de los puntos de vapores de lixiviados donde se toman muestras.
- D. Nombre de la empresa, persona de contacto, domicilio postal, número de teléfono.
- E. Nombre de las instalaciones y lugar físico.
- F. Nombre de la organización que realiza los análisis, persona de contacto, domicilio postal, número de teléfono.
- G. Fotografías de los lugares donde se realizaron las tomas de muestras.

II. Resumen – Esta sección resumirá en forma tabular los resultados de las pruebas para cada punto de toma de muestras: Para cada lugar de toma de muestras, el informe de los muestreos indicará las velocidades (velocidad de los tubos en pies/segundo), los flujos (flujo del tubo en pies cúbicos/minuto reales), concentraciones medidas, temperatura y presión medidas en la sonda de prueba y horarios de los muestreos.

III. Procedimientos para Realizar los Análisis - Esta sección describirá los procedimientos utilizados para los análisis. Esta sección incluirá: Una breve descripción de los muestreos y los procedimientos utilizados para recuperar y analizar las muestras. Las duraciones de los muestreos, las especificaciones de los equipos, la información sobre el tren de muestreo y otros detalles pertinentes.

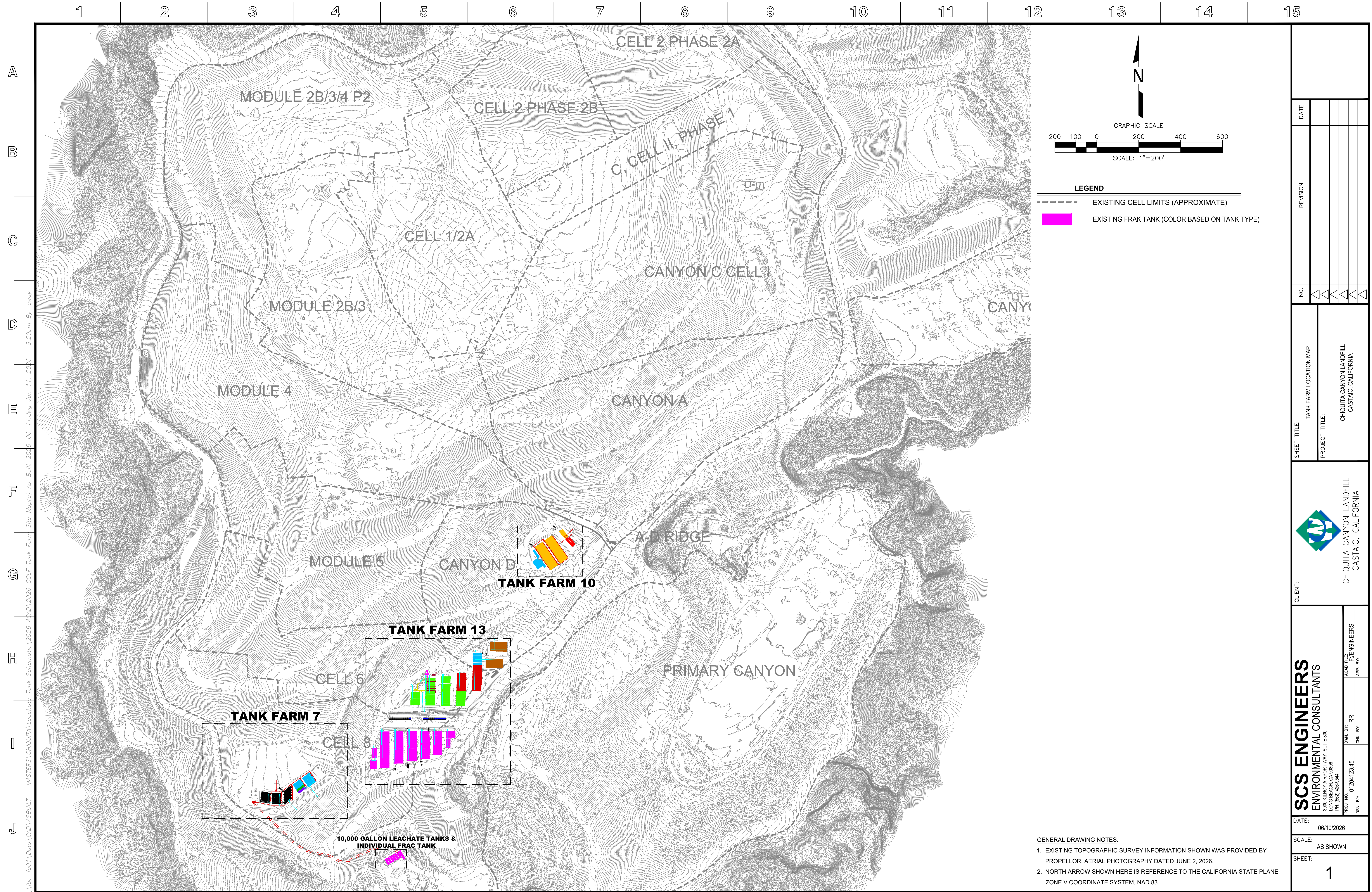
IV. Datos y Cálculos - Esta sección incluirá copias de todos los datos crudos y por lo menos un cálculo de ejemplo por cada cantidad entregada, mostrando todas las ecuaciones utilizadas:

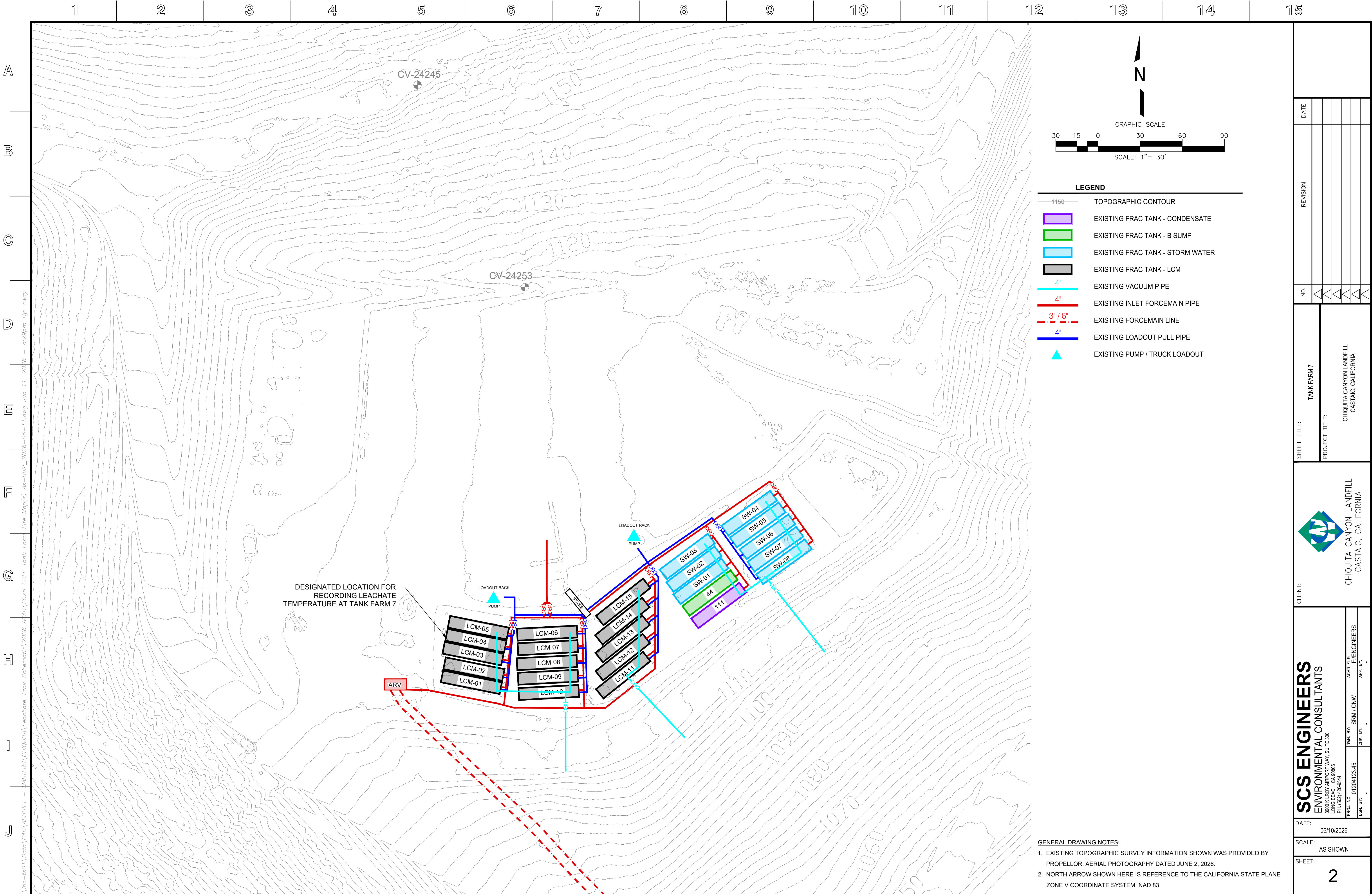
- A. Todos los datos crudos utilizados en los cálculos:
- B. Datos de laboratorio, que incluyen blancos, datos de aseguramiento de la calidad (QA) y resultados de los análisis.
- C. Un cálculo de ejemplo por cada resultado calculado que muestre cómo derivó el resultado de los datos crudos.
- D. **Documentos sobre la cadena de custodia.** Mostrar los nombres de los custodios, el método de transporte, las horas/los lugares de salida y llegada.

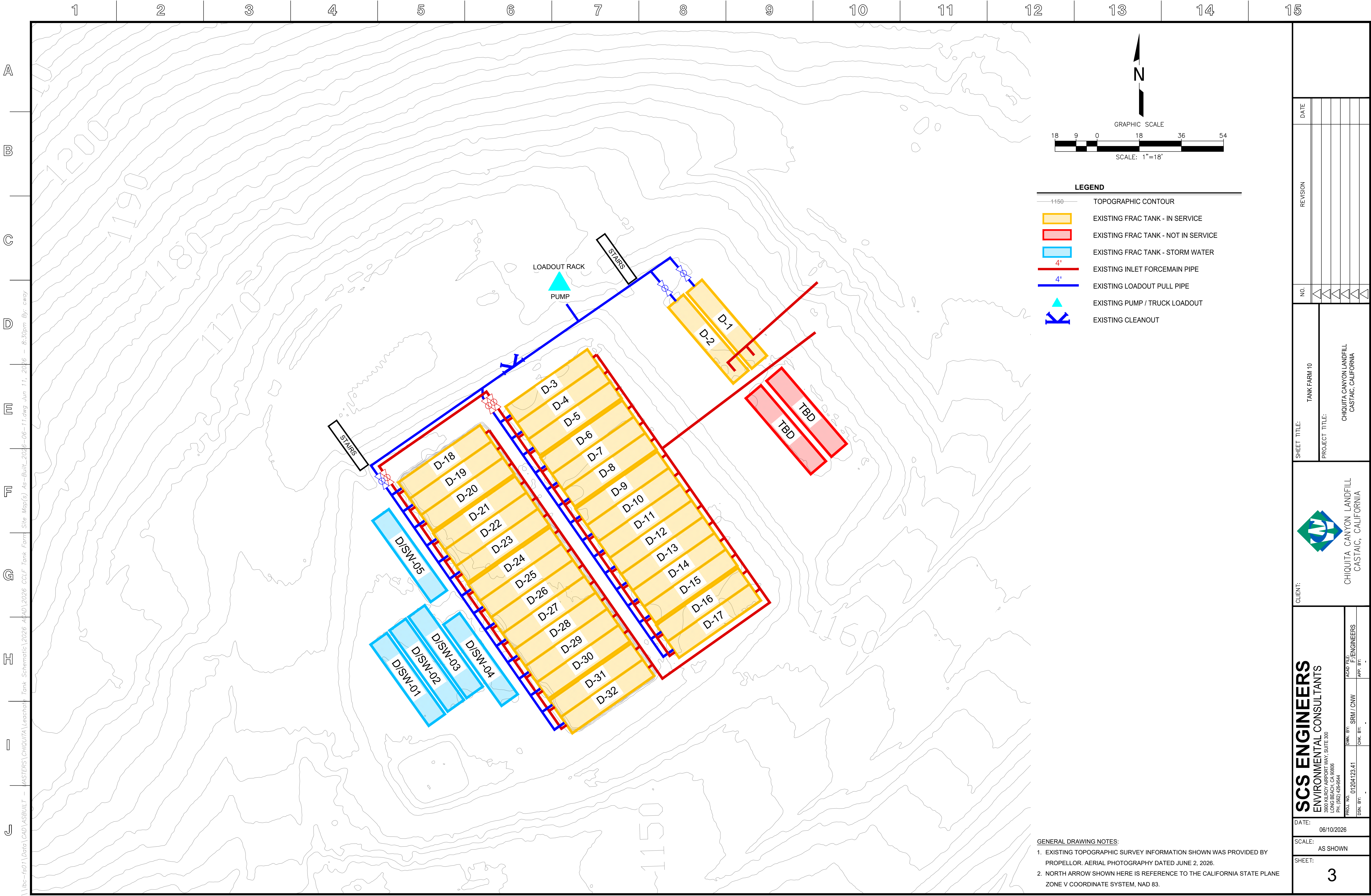
Además, este VSP incorpora esa aprobación condicional del protocolo original del SCAQMD con fecha 27 de agosto de 2024 (**Apéndice C**).

