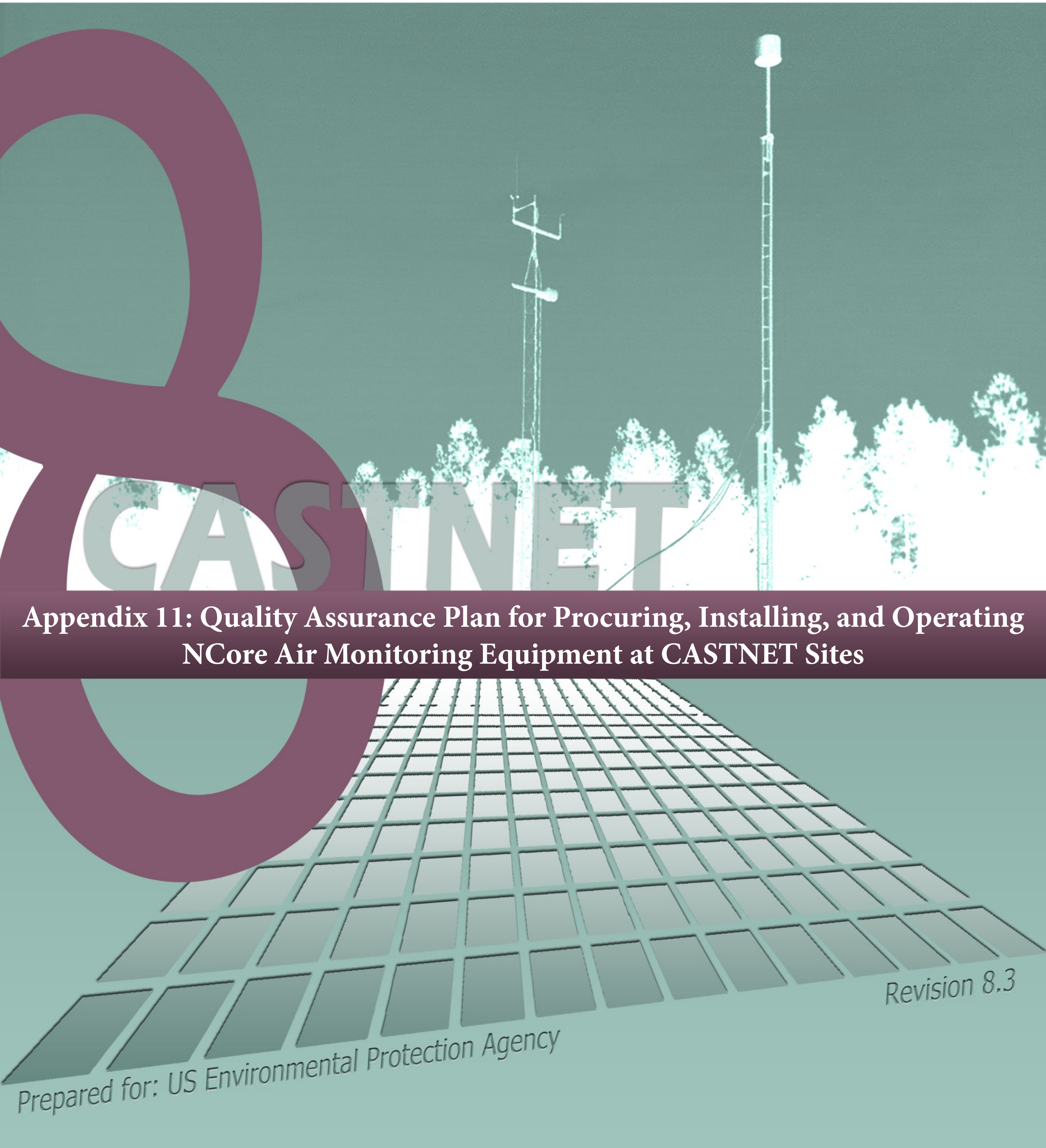

Appendix 11: Quality Assurance Plan for Procuring, Installing, and Operating NCore Air Monitoring Equipment at CASTNET Sites

Revision 8.3

Prepared for: US Environmental Protection Agency

Clean Air Status and Trends Network

Quality Assurance Project Plan

Revision 8.3

Appendix 11:

Quality Assurance Plan (QAP) for Procuring, Installing, and Operating NCore Air Monitoring Equipment at CASTNET Sites

June 2016

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List of Acronyms and Abbreviations

AIRNow	website operated by EPA, NOAA, NPS, tribal, state, and local agencies to provide the public with access to national air quality information
AMEC	AMEC Environment & Infrastructure, Inc.
AQS	EPA's Air Quality System
CASTNET	Clean Air Status and Trends Network
CFR	Code of Federal Regulations
CO	carbon monoxide
CR3000	data logger manufactured by Campbell Scientific, Inc. that is used in CASTNET
DQI	Data Quality Indicator
EPA	U.S. Environmental Protection Agency
CDMSA	CASTNET Data Management System Application
m	meters
MLM	Multi-Layer Model
MS	Microsoft
NAAQS	National Ambient Air Quality Standards
NCore	National Core Multi-pollutant Monitoring Network
NIST	National Institute of Standards and Technology
NO/NOy	nitric acid/total reactive oxides of nitrogen
NPS	National Park Service
O_3	ozone
PM	particulate matter
ppb	parts per billion
QA	quality assurance
QAP	Quality Assurance Plan
QAPP	Quality Assurance Project Plan
QC	quality control
SO_2	sulfur dioxide
SOP	standard operating procedures
SSRF	Site Status Report Form used at CASTNET sites
ZSP	Zero, span, and precision

1.0 Overview

1.1 Purpose

In October 2006, EPA issued final amendments to the ambient air monitoring regulations described in 40 CFR Parts 53 and 58. One of the most significant changes was the requirement for establishing National Core (NCore) multi-pollutant monitoring stations. These stations will provide data on several pollutants [e.g., sulfur dioxide (SO_2), carbon monoxide (CO), and reactive oxides of nitrogen (NO/NO_y)] at low concentration levels. Each state has a specific number of urban and rural NCore stations that must be established. AMEC has been tasked to purchase, install, and operate NCore required monitoring equipment at CASTNET sites in states where rural NCore monitoring requirements have not been met. NCore measurements began at the CASTNET Bondville, IL (BVL130) site at the end of July 2012.

This Quality Assurance Plan (QAP) documents the types and quality of field measurements generated by the NCore instruments operated at CASTNET sites, using BVL130 measurements as specific examples. This QAP is Appendix 11 to the overall CASTNET QAPP which documents information on all aspects of CASTNET field and laboratory measurements and the associated quality assurance (QA) and quality control (QC) procedures. These are incorporated herein by reference. This QAP was designed to provide the basis for establishing NCore measurements at any CASTNET site.

EPA's (2012) NCore monitoring objectives include:

- Support for development of emission reduction strategies by providing representative air quality measurements and through air quality model evaluation and application;
- Accountability of emission strategy progress through tracking long-term trends of criteria and non-criteria pollutants and their precursors;
- Timely reporting of data to the public through EPA's AIRNow and Air Quality System (AQS) websites, and by providing information that supports air quality forecasting;
- Support for long-term health assessments that contribute to continuing reviews of the National Ambient Air Quality Standards (NAAQS);
- Compliance demonstration by establishing nonattainment/attainment areas through comparison of measurements with the NAAQS;
- Support to scientific studies ranging across technological, health, and atmospheric process disciplines; and
- Support to ecosystem assessments recognizing that national air quality networks benefit ecosystem assessments and, in turn, benefit from data specifically designed to address ecosystem analyses.

1.2 Background

CASTNET is a long-term environmental monitoring network that measures changes in ambient air quality and assesses atmospheric deposition across the United States. Operating since 1987, CASTNET has evolved into a national monitoring program that consists currently of 89 monitoring stations nationwide as of June 2013. EPA operates a majority of the CASTNET monitoring stations. The National Park Service (NPS) operates 24 of the 89 stations in cooperation with EPA. CASTNET stations measure rural, regionally representative concentrations of sulfur and nitrogen pollutants and ozone (O_3) in order to detect and quantify trends, define the geographic distribution of rural pollutants, and estimate dry deposition of pollutants. CASTNET sites are well suited to host NCore measurements because of their rural, regional characteristics and extensive existing infrastructure.

1.3 Organization

The NCore work is authorized through task orders under the CASTNET project umbrella. Consequently, the CASTNET project organization is responsible for the NCore work. Section 1.2 of the CASTNET QAPP discusses CASTNET project organization. Table 1-2 and Figures 1-11 and 1-12 in the QAPP show specific roles, responsibilities, and authorities of AMEC positions within CASTNET project organization.

1.4 Problem Definition

EPA is requiring the use of highly sensitive commercial air pollutant monitors for the characterization of the precursor gases CO, SO_2, and NO/NO_y at rural NCore sites. These precursor gases play important roles in the formation of O_3, air toxics, and particulate matter (PM) on local and regional scales. Data on these gases will be used to fulfill the monitoring objectives listed in Section 1.1. The challenge is to implement the high sensitivity gas monitoring using the appropriate monitoring, calibration, and data acquisition equipment and QA/QC procedures in order to produce reliable and usable information. This QAP summarizes the approach to producing useful measurements and related data.

1.5 Project Description

EPA issued task orders to procure, install, and operate NCore instruments at the Bondville, IL (BVL130) site. Section 2.0 summarizes the technical approach to this work.

2.0 Technical Approach

2.1 Procurement of NCore Monitoring Equipment

AMEC will purchase instruments and equipment as directed by EPA. The first site selected for rural NCore monitoring was Bondville, IL, (BVL130). The instruments include analyzers for continuous monitoring for low-level concentrations of NO/NO_y, SO_2, and CO. Additionally, AMEC acquired the equipment and supplies necessary to operate the analyzers, including compressed gas standards, glass/Teflon manifolds and tubing, and mass flow controllers. The equipment is acceptable for NCore monitoring, as described in the EPA (2005) Technical Assistance Document for Precursor Gas Measurements in the NCore Multi-pollutant Monitoring Network. All purchased instruments and equipment are inspected and tested by AMEC and operation is verified prior to deployment.

The specific instruments operated at the BVL130 CASTNET site are listed in Table 1. Teledyne API ultra-sensitive analyzers were selected for continuous measurements of NO/NO_y, SO_2, and CO. Instrument specifications are listed in Attachment A. Standard Operating Procedures (SOP) are provided in Attachment B. NCore also requires the continuous measurement of temperature, relative humidity, and wind speed and direction. CASTNET meteorological measurements are summarized in Table 2.

Table 1: BVL130, IL NCore Site Instruments

Parameter	Model	Method
SO_2	API[1] T100U	UV Fluorescence
NO/NO_y	API T200U/NO_y	Chemiluminescence
CO	API T300U	Gas Filter Correlation
Multigas Calibration	API T700U	Dynamic Dilution Calibrator
Zero Air	API 701H	Zero Air System
O_3	Thermo 49i[2]	UV Photometric
Data Logger	CR3000[3]	LoggerNet DAS

Notes: Superscripts define the abbreviation and not the instrument.

1. Teledyne API instruments.
2. Thermo Scientific ozone analyzer.
3. Campbell Scientific data logger.

Table 2: CASTNET Meteorological Measurements

Temperature:	Winds:
Temperature (at 2 and 9 meters)	Speed
Delta temperature (difference between 2 and 9 meters)	Direction
Relative Humidity	Sigma theta (standard deviation of direction)
Solar Radiation	Precipitation
	Surface Wetness

2.2 Installation

AMEC will install NCore instruments and equipment at selected CASTNET sites as directed by EPA. AMEC has already installed and is operating analyzers for continuous monitoring of NO/NO_y, SO_2, and CO at BVL130, including additional equipment (multigas calibrator and zero air supply) and supplies needed to meet the requirements listed in 40 CFR Part 58. The existing CASTNET data logger (CR3000) is used to acquire and manage the measurements. Measured data are collected hourly from a centralized server and automatically uploaded into the AMEC CASTNET database. During the installation trip, AMEC trained the site operator and provided SOP (Attachment B) and other documentation deemed necessary to ensure proper operation and data collection.

2.3 Site Description

The CASTNET NCore monitoring site is located about 4 miles south of the Town of Bondville, IL and southwest of the city limits of Champaign, IL. A detailed NCore site characterization is given in the Sonoma Technology Inc. (2009) report to EPA. The following table (Table 3) summarizes the site characteristics. Figures 1 and 2 shows the location of the site on MapQuest and Google maps; and Figures 3 through 5 give site photos.