Appendix A

Chiquita Canyon Leachate Tank Farm: As built Drawings







LEGEND

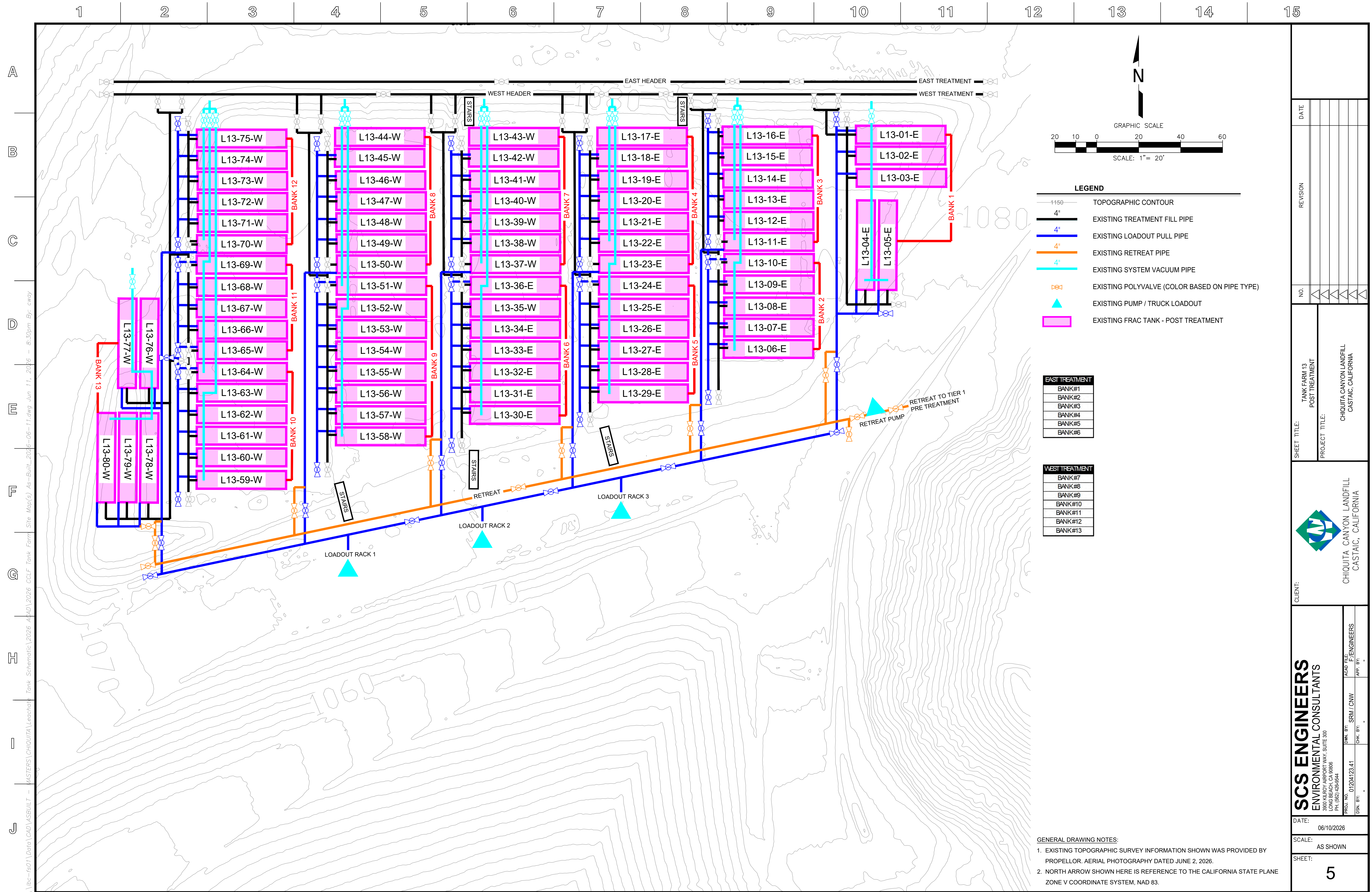
1150	TOPOGRAPHIC CONTOUR
[Yellow Box]	EXISTING FRAC TANK - IN SERVICE
[Red Box]	EXISTING FRAC TANK - NOT IN SERVICE
[Blue Box]	EXISTING FRAC TANK - STORM WATER
4"	EXISTING INLET FORCEMAIN PIPE
4"	EXISTING LOADOUT PULL PIPE
[Pump Symbol]	EXISTING PUMP / TRUCK LOADOUT
[Cleanout Symbol]	EXISTING CLEANOUT

GENERAL DRAWING NOTES:

- EXISTING TOPOGRAPHIC SURVEY INFORMATION SHOWN WAS PROVIDED BY PROPELLOR. AERIAL PHOTOGRAPHY DATED JUNE 2, 2026.
- NORTH ARROW SHOWN HERE IS REFERENCE TO THE CALIFORNIA STATE PLANE ZONE V COORDINATE SYSTEM, NAD 83.

DATE:	
REVISION	
NO.	
SHEET TITLE:	TANK FARM 10
	PROJECT TITLE:
CLIENT:	CHIQUITA CANYON LANDFILL
	CASTAIC, CALIFORNIA
SCS ENGINEERS	ENVIRONMENTAL CONSULTANTS
	1500 ALABAMA AVE. SUITE 300 LONG BEACH, CA 90806 PH: (562) 426-9544
PROJ. NO.	01204123.41
DSN. BY:	SRM / CNW
CHK. BY:	
APP. BY:	
DATE:	06/10/2026
SCALE:	AS SHOWN
SHEET:	3





APPENDIX B

Information on TSI Articulated Probe Thermal Anemometer

TSI THERMAL ANEMOMETRY PROBES

FOR MAXIMUM FLEXIBILITY
IN DESIGNING YOUR
THERMAL ANEMOMETRY
APPLICATION



UNDERSTANDING, ACCELERATED

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INTRODUCTION TO THERMAL ANEMOMETRY

Thermal anemometers measure fluid velocity by sensing the changes in heat transfer from a small, electrically-heated element exposed to the fluid. In the “constant temperature anemometer,” the cooling effect caused by the flow passing the element is balanced by the electrical current to the element, so the element is held at a constant temperature. The change in current due to a change in flow velocity shows up as a voltage at the anemometer output.

A key feature of the thermal anemometer is its ability to measure very rapid changes in velocity. This is accomplished by coupling a very fine sensing element (typically a wire four to six microns in diameter or a platinum thin film deposited on a quartz substrate) with a fast feedback circuit which compensates for the drop in the natural sensor response. Time response to flow fluctuations as short as a few microseconds can be achieved. For this reason, the thermal anemometer has become a standard tool for researchers studying turbulence. The small sensor size, normally only a millimeter in length, also makes the technique valuable in applications where access is difficult or larger sensors obstruct the flow.

Since the actual measurement is of heat transfer between the sensor and its environment, the thermal anemometer will respond to changes in parameters other than velocity, such as temperature, pressure, and fluid composition. While this adds to versatility, it also means that when more than one parameter is changing, special techniques must be used to extract velocity. Modern systems will automatically correct the velocity reading for temperature changes.

When selecting a thermal anemometry probe, the user must choose between film and wire sensors. The choice is based on the fluid characteristics, the velocity range, the number of velocity components, contamination in the flow, and access to the flow.

The traditional sensor for research thermal anemometry has been a fine wire. For very low turbulence intensities, the wire sensor is still superior—and the smaller the wire, the better the results. For those applications that require a wire sensor, the 4 micrometer-diameter platinum-coated tungsten wire is almost a standard for measurements at normal room temperatures and below. Tungsten is very strong and has a high temperature coefficient of resistance. It will, however, deteriorate at high temperatures in oxidizing atmospheres (such as air). Platinum wires, though weaker, can also be made very small and will withstand high temperature in an oxidizing atmosphere. If more strength is needed at high temperatures, an alloy such as platinum-iridium should be selected.

The rigidity and strength of cylindrical film sensors, relative to wire sensors, make them the preferred choice in a wide range of thermal anemometry applications. Rigidity is especially important for multi-sensor measurements where the algorithms used for data reduction assume a straight sensor. Also, film sensors are less susceptible to damage or coating by particles in the flow than are wire sensors.

SENSOR PROBE SELECTION

The chart below lists all the probes featured in this catalog and summarizes their key selection characteristics:

Cylindrical Sensors								
Model No.*	Page Number	Designation	Size	Temperature	Fluid	Sensor Type	Sensor Orientation	Sensor Position
1201	6	S	R	L	G	F	90	I
1210	6	S	R	L	G,L	W,F	90	I
1220	6	S	R	H	G	W,F	90	I
1260A	6	S	M	L	G,L	W,F	90	I
1276	7	S	SM	L	G,L	W,F	90	I
1214	7	S	R	L	G	W,F	90	I
1213	7	S	R	L	G,L	W,F	45	I
1211	7	S	R	L	G	W,F	0	I
1212	8	S	R	L	G,L	W,F	90	U
1222	8	S	R	H	G	W,F	90	U
1262A	8	S	M	L	G,L	W,F	90	U
1277	8	S	SM	L	G	F	0	U
1218	9	BL,S	R	L	G,L	W,F	90	U
1261A	9	BL,S	M	L	G,L	W,F	90	U
1241	10	X	R	L	G,L	W,F	45	I
1248A	10	X	M	L	G,L	W,F	45	I
1240	10	X	R	L	G,L	W,F	90	I
1247A	11	X	M	L	G,L	W,F	90	I
1246	11	X	R	L	G,L	W,F	45	U
1245	11	X	R	L	G,L	W,F	90	U
1249A	12	X	M	L	G,L	W,F	45	U
1243	12	BL,X	R	L	G,L	W,F	45	U
1244	12	II	R	L	G,L	W,F	90	I
1299	13	T	OP	L	G	F	54	I
1299A	13	T	OP	L	G	F	-	U

*Probes are listed in numerical order in the index on page 26.

Sensor Designation

Cylindrical Sensors

S = Single T = Triple sensor
 II = 2 parallel sensors BL = Boundary layer
 X = "X" probe

Sensor Size

(Diameter of probe body closest to sensor)

R = Regular (3.2 mm)
 M = Miniature (1.5 mm)
 SM = Subminiature (0.9 mm)
 OP = One Piece (4.6 mm)

Temperature

(Maximum exposure temperature of probe body)**

L = 150°C, (except 60°C for 1201)
 H = 300°C

Maximum temperature for water probes
 is approximately 30°C

Fluid

G = Gas
 L = Liquid

Sensor Type

W = Wire
 F = Platinum film

Sensor Orientation

(Relative to connector end of probe)

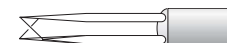
0 = 0°



90 = 90°



45 = 45°



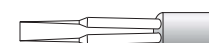
54 = 54.74°



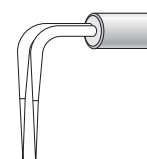
Sensor Position

(Relative to connector end of probe)

I = In-line



U = Upstream



PROBE SELECTION

The probe family includes hot film sensors and hot wire sensors. The choice between them is critical for most applications. Hot films consist of a thin film of platinum deposited on a quartz substrate, typically a cylinder attached to the sensor supports. Various cylinder diameters permit different spatial resolutions.

This catalog describes a full line of standard probes mainly classified by sensor type, the number of sensors, and the direction the mean flow moves relative to the probe body. They should handle the vast majority of applications. The catalog also includes probe supports (usually required since they contain the necessary cable connections) and probe shields which help protect the delicate sensor.

FOUR STEPS IN CHOOSING A PROBE

The four steps outlined here help determine the key measurement and environmental parameters that must be known in order to select the best probe and probe support for an application. The selection process then becomes relatively straightforward.

Step 1. Identify environmental conditions (determines the applicable sensors)

High temperature gases—Sensors are normally operated well above the environment temperature. The maximum operating temperature of film sensors is 425°C, while for tungsten wires it is 300°C. Platinum wires can operate at much higher temperatures but are much weaker than tungsten. Platinum iridium is stronger than platinum but has a lower temperature coefficient (providing lower S/N ratio). The probe must also be selected for the appropriate temperature range.

Clean liquids—Most liquids are sufficiently conductive that the sensor element must be insulated. Thus, only coated film sensors ("W" designation) can be used. Standard construction techniques for probes used in conductive liquids limits the fluid temperature to approximately 30°C. In a truly insulating liquid (e.g. oil), a non-coated sensor should be used since it tends to collect less contamination. In liquids, boundary layer lag can substantially reduce the expected frequency response.

Step 2. Number of velocity components to be measured (there are limits to the magnitude of the turbulence intensity that can be accurately measured)

A single cylindrical sensor perpendicular to the flow will give a good measurement of the instantaneous velocity in the mean flow direction.

Two cylindrical sensors, properly oriented, will measure two components of velocity.

Three cylindrical sensors, properly oriented, will measure all three velocity components.

Step 3. Hot wires versus cylindrical film sensors where either can be used

Hot wires—Provide the best S/N ratio and generally better frequency response than film sensors. With multiple sensors, they do not stay positioned as well (lengthen and bend when heated), causing errors in velocity component calculations.

Cylindrical film sensors—Generally do not contaminate as easily (due to larger diameter) and will not shift resistance due to strain in a high velocity environment or due to particle impact.