Table 3: BVL130, IL NCore Site Characteristics

Site ID	BVL130	**Start date**	02/01/1988
Site name	Bondville, IL	**Primary Land Use**	Agricultural (corn)
County	Champaign	**Terrain surrounding site**	Flat
State abbreviation	IL	**Nearest NADP site code**	IL11
Latitude; decimal degrees	40.0519	**Distance to nearest NADP site; km**	0.109
Longitude; decimal degrees	-88.3724	**Does site conform to deposition model assumptions?**	Yes
Elevation; m	212		
Operating agency	EPA		

Figure 1: Small Scale MapQuest Map of BVL130, IL

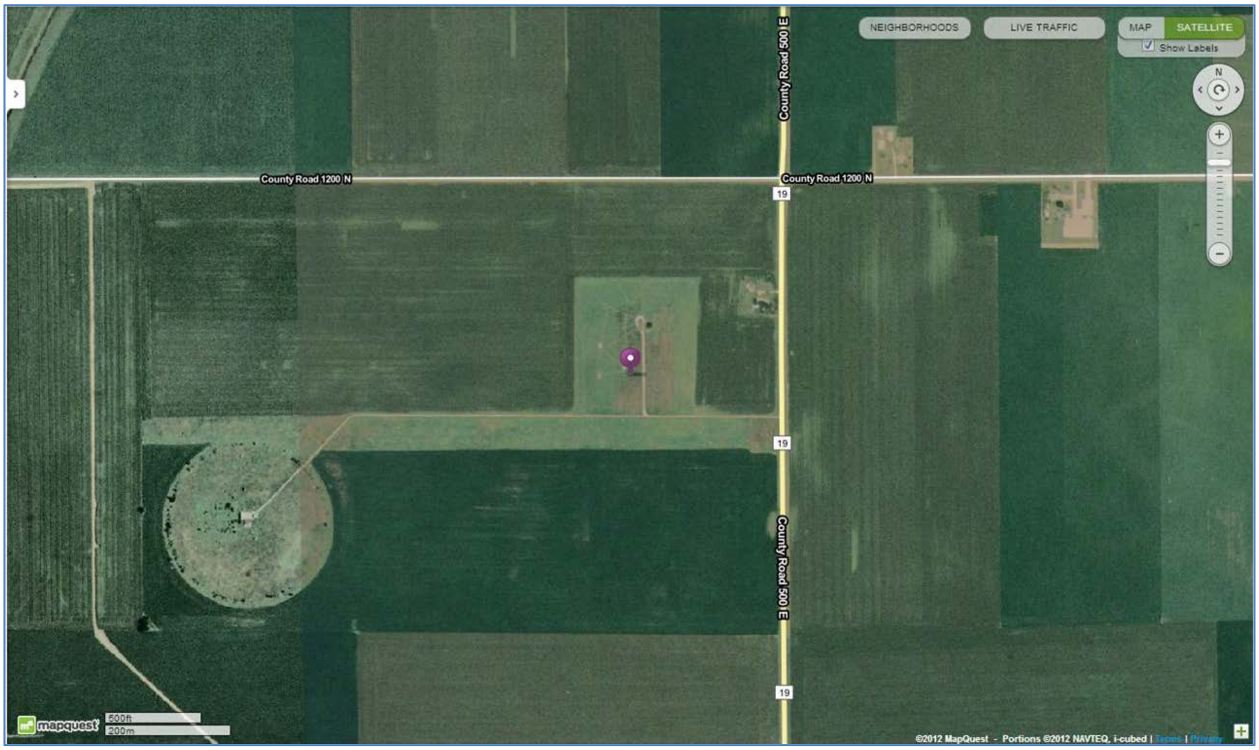


Figure 2: Large Scale Google Earth Map of BVL130, IL

Figure 3: BVL130 CASTNET Sampling Towers and Old Shelter

Figure 4: BVL130 New CASTNET Shelter

Figure 5: BVL130 Shelter Instrument Rack

2.4 Site Operations

NCore sensors have been operated at the CASTNET site at BVL130 since July 28, 2012. The NCore analyzers are located (Figure 4) in the same shelter that houses the standard CASTNET analyzers. Sampling is conducted at 10 m. The NO_y converter is mounted near the 10-m sampling height.

Collecting quality data starts with having sufficiently trained staff. AMEC field operations personnel were trained over the course of a week by personnel from Teledyne API. The BVL130 site operator was trained onsite during the installation of the NCore sampling systems. The NCore training supplemented the standard CASTNET training.

All supplies used to conduct monitoring and sampling meet the specifications of EPA and Teledyne API. The calibration gases used for the gaseous criteria monitors are traceable to the National Institute of Standards and Technology (NIST) and are protocol gases. The analyzers are mounted inside a secure trailer which is temperature controlled. All of the sites maintain a site narrative log. Those entering the site state the purpose of the visit and sign and date the site log. When work is done on a specific sampler, the site operator or AMEC field operations personnel note the work and sign and date the log. The NCore site at BVL130 adheres to EPA established requirements for siting. The site is situated away from trees, buildings, roadways, and other structures or natural occurrences that could affect the representativeness of the pollutants measured.

Site operators visit CASTNET sites each Tuesday and as directed by AMEC (e.g., for equipment repair). Detailed procedures for equipment checks, preventive and corrective maintenance, sample media collection, data logger operation, filter pack change-outs, documentation, and shipment of samples are described in the CASTNET Field SOP in Appendix 1 of the QAPP. The site operator also checks the NCore equipment as part of the site visit. Site operator activities are documented on various forms, such as the site narrative log, Site Status Report Form (SSRF), and Trace Gas Maintenance Forms (Figures 6 and 7), which are specific to the NCore samplers. All original field documentation is sent monthly and stored at the AMEC Data Management Center (DMC) in Gainesville, FL. Copies are also filed at the CASTNET site.

An AMEC data analyst reviews QC data (Figure 8) every other day and polled NCore concentration data (Tables 4 and 5) weekly. Each morning, a data analyst reviews data for the previous day for all EPA-sponsored CASTNET sites and performs a reasonableness check of the data for all parameters, including NCore data. Daily review requires the data analyst to be informed of current weather conditions across the country as well as expected differences between sites based on seasonal and regional conditions. The data analyst will note any questionable values and enter all observations per site into the CASTNET Problem Tracking System in the CASTNET Data Management System Application (CDMSA). Any site that did not poll or only partially polled is re-polled.

All NCore instruments are calibrated (Section 3.0) in accordance with EPA procedures and schedules. All calibration gases used for the precision and span checks are NIST traceable.

Figure 6: BVL130 Trace Gas Maintenance Form 1 Detail

BVL130 Trace Gas Maintenance Form

Initials	MJS
Time	1700
Date	28-Jul-12

	Parameter	**Displayed As**	**Units**	**Acceptable Values**	Current Value
	Shelter (Ambient) Temperature		°C		27.0
T200U NO-NOy	Sample Pressure	SAMP	inHG-A	Ambient -1 ± 1	28.6
	Reaction cell Pressure	RCEL	inHG-A	2 - 5 must be constant	2.6
	Sample Flow	SAMP FLW	sccm	1000 ± 100	904
	Box Temperature	BOX TEMP	°C	Ambient temp + 3-7	32.6
	Converter Temperature (Bypass Box)		°C	315 ± 5	315
T300U CO	Sample Pressure	PRES	inHG-A	Ambient -1.5 ± 1	26.6
	Sample Flow	SAMP FL	LPM	1.8 ± 20%	1.716
	Bench Temperature	BENCH TEMP	°C	48 ± 0.1	48
	Oven Temperature	OVEN TEMP	°C	46 ± 0.1	46
	Auto-Reference Ratio	AZERO RATIO		1.165 -1.225	1.199
T100U SO2	Sample Pressure	PRES	inHG-A	Ambient - 2	24.7
	Sample Flow	SAMP FL	sccm	650 ± 10%	584
	Box Temperature	BOX TEMP	°C	Ambient ± 5	31.1
701H Zero Air	Zero Air Pressure		PSIG	30 ± 2	31
	Power			Light On (Y/N)	on
	Dew Point Indicators			Green-Lit, Red-Off	green
Gas Cylinders	Multigas Tank Pressure		PSI	> 500	1550
	Multigas Calibration Gas Pressure	CAL PRES	PSI	30 - 35	32.5
	NPN Tank Pressure		PSI	> 500	2000
	NPN Calibration Gas Pressure	CAL PRES	PSI	30 - 35	33

Figure 7: BVL130 Trace Gas Maintenance Form 2 Detail

BVL130 Trace Gas Maintenance Form		Initials	MJS
		Time	1300
		Date	25-Jul-12
	Analyzer	**Filter size**	Replaced?
Inside Filters	NO (Monthly)	1 µm	Y
	NO (Monthly)	1 µm	Y
	CO (Monthly)	1 µm	Y
	SO_2 (Monthly)	1 µm	Y
Outside Filters	NO (2 Weeks)	5 µm	Y
	NOy (2 Weeks)	5 µm	Y
	SO_2 & CO (2 Weeks)	5 µm	Y
	Analyzers	**Acceptable Values**	Value
Leak Ckeck	NO (After Filter Change)	Flow < 80 sccm	65
		Pressure < 4 inHG	2
	SO_2 (After Filter Change)	Flow < 10 sccm	1
		Pressure < 10 inHG	7.3
	CO (After Filter Change)	Flow < 10 sccm	1
		Pressure < 10 inHG	7.1
	Manual Calibration		
Analyzer	**Level**	**Expected**	Value
NO	Zero	0	
	Span	90	
	Precision	15	
NOy	Zero	0	
	Span	90	
	Precision	15	
NPN	Span	90	
CO	Zero	0	
	Span	1800	
	Precision	150	
SO_2	Zero	0	
	Span	90	
	Precision	15	

Table 4: BVL130 NO_y Concentrations (ppb) – October 10, 2012 through October 20, 2012

Date_Time	NO_y	Date_Time	NO_y	Date_Time	NO_y	Date_Time	NO_y	Date_Time	NO_y
10/10/12 00:00	0.785	05:00	5.542	10:00	0.963	15:00	3.883	20:00	1.741
01:00	0.928	06:00	5.628	11:00	0.966	16:00	4.351	21:00	1.666
02:00	1.115	07:00	9.08	12:00	1.023	17:00	4.5	22:00	1.354
03:00	1.486	08:00	4.244	13:00	1.142	18:00	4.105	23:00	0.927
04:00	1.784	09:00	1.978	14:00	-0.243	19:00	3.716	**10/19/12 00:00**	2.062
05:00	3.38	10:00	1.627	15:00	0.849	20:00	5.525	01:00	0.927
06:00	2.539	11:00	2.047	16:00	1.493	21:00	3.966	02:00	1.099
07:00	2.572	12:00	2.087	17:00	1.768	22:00	2.867	03:00	2.467
08:00	1.993	13:00	2.024	18:00	1.738	23:00	2.213	04:00	1.728
09:00	1.865	14:00	1.925	19:00	1.38	**10/17/12 00:00**	2.246	05:00	2.163
10:00	1.883	15:00	1.986	20:00	1.382	01:00	2.134	06:00	1.606
11:00	2.949	16:00	2.551	21:00	1.864	02:00	2.074	07:00	1.177
12:00	2.182	17:00	6.526	22:00	2.044	03:00	1.77	08:00	0.875
13:00	2.944	18:00	8.48	23:00	2.306	04:00	2.468	09:00	0.715
14:00	3.56	19:00	5.852	**10/15/12 00:00**	2.284	05:00	2.598	10:00	0.882
15:00	3.11	20:00	5.145	01:00	1.825	06:00	3.282	11:00	0.833
16:00	6.497	21:00	6.501	02:00	1.656	07:00	3.334	12:00	0.933
17:00	1.325	22:00	6.642	03:00	1.792	08:00	3.322	13:00	0.975
18:00	2.887	23:00	4.484	04:00	2.563	09:00	3.445	14:00	1.172
19:00	4.148	**10/13/12 00:00**	4.306	05:00	2.88	10:00	3.496	15:00	1.448
20:00	4.537	01:00	3.744	06:00	3.43	11:00	3.303	16:00	1.875
21:00	6.584	02:00	4.076	07:00	3.445	12:00	3.028	17:00	1.478
22:00	11.57	03:00	4.904	08:00	2.74	13:00	3.307	18:00	1.648
23:00	7.064	04:00	7.044	09:00	2.775	14:00	3.393	19:00	1.522
10/11/12 00:00	5.584	05:00	6.654	10:00	3.22	15:00	2.951	20:00	2.226
01:00	3.601	06:00	6.702	11:00	2.426	16:00	2.736	21:00	2.139
02:00	2.303	07:00	7.564	12:00	2.186	17:00	2.488	22:00	1.254
03:00	2.807	08:00	5.158	13:00	2.053	18:00	3.881	23:00	1.362
04:00	2.856	09:00	3.611	14:00	1.909	19:00	1.449	**10/20/12 00:00**	1.364
05:00	2.279	10:00	4.038	15:00	2.023	20:00	0.933	01:00	1.706
06:00	2.185	11:00	4.247	16:00	2.271	21:00	1.195	02:00	1.817
07:00	2.387	12:00	6.605	17:00	2.566	22:00	0.843	03:00	1.718
08:00	2.088	13:00	5.943	18:00	3.051	23:00	1.343	04:00	1.759
09:00	2.084	14:00	4.198	19:00	2.92	**10/18/12 00:00**	1.188	05:00	3.492
10:00	2.784	15:00	2.63	20:00	20.16	01:00	1.204	06:00	2.22
11:00	2.926	16:00	2.858	21:00	41.09	02:00	0.906	07:00	4.104
12:00	2.698	17:00	2.113	22:00	48.07	03:00	0.846	08:00	2.545
13:00	2.306	18:00	1.81	23:00	29.92	04:00	0.731	09:00	2.667
14:00	2.428	19:00	1.943	**10/16/12 00:00**	21.83	05:00	3.804	10:00	1.941
15:00	2.14	20:00	2.306	01:00	12.99	06:00	2.891	11:00	1.476
16:00	2.636	21:00	2.38	02:00	10.59	07:00	2.856	12:00	1.612
17:00	4.275	22:00	2.605	03:00	7.1	08:00	2.978	13:00	1.395
18:00	4.825	23:00	3.534	04:00	5.965	09:00	2.81	14:00	1.368
19:00	4.71	**10/14/12 00:00**	2.915	05:00	6.355	10:00	2.694	15:00	1.309
20:00	6.838	01:00	2.523	06:00	4.63	11:00	1.463	16:00	1.738
21:00	5.776	02:00	3.335	07:00	8.3	12:00	0.984	17:00	1.834
22:00	4.466	03:00	1.923	08:00	6.129	13:00	1.015	18:00	4.651
23:00	4.337	04:00	0.886	09:00	6.094	14:00	1.05	19:00	3.152
10/12/12 00:00	5.757	05:00	3.752	10:00	8.65	15:00	1.413	20:00	5.305
01:00	3.572	06:00	2.408	11:00	6.436	16:00	1.71	21:00	13.79
02:00	3.593	07:00	1.117	12:00	5.284	17:00	1.452	22:00	10.01
03:00	3.462	08:00	1.121	13:00	4.52	18:00	2.208	23:00	3.662
04:00	3.085	09:00	1.025	14:00	3.868	19:00	3.812		