Step 4. Probe and support selection

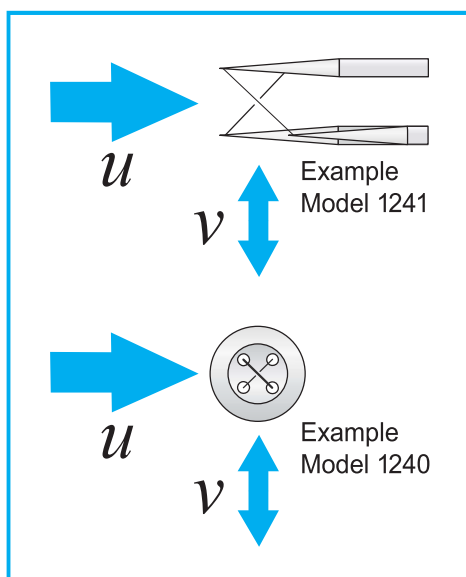
Once the type and number of sensors is determined, further selections depend on the access to the flow and where the measurement is made. Right angle adapters, miniature probes, and cross flow designs are all variations that help you get the sensor where it belongs with minimum flow field disturbance.

X-PROBE SELECTION

When selecting an X-probe, keep in mind that an X-probe measures two components of velocity (U and V) that are both in the plane formed by the two sensors. The U and V components will each be at 45 degrees to each sensor. It is assumed that the flow is two-dimensional, with the W component (normal to the plane formed by the two sensors) small in comparison to the total velocity vector. The X-probe should be aligned such that the major flow is in the U direction.

SPECIAL DESIGNS

If you find that no standard probe meets your requirements, define your measurement needs according to the steps outlined and contact TSI. This is often an iterative process as we work with you to get the best possible answer, but it is one that has proved worthwhile to thousands of users around the world, each having a unique application.



HOW TO USE THIS CATALOG

Once you have completed the above steps, you are ready to use the catalog to find the correct probe and probe support for your application. As closely as possible, the catalog has been designed to lead you logically to the probe you need.

The catalog is organized according to the following characteristics:

- + First, by broad sensor type
- + Second, by the number of sensors (one, two, or three) mounted on the probe
- + Third, by the direction of the mean flow relative to the probe body (end flow or cross flow)
- + Fourth, by the specific configuration of the probe (high temperature, miniature, etc.)

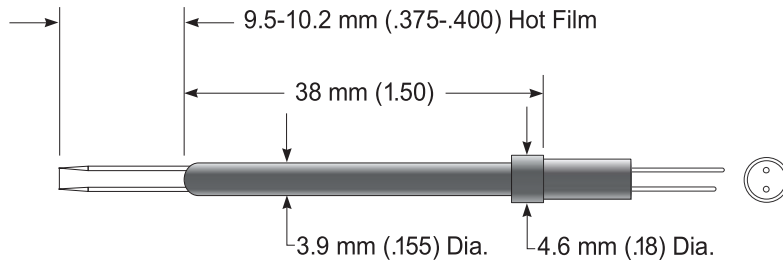
Once you have located the type of probe you need, review the list of recommended sensors to determine if the specific sensor type (air or water, wire or film) which you need is available. See the sensor specification table on page 5 for a description of the sensor designations listed in the probe section and detailed specifications on each type of sensor.

When the probe type has been determined, the final step is to locate the best probe support and shield. A wide variety of supports and shields are listed in the pages following the probes. Your choice will be largely based on access requirements.

PROBES FOR SINGLE CYLINDRICAL SENSORS

Probes for single cylindrical sensors are used for one-dimensional flow measurements. Within this category, the Model 1210 and its equivalent disposable probe, the Model 1201, are the most frequently used probe models.

Model 1201 Disposable Probe

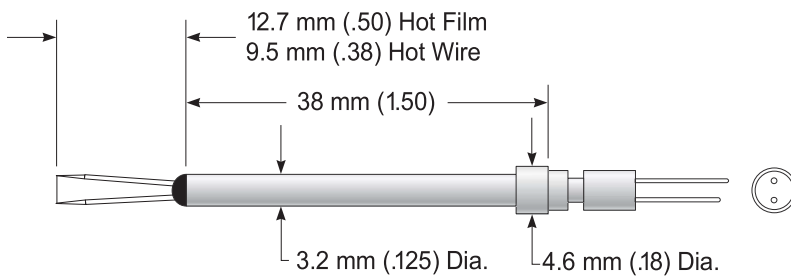


Recommended Sensors

For Gas Applications

- + 1201-6 (package of 6)
- + 1201-12 (package of 12)
- + The 1201 probes have a -20 film sensor.
- + Max. Fluid Temp. = 60°C

Model 1210 General Purpose Probe



Recommended Sensors

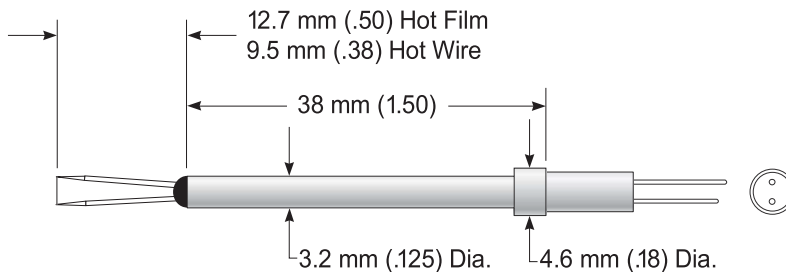
For Gas Applications

- + 1210-T1.5
- + 1210-20
- + Max. Fluid Temp. = 150°C

For Liquid Applications

- + 1210-20W

Model 1220 High Temperature Straight Probe

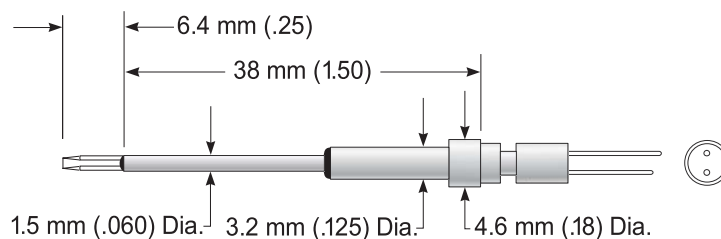


Recommended Sensors

For Gas Applications

- + 1220-PI2.5
- + 1220-20
- + Max. Fluid Temp. = 300°C

Model 1260A Miniature Straight Probe



Recommended Sensors

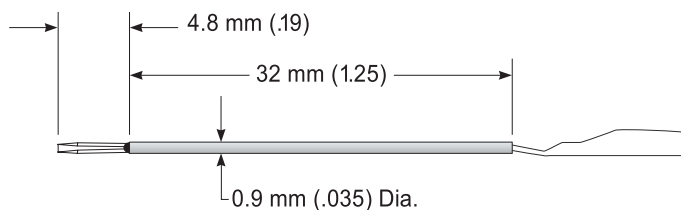
For Gas Applications

- + 1260A-T1.5
- + 1260A-10
- + Max. Fluid Temp. = 150°C

For Liquid Applications

- + 1260A-10W

Model 1276 Subminiature Straight Probe



Recommended Sensors

For Gas Applications

- + 1276-P5*
- + 1276-10A
- + Max. Fluid Temp. = 150°C

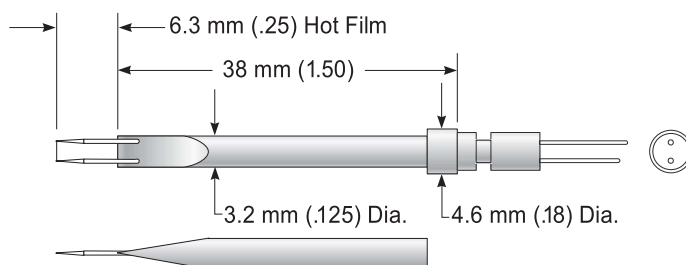
For Liquid Applications

- + 1276-10AW

* Use for temperature measurement only with constant current bridge.

Model 1214 Streamlined Probe

For high speed (e.g. supersonic) flows



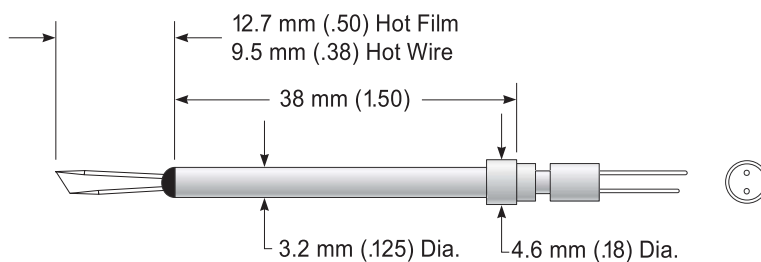
Recommended Sensors

For Gas Applications

- + 1214-T1.5
- + 1214-20
- + Max. Fluid Temp. = 150°C

Model 1213 Sensor 45° to Probe

Single sensors 45° to probe axis can be used in steady flows to measure turbulent shear stress or two components of velocity by rotating the probe about its axis.



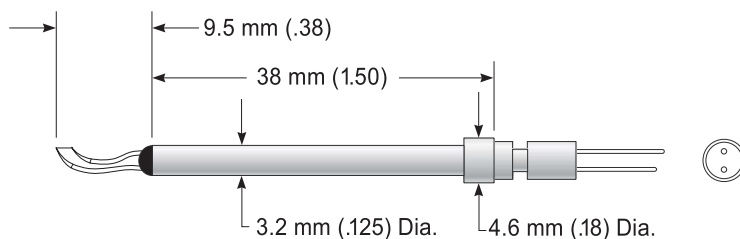
Recommended Sensors

For Gas Applications

- + 1213-T1.5
- + 1213-20
- + Max. Fluid Temp. = 150°C

Model 1211 Standard Probe

In cross flow applications, probe interference is reduced by mounting the sensor parallel to the probe body.



Recommended Sensors

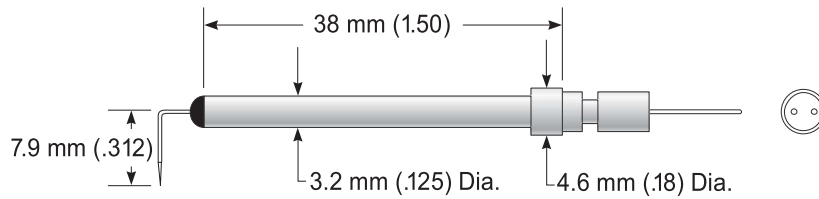
For Gas Applications

- + 1211-T1.5
- + 1211-10
- + 1211-20
- + Max. Fluid Temp. = 150°C

PROBES FOR SINGLE CYLINDRICAL SENSORS

For minimum probe interference in cross flow applications, the sensor needles are bent so the sensor is upstream of the probe.

Model 1212 Standard Single Sensor Probe



Recommended Sensors

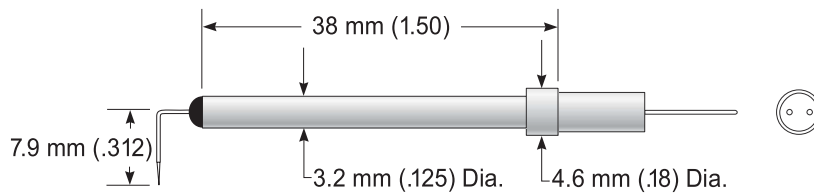
For Gas Applications

- + 1212-T1.5
- + 1212-20
- + Max. Fluid Temp.= 150°C

For Liquid Applications

- + 1212-20W

Model 1222 High Temperature Single Sensor Probe

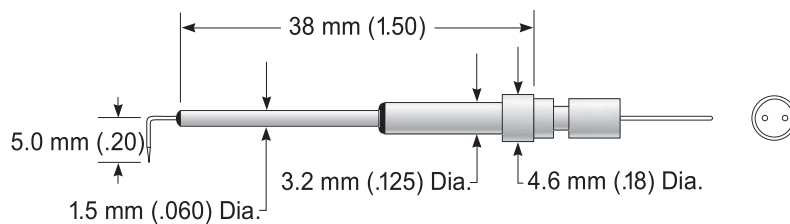


Recommended Sensors

For Gas Applications

- + 1222-PI2.5
- + 1222-20
- + Max. Fluid Temp.= 300°C

Model 1262A Miniature Probe



Recommended Sensors

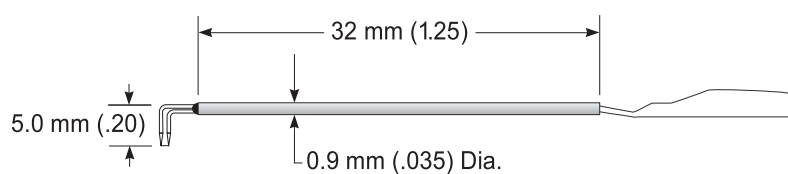
For Gas Applications

- + 1262A-T1.5
- + 1262A-10
- + Max. Fluid Temp.= 150°C

For Liquid Applications

- + 1262A-10W

Model 1277 Subminiature Probe



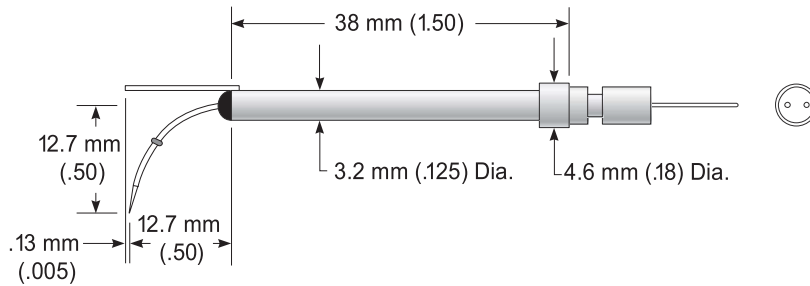
Recommended Sensors

For Gas Applications

- + 1277-10A
- + Max. Fluid Temp.= 150°C

Boundary layer probes provide a protective pin to allow measurements very near the surface and a long radius bend to minimize disturbances.