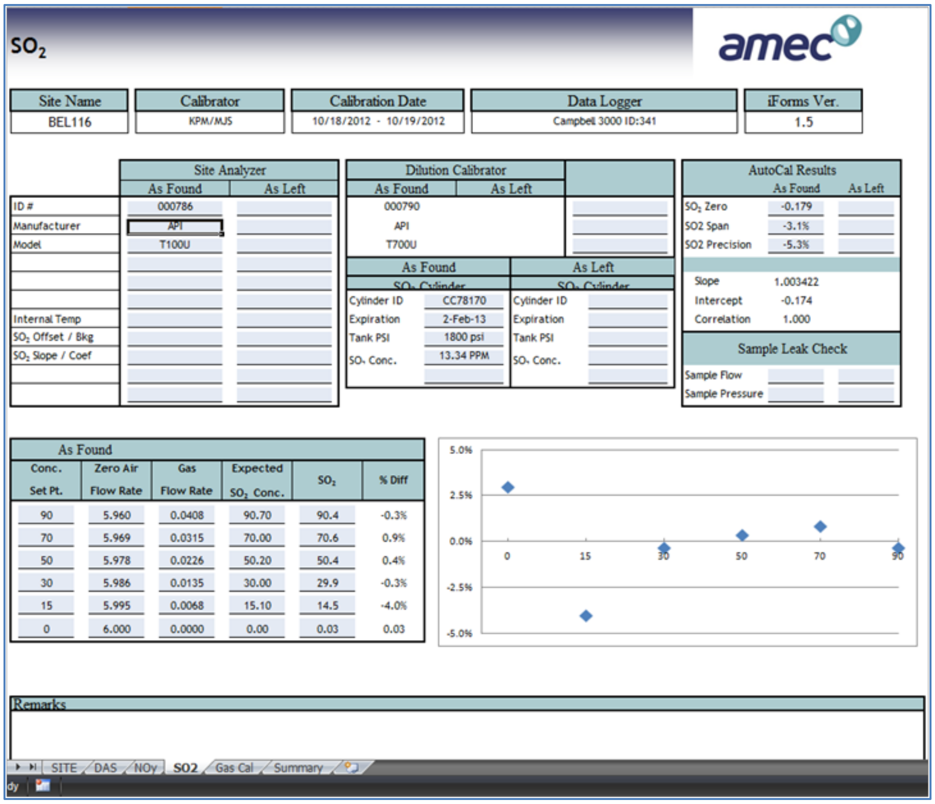
Table 5: BVL130 SO_2 Concentrations (ppb) – October 10, 2012 through October 20, 2012

Date_Time	SO_2	Date_Time	SO_2	Date_Time	SO_2	Date_Time	SO_2	Date_Time	SO_2
10/10/12 00:00	-0.261	05:00	-0.235	10:00	-0.152	15:00	3.715	20:00	0.001
01:00	-0.3	06:00	3.346	11:00	-0.1	16:00	0.793	21:00	-0.081
02:00	-0.268	07:00	-0.084	12:00	-0.101	17:00	0.671	22:00	-0.109
03:00	-0.206	08:00	-0.101	13:00	-0.028	18:00	0.464	23:00	-0.123
04:00	-0.162	09:00	-0.217	14:00	-1.567	19:00	0.419	**10/19/12 00:00**	-0.131
05:00	-0.111	10:00	-0.276	15:00	-1.068	20:00	4.012	01:00	-0.117
06:00	4.439	11:00	-0.275	16:00	-0.536	21:00	0.765	02:00	-0.152
07:00	0.768	12:00	-0.198	17:00	-0.346	22:00	0.15	03:00	-0.117
08:00	0.229	13:00	-0.208	18:00	-0.243	23:00	0.105	04:00	-0.114
09:00	0.156	14:00	-0.15	19:00	-0.166	**10/17/12 00:00**	0.029	05:00	-0.082
10:00	-0.079	15:00	-0.238	20:00	-0.084	01:00	-0.045	06:00	-0.072
11:00	-0.171	16:00	-0.283	21:00	0.013	02:00	-0.005	07:00	-0.105
12:00	-0.254	17:00	-0.219	22:00	-0.086	03:00	0.009	08:00	-0.169
13:00	-0.268	18:00	-0.224	23:00	-0.025	04:00	0.076	09:00	-0.157
14:00	0.266	19:00	-0.276	**10/15/12 00:00**	-0.043	05:00	0.233	10:00	-0.158
15:00	-0.237	20:00	-0.265	01:00	-0.177	06:00	0.722	11:00	-0.174
16:00	-0.153	21:00	-0.223	02:00	-0.208	07:00	0.375	12:00	-0.151
17:00	-0.192	22:00	-0.086	03:00	-0.189	08:00	0.375	13:00	-0.19
18:00	-0.208	23:00	0.39	04:00	0.18	09:00	0.472	14:00	-0.165
19:00	-0.239	**10/13/12 00:00**	0.761	05:00	0.384	10:00	0.422	15:00	-0.164
20:00	-0.301	01:00	0.087	06:00	0.526	11:00	0.403	16:00	0.068
21:00	-0.274	02:00	0.151	07:00	0.782	12:00	0.454	17:00	-0.137
22:00	-0.297	03:00	0.756	08:00	0.425	13:00	0.605	18:00	-0.154
23:00	-0.324	04:00	1.754	09:00	0.081	14:00	0.551	19:00	-0.161
10/11/12 00:00	-0.317	05:00	1.743	10:00	-0.011	15:00	0.371	20:00	-0.111
01:00	-0.32	06:00	2.024	11:00	-0.081	16:00	0.212	21:00	-0.161
02:00	-0.347	07:00	4.004	12:00	-0.107	17:00	0.16	22:00	-0.19
03:00	-0.369	08:00	5.075	13:00	-0.14	18:00	0.62	23:00	-0.139
04:00	-0.361	09:00	0.124	14:00	-0.133	19:00	0.083	**10/20/12 00:00**	-0.16
05:00	-0.347	10:00	-0.131	15:00	-0.135	20:00	-0.106	01:00	-0.154
06:00	-0.356	11:00	-0.166	16:00	-0.131	21:00	0.031	02:00	-0.163
07:00	-0.261	12:00	0.252	17:00	-0.16	22:00	-0.04	03:00	-0.122
08:00	-0.124	13:00	0.764	18:00	-0.105	23:00	0.266	04:00	-0.094
09:00	0.098	14:00	0.413	19:00	-0.102	**10/18/12 00:00**	0.035	05:00	-0.147
10:00	0.816	15:00	0.074	20:00	-0.061	01:00	0.018	06:00	3.433
11:00	0.808	16:00	0.213	21:00	0.134	02:00	-0.04	07:00	-0.148
12:00	0.31	17:00	0.256	22:00	0.326	03:00	-0.103	08:00	0.296
13:00	0.252	18:00	-0.105	23:00	-0.027	04:00		09:00	2.18
14:00	0.197	19:00	-0.12	**10/16/12 00:00**	-0.135	05:00		10:00	0.558
15:00	0.217	20:00	-0.151	01:00	-0.197	06:00		11:00	0.048
16:00	0.464	21:00	-0.127	02:00	-0.17	07:00	-0.549	12:00	-0.051
17:00	0.384	22:00	-0.041	03:00	-0.169	08:00	-0.598	13:00	-0.109
18:00	0.425	23:00	7.517	04:00	-0.197	09:00	-0.039	14:00	-0.157
19:00	0.232	**10/14/12 00:00**	6.114	05:00	-0.17	10:00	0.533	15:00	-0.165
20:00	0.025	01:00	2.942	06:00	5.643	11:00	0.179	16:00	0.093
21:00	-0.066	02:00	5.964	07:00	0.245	12:00	-0.019	17:00	-0.049
22:00	-0.058	03:00	0.39	08:00	1.629	13:00	-0.026	18:00	-0.183
23:00	-0.113	04:00	-0.041	09:00	2.826	14:00	-0.043	19:00	-0.061
10/12/12 00:00	0.079	05:00	-0.116	10:00	4.497	15:00	0.088	20:00	0.291
01:00	0.057	06:00	3.8	11:00	3.282	16:00	0.231	21:00	0.177
02:00	-0.136	07:00	-0.024	12:00	3.984	17:00	0.179	22:00	-0.112
03:00	-0.116	08:00	-0.026	13:00	4.745	18:00	0.015	23:00	-0.182
04:00	-0.201	09:00	-0.067	14:00	5.17	19:00	-0.106		

Figure 8: Time Series Plots of NCore Data from BVL130, IL

Notes: Zero data are given in ppb.
Precision, span, and NPN data are provided as percent differences.

Figure 9: Calibration Summary Form for SO_2



SO_2

Site Name	Calibrator	Calibration Date	Data Logger	iForms Ver.
BEL116	KPM/MJS	10/18/2012 - 10/19/2012	Campbell 3000 ID:341	1.5

	Site Analyzer		Dilution Calibrator	
	As Found	As Left	As Found	As Left
ID #	000786		000790	
Manufacturer	API		API	
Model	T100U		T700U	
Internal Temp				
SO_2 Offset / Bkg				
SO_2 Slope / Coef				

	As Found SO_2 Cylinder	As Left SO_2 Cylinder
Cylinder ID	CC78170	
Expiration	2-Feb-13	
Tank PSI	1800 psi	
SO_2 Conc.	13.34 PPM	

AutoCal Results	As Found	As Left
SO_2 Zero	-0.179	
SO2 Span	-3.1%	
SO2 Precision	-5.3%	
Slope	1.003422	
Intercept	-0.174	
Correlation	1.000	

Sample Leak Check		
Sample Flow		
Sample Pressure		

As Found

Conc. Set Pt.	Zero Air Flow Rate	Gas Flow Rate	Expected SO_2 Conc.	SO_2	% Diff
90	5.960	0.0408	90.70	90.4	-0.3%
70	5.969	0.0315	70.00	70.6	0.9%
50	5.978	0.0226	50.20	50.4	0.4%
30	5.986	0.0135	30.00	29.9	-0.3%
15	5.995	0.0068	15.10	14.5	-4.0%
0	6.000	0.0000	0.00	0.03	0.03

Remarks

SITE DAS NOy SO2 Gas Cal Summary

2.5 Data Collection

AMEC utilizes an automated Data Acquisition System (DAS) for collection of data at the monitoring sites, including BVL130. The DAS used at BVL130 is a Campbell Scientific CR3000 Micrologger data logger. Measured data are collected hourly from a centralized server and automatically uploaded into the AMEC database using Campbell's LoggerNet polling software. CASTNET Internet protocol (IP)-enabled sites (including BVL130) use a Sierra Wireless AirLink Raven X modem to access the Internet through cellular service that provides a public static IP address. Multiple Ethernet-enabled devices share the Internet connection and communicate locally. All sites capable of receiving cellular service are enabled for IP communication. The other sites are served by telephone modems. The data logger program, which was developed by AMEC, allows site operators and site calibrators access to CR3000 data. The program acquires data and also flags the data according to their status. The data logger employs three levels of security, which are password protected.

The CASTNET database has been designed to support the project goal of providing information for assessing the effectiveness of ongoing and future emission reductions mandated under the 1990 Clean Air Act Amendments. Two principal functions of CASTNET data management are the routine delivery of data to EPA and the analysis of data for presentation in project reports.

The CASTNET data are managed and analyzed using Microsoft (MS) SQL Server 7.0 and Oracle 11g, two relational database management systems. Defined tables are used to archive measurements and supporting data. The Oracle database is also used for data archival and delivery of data to EPA. The database contains archives of concentrations measured on exposed filters; continuous NCore, O_3, flow and meteorological data; and deposition model output of hourly, weekly, quarterly, and annual dry deposition fluxes over the period beginning in 1987.

NCore hourly concentration measurements will be delivered to AIRNow daily. Monthly data will be delivered to AQS every 90 days.

3.0 Quality Control Requirements

Trace gas sampling is performed at 10 m using a tilt-down aluminum tower manufactured by Aluma Tower, Inc. Ambient concentrations are measured using the analytical methods listed in Table 1. Zero, span, and precision (ZSP) checks of the NCore analyzers are performed automatically every other day based on the concentration levels listed in Table 4. API multigas calibration and zero air system, protocol gas cylinders and the CR3000 produce the calibration gases and control the process. CASTNET data analysts review data for the previous day for all EPA-sponsored CASTNET sites including NCore data. A data analyst will note questionable values and enter observations per site into the CASTNET Problem Tracking System. Precision and span checks are judged successful if the results are within ± 10% of the test values. Zeroes must be within 3% of full scale values (2% for CO). If the ZSP results exceed the criteria, data are invalidated back to the previous successful ZSP and forward to the next passing ZSP. Troubleshooting is performed to determine root cause and appropriate corrective action is implemented. Instrument calibration is performed only if troubleshooting reveals that it is necessary. The AMEC DAS and the API instruments allow the opportunity for the remote calibration of NCore instruments.

Field calibrations are critical to achieving and maintaining DQI criteria. Every six months, AMEC or subcontractor technicians visit each site to perform routine calibration and maintenance of all sensors and instruments. AMEC personnel may calibrate the NCore sensors independent of the routine calibration visit. The concentration levels listed in Table 4 are used for the multipoint calibrations, again using the API multigas calibration and zero air systems and the CR3000 data logger. The results of the individual sensor calibration data are summarized on the electronic Calibration Summary Form (Figure 9). The information on this form is then entered into the calibration summary database, which is maintained by the AMEC DMC. Any condition that might require attention during the next scheduled calibration visit is noted in the Remarks section on the form. Routine and supplemental maintenance are also recorded in the Remarks section of the calibration form. These are in turn automatically imported into the calibration summary database.

The requirements, acceptance criteria, and procedures for the instrument calibrations are listed in Attachment C to this QAP. The results of the ZSP checks and 6-month multipoint calibrations are used to estimate precision and bias and to gauge compliance with acceptance criteria. Attachment C also includes information on:

- Specified API shelter temperature -- hourly averages with a standard deviation of ± 2° C
- NPAP audits
- State audits
- Zero air checks
- Gas Dilution System checks
- Completeness criterion (CASTNET requires 90%).
- Siting requirements.

3.1 NPN Cylinder Replacement When the Converter is Unchanged

Proper measurement of NO_y requires an accounting for changing the NPN gas cylinder even when the converter itself has not been changed. Change in this case includes hardware and any temperature adjustment. The converter efficiency must be calculated accurately and tracked properly. The Excel spreadsheet in Figure 10 illustrates the calculation of the converter efficiency.

The formula for the efficiency "as found" (i.e., the converter efficiency prior to the cylinder exchange) divides the original limit in ppb by 0.95 to calculate an expected value for an 100% ideal efficiency, based on the converter's performance at a time prior to cylinder exchange. In this case the efficiency is calculated after installation and burn-in of the original cylinder. This ideal efficiency is used to divide the most recent cylinder concentrations to determine the current state of the converter. In this example it has degraded to 98.9% of its original efficiency.

The formula for the efficiency "as left" is divided into the "as left" concentrations, which were calculated by the current efficiency, to determine the conversion numbers for the "as left" cylinder, assuming an ideal 100% conversion. That value is then multiplied by 0.95 to determine the new 95% conversion floor for concentrations (ppb) in the "as left cylinder."

The percent differences in NTN levels should be noted after a tank change. If there is a step change of 2% or more contained within the 5-point average (Figure 10), a problem has likely occurred, which should trigger an investigation.

Figure 10: Calculation of Converter Efficiency

For NPN Cylinder Replacement When the Converter is Unchanged

Original Cylinder ID	**Concentration**	**Units**
	3.08	ppm
New Cylinder ID	**Concentration**	**Units**
	3.08	ppm

Original 95% Criteria Limit	**Original Cylinder's Converter Efficiency**	**New 95% Criteria Limit**
83 ppb	100.3%	88.1 ppb

Original Cylinder - Last 5 ZPS results

site_id	begindatetime	startdatetime	enddatetime	parameter	level	expected_value	value	value_d	value_f	expected_value_stdev	value_stdev	gas_flow	dilution_flow	tech	analyzer_id
PND165	05-Apr-14	05-Apr-14	05-Apr-14	NPN	level 1	89.3	88.4			0.046	0.02	0.116	3.894		112
PND165	09-Apr-14	09-Apr-14	09-Apr-14	NPN	level 1	89.3	88			0.023	0.017	0.116	3.893		112
PND165	13-Apr-14	13-Apr-14	13-Apr-14	NPN	level 1	89.3	87.7			0.027	0.021	0.116	3.893		112
PND165	17-Apr-14	17-Apr-14	17-Apr-14	NPN	level 1	89.4	87.8			0.045	0.025	0.116	3.894		112
PND165	21-Apr-14	21-Apr-14	21-Apr-14	NPN	level 1	89.3	86.4			0.015	0.011	0.116	3.894		112

New Cylinder - Last 5 ZPS results

site_id	begindatetime	startdatetime	enddatetime	parameter	level	expected_value	value	value_d	value_f	expected_value_stdev	value_stdev	gas_flow	dilution_flow	tech	analyzer_id
PND165	02-May-14	02-May-14	02-May-14	NPN	level 1	89.3	93			0.041	0.013	0.116	3.894		112
PND165	03-May-14	03-May-14	03-May-14	NPN	level 1	89.3	94.1			0.03	0.034	0.116	3.893		112
PND165	07-May-14	07-May-14	07-May-14	NPN	level 1	89.3	92.8			0.031	0.024	0.116	3.894		112
PND165	11-May-14	11-May-14	11-May-14	NPN	level 1	89.3	92.1			0.031	0.018	0.116	3.895		112
PND165	15-May-14	15-May-14	15-May-14	NPN	level 1	89.3	93			0.028	0.009	0.116	3.893		112

4.0 Assessment/Oversight

Section 5.0 of the CASTNET QAPP summarizes assessment/oversight procedures that apply to all CASTNET measurements and activities, including operation of the NCore measurement systems. Perhaps the most important assessment of NCore measurements is the review of ZSP checks every other day and NTN/converter efficiency estimates every four days (see Figure 8). If the ZSP results exceed the criteria listed in Table 6 and Attachment C, troubleshooting is performed to determine root cause and appropriate corrective action is implemented. Instrument calibration is performed only if the review reveals it is necessary. Six-month field calibrations are also critical to achieving and maintaining DQI criteria. Results from the ZSP checks and the 6-month calibrations are used to assess NCore data validity. The QC results are archived in the CASTNET database.

Table 6: Quality Control Checks for NCore Analyzers

Zero, Precision, and Span Checks Every Other Day			
Parameter	**Zero (ppb)**	**Precision (ppb)**	**Span (ppb)**
SO_2	± 1.5	25 ± 10%	90 ± 10%
NO/NO_y/NPN	± 1.5	15 ± 10%	90 ± 10%
CO	± 30.0	250 ± 10%	1800 ± 10%

Notes: The NPN checks are performed exclusively at span level at a frequency of every fourth day.
Span concentrations are 90% of full scale.
If the ZSP results exceed the criteria, data are invalidated back to the previous successful ZSP and forward to the next passing ZSP.

Multipoint Calibrations Every Six Months						
Parameter	**Calibration Concentration Levels (ppb)**					
SO_2	90	40	15	7	4	0.0
NO/NO_y/NPN	90	40	15	7	4	0.0
CO	1800	800	300	150	80	0.0

5.0 Data Validity and Usability

Section 4.0 of the CASTNET QAPP describes the data validation procedures implemented for all CASTNET measurements. These apply to NCore data as well. In general, continuous measurements undergo three levels of validation.

After daily polling of all stations, Level 1 validation procedures are initiated. Level 1 validation consists of a set of automated screening protocols that consist of three Visual Basic executables and two database triggers. The triggers initiate the transfer of data between tables, translation of data status flags, and data screening. The executables create the data template, generate reports on the completeness of the data and the results of data screening, and archive the data. The screened data are delivered via file transfer protocol (FTP) to EPA daily.

The purpose of Level 2 validation is to develop a complete database. The process involves a data analyst reviewing data at the end of a month and retrieving missing data using LoggerNet. Essentially, this step represents a double check of the daily review process. Level 2 validation is complete when the data for all time periods for all of the sampling sites have been accounted for, data have been recovered from the on-site data loggers and entered into the database, and sources of missing data are documented.

Level 3 validation involves a more detailed evaluation of the data. The SSRF, site narrative log sheets, ZSP data, calibration data, and audit results are reviewed for each site. In addition, data are screened using tools that identify potential problems such as values greater than the expected range and invalid combinations of status flags, values, and spikes. All review and editing activities are documented both electronically and on hard copy forms.

When all documentation is reviewed and the database is edited to the satisfaction of the Data Management, Analysis, Interpretation and Reporting Manager (DMAIRM) or designee, the QA Manager audits the database. Upon completion of the QA review, the database is verified as Level 3.

6.0 References

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Sonoma Technology, Inc. 2009. NCore Site Characterization, ISWS Climate Station – Champaign County, IL. Prepared for U.S. Environmental Protection Agency (EPA), Research Triangle Park, NC. Contract # EP-D-05-004. http://ncore.sonomatechdata.com/ScreenViewonly_Quality/ISWSClimateStation.pdf (accessed December 2012).

U.S. Environmental Protection Agency. 2013. QA Handbook for Air Pollution Measurement Systems, Volume II, Appendix D. https://www3.epa.gov/ttnamti1/files/ambient/pm25/qa/QA-Handbook-Vol-II.pdf (accessed July 2016).

ATTACHMENT A

Teledyne API Instrument Specifications

TELEDYNE
ADVANCED POLLUTION INSTRUMENTATION
A Teledyne Technologies Company

T SERIES

Model T100U Ultra-Sensitive UV Fluorescence SO_2 Analyzer

The Model T100U Ultra-Sensitive SO_2 analyzer has been developed specifically to address the challenges of low level monitoring as required, for example, in the US NCore network. It uses the proven UV fluorescence principle, and is designed to allow ultra-sensitive SO_2 measurements while still meeting the requirements for use as a US EPA compliance analyzer.

The analyzer uses both the light and dark phases of the pulsed UV light source to continuously detect and correct for electronic noise, giving exceptionally stable and sensitive performance. A separate UV detector allows the instrument to continuously correct for variations in lamp intensity. Exceptional stability is achieved with the use of an optical shutter to compensate for PMT drift, and a reference detector to correct for changes in UV lamp intensity. A hydrocarbon "kicker" and advanced optical design combine to prevent inaccuracies due to interferents.

All T Series instruments offer an advanced color display, capacitive touch screen, intuitive user interface, flexible I/O, and built-in data acquisition capability. All instrument set up, control and access to stored data and diagnostic information is available through the front panel, or via RS232, Ethernet, or USB com ports either locally or by remote connection using the included APIcom™ software.

- **Ranges: 0-5 ppb to 0-20,000 ppb, user selectable**
- **Dual ranges and auto ranging**
- **Large, vivid, and durable color graphics display with touch screen interface**
- **Ethernet, RS-232, and (optional) USB com ports**
- **Front panel USB connections for peripheral devices and firmware upgrades**
- **8 analog inputs (optional)**
- **Adaptive signal filtering optimizes response time**
- **Temperature & pressure compensation**
- **Comprehensive internal data logging with programmable averaging periods**
- **Ability to log virtually any operating parameter**
- **Two-year warranty**

Free Customer Support by telephone and email for the life of the instrument

Specifications

General

Ranges:	Min: 0-5 ppb Full scale Max: 0-20,000 ppb Full scale (selectable, dual ranges and auto ranging supported)
Measurement Units:	ppb, ppm, µg/m^3, mg/m^3 (selectable)
Zero Noise:	25 ppt (RMS)
Span Noise:	0.5% of reading (RMS) above 5 ppb
Lower Detectable Limit:	50 ppt
Zero Drift:	< 0.2 ppb/24 hours
Span Drift:	< 0.5% of full scale/24 hours
Lag Time:	30 seconds
Rise and Fall Time:	< 140 seconds to 95%
Linearity:	1% of full scale
Precision:	0.5% of reading
Sample Flow Rate:	650 cm^3/min ±10%

Electrical Specifications

Power Requirements:	100V-120V, 220V-240V, 50/60 Hz
Analog Output Ranges:	10V, 5V, 1V, 0.1V (selectable)
Recorder Offset:	±10%

Communication Specifications

Included I/O:	1 x Ethernet: 10/100Base-T 2 x RS232 (300-115,200 baud) 2 x USB device ports 8 x opto-isolated digital outputs 6 x opto-isolated digital inputs 4 x analog outputs
Optional I/O:	1 x USB com port 1 x RS485 8 x analog inputs (0-10V, 12-bit) 4 x digital alarm outputs Multidrop RS232 3 x 4-20mA current outputs

Physical Specifications

Operating Temperature Range:	5 - 40°C (with EPA Equivalency)
Dimensions (HxWxD):	7" x 17" x 23.5" (178 x 432 x 597 mm)
Weight:	45 lbs (20.5 kg)

Certifications

US EPA:	EQSA-0495-100

How to Order

Model T100U includes:

- ☐ Two year warranty
- ☐ Internal pump or external pump (optional)
- ☐ Dual ranges and auto ranging
- ☐ 47mm diameter particulate filter
- ☐ 8 isolated digital outputs
- ☐ 6 isolated digital inputs
- ☐ RS-232 ports
- ☐ Ethernet port
- ☐ USB ports for peripheral devices
- ☐ APIcom™ remote control software
- ☐ Select AC input voltage
  - ☐ 100V - 120V ☐ 50Hz
  - ☐ 220V - 240V ☐ 60Hz
- ☐ Select DC output voltage
  - ☐ 10V ☐ 5V
  - ☐ 1V ☐ 0.1V

Calibration Options:

- ☐ Ambient zero and ambient span
- ☐ Zero scrubber and internal span source (IZS)

Mounting Options:

- ☐ Rack mount brackets with chassis slides
- ☐ Rack mount brackets only
- ☐ Handle

I/O Options:

- ☐ 4-20mA outputs (up to three channels)
- ☐ USB com port
- ☐ 8 Analog Inputs
- ☐ Multi-drop RS232
- ☐ RS485

Other Options:

- ☐ NO optical filter (Recommended for high NO_x applications.)
- ☐ Concentration alarm relays
- ☐ Expendables kit

The values expressed above are in accordance with EPA definitions.
All error specifications are based on constant conditions.
Specifications subject to change without notice.
Printed documents are uncontrolled. SAL000041B (DCN 5880) T100U/10.13.10

TELEDYNE
ADVANCED POLLUTION INSTRUMENTATION
A Teledyne Technologies Company

9480 Carroll Park Drive ■ San Diego, CA 92121-5201
Ph. 858-657-9800 Fax 858-657-9816
Email api-sales@teledyne.com

For more information about the Teledyne API family of monitoring instrumentation products, call us or visit our website at

www.teledyne-api.com

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T SERIES

Model T200U Ultra-Sensitive Chemiluminescence $NO/NO_2/NO_x$ Analyzer

The Model T200U Ultra-Sensitive $NO/NO_2/NO_x$ analyzer has been developed specifically to address the challenges of low level monitoring as required, for example, in the US NCore network. It uses the proven chemiluminescence principle and is designed to allow ultra-sensitive measurements with a lower detectable limit of 50 ppt while still meeting the requirements for use as a US EPA compliance analyzer.