Model 1218 Standard Boundary Layer Probe



Recommended Sensors

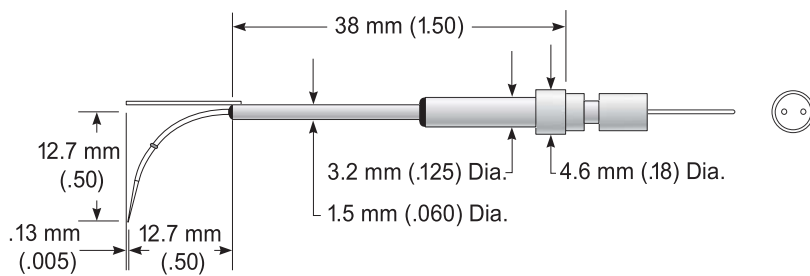
For Gas Applications

- + 1218-T1.5
- + 1218-10
- + 1218-20
- + Max. Fluid Temp. = 150°C

For Liquid Applications

- + 1218-20W

Model 1261A Miniature Boundary Layer Probe



Recommended Sensors

For Gas Applications

- + 1261A-T1.5
- + 1261A-10
- + Max. Fluid Temp. = 150°C

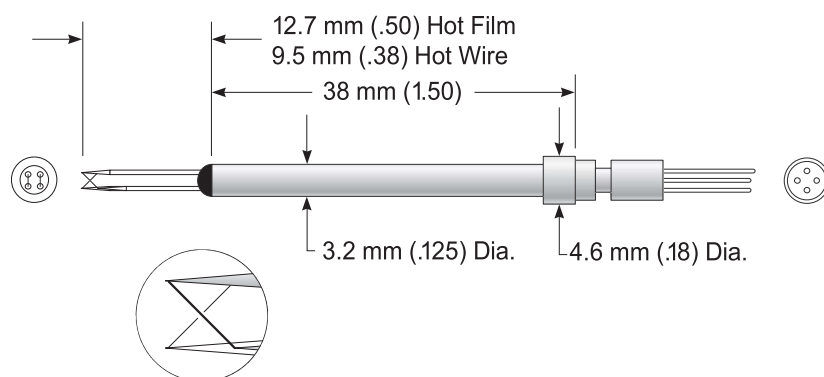
For Liquid Applications

- + 1261A-10W

PROBES FOR DUAL CYLINDRICAL SENSORS

Dual sensor probes position two sensors in close proximity, generally in an "X" configuration, for measuring two components of flow and the correlation between them. For accurate measurements, the maximum turbulence intensity is limited by the sensitivity to the flow perpendicular to the measured components.

Model 1241 End Flow "X" Probe



Recommended Sensors

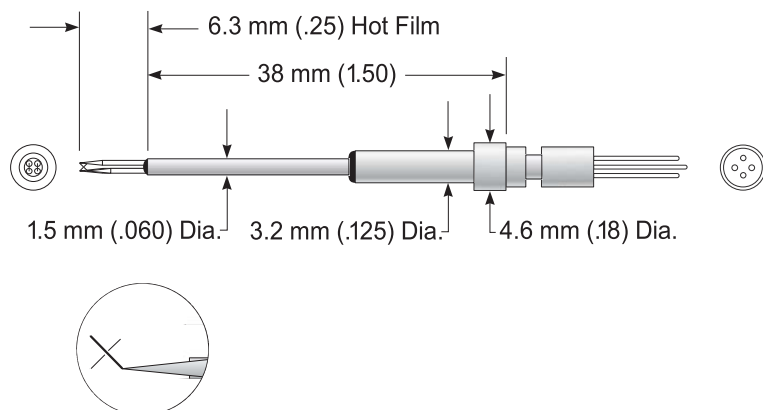
For Gas Applications

- + 1241-T1.5
- + 1241-20
- + Max. Fluid Temp. = 150°C

For Liquid Applications

- + 1241-20W

Model 1248A Miniature End Flow "X" Probe



Recommended Sensors

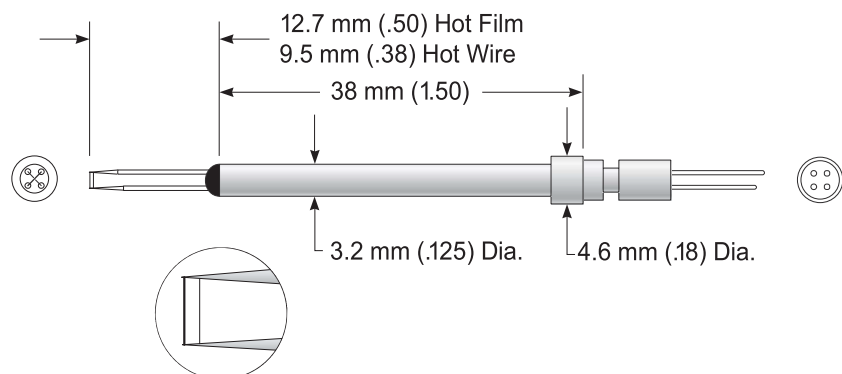
For Gas Applications

- + 1248A-T1.5
- + 1248A-10
- + Max. Fluid Temp. = 150°C

For Liquid Applications

- + 1248A-10W

Model 1240 Standard Cross Flow "X" Probe



Recommended Sensors

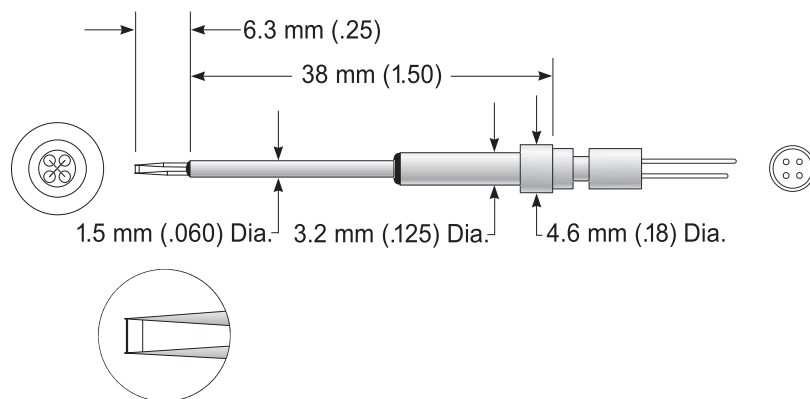
For Gas Applications

- + 1240-T1.5
- + 1240-20
- + Max. Fluid Temp. = 150°C

For Liquid Applications

- + 1240-20W

Model 1247A Miniature Cross Flow "X" Probe



Recommended Sensors

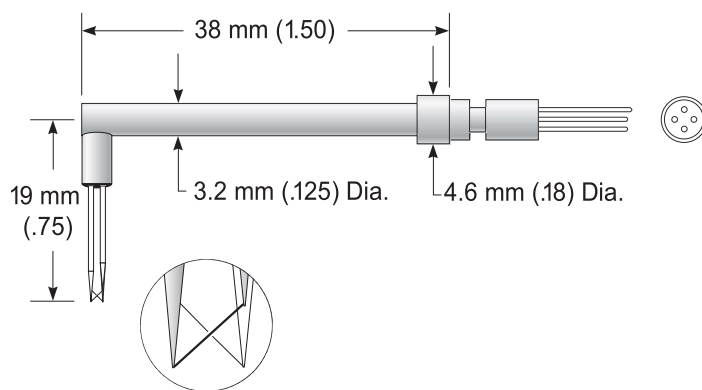
For Gas Applications

- + 1247A-T1.5
- + 1247A-10
- + Max. Fluid Temp. = 150°C

For Liquid Applications

- + 1247A-10W

Model 1246 Cross Flow "X" Probe, Sensors Upstream



Recommended Sensors

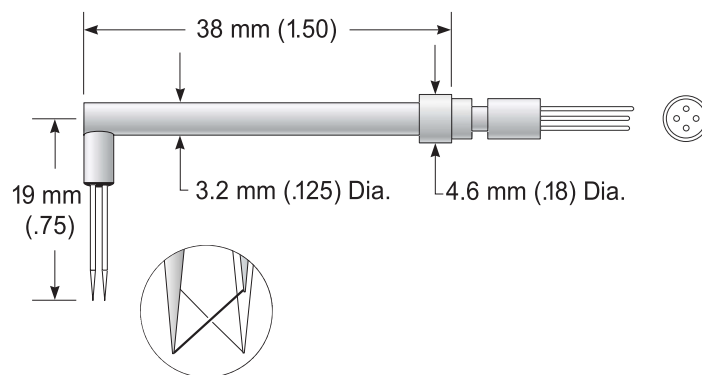
For Gas Applications

- + 1246-T1.5
- + 1246-20
- + Max. Fluid Temp. = 150°C

For Liquid Applications

- + 1246-20W

Model 1245 Cross Flow "X" Probe, Sensors Upstream



Recommended Sensors

For Gas Applications

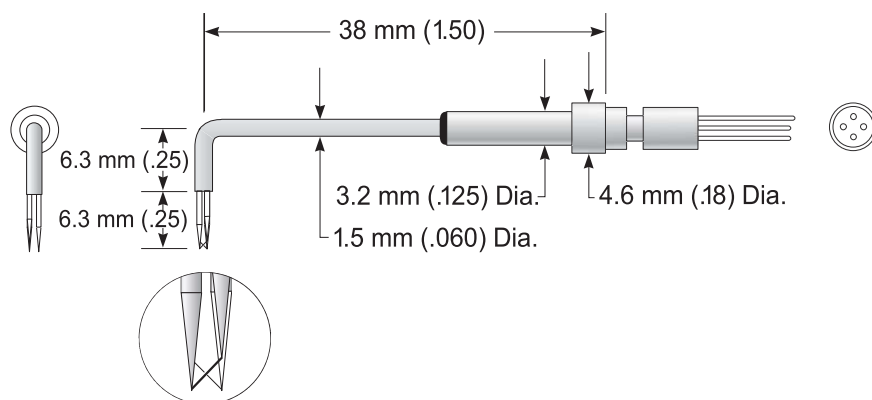
- + 1245-T1.5
- + 1245-20
- + Max. Fluid Temp. = 150°C

For Liquid Applications

- + 1245-20W

PROBES FOR DUAL CYLINDRICAL SENSORS

Model 1150 Standard Probe Support



Recommended Sensors

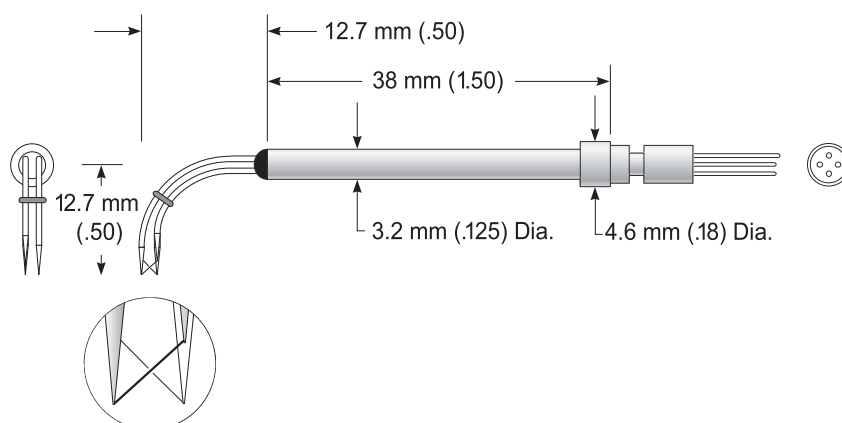
For Gas Applications

- + 1249A-T1.5
- + 1249A-10
- + Max. Fluid Temp. = 150°C

For Liquid Applications

- + 1249A-10W

Model 1160 High Temperature Probe Support



Recommended Sensors

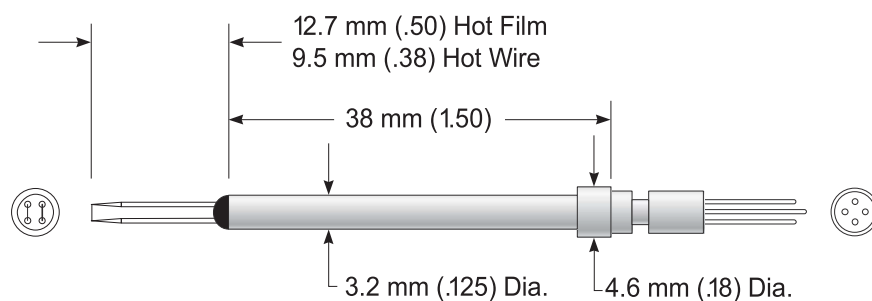
For Gas Applications

- + 1243-T1.5
- + 1243-20
- + Max. Fluid Temp. = 150°C

For Liquid Applications

- + 1243-20W

Model 1244 End Flow Parallel Sensor Probe



Recommended Sensors

For Gas Applications

- + 1244-T1.5
- + 1244-20
- + Max. Fluid Temp. = 150°C

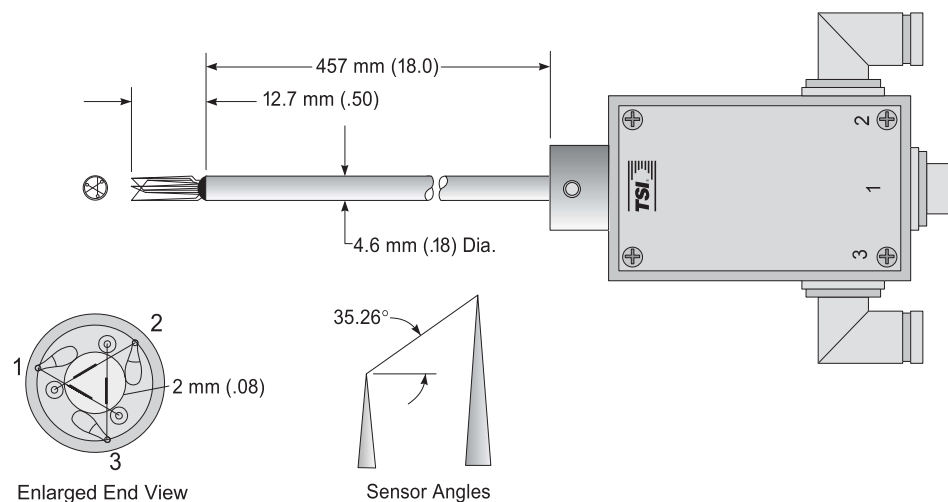
For Liquid Applications

- + 1244-20W

PROBES FOR THREE CYLINDRICAL SENSORS

Three-sensor probes are used to locate three sensors in close proximity. They are generally used to measure all three velocity components. Good measurements require that the flow vector stays within the one octant defined by the three sensors. The sensors are located optimally for maximum spatial resolution and minimum probe interference.