The Model T200U combines a gold plated reaction cell with an enhanced performance pump, special low noise photomultiplier tube, and unique signal conditioning to provide exceptional sensitivity. In addition, a pre-reactor separates the $NO-O_3$ reaction from background chemiluminescence to allow accurate auto-zero of the analyzer.

All T Series instruments offer an advanced color display, capacitive touch screen, intuitive user interface, flexible I/O, and built-in data acquisition capability. All instrument set up, control and access to stored data and diagnostic information is available through the front panel, or via RS232, Ethernet, or USB com ports either locally or by remote connection using the included APIcom™ software.

- **Ranges: 0-5 ppb to 0-2,000 ppb, user selectable**
- **Independent ranges and auto ranging**
- **Large, vivid, and durable color graphics display with touch screen interface**
- **Ethernet, RS-232, and (optional) USB com ports**
- **Front panel USB connections for peripheral devices and firmware upgrades**
- **8 analog inputs (optional)**
- **Adaptive signal filtering optimizes response time**
- **Temperature & pressure compensation**
- **50 ppt lower detectable limit**
- **Catalytic ozone scrubber**
- **Comprehensive internal data logging with programmable averaging periods**
- **Ability to log virtually any operating parameter**
- **Two-year warranty**

Free Customer Support by telephone and email for the life of the instrument

Specifications

General

Ranges:	Min: 0-5 ppb Full scale Max: 0-2,000 ppb Full scale (selectable, independent NO, NO_2, NO_x ranges and auto ranging supported)
Measurement Units:	ppb, µg/m³ (selectable)
Zero Noise:	< 25 ppt (RMS)
Span Noise:	< 0.5% of reading (RMS) above 5 ppb
Lower Detectable Limit:	50 ppt
Zero Drift:	< 0.1 ppb/24 hours
Span Drift:	< 0.5% of reading/24 hours
Lag Time:	20 seconds
Rise and Fall Time:	< 50 seconds to 95%
Linearity:	1% of full scale
Precision:	0.5% of reading above 5 ppb
Sample Flow Rate:	1000 cm³/min ±10%

Electrical Specifications

Power Requirements:	100V-120V, 220V-240V, 50/60 Hz
Analog Output Ranges:	10V, 5V, 1V, 0.1V (selectable)
Recorder Offset:	±10%

Communication Specifications

Included I/O:	1 x Ethernet: 10/100Base-T 2 x RS232 (300-115,200 baud) 2 x USB device ports 8 x opto-isolated digital outputs 6 x opto-isolated digital inputs 4 x analog outputs
Optional I/O:	1 x USB com port 1 x RS485 8 x analog inputs (0-10V, 12-bit) 4 x digital alarm outputs Multidrop RS232 3 x 4-20mA current outputs

Physical Specifications

Operating Temperature Range:	5 - 40°C
Dimensions (HxWxD):	7" x 17" x 23.5" (178 x 432 x 597 mm)
Weight:	Analyzer: 40 lbs (18 kg) External pump: 21 lbs (9.5 kg)

Certifications

US EPA:	RFNA-1194-099

How to Order

Model T200U includes:

- ☐ Two year warranty
- ☐ External pump
- ☐ Independent ranges and auto ranging
- ☐ 47mm diameter particulate filter
- ☐ 8 isolated digital outputs
- ☐ 6 isolated digital inputs
- ☐ RS-232 ports
- ☐ Ethernet port
- ☐ USB ports for peripheral devices
- ☐ APIcom™ remote control software
- ☐ Select AC input voltage
  - ☐ 100V - 120V ☐ 50Hz
  - ☐ 220V - 240V ☐ 60Hz
- ☐ Select DC output voltage
  - ☐ 10V ☐ 5V
  - ☐ 1V ☐ 0.1V

Calibration Options:

- ☐ Ambient zero and ambient span

Mounting Options:

- ☐ Rack mount brackets with chassis slides
- ☐ Rack mount brackets only
- ☐ Handle

I/O Options:

- ☐ 4-20mA outputs (up to three channels)
- ☐ USB com port
- ☐ 8 Analog Inputs
- ☐ Multi-drop RS232
- ☐ RS485

Other Options:

- ☐ Ammonia removal sample conditioner
- ☐ Expendables kit

The values expressed above are in accordance with EPA definitions.
All error specifications are based on constant conditions.
Specifications subject to change without notice.
Printed documents are uncontrolled. SAL000049B (DCN 5880) T200U/10.13.10

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A Teledyne Technologies Company

9480 Carroll Park Drive ■ San Diego, CA 92121-5201
Ph. 858-657-9800 Fax 858-657-9816
Email api-sales@teledyne.com

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T SERIES

Model T300U Ultra-Sensitive Gas Filter Correlation CO Analyzer

The Model T300U Ultra-Sensitive CO analyzer has been developed specifically to address the challenges of low level monitoring as required, for example, in the US NCore network. Using IR absorption with a Gas Filter Correlation Wheel, the T300U is designed to allow ultra-sensitive CO measurements while still meeting the requirements for use as a US EPA compliance analyzer.

The optical bench is enclosed in a temperature controlled oven, dramatically decreasing instrument noise and drift. The objective and field mirrors in the sample cell are gold plated to maximize signal to noise performance, while a temperature-controlled Nafion dryer on the inlet minimizes water interference caused by ambient humidity changes. Periodically, the T300U seamlessly corrects its baseline by routing the sample through a heated catalytic CO scrubber. This Auto Reference function corrects zero drift and reduces the effect of interferences.

All T Series instruments offer an advanced color display, capacitive touch screen, intuitive user interface, flexible I/O, and built-in data acquisition capability. All instrument set up, control and access to stored data and diagnostic information is available through the front panel, or via RS232, Ethernet, or USB com ports either locally or by remote connection using the included APIcom™ software.

- **Ranges: 0-100 ppb to 0-100 ppm, user selectable**
- **Dual ranges and auto ranging**
- **Large, vivid, and durable color graphics display with touch screen interface**
- **Ethernet, RS-232, and (optional) USB com ports**
- **Front panel USB connections for peripheral devices and firmware upgrades**
- **8 analog inputs (optional)**
- **Adaptive signal filtering optimizes response time**
- **Temperature & pressure compensation**
- **GFC wheel guaranteed for 5 years**
- **Comprehensive internal data logging with programmable averaging periods**
- **Ability to log virtually any operating parameter**
- **Two-year warranty**

Free Customer Support by telephone and email for the life of the instrument

Specifications

General

Ranges:	Min: 0-100 ppb Full scale Max: 0-100 ppm Full scale (selectable, dual ranges and auto ranging supported)
Measurement Units:	ppb, ppm, µg/m³, mg/m³ (selectable)
Zero Noise:	< 10 ppb (RMS)
Span Noise:	< 0.5% of reading (RMS) above 2.5 ppm
Lower Detectable Limit:	< 20 ppb
Zero Drift:	< 20 ppb/24 hours
Span Drift:	< 0.5% of reading/24 hours above 5 ppm
Lag Time:	10 seconds
Rise and Fall Time:	< 60 seconds to 95%
Linearity:	1% of full scale
Precision:	0.5% of reading
Sample Flow Rate:	1800 cm³/min ±20%

Electrical Specifications

Power Requirements:	100V-120V, 220V-240V, 50/60 Hz
Analog Output Ranges:	10V, 5V, 1V, 0.1V (selectable)
Recorder Offset:	±10%

Communication Specifications

Included I/O:	1 x Ethernet: 10/100Base-T 2 x RS232 (300-115,200 baud) 2 x USB device ports 8 x opto-isolated digital outputs 6 x opto-isolated digital inputs 4 x analog outputs
Optional I/O:	1 x USB com port 1 x RS485 8 x analog inputs (0-10V, 12-bit) 4 x digital alarm outputs Multidrop RS232 3 x 4-20mA current outputs

Physical Specifications

Operating Temperature Range:	5 - 40°C
Dimensions (HxWxD):	7" x 17" x 23.5" (178 x 432 x 597 mm)
Weight:	50 lbs (22.7 kg)

Certifications

US EPA:	RFCA-1093-093

How to Order

Model T300U includes:

- ☐ Two year warranty
- ☐ Internal pump
- ☐ Dual ranges and auto ranging
- ☐ 47mm diameter particulate filter
- ☐ 8 isolated digital outputs
- ☐ 6 isolated digital inputs
- ☐ RS-232 ports
- ☐ Ethernet port
- ☐ USB ports for peripheral devices
- ☐ APIcom™ remote control software
- ☐ Select AC input voltage
  - ☐ 100V - 120V ☐ 50Hz
  - ☐ 220V - 240V ☐ 60Hz
- ☐ Select DC output voltage
  - ☐ 10V ☐ 5V
  - ☐ 1V ☐ 0.1V

Calibration Options:

- ☐ Ambient zero and ambient span

Mounting Options:

- ☐ Rack mount brackets with chassis slides
- ☐ Rack mount brackets only
- ☐ Handle

I/O Options:

- ☐ 4-20mA outputs (up to three channels)
- ☐ USB com port
- ☐ 8 Analog Inputs
- ☐ Multi-drop RS232
- ☐ RS485

Other Options:

- ☐ Concentration alarm relays
- ☐ Expendables kit

The values expressed above are in accordance with EPA definitions.
All error specifications are based on constant conditions.
Specifications subject to change without notice.
Printed documents are uncontrolled. SAL000055C (DCN 5942) T300U/01.28.11

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ADVANCED POLLUTION INSTRUMENTATION
A Teledyne Technologies Company

9480 Carroll Park Drive ■ San Diego, CA 92121-5201
Ph. 858-657-9800 Fax 858-657-9816
Email api-sales@teledyne.com

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T SERIES

Model T700U Dynamic Dilution Calibrator

The Model T700U is a microprocessor based calibrator for precision gas analyzers. Using highly accurate mass flow controllers combined with compressed sources of standard gases, calibration standards are provided for multipoint span and zero checks using up to 4 gas sources.

In addition to the features of the Model T700, the Model T700U is designed for the demanding requirements of ultra-sensitive measurements. The ability to calibrate and verify linearity for NO_2 at levels below 5 ppb is difficult with standard calibrators. To overcome this limitation, the Model T700U ozone generator operates in two modes; a high range with similar performance to the Model T700 ozone generator, and a low range, or "fractional" mode, for producing accurate ozone levels down to 3 ppb. To ensure the highest accuracy of NO_2 output, the calibrator measures the ozone concentration prior to performing a GPT, and the range is selected automatically by the Model T700U based on ozone concentration and flow specified by the user.

All T Series instruments offer an advanced color display, capacitive touch screen, intuitive user interface, flexible I/O, and built-in data acquisition capability. All instrument set up, control and access to stored data and diagnostic information is available through the front panel, or via RS232, Ethernet, or USB com ports either locally or by remote connection using the included APIcom™ software.

- ***New*** **- Ultra-stable ozone output to 3 ppb**
- **Ultra-low gas phase titration (GPT) to 3 ppb NO_2**
- **Built-in photometer, ozone generator, and GPT chamber**
- **Large, vivid, and durable color graphics display with touch screen interface**
- **Ethernet, RS-232, and (optional) USB com ports**
- **Front panel USB connections for peripheral devices and firmware upgrades**
- **12 independent timers for sequences**
- **Nested sequences (up to 5 levels)**
- **Software linearization of mass flow controllers (MFC)**
- **4 calibration ports (configurable for single or multi-blend gases)**
- **3rd MFC for wide dynamic range (optional)**
- **Glass gas phase titration chamber (GPT)**
- **Inlets for external ozone reference sources**
- **Two-year warranty**

Free Customer Support by telephone and email for the life of the instrument

Specifications

Dilution System

Flow Measurement Accuracy:	± 1% of full scale
Repeatability of Flow Control:	± 0.2% full scale
Linearity of Flow Measurements:	± 0.5% full scale
Flow Range of Dilution Air:	0 to 10 SLPM
Flow Range of Cylinder Gases:	0 to 200 cc/min
Zero Air Requirements:	10 SLPM @ 30 psi
Optional:	20 SLPM @ 30 psi
Input Pressure:	20-40 psig required
Calibration Gas Input Ports:	4 (configurable)
Diluent Gas Input Ports:	1

NO_2 Generation (GPT modes)

Minimum Output:	20 ppb LPM
Minimum Concentration:	3 ppb
Precision:	± 2% (with GPTPS)

Ozone Generator Module

Maximum Output:	6 ppm LPM
Minimum Output:	20 ppb LPM
Minimum Ozone Concentration:	3 ppb
Response Time:	180 seconds to 98%
Optical Feedback:	Standard

UV Photometer Option

Range:	100 ppb to 10 ppm (selectable)
Precision:	1.0 ppb
Linearity:	1.0% of reading
Rise/Fall Time:	<20 seconds (photometer response)
Response Time:	180 seconds to 95% (system response)
Zero Drift:	< 1.0 ppb/24 hours

Electrical Specifications

Power Requirements:	85V-264V, 47Hz-63Hz
Analog Output Ranges (Test Channel):	10V, 5V, 1V, 0.1V (selectable)

Communication Specifications

Included I/O:	1 x Ethernet: 10/100Base-T 2 x RS232 (300-115,200 baud) 2 x USB device ports 8 x digital control outputs 12 x digital control inputs 8 x digital status outputs
Optional I/O:	1 x USB com port 1 x RS485 Multidrop RS232

Physical Specifications

Operating Temperature Range:	5 - 40°C
Dimensions (HxWxD):	7" x 17" x 24" (178 x 432 x 609 mm)
Weight:	31 lbs (14.06 kg) 39.2 lbs (17.78 kg) with photometer, GPT, and O_3 generator

The values expressed above are in accordance with EPA definitions.
All error specifications are based on constant conditions.
Specifications subject to change without notice.
Printed documents are uncontrolled. SAL000063C (DCN 6383) T700U/02.23.12

How to Order

Model T700U includes:

- ☐ Two year warranty
- ☐ O_3 generator with photometer feedback and GPT mixing chamber
- ☐ UV photometer module
- ☐ 4 calibration gas inlet ports
- ☐ 1 diluent gas inlet port
- ☐ 8 digital control outputs
- ☐ 12 digital control inputs
- ☐ 8 digital status outputs
- ☐ RS-232 ports
- ☐ Ethernet port
- ☐ USB ports for peripheral devices
- ☐ APIcom™ remote control software
- ☐ Select AC input voltage
  - ☐ 100V - 120V ☐ 50Hz
  - ☐ 220V - 240V ☐ 60Hz
- ☐ Select DC output voltage
  - ☐ 10V ☐ 5V
  - ☐ 1V ☐ 0.1V

Mounting Options:

- ☐ Rack mount brackets with chassis slides
- ☐ Rack mount brackets only
- ☐ Handle

I/O Options:

- ☐ USB com port
- ☐ Multi-drop RS232
- ☐ RS485
- ☐ 12V external valve driver
- ☐ 24V external valve driver

Other Options:

- ☐ 3rd source MFC (optional)
- ☐ Photometer certifications

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9480 Carroll Park Drive ■ San Diego, CA 92121-5201
Ph. 858-657-9800 Fax 858-657-9816
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TELEDYNE INSTRUMENTS
Advanced Pollution Instrumentation
A Teledyne Technologies Company

IMPROVED

MODEL **701H**

High Performance Zero Air System

- **Standard two year warranty**
- **Regenerative, heatless dryer for maintenance-free water removal independent of inlet dewpoint**
- **Long life scrubbers for SO_2, NO, NO_2, O_3, H_2S, CO and Hydrocarbons**
- **Dewpoint sensor/alarm**
- **Automatic water drain**
- **Automatic pump control based on flow demand**
- **Ideal zero air for “trace level” or “ultra-sensitive” measurement applications**
- **May be used to provide combustion air for FID**
- **Source of purge air for permeation tube ovens**
- **Zero air for Ozone Generators**

The Model 701H is an excellent source of high purity zero air for all your process and analytical instrument needs. It is the ideal zero air source for ambient background monitoring applications using highly sensitive analyzers such as the model 100EU, 200EU and 300EU trace gas analyzers. It also may be used as a source of purge air for permeation tube ovens or burner air for FID analyzers.

The regenerative, heatless dryer removes water and produces gas with a dewpoint of less than -40°C at a flowrate of up to 30 LPM and assists in the removal of other gases, greatly increasing the life of the chemical scrubbers.

The Model 701H includes a high flow rate oil and diaphragm free pump, scrubbers to remove SO2, NO, NO2, O3 and H2S, and high performance scrubbers to remove CO and Hydrocarbons. The 701H also incorporates a dewpoint sensor that warns if the dewpoint exceeds -16°C.

Inlet air is pulled into the pump and routed through a pre-cooler and water trap to remove moisture. The air then passes through the regenerative scrubber for final drying and then to the storage tank.

Tank pressure is monitored and maintained at a preset level by cycling the pump automatically as needed, thereby extending both the pump and scrubber life.

Outlet air then passes through a filter to assure a clean, dry, analytical zero air supply.

A microcontroller cycles the regenerative dryer and water trap valves preventing the pump from starting

FREE
Customer Support by telephone and email for the life of the instrument

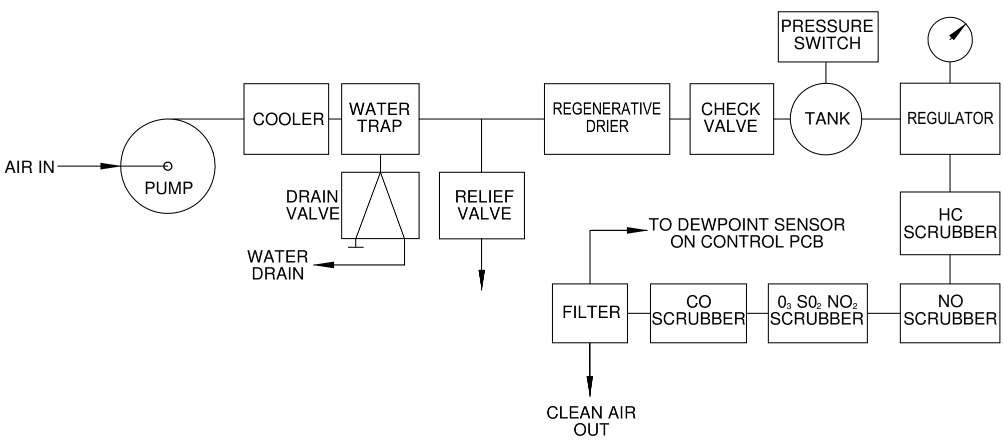
MODEL **701H**

High Performance Zero Air System

Specifications

Output:	30 SLPM @ 35 psig	Mounting:	Bench type mounting, rack mount optional
Dewpoint:	-40°C ≤ 30 LPM (typ.@60Hz)	Dimensions (HxWxD):	8.75" (22.2 cm) x 17" (43.2 cm) x 28" (71.12 cm)
Dryer:	Regenerative heatless dryer with lifetime of greater than 5 years	Weight:	69 lbs (31 kg)
Output concentrations (maximum):	SO_2 < 0.025 ppb NO < 0.025 ppb NO_2 < 0.025 ppb O_3 < 0.3 ppb CO < 10 ppb Hydrocarbons < 0.25 ppb	Power Requirements:	100V 50/60 Hz, 115V 60 Hz, 220V 50/60 Hz, 230V 50 Hz, 240V/50 Hz, 400 Watts
Pump:	Internal long-life, oil-less piston pump	Approvals:	CE

Schematic



How to Order

Model 701H Zero Air System includes:

- Standard two year warranty
- Internal pump
- Regenerative dryer
- High performance scrubbers for SO_2, NO, NO_2, O_3, H_2S, CO & Hydrocarbons
- 30 SLPM pump
- Dewpoint sensor

Specify input AC voltage & frequency:

☐ 100V / 50 Hz ☐ 100V / 60Hz
☐ 220V / 50Hz ☐ 115V / 60Hz
☐ 230V / 50Hz(CE) ☐ 220V / 60Hz
☐ 240V / 50Hz

Additional Options:

☐ Rack mount brackets (19") with chassis slides
☐ Rack mount brackets only
☐ 13 SLPM flow restriction

Specifications subject to change without notice. Printed documents are uncontrolled. SAL000031 B (DCN 5584) M701H 10.09

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A Teledyne Technologies Company

9480 Carroll Park Drive ■ San Diego, CA 92121-5201
Ph. 858-657-9800 Fax 858-657-9816
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ATTACHMENT B

Standard Operating Procedures for NCore Instruments

MODEL T100U SULFUR DIOXIDE (SO_2) ANALYZER STANDARD OPERATING PROCEDURE (SOP)

Effective Date: 7-7-16

Reviewed by: Kevin P. Mishoe
Field Operations Manager

Reviewed by: Marcus O. Stewart
QA Manager

Approved by: Holton K. Howell
Project Manager

TABLE OF CONTENTS

Annual Review			
Reviewed by:	Title:	Date:	Signature:

T100U SOP

1.0 PURPOSE

The purpose of this SOP is to provide consistent guidance for maintenance and handling of the Teledyne Advanced Pollution Instrumentation (API) Model T100U SO_2 Analyzer. This SOP is designed to be used by the Clean Air Status and Trends Network (CASTNET) field calibration laboratory and field personnel.

2.0 SCOPE

This SOP applies to all CASTNET sites operating trace level Teledyne API T100U SO_2 analyzers. The reader must also be familiar with five documents listed in Section 7.0 (References) of this SOP. The documents include the EPA (2005) Technical Assistance Document (TAD) for National Core (NCore) Monitoring, the API T100U Operation Manual (Manual), the Addendum to the Manual, EPA (2008) Quality Assurance (QA) Handbook for Air Pollution Measurement Systems, Volume II, Appendix D (QA Handbook) and Model T300/T300M Operation Manual. The various sections throughout this SOP cross-reference the five documents. Abbreviations are provided in Section 9.0.

CASTNET is mandated to use trace gas instruments that are Federal Reference or Equivalent Methods. The following settings and operational parameters must be used to maintain equivalency:

- Ambient temperature must be within 5 degrees Celsius (°C) to 40°C (Manual Section 2.2, p. 31)
- 1 micrometer (µm) Teflon [polytetrafluoroethylene (PTFE)] filter in internal assembly (TAD Section 3.3.4.3, p. 17 of 31)
- Sample flow of 650 ± 65 cubic centimeters per minute (ccm) (Manual Section 2.2, p. 31)
- Dynamic Span = OFF
- Dynamic Zero = OFF
- Pressure/Temp compensation = ON

3.0 SUMMARY

3.1 CASTNET Site Overview

Figure 1 shows the instrument communication system at a CASTNET site. The instruments include the NCore trace gas analyzers and the standard CASTNET sensors. Figure 2 provides SO_2 validation criteria based on the tables in QA Handbook, Volume II, Appendix D.