Model 1299 End Flow 3-D Probe

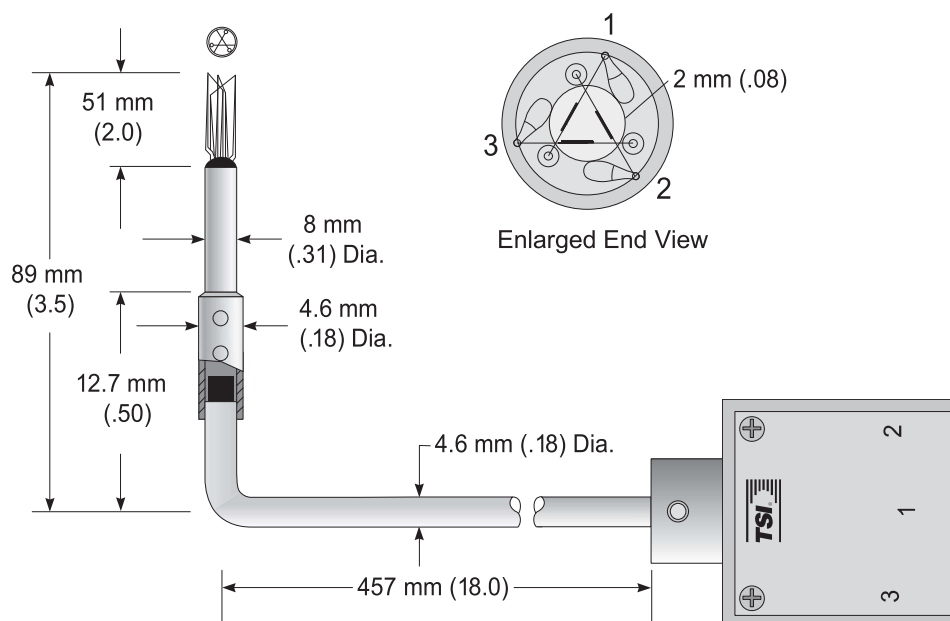


Recommended Sensors

For Gas Applications

- + 1299-18-20
- + Max. Fluid Temp. = 150°C

Model 1299A Cross Flow 3-D Probe



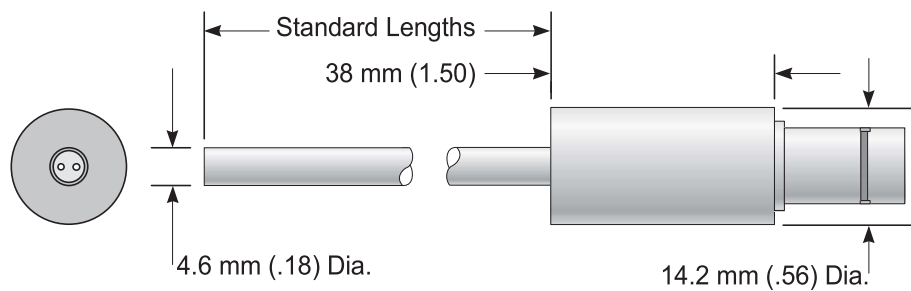
Recommended Sensors

For Gas Applications

- + 1299A-18-20
- + Max. Fluid Temp. = 150°C

SINGLE SENSOR PROBE SUPPORTS

Model 1150 Standard Probe Support

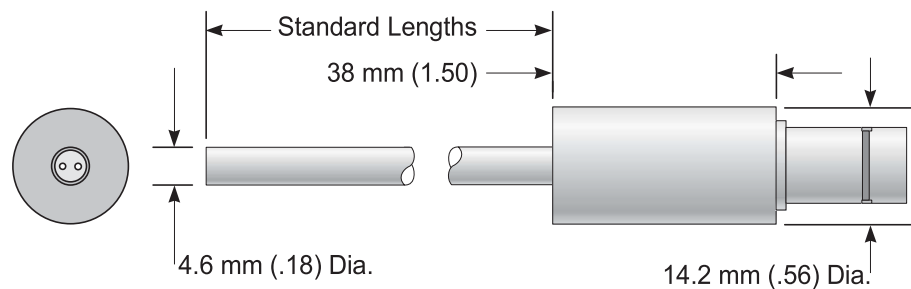


Designed for most standard TSI single sensor plug-in probes.

Specify

- + 1150-6 for 152 mm (6 in.) length
- + 1150-18 for 457 mm (18 in.) length
- + 1150-36 for 915 mm (36 in.) length
- + Max. Fluid Temp. = 150°C

Model 1160 High Temperature Probe Support

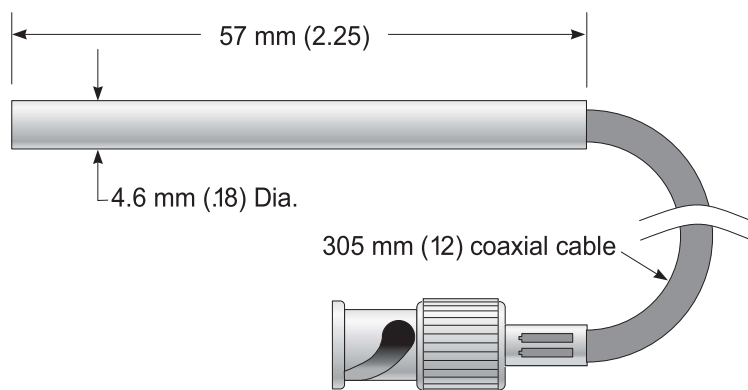


Designed for most standard TSI single sensor plug-in probes.

Specify

- + 1160-6 for 152 mm (6 in.) length
- + 1160-18 for 457 mm (18 in.) length
- + Max. Fluid Temp. = 300°C

Model 1151 Probe Support

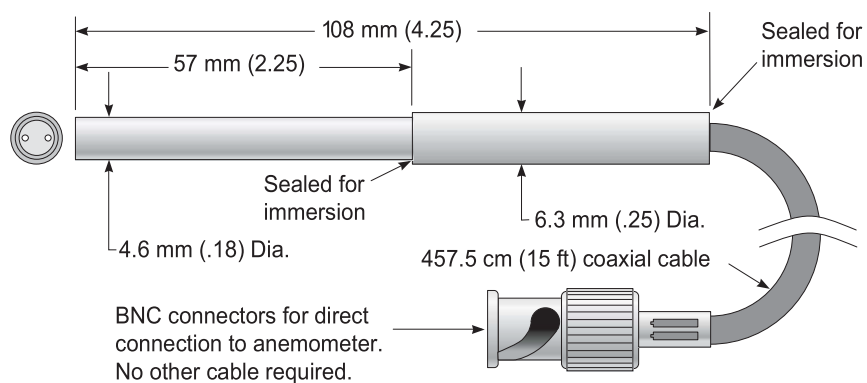


Convenient probe support for small spaces.

Specify

- + 1151-1
- + Max. Fluid Temp. = 150°C

Model 1159 Immersible Probe Support

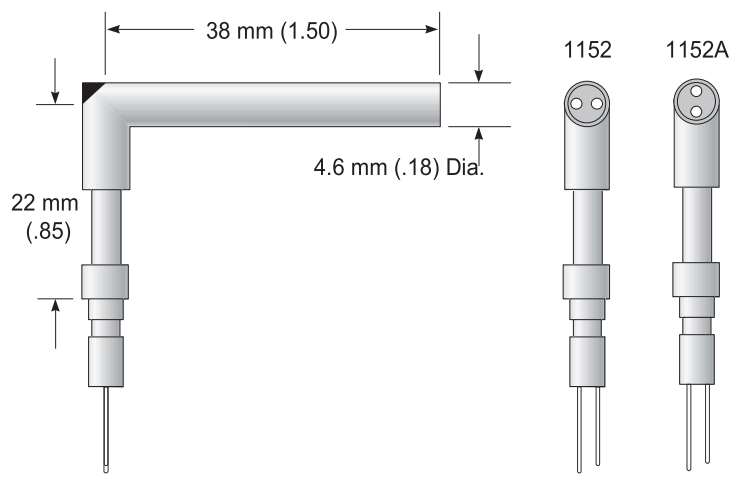


Small probe can be immersed entirely for liquid flow applications.

Specify

+ 1159-15

Model 1152 90° Angle Adapter



Right angle bend provides access to upstream points with straight probes.

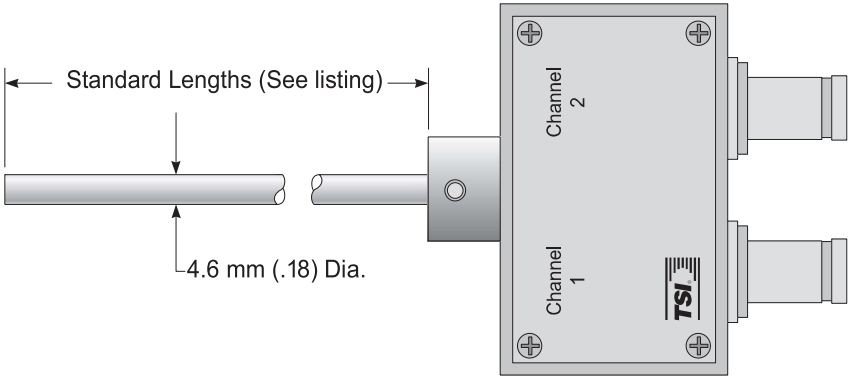
Specify

+ 1152

+ 1152A

DUAL SENSOR PROBE SUPPORTS

Model 1155 Standard Probe Support

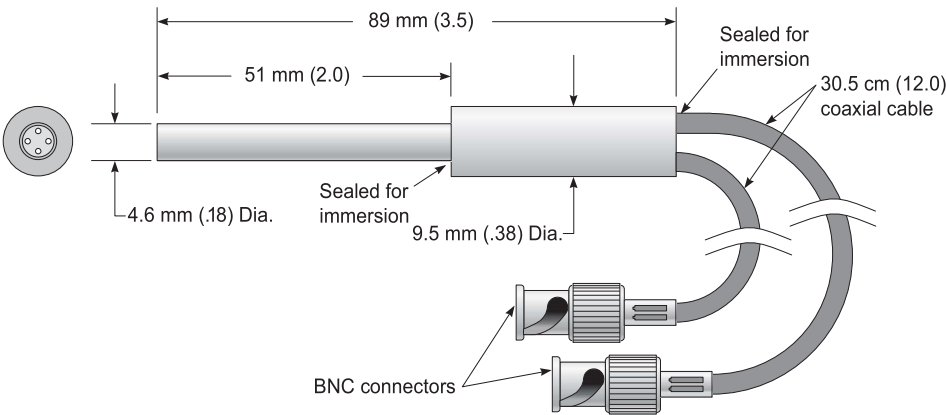


Designed for most standard TSI dual sensor plug-in probes.

Specify

- + 1155-6 for 152 mm (6 in.) length
- + 1155-18 for 457 mm (18 in.) length
- + 1155-36 for 915 mm (36 in.) length
- + Max. Fluid Temp. = 150°C

Model 1156-1 Probe Support

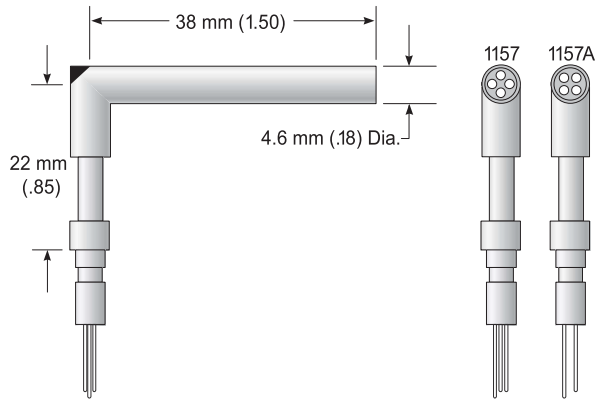


Convenient probe support for small spaces.

Specify

- + 1156-1
- + Max. Fluid Temp. = 150°C

Model 1157 90° Angle Adapter

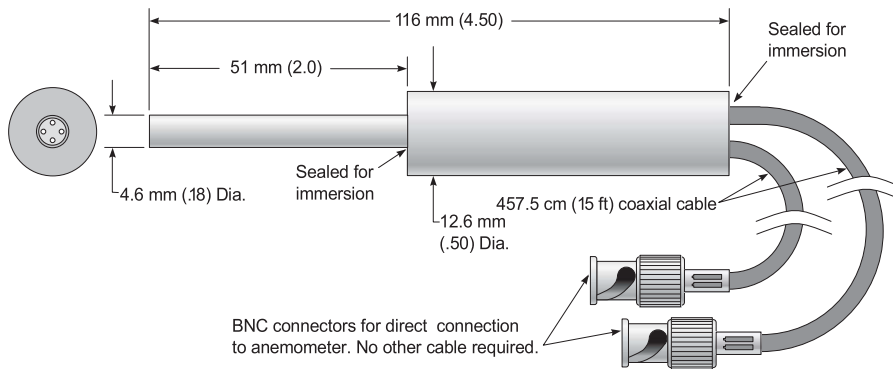


Right angle bend provides access to upstream points with straight probes.

Specify

- + 1157
- + 1157A (for use with Models
- + 1240 and 1247A
- probes only)

Model 1154 Dual Sensor Probe Support for Liquids



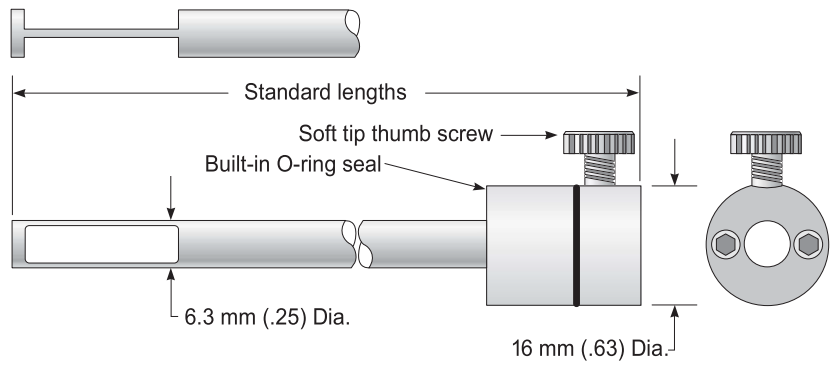
Small probe can be immersed for liquid flow applications.

Specify

- + 1154-15

PROBE ACCESSORIES

Model 1139 Shield With Window

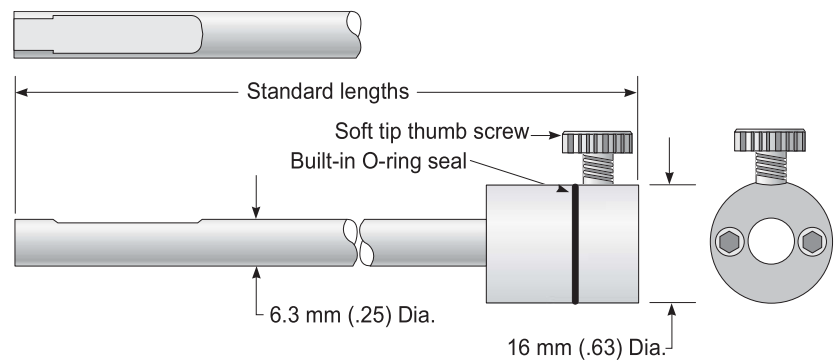


Completely protects sensor while providing opening for cross-flow measurements. Probe can be extended beyond end for unobstructed measurements. Fits Model 1150 Probe Supports.

Specify

- + 1139-6 for 152 mm (6 in.) length
- + 1139-18 for 457 mm (18 in.) length
- + 1139-36 for 915 mm (36 in.) length

Model 1160 High Temperature Probe Support



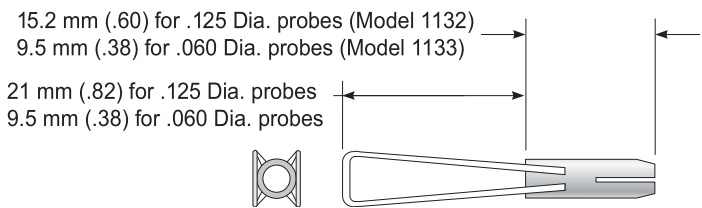
Protects probe when used as a shield, locks probe into socket when extended. Provides sturdy support for probe. Fits Model 1150 Probe Supports and most standard probes.

Specify

- + 1158-6 for 152 mm (6 in.) length
- + 1158-18 for 457 mm (18 in.) length
- + 1158-36 for 915 mm (36 in.) length

Model 1132 Wire Shield

Model 1133 Miniature Wire Shield

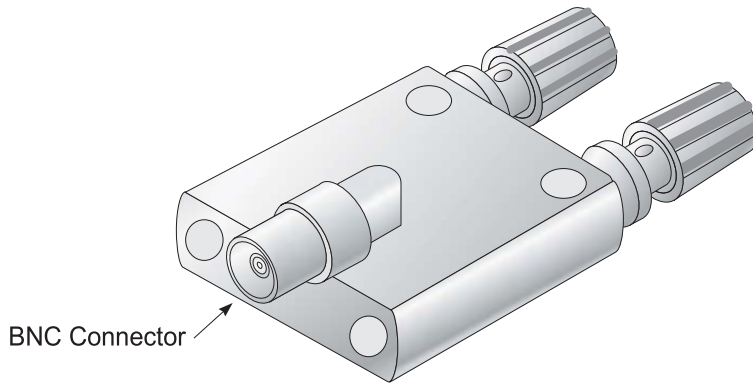


Protects probe from breakage while in use. Can be installed and removed as required using friction fit.

Specify

- + 1132 for 3.18 mm (1/8 in.) diameter probes
- + 1133 for 1.5 mm (.060 in.) diameter probes

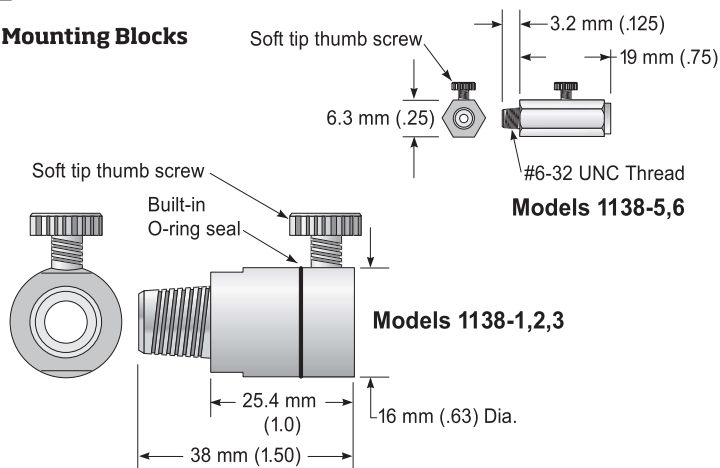
Model 1108 BNC Subminiature Probe Adapter



Adapts from probe wires to BNC connector for subminiature probes with wire leads.

Specify
+ 1108

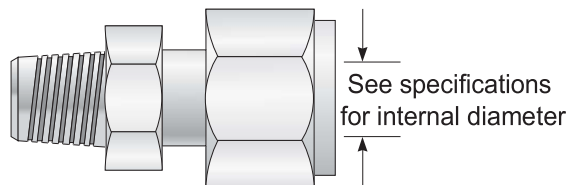
Model 1138 Mounting Blocks



A sealing fitting for probe traversing and for mounting probe supports to the wall of a test section.

Specify
+ 1138-1 for .250 in. Prot. Sleeve-1/4 NPT
+ 1138-2 for .180 in. Probe Support-1/4 NPT
+ 1138-3 for .125 in. Standard Probe-1/8 NPT
+ 1138-6 for .035 in. Submin. Probe-6-32

Model 1137 Mounting Block

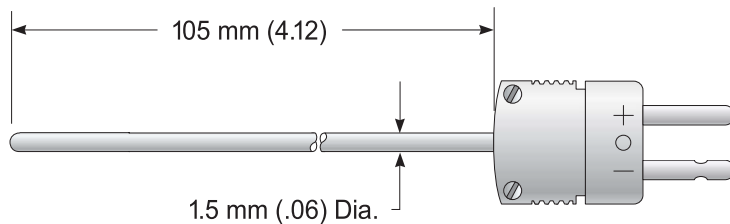


Sealing fittings for probe traversing and for mounting probe supports to the wall of a test section. Has nylon ferrules for higher pressure applications.

Specify
+ 1137-1 for .250 diameter, 1/4-18 NPT
+ 1137-2 for .180 diameter, 1/4-18 NPT
+ 1137-3 for .125 diameter, 1/8-27 NPT
+ 1137-4 for .060 diameter, 1/8-27 NPT

PROBE ACCESSORIES

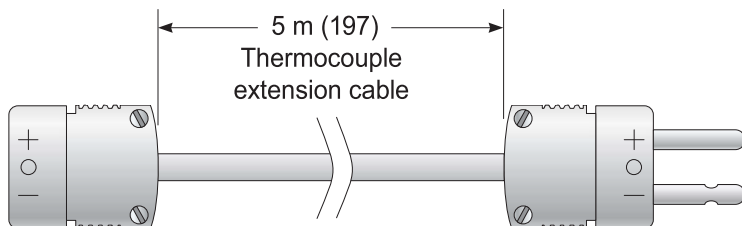
Model 1341 Thermocouple Probe



Measures temperature of measurement environment. Type-T copper-constantan.

Specify
+ 1341

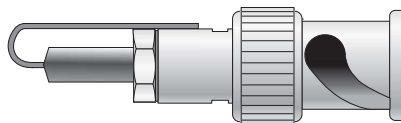
Model 1340 Thermocouple Extension Cable



Cable 5 m long connects Model 1340 Thermocouple to anemometer. Type-T copper-constantan.

Specify
+ 1340

Model 1304 Control Resistor



BNC Connector for direct connection to 1050 anemometer or 1750 anemometer

Model 1304 control resistors are used with bridges that have a 5 to 1 ratio, such as 1750 and 1050/1053/1054 anemometers.

Specify
+ 1304-XX
where XX is the resistance to the nearest 1 ohm. To determine the correct resistance, refer to equation 2 on page 22.

Model 10120 Hot Wire/Film Sensor Repair Kit

Includes equipment needed to attach hot wire or cylindrical film sensors designed for gas applications to needle supports. Kit includes soldering iron with spare tips, single-edge razor blades, soldering stand with clip, jeweler's broach, soft solder (400°F melting point), distilled water, brush, acid flux, and a file. A microscope or magnifier of about 10X to 20X is also recommended.

Specify

- + 10120 for 110 VAC, 60 Hz
- + 10120-1 for 220 VAC, 50 Hz

Model 10121 Hot Film Replacement Sensors

These are high-quality, alumina-coated hot film sensors (cylindrical elements for air only) for field replacement use. They are furnished in quantities of 10.

Specify

- + 10121-10 for 0.025 mm (0.0015 in.) dia. with 0.5 mm (0.020 in.) sensor length
- + 10122-20 for 0.05 mm (0.002 in.) dia. with 1.0 mm (0.040 in.) sensor length
- + 10122-60 for 0.15 mm (0.006 in.) dia. with 2 mm (0.080 in.) sensor length

Model 10122 Hot Wire Replacement Sensors

These are high-quality, platinum-coated tungsten hot wire sensors for field replacement use, furnished in quantities of 12 on a card. The ends of the wires are plated to isolate the active sensor region.

Specify

- + 10122-T1.5 for 0.0038 mm (0.00015 in.) dia. with 1.25 mm (0.050 in.) sensor length
- + 10122-T2 for 0.005 mm (0.0002 in.) dia. with 1.25 mm (0.050 in.) sensor length

Model 10123 Wire for Hot Wire Sensors

This is the same high-quality, platinum-coated tungsten wire used in the Model 10122 but furnished on a spool in a 2-meter length.

Specify

- + 10123-T1.5 for 0.0038 mm (0.00015 in.) dia. with 2-meter length of wire
- + 10123-T2 for 0.005 mm (0.0002 in.) dia. with 2-meter length of wire

DETERMINING OPERATING RESISTANCE OF A SENSOR

Each TSI probe is furnished with complete sensor data showing the recommended operating resistance (R_{op}) of the sensor.

Fragile Sensors To be opened only by user					
Probe Model			TSI Ref. No.		
Sensor No.	Probe RES at 0°C R ₀ , Ω	R ₁₀₀ -R ₀ Ω	Recommended Oper. RES R _{op} , Ω	Recommended Oper. Temp. T _{op} , °C	Internal Probe RES R _{int} , Ω
1					
2					
3					

Notes: 1. Control RES (if required)=(R_{op}+R cable) x 5 on 5:1 BRIDGE
2. R₀=R sensor+R_{int}

Call 1-800-874-2811 for service. Made in U.S.A.