Figure 1 CASTNET Site Overview

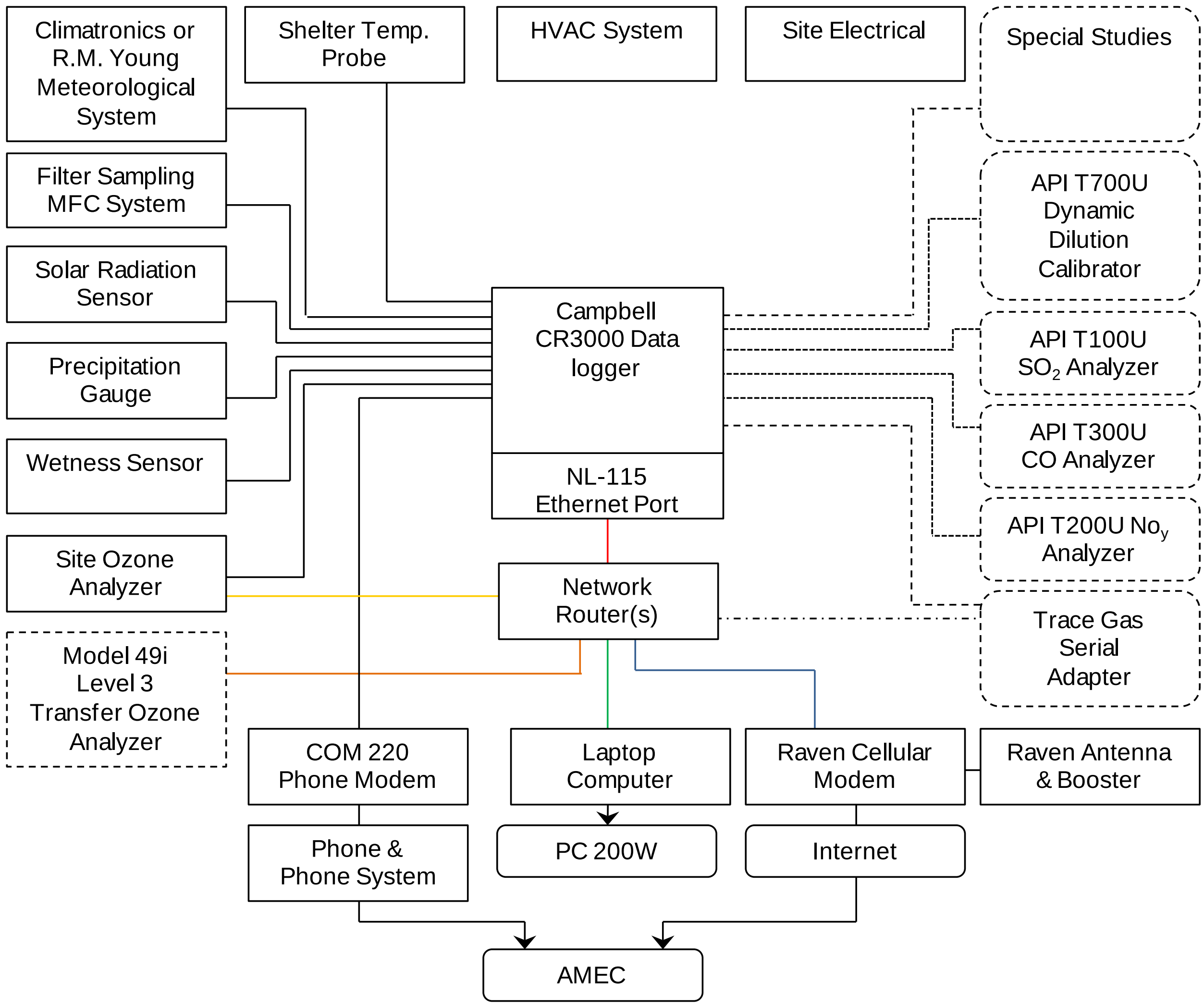


Figure 2 Critical and Operational Criteria for SO_2 Measurements

Requirement	Frequency	Acceptance Criteria	Information /Action
		CRITICAL CRITERIA – SO_2	
One Point QC Check Single analyzer	1/ 2 weeks	≤ +10% (percent difference)	0.01-0.10 parts per million (ppm) Relative to routine concentrations 40 CFR Part 58 Appendix (App) A, Section (Sec) 3.2
Zero/span check	1/ 2 weeks	Zero drift ≤ ± 1.5 ppb Span drift ≤ ± 10%	
		OPERATIONAL CRITERIA – SO_2	
Shelter Temperature			
Temperature range	**Daily** (hourly values)	5 to 40° C. (Hourly average)*	Generally the 5 to 40° C range will apply but the most restrictive operable range of the instruments in the shelter may also be used as guidance
Temperature Control	Daily (hourly values)	≤ ± 2° C SD over 24 hours	
Temperature Device Check	2/year	± 2° C of standard	
Precision (using 1-point QC checks)	Calculated annually and as appropriate for design value estimates	90% CL CV ≤ 10%	90% Confidence Limit of Coefficient of Variation (CV), 40 CFR Part 58 App A, Sec 4.1.2
Bias (using 1-point QC checks)	Calculated annually and as appropriate for design value estimates	95% CL ≤ + 10%	95% Confidence Limit of absolute bias estimate, 40 CFR Part 58 App A, Sec 4.1.3
Annual Performance Evaluation			
Single analyzer	Every site 1/year 25 % of sites quarterly	Percent difference of each audit level ≤ 15%	3 consecutive audit concentrations not including Zero, 40 CFR Part 58 App A, Sec 3.2.2
Primary QA Organization (PQAO)	annually	95% of audit percent differences fall within the one point QC check 95% probability intervals at primary QA organization level of aggregation	40 CFR Part 58 App A, Sec 4.1.4
Federal Audits (NPAP)	1/year at selected sites 20% of sites audited	Mean absolute difference ± 15%	40 CFR Part 58 App A, Sec 2.4
State audits	1/year	State requirements	
Verification/Calibration	Upon receipt/adjustment/repair/installation/moving 1/6 months if manual zero/span performed biweekly 1/year if continuous zero/span performed daily	All points within ± 2 % of full scale of best-fit straight line	Multi-point calibration (0 and 4 upscale points)
Zero Air		Concentrations below lower detection limit (LDL)	
Gaseous Standards		Traceable to National Institute of Standards and Technology (NIST) (e.g., EPA Protocol Gas)	Vendor must participate in EPA Protocol Gas Verification Program 40 CFR Part 58 App A, Sec 2.6.1
Requirement	**Frequency**	**Acceptance Criteria**	**Information /Action**
Zero Air/ Zero Air Check	1/year	Concentrations below LDL	
Gas Dilution Systems	1/3 months	Accuracy ± 2 %	
Detection			
Noise	NA	0.005 ppm	40 CFR Part 53.20
Lower detectable level	1/year	0.01 ppm	40 CFR Part 53.20
		SYSTEMATIC CRITERIA- SO_2	
Standard Reporting Units	All data	ppm [final units in EPA Air Quality System (AQS)]	
Completeness (seasonal)	Quarterly	75%	Annual standard
	24 hours	75%	24-hour standard
	3 hours	75%	3-hour standard
Sample Residence Times		< 20 seconds	
Sample Probe, Inlet, Sampling train		Borosilicate glass (e.g., Pyrex) or Teflon	40 CFR Part 58 App E
Siting		Un-obstructed probe inlet	40 CFR Part 58 App E

Notes: Guidance for the application of data flags is based on the validation template in Appendix D of volume II of the EPA Quality Assurance Handbook, Revision 1. No data adjustments will be made during routine procedures.
*As per EPA Automated Equivalent Method EQSA-0495-100.

4.0 MATERIALS AND SUPPLIES

The operation of the T100U analyzer requires that the gas lines to/from analyzer are Teflon fluorinated ethylene propylene (FEP) (TAD Section 3.3.4.3, p. 17 of 31) or Teflon PTFE. The system utilizes a dynamic dilution gas calibrator (T700U) with a compressed SO_2 gas cylinder with concentrations between 3 parts per million (ppm) and the lowest value allowing at least a ± 2% certification [currently 13 ppm (1%) for Scott-Marrin or 20 ppm (1%) for AirLiquide]. For cylinders stored at the field monitoring site, a minimum of 300 pounds per square inch (psi) + 25 psi/month for each additional pollutant analyzer is required if the same cylinder is used for QC checks. For example, a blended cylinder of nitric oxide (NO) and SO_2 supplying two analyzers should have at least 600 psi for the cylinder to be stored for 6 months.

The T100U system also requires

- assorted fittings and tools
- 47 millimeter (mm), 5 µm Teflon inlet filter (used at sample inlet to extend life of inlet tubing)
- 47 mm 1 µm Teflon inlet filter (Manual Section 2.2, p. 31)
- zero air supply capable of at least 6 standard liters per minute (slpm) with a concentration lower than the lower detection limit (LDL) of SO_2
- zero air with a dew point ≤ -15°C (Manual Section 9.1.1.1, p. 182).

5.0 SAFETY

The T100U is a heavy, high voltage instrument. With a weight of about 45 pounds with the pump, it is recommended that two people lift and carry the instrument. High voltages are present inside the instrument case. The power connection must have a functioning ground connection. The power must be off because exposure to the ultra violet (UV) light could cause eye damage. The use of safety glasses with UV blocking material is mandatory in this situation. SO_2 is a toxic gas. Consequently, the material safety data sheet (MSDS) for the SO_2 cylinder must be posted onsite. Exhaust from the SO_2 analyzer and the calibration system must be vented outside the shelter.

6.0 PROCEDURES

6.1 Set-Up/Installation

The first step is to unpack the analyzer from its shipping container and visually inspect the instrument for any damage. Then, identity loose fittings, screws, or items that may appear to be out of place. Loose fittings and screws should be tightened in place if practical and noted in the Remarks section of the specific iForm. The CASTNET Field Operations Manager (FOM) or his designee should be notified about any remaining loose pieces.

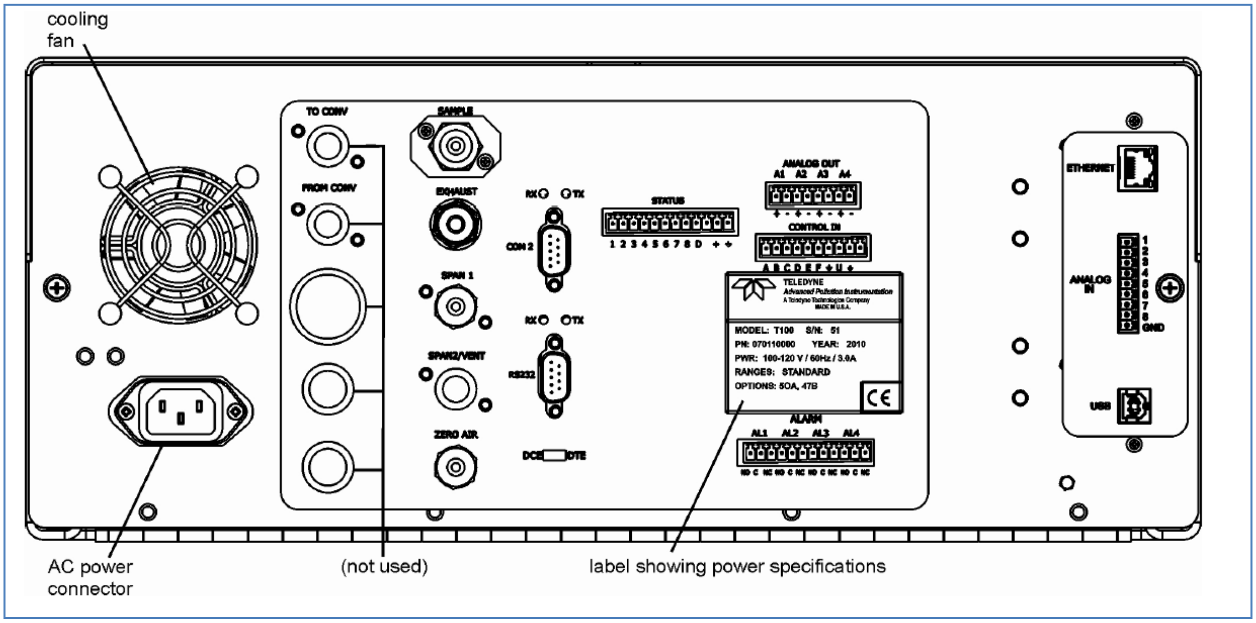
6.1.1 Remove Shipping Screws

Remove the two red shipping screws from the top of the sensor base before operating the instrument.

6.1.2 Ventilate Instrument

Before powering on the T100U, the instrument must be properly ventilated. Minimum ventilation clearances are as follows (Manual Section 3.3.1, p. 41):

Figure 2 T100U Rear Panel



- Back -- 4 inches
- Sides -- 1 inch
- Above and below – 1 inch

6.1.3 Use Teflon Tubing and Fittings

Only FEP or PTFE tubing and fittings should be used for the T100U (TAD Section 3.3.4.3, p. 17 of 31). No stainless steel or brass fittings are allowed.

6.1.4 Implement Rear Panel Connections

Complete the rear panel connections shown in Figure 3 (Manual Section 3.2, p. 39):

- Connect Ethernet cable to Ethernet port
- Connect sample tubing to sample port
- Connect exhaust tubing to exhaust port and direct tubing outside the shelter. Total exhaust tubing length should be less than 10 meters. (Manual Section 3.3.2.1, p. 59)
- Connect instrument power cord to alternating current (AC) power connector.

6.1.5 Verify Teflon Filter is Installed

Verify clean 47 mm 1 µm Teflon filter is installed inside internal filter assembly. If filter is visibly dirty or status is unknown, replace filter before operation. See SOP Section 6.4.4 for internal sample filter replacement procedures (TAD Section 3.3.4.3, p. 17 of 31).

6.1.6 Complete Start-up Procedures

Complete the following steps:

- Pump and exhaust fan should start immediately (Manual Section 3.4.1, p. 68)
- Allow 60 minutes of warm-up (Manual Section 3.4.1, p. 68)
- Check test functions using worksheet from Manual Appendix C
- Check the instrument for vibration. When pumps age, they sometimes will vibrate more than normally, causing cracks if the tubing is touching another surface. Verify the tubing inside the analyzer is not showing signs of wear (cracks or worn surfaces) or resting against another surface. Replace any damaged tubing. Rebuild or replace the pump if the vibration causes any other components in the analyzer to move.

6.2 Acceptance Testing

Complete the following checks, tests, and calculations as the bases for instrument acceptance.

- Perform vacuum leak check as described in SOP Section 6.7

- Verify precision (also performed quarterly). Analyzer should have a 95% probability limit for precision of ± 15% or less (TAD Section 3.3.1.1, p. 5 of 31) based on Equations 1 and 2 in the TAD section.

- Verify bias (also performed quarterly). Analyzer should have an upper bound for average bias of ± 15% (TAD Section 3.3.1.2, p. 6 of 31)

- Calculate method detection limit (MDL) according to the procedure in 40 CFR 136 Appendix B. The MDL should be 0.3 ppb or lower over an averaging time of no more than 5 minutes.

- Estimate LDL according to the procedure in 40 CFR 53.23 (c). The Addendum indicates the LDL is 50 ppt.

- Verify linear range by demonstrating all points recorded during the multipoint audit are within 1% of full scale of the best fit straight line.

- Estimate zero/ span drift (TAD Section 3.3.1.9, p. 10 of 31) over 12- and 24-hour periods of continuous unadjusted operation. Zero drift should be less than 0.2 ppb for 12 and 24 hours and less than 1% full scale for 24-hour span drift. The Addendum indicates span drift (24-hr) should be less than 0.5% of full scale.

- Verify NO rejection ratio is > 100:1 (TAD Section 3.3.1.10, p. 10 of 31)
  Generate zero air and record the 5-minute average concentration once the stability is below 0.025 ppb. Generate 100 ppb of NO and record the 5-minute average concentration once the stability is below 0.025 ppb. Introduction of 100 ppb of NO calibration gas to the SO_2 analyzer must produce a reading no greater than 1 ppb.

- Verify test functioning using Trace Gas Maintenance Forms 1 and 2 (Figures 6 and 7 in QAPP Appendix 11).

6.3 Configuration

Set clock to current date and time of day (standard time) (Manual Section 5.6, pp. 101–102)
The clock will automatically be set by the site data logger and only needs to be set manually if the instrument is to be operated independently.
Setup → Clk → Time → (Set to current local standard time) → ENTR*
Setup → Clk → Date → (Set to current date) → ENTR

*The T100U uses abbreviations to show parameters on its display screen. The abbreviations are defined in Section 9.0 of this SOP.

Analog range configuration is not applicable for digital communications

Range units = ppb (Manual Section 5.4.4, p. 96)
To check:
Sample → Test → RNGE
To change:
Setup → Rnge → Unit → PPB ENTR

Range concentration = 0100.0
To check:
Sample → Test → RNGE
To Change:
Setup → Rnge → Set → 00100.0 ENTR

Range mode = Single (SNGL) (Manual Section 5.4.3.1, p. 93)
To check:
Setup → Rnge → Mode → RANGE MODE
To Change:
Setup → Rnge → Mode → SNGL

Set Machine ID (Manual Section 5.1.1, p. 89)

To check:

Setup → More → Comm → ID

To change:

Setup → More → Comm → ID → (Set to desired value) → ENTR

Set Ethernet settings

Setup → More → Comm → INET

- DHCP = Off
- INST IP = 192.168.0.43
- GATEWAY IP = 192.168.0.1
- SUBNET MASK = 255.255.255.0
- TCP PORT 1 = 3000
- TCP PORT 2 = 502

Set alarm limits

The alarm limits will be set according to the list of acceptable values in Figure 6 and 7 of QAPP Appendix 11.

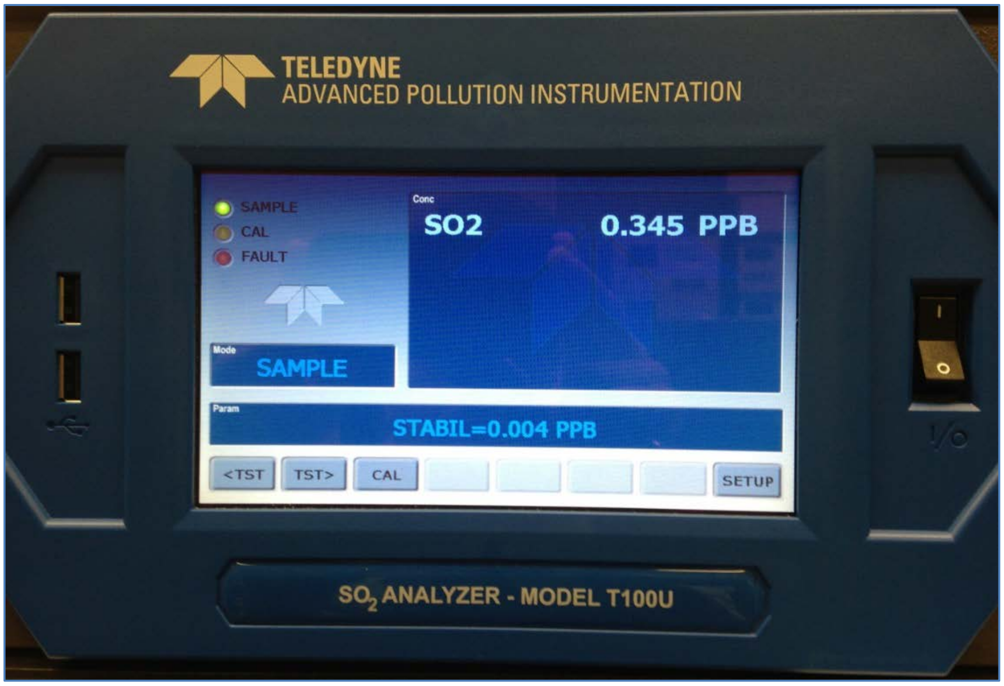
The API T100U SO_2 analyzer uses the temperature and pressure readings at the time of calibration as a reference for compensation. Therefore, there is no need to confirm standard temperature and pressure compensation is enabled.

6.4 Operation

6.4.1 Instrument Display Screen

Figure 4 displays the normal operating screen.

Figure 4 Instrument Display Screen



Descriptions of the various display components are listed in Table 1 (Manual Table 3–2, p. 37).

Table 1 Analyzer Display Functions

Field	Description/Function			
Status	LEDs indicating the states of Sample, Calibration and Fault, as follows:			
	Name	Color	State	Definition
	SAMPLE	Green	Off	Unit is not operating in sample mode, DAS is disabled.
			On	Sample Mode active; Front Panel Display being updated; DAS data being stored.
			Blinking	Unit is operating in sample mode, front panel display being updated, DAS hold-off mode is ON, DAS disabled
	CAL	Yellow	Off	Auto Cal disabled
			On	Auto Cal enabled
			Blinking	Unit is in calibration mode
	FAULT	Red	Off	No warnings exist
			Blinking	Warnings exist
Conc	Displays the actual concentration of the sample gas currently being measured by the analyzer in the currently selected units of measure			
Mode	Displays the name of the analyzer's current operating mode			
Param	Displays a variety of informational messages such as warning messages, operational data, test function values and response messages during interactive tasks.			
Control Buttons	Displays dynamic, context sensitive labels on each button, which is blank when inactive until applicable.			

Recommended method performance criteria are discussed in TAD Sec 3.3.1, pp. 4–12.

6.4.2 Instrument Components

Figure 5 is an image of internal layout and major instrument components (Addendum p. 12) of the T100U.

Figure 5 Instrument Components

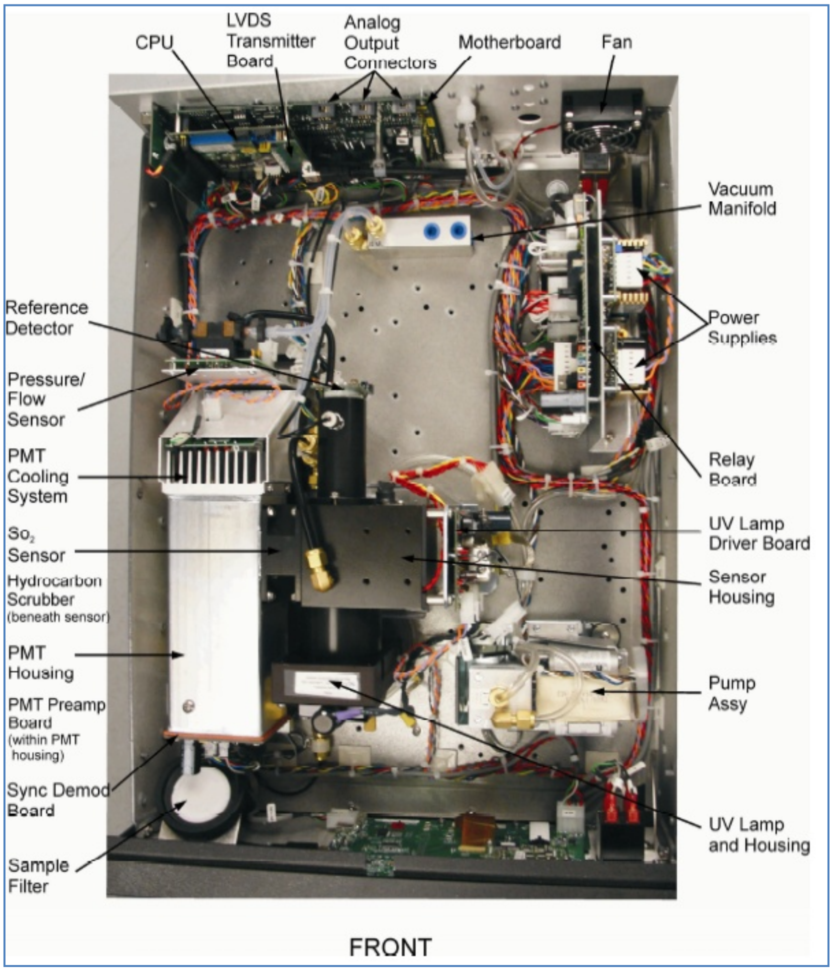
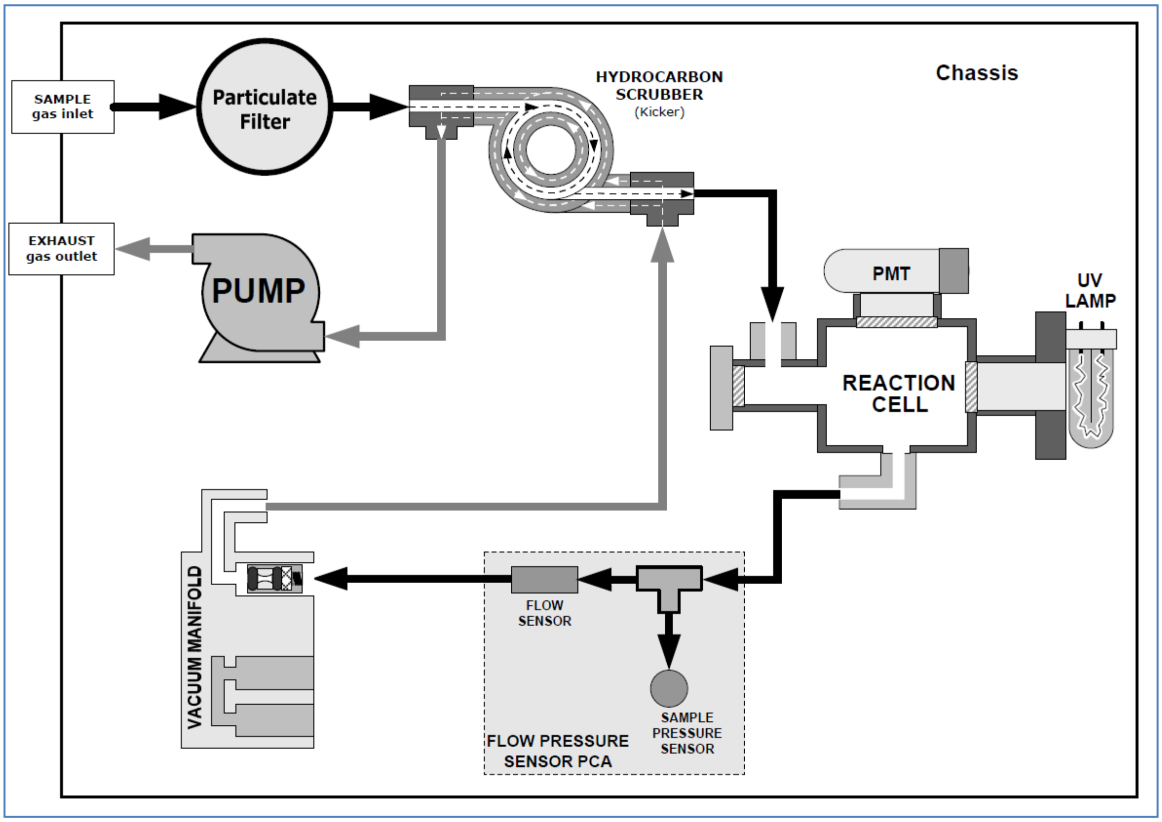


Figure 6 shows the pneumatic layout of the analyzer (Manual Section 3.3.2.2, Figure 3–18, p. 61).

Figure 6 Pneumatic Layout



6.4.3 Weekly Site Operator Activities

Weekly site operator activities are provided in Figure 7 (instrument suites may vary per site). They include:

- Leak checks
- Checking sample lines (moisture, dirt, and obstructions)
- Site logbook entries
- Changing particulate filters
- Review of zero/precision/span (zps) results

Figure 7 Site Operator Trace Gas Checklist (Page 1 of 3)

Site Operator Trace Gas Checklist

- Record date, data logger time, site technicians present, and purpose of site visit in the site log book.
- Confirm that the analyzers are on. If not, contact AMEC.
- Are there any error messages on the analyzers? If so, record the messages on the Trace Gas Maintenance Forms and in site log book. Clear the messages and monitor the analyzer status. If an error message returns, contact AMEC immediately. If not, notify AMEC during call-in.
- Is the Gas Calibrator in Standby mode? If not, do not perform any maintenance or checks on the analyzers or equipment until it is in Standby mode.
- Complete Trace Gas Maintenance Forms 1 and 2. See Form 2 for analyzer filter change detail and schedule and for leak check procedure.
- Record any disturbance to the analyzers' sampling systems and the time of the disturbances in the site log book.
- If analyzer sampling system leak checks were performed, are leak checks within criteria? If not, contact AMEC for technical support.
- E-mail Trace Gas Maintenance Forms 1 and 2 to AMEC.
- Contact an AMEC Field Technician to report site visit findings and activities.
- Finish site log book documentation including site exit time.

Page 1 of 3

Figure 7 Site Operator Trace Gas Checklist (Page 2 of 3)

Site Operator Trace Gas Checklist

Note: Specific dates for changing particulate filters is found on the Trace Gas Maintenance Forms

Changing the external sample particulate filter every other week

- 'Down' all parameters on the affected tower and record the data logger time in the site logbook
- Lower the tower containing the external sample particulate filter
- Either remove or cap the CASTNET filter pack
- Unscrew the orange retaining ring. The green filter wrenches may be required
- Install new 5 µm PTFE 47 mm diameter filter and discard the used filter
- Reinstall the retaining ring and tighten 1/8 turn past hand tight using green filter wrenches

Changing the internal sample particulate filter once a month

- 'Down' the SO_2 channel and record the data logger time in the site logbook
- Turn off the analyzer to prevent particles from being drawn into the sample line
- Open the hinged front panel and unscrew the knurled retaining ring on the filter assembly
- Replace the filter element with a 1 µm PTFE 47 mm diameter filter
- Reinstall the PTFE O-ring with the notches facing up, otherwise sample flow will be restricted
- Replace the glass window and hand-tighten the retaining ring
- Restart the analyzer
- Repeat this procedure for the NO and NO_y filters inside the bypass box and for the CO filter on the back of the CO analyzer. Down the appropriate analyzer channel.

Page 2 of 3

Figure 7 Site Operator Trace Gas Checklist (Page 3 of 3)

Site Operator Trace Gas Checklist

Sampling system leak checks to be performed immediately after particulate filter change

Note: Specific criteria for leak checks are found on the Trace Gas Maintenance Forms

$NO\text{-}NO_y$

- With the analyzer's channel still down, cap the $NO\text{-}NO_y$ sample inlet
- After 3 minutes, record the highest displayed pressure and flow over 30 second period in their appropriate boxes on the Trace Gas Maintenance Form 1
- Before the tower is raised make sure the cap is removed from the inlet
- Once the sampling system is returned to normal operation, 'Up' the channel and record the data logger time in the site logbook

SO_2

- With the analyzer's channel still down, remove the sample tubing from the back of the analyzer and cap the sample inlet port
- Once stable, record the displayed pressure and flow in their appropriate boxes on the Trace Gas Maintenance Form 1
- Remove the cap and reconnect the sample tubing to the back of the analyzer
- Leave the channel 'Down'

CO

- With the analyzer's channel still down, cap the CO/SO_2 sample inlet
- Once stable, record the displayed pressure and flow in their appropriate boxes on the Trace Gas Maintenance Form 1
- Before the tower is raised make sure the cap is removed from the inlet
- Once the sampling system is returned to normal operation, 'Up' the CO