Example of Sensor Data Label

The operating resistance of the sensor determines the temperature at which the sensor will be operated. Operating resistances are calculated from sensor resistance data taken at 0°C (R₀) and 100°C (R₁₀₀-R₀) and include the internal probe resistance (R_{int}). The operating resistance listed with each probe corresponds to the recommended operating temperature of the sensor (T_{op}) which is also included with the probe. Sensors for use in air or other gases are usually run at temperatures of 250°C, while water sensors are run at 67°C. These sensor temperatures have been selected to optimize sensitivity and signal-to-noise ratio, and provide maximum sensor life. If a different sensor temperature is desired, it can be calculated from:

Equation 1

$$R_{op} = \frac{T_s (R_{100} - R_0)}{100^\circ C} + R_0$$

where:

- R_{op} = Operating resistance of the sensor (ohms)
- T_s = Desired sensor temperature (°C)
- R₁₀₀-R₀ = Sensor resistance change between 0°C and 100°C (ohms)
- R₀ = Sensor resistance at 0°C (ohms)

The operating resistance of the sensor can be set with a variable resistance decade or with a fixed control resistor. The required control resistor value can be determined by:

Equation 2

$$R_{CR} = (R_{op} + R_c) \times 5$$

(for 5:1 bridge ratio)

where:

- R_{CR} = Control resistor value (ohms)
- R_c = Probe cable resistance, including probe support (ohms)

For TSI 1050 Anemometers with resistance decades, or for IFA 100, IFA 300, and FlowPoint™ Anemometers, the operating resistance can be set directly if the probe cable resistance is properly accounted for.

PROBE CALIBRATION

The probe current versus velocity curves* on page 23 show the sensitivity of various types of sensors. Velocity sensitivity is taken directly from the slope of the curve as amps per units of velocity. To convert from current sensitivity to bridge voltage sensitivity, use the following equation:

Equation 3

$$\frac{\Delta E_B}{\Delta V} = \frac{\Delta I_s}{\Delta V} (R_{op} + R_B)$$

where:

- $\frac{\Delta E_B}{\Delta V}$ = The slope of the calibration curve at the velocity of interest, proportional to the ratio of change in sensor current (ΔI_s) for a small change in velocity (ΔV) past the sensor.
- E_B = Bridge voltage
- V = Velocity
- R_{op} = Sensor operating resistance
- R_B = Bridge resistor in series with the sensor (10 ohms for IFA 300 STD Bridge)

The curves can also be used to determine the electrical power dissipated in the sensor or to estimate the approximate bridge voltage at a given velocity:

Equation 4

$$E_B = I_s (R_{op} + R_B)$$

where:

- E_B = Bridge voltage
- I_s = Sensor current
- R_{op} = Sensor operating resistance
- R_B = Bridge resistor

The sensor curves shown are valid only for the sensor resistance listed. For a different resistance sensor, correct the sensor current by:

Equation 5

$$I_{s2} = I_{s1} \sqrt{\frac{R_{op1}}{R_{op2}}}$$

where:

- I_{s2} = New sensor current
- I_{s1} = Sensor current from curve
- R_{op1} = Sensor resistance listed on curve
- R_{op2} = Actual sensor resistance

Sensitivity to Resistance Change

Often in anemometry, questions may arise regarding: 1) Effect of cable length on calibration; 2) "Noise" from slip rings and other types of "contact problems;" 3) Effects of resistance shifts of the sensor; 4) Stability requirements of other resistors in the bridge. These questions all relate to the effect of resistance changes on the output voltage. This can be expressed as:

Equation 6

$$\frac{\Delta E_B}{\Delta R_{op}} = -\frac{I_s}{2} \frac{(R_{op}/R_B)(2R_{op}/R_e - 1) + 1}{(R_{op}/R_e) - 1}$$

For example, if $R_{op} = 9$ ohms, $R_e = 6$ ohms, and $R_B = 10$ ohms, then:

$$\frac{\Delta E_B}{\Delta R_{op}} = -2.8 I_s (\text{volts/ohm})$$

From the sensor current curves at the right and equation (3), a resistance change can be related to velocity sensitivity.

Effects of Amplifier Drift

The following relationship gives the ratio of bridge voltage (output) change to a change in amplifier input voltage.

Equation 7

$$\frac{\Delta E_B}{e_b} = -\frac{I}{2} \left[1 + \frac{R_B}{R_{op}} \right] \frac{(R_{op}/R_B)(2R_{op}/R_e - 1) + 1}{(R_{op}/R_e) - 1}$$

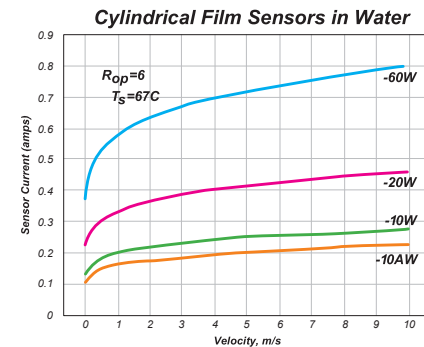
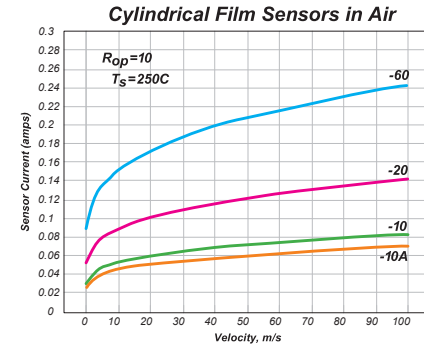
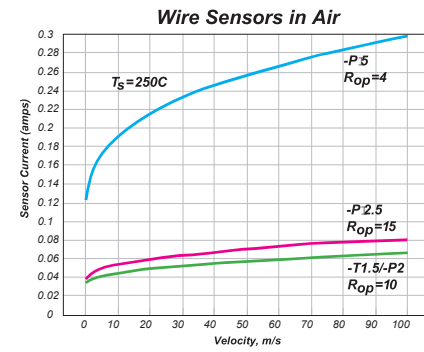
Using the above example:

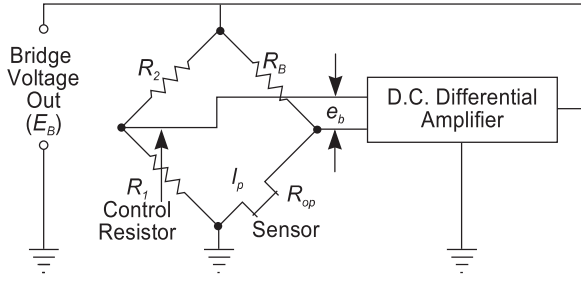
$$\frac{\Delta R_B}{e_B} = -3.63$$

Therefore, a change of 10 microvolts at the amplifier input (equivalent input drift for example) gives only 36.3 microvolts at the anemometer output for the assumed conditions. A constant temperature anemometer is inherently a very stable instrument.

Conduction Loss to Supports

The steady-state effects of conduction losses to supports have little influence on the mean velocity accuracy if the sensor is properly calibrated. Only when attempts are made to predict the calibration heat transfer equations will the steady state conduction to supports become a factor. In noncylindrical film sensors, the dynamic effects of nonsteady state heat conduction to the supporting structure can be significant, particularly in gases. For example, the high frequency (compensated) sensitivity can be less than half of that predicted by a steady-state calibration curve. The actual attenuation depends on many factors including the size and shape of the sensor and its environment. In general, the high heat transfer rates in water reduce this error to acceptable levels, while in gases a dynamic calibration is required for optimum results. It should be emphasized that this effect is usually negligible in both hot wires and cylindrical film sensors. This is because the conduction loss to the supports is small and the supports are a sufficiently large heat sink so their temperature change is small.





Schematic of Constant Temperature Anemometer

Calibration Adjustments

Calibrations are made by plotting Bridge Voltage, E_B , as a function of Velocity and then fitting the data with a polynomial or exponential curve fit. If the calibration must be adjusted for use with a different bridge resistance, R_B , or cable resistance, R_c , it is useful to assume that the sensor current is constant (for a given velocity and sensor temperature). For convenience, internal probe resistance is included in sensor resistance data, but probe support resistance can be measured or nulled out and should be included with cable resistance, R_c . Then we can calculate a new bridge voltage for each velocity.

Equation 8

$$I_s = \frac{E_B}{(R_B + R_c + R_{op})}$$

and so:

$$E'_B = E_B \frac{(R'_B + R'_c + R_{op})}{(R_B + R_c + R_{op})}$$

Temperature Sensitivity

Bridge Voltage is corrected for ambient temperature changes as follows. A reasonable assumption is that

$$\frac{E_B^2}{(T_s - T)}$$

is constant for a given velocity as temperature changes. Therefore, we can predict a bridge voltage E'_B for a new temperature, T' , as follows.

Equation 9

$$E'_B = E_B \left[\frac{T_s - T'}{T_s - T} \right]^{1/2}$$

Directional Sensitivity of Cylindrical Sensors

The following provides a very brief introduction to techniques for measurements with cylindrical thermal sensors. To simplify this presentation, it is assumed that the sensor is sufficiently long so that the following approximation can be used:

Equation 10

$$V_{eff} = V \cos \alpha$$

In other words, the effective cooling velocity past the sensor varies as the cosine of the angle between the sensor axis and the velocity vector. At 90° , $V_{eff} = V$ and at 0° $V_{eff} = 0$. It should be noted that in the ideal case, the sensitivity remains constant as the velocity vector moves around the sensor at a constant angle, α , to the sensor axis.

Single Sensor Oriented Perpendicular to the Mean Flow

Let the mean flow be represented by V_1 and the fluctuations represented by v_1 , v_2 , and v_3 where v_2 represents the fluctuations in the direction parallel to the sensor and v_3 represents the fluctuations in a direction perpendicular to v_1 and v_2 . The effective velocity measured will be:

Equation 11

$$V_{eff} = \sqrt{(\bar{V}_1 + v_1)^2 + v_3^2}$$

If we neglect v_3 , then:

$$\bar{V}_1 = \bar{V} = \bar{V}_{eff}$$

and

$$\sqrt{v_1^2} = \sqrt{\bar{V}_1^2}$$

The value of V_1 is the average value while

$$\sqrt{\bar{V}_1^2}$$

is the rms value.

When

$$\sqrt{\bar{V}_1^2} / \bar{V} = 0.2$$

(= 20% turbulence intensity), the error due to ignoring v_3 is about 2% for isotropic, normally distributed, and normally correlated turbulence.[†] The mean velocity error is also about 2%.

X Probe (Two cylindrical sensors oriented at 90° to each other)

The X probe is used to measure two velocity components. Writing the equations for the effective velocity for the two sensors "A" and "B" with the mean velocity in the plane of the two sensors $V_3 = 0$ and $\bar{\alpha}_1$ = the angle between V_1 and sensor B gives:

Equation 12

$$V_{A,eff}^2 = (V_1 \cos \alpha_1 - V_2 \sin \alpha_1)^2 + v_3^2$$

$$V_{B,eff}^2 = (V_1 \sin \alpha_1 + V_2 \cos \alpha_1)^2 + v_3^2$$

If the sensors are further aligned so $\alpha_1 = 45^\circ$ and v_3^2 is assumed negligible, then rearranging the above equations gives:

Equation 13

$$V_1 = 2^{-1/2} (V_{A,eff} + V_{B,eff})$$

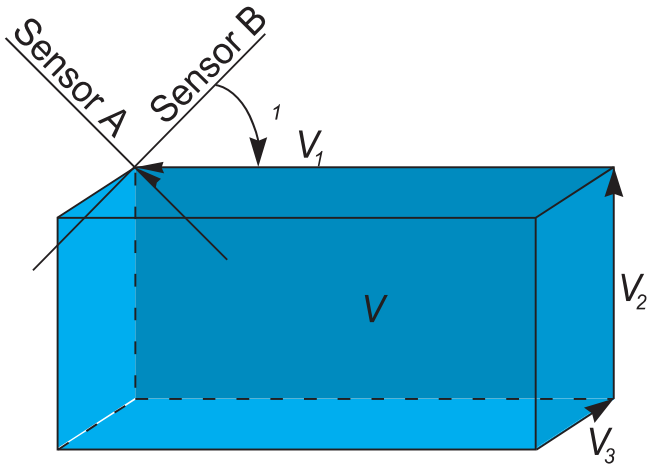
Finally, if the sensors are aligned so that $\overline{V}_2 = 0$ and $\overline{V}_1 = \overline{V}$, then:

Equation 14

$$\begin{aligned}\overline{V} &= 2^{-1/2} (V_{A,eff} + V_{B,eff}) \\ \overline{v_1^2} &= 2^{-1} (V_{A,eff} + V_{B,eff})^2 \\ \overline{v_2^2} &= 2^{-1} (V_{A,eff} - V_{B,eff})^2 \\ \overline{v_1 v_2} &= 2^{-1} (V_{A,eff} + V_{B,eff}) (V_{A,eff} - V_{B,eff})\end{aligned}$$

Neglecting v_3 gives an error of about 8% when the turbulence intensity is 20%, with the same flow field as discussed for the single wire.[†]

The above is given here to provide some insight into how single sensors and X probes are used and the limitations at high turbulence intensities. Refinements of the equations as well as other considerations are contained in the extensive literature on thermal sensors contained in the Freymuth bibliography.



Configuration of X-probe.

Nomenclature

E_B	= bridge voltage output
ΔE_B	= small change in bridge voltage output
e_b	= small voltage change at amplifier input
f	= frequency, (Hz)
I_s	= current through sensor (amps)
DI_s	= small change in sensor current
R_c	= probe cable resistance (includes probe support resistance, but not internal probe resistance)
R_{CR}	= control resistor value
R_e	= resistance of sensor at ambient (environment) fluid temperature (ohms)
R_o	= sensor resistance at 0°C
R_{op}	= resistance of sensor at operating temperature
DR_{op}	= small change in sensor resistance
R_B	= bridge resistor in series with the sensor, 10 ohms for FlowPoint, IFA 100, IFA 300 except 2 ohms for IFA 100, IFA 300 Hi Power Bridge; 40 ohms for Model 1053B, 1054A, 1054B, and #1 Bridge on Model 1050; 10 ohms for #2 Bridge on Model 1050 and 2 ohms on #3 Bridge on Model 1050; 20 ohms for Model 1750.
T	= fluid temperature
T_s	= sensor operating temperature (°C)
V	= fluid velocity past sensor
ΔV	= small change in fluid velocity past sensor
V_1, V_2, V_3	= orthogonal components of V relative to flow facility
V_{eff}	= effective cooling velocity past sensor (equivalent value of VN)
VA_{eff}	= effective velocity as seen by sensors (and similarly for sensor B)
v	= small fluctuations in velocity V
a_1	= angle between velocity vector and sensor axis

SPECIFICATIONS

Hot Wire and Hot Film Sensors

Hot Wire							
Type	Dash No. Designation Suffix in Probe No.	Diameter (D) of Sensing Area or Width in m (in.)	Length (L) of Sensing Area in mm (in.)	Distance Between Supports in mm (in.)	Maximum Sustained Ambient Temperature (C°)	Maximum Sensor Operating Temperature (C°)	Temperature Coefficient of Resistance (C°)
Tungsten Platinum Coated	-T1.5	3.8 (0.00015)	1.27 (0.05)	1.52 (0.06)	150	300	0.0042
Platinum	-P2	5.1 (0.0002)	1.27 (0.05)	1.27 (0.05)	300	800	0.00385
Platinum Iridium (Alloy)	-PI2.5	6.3 (0.00025)	1.27 (0.05)	1.27 (0.05)	300	800	0.0009
Platinum Iridium (Alloy)	-PI5	12.7 (0.0005)	1.27 (0.05)	1.27 (0.05)	300	800	0.00094
Hot Film Gas							
Type	Dash No. Designation Suffix in Probe No.	Diameter (D) of Sensing Area or Width in m (in.)	Length (L) of Sensing Area in mm (in.)	Distance Between Supports in mm (in.)	Maximum Sustained Ambient Temperature (C°)	Maximum Sensor Operating Temperature (C°)	Temperature Coefficient of Resistance (C°)
Platinum	-10A	25.4 (0.001)	0.25 (0.01)	0.76 (0.03)	150/300	425	0.0024
Platinum	-10	25.4 (0.001)	0.51 (0.02)	1.27 (0.05)	150/300	425	0.0024
Platinum	-20	50.8 (0.002)	1.02 (0.04)	1.65 (0.065)	150/300	425	0.0024
Hot Film Liquid							
Type	Dash No. Designation Suffix in Probe No.	Diameter (D) of Sensing Area or Width in m (in.)	Length (L) of Sensing Area in mm (in.)	Distance Between Supports in mm (in.)	Maximum Sustained Ambient Temperature (C°)	Maximum Sensor Operating Temperature (C°)	Temperature Coefficient of Resistance (C°)
Platinum	-10AW	25.4 (0.001)	0.25 (0.01)	0.76 (0.03)	30	67	0.0024
Platinum	-10W	25.4 (0.001)	0.51 (0.02)	1.27 (0.05)	30	67	0.0024
Platinum	-20W	50.8 (0.002)	1.02 (0.04)	1.65 (0.065)	30	67	0.0024

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UNDERSTANDING, ACCELERATED

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APPENDIX C

Source Test Protocol Evaluation, August 27, 2024

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
SCIENCE & TECHNOLOGY ADVANCEMENT * SOURCE TEST ENGINEERING BRANCH
SOURCE TEST PROTOCOL EVALUATION

S/T ID: **P24228**

SCAQMD ID: **FACILITY ID NO. 119219**
COMPANY: **Chiquita Canyon Landfill, LLC, Castaic**
EQUIPMENT: **Landfill Leachate and Condensate Storage Tanks - Vapor Sampling
Tank Farm #7
Tank Farm #9
Flare Station Inlet**

TEST LOCATION: **29201 Henry Mayo Dr., Castaic**

REQUESTED BY: **Baitong Chen (Memo Dated July 24, 2024)**
TYPE OF TEST: **PERFORMANCE/COMPLIANCE PROTOCOL**
DOCUMENT DATE: **July 11, 2024**
REASON FOR TEST: **(TESTING SUBJECT TO THE FOLLOWING RULE, PERMIT, OR SPECIFIED CONDITIONS):**
- Priority handling requested due to Abatement Order (Case 6177-4). Testing per OA Condition 72. Testing is intended to determine the vapor emissions from the landfill leachate and condensate storage tanks within the tank vents/manifolds, gas headers, and flare station inlet.

REQUESTED EVAL: **H2S, TRS, TO-15**
TEST FIRM: **Montrose Air Quality Services, LLC**

STE EVALUATOR: **Rodney Davis EXT: 2206** *REVIEW DATE:* **August 27, 2024**

OVERVIEW OF EVALUATION:

<i>OVERALL CONFIDENCE IN SOURCE TEST PROPOSAL:</i>	☐ ACCEPTABLE	☒ CONDITIONALLY ACCEPTABLE	☐ UNACCEPTABLE ☐ NOT REVIEWED
<i>DEFICIENCIES IDENTIFIED:</i>	Deficiency noted concerning the proposed sampling location(s) and/or representativeness with respect to process and required testing		
<i>MODIFICATIONS OR REMEDIAL MEASURES REQUIRED:</i>	- There are some important reminders concerning the proposed testing. - This source test proposal must be modified to address the deficiencies described in the following section of this evaluation, and the source testing which incorporates these modifications may proceed without further discussion.		

(REFER TO THE NEXT SECTION FOR A COMPLETE DISCUSSION OF THESE DEFICIENCIES)

S P E C I F I C R E Q U I R E M E N T S

This source test protocol has been reviewed by the Source Test Engineering Branch staff. The following item(s) specifically explain the required modifications to the existing source test protocol which must be implemented, or items requiring further discussion or explanation, before testing can proceed:

- ☒ Completeness of Protocol
- ☒ Representativeness of Data & Process
- ☒ Rule/Permit Fulfillment
- ☒ Sampling & Analytical Methods
- ☒ Quality Assurance
- ☒ Calculations

COMPLETENESS OF PROTOCOL

- The report shall be submitted in a digital and/or hardcopy format.
- Each page of the final test report (including raw analytical and field data, as well as other third-party reports) must have a unique and sequential page number which can be referenced in future correspondences.

REPRESENTATIVENESS OF DATA & PROCESS

- The final report shall include pictures of each source location and its corresponding sample location.
- The tester shall adhere to the following requirements when measuring velocity per SCAQMD Methods 1-4:
 - Cyclonic flow checks must be performed using an S-Type Pitot tube, and the instrument used for measuring cyclonic flow angles must be documented in the test report;
 - Sample ports shall be located according to SCAQMD Method 1.1;
 - As applicable, calibration data for the sling psychrometer shall be included with the test report.
- As stated in section 2.1 of the protocol, if low flow rates (delta P less than 0.05 inches of w.c.) are detected during or before the source test program, a standard or “S” type pitot tube that meets Method 2.1 is to be required along with a calibrated digital manometer. Calibration documentation must be included with the test report to validate the accuracy of the differential pressure gauge.
- As a reminder for velocity pressure measurements (as described in Section 2.1.2 of South Coast AQMD Method 2.1) using typical 10-inch water column inclined-vertical manometers and magnehelics readings are not considered accurate if:
 - a) Average readings are <0.05” w.c.;
 - b) >10% of points are <0.05” w.c. (12 or more traverse points); and
 - c) >1-point is <0.05” w.c. (traverses of less than 12 points).

S P E C I F I C R E Q U I R E M E N T S

- Per section 5.0 Process Equipment Information, process data to be monitored will include landfill gas throughput and report wellhead vacuum and tank pressures, if applicable.
- Notification of the source test shall be made to the South Coast AQMD at least ten days prior to the source test. Notification shall be made to Rodney Davis (Phone: (909) 396-2206, email: rdavis@aqmd.gov), Baitong Chen, bchen@aqmd.gov; Nathaniel Dickel, ndickel@aqmd.gov; Christina Ojeda, ojeda@aqmd.gov and shall include the facility name, ID number and address, and the date and time of the source test.

RULE/PERMIT FULFILLMENT

- Testing must be conducted pursuant to the following Order of Abatement Conditions:
All of the above requirements have been addressed in this protocol and are satisfactory as proposed, or as modified as discussed in this review. The source test report emission information must also be formatted to satisfy the above Rule/Permit Conditions.

SAMPLING & ANALYTICAL METHODS

- Pressure/vacuum as well as flow control rate into the TO-15 canister are to be recorded on the canister field test data sheet as indicated by the sampler vacuum/pressure gauge and flow control device. Canisters and gauges should be tested clean and leak tight.
- South Coast AQMD Method 307-91 for H₂S and/or SO₂ requires samples to be analyzed the same day or within 24 hours of collection in duplicate.
- Speciated volatile organic compounds sampled by EPA Method TO-15 must report all compounds listed in Tables 1 and 2 of Appendix D of the test method.

QUALITY ASSURANCE

- All applicable pieces of source test and process equipment used directly or indirectly for measurement of source test emission data must be calibrated, and the calibrations included in the final report (this includes gas meters, Pitot tubes, pressure gages, nozzles, temperature devices, calibration gases, fuel usage meters, totalizers, etc.).
- Where appropriate, field blanks, reagent blanks and recovery spikes must be performed, and the information submitted with the source test report. Only reagent blanks may be deducted for emission calculations.
- All raw data field data sheets, as well as recorder strip charts, must accompany the test report.
- Where laboratory instrument analysis is required, instrument raw strip charts, calibrations and standards, and limit of detection must be included in the source test report. This also includes equipment transfer and “chain-of-custody” form clearly

S P E C I F I C R E Q U I R E M E N T S

describing all equipment and laboratory ID numbers, dates and times, required analysis, and the signature/initials of persons involved in transfers. TCA analyses must also include trap burnouts from the previous test, if applicable.

- The terms “non-detect” or “non-detectable” are no longer used for emission reporting purposes. Instead, non-detectable results are reported with respect to the limit of detection of the analytical instrument or method (e.g. report “<10 micrograms/liter”, if detection limit is 10 micrograms/liter). Non-detectable emission results must have supporting documentation to show that acceptable sample volume was collected pursuant to rule or permit limits and analytical method limits of detection.
- The Chain-of-Custody forms for transferring the SCAQMD Method 25.3 vial (midget impinger) samples to the analytical laboratory must include the temperature of the vials at the time of transfer.
- Equipment used by the source testing contractors must adhere to the Chapter III calibration and maintenance requirements of the Source Test Manual.

CALCULATIONS

- All calculations concerning intermediate process, emission, and/or flow information must be shown and included in the final report. This also applies to calculations concerning laboratory analyses emission calculations.

B O I L E R P L A T E R E M A R K S

(Do Not Include in Report)

FINAL TEST REPORT

The final Source Test Report must include the following information:

1. Signed "Statement of Non-Conflict as an Independent Laboratory" (SCAQMD Rule 304(k)) and CARB Lab Approval or SCAQMD Lab Approval Program (LAP) document (if applicable).
2. A brief opening statement identifying the Facility I.D., the equipment A/N, P/O, or Device I.D. and the reason(s) for testing (applicable rules permit conditions, etc.). Include a copy of the Permit-to-Construct, Permit-to-Operate, or Facility Permit. Also identify the test dates, the personnel on hand for the test, names, titles and phone numbers of responsible test firm and facility personnel.
3. A summary of the Source Test results, including applicable rules and permit conditions (show allowable standards) and source test data properly formatted to satisfy these requirements.
4. A brief process description. Indicate equipment operation during testing; as well as any other information which may influence the final report.
5. A "self-critique" of anything that transpired during the test which you feel is useful in the interpretation of the test results.
6. A simple schematic diagram of the process, showing the sampling location, with respect to the upstream and downstream flow disturbances. Also include a cross-sectional diagram of the stack or duct at the sampling location, depicting the sampling points with respect to compass direction.
7. The sampling and analytical procedures. Be specific about all aspects of sampling and analysis. Include diagrams of test equipment and methods.
8. Complete raw field data, including production data indicative of the testing interval, lab analyses, and the test results (show all calculations).
9. Current calibration data regarding all sampling and measuring equipment utilized during testing. This also includes all laboratory calibrations, as well as facility fuel meter calibrations. (See SCAQMD Source Testing Manual, Chapter III or "Quality Assurance Handbook For Air Pollution Measurement Systems", Vol..III, U.S. EPA-600/4-77-0276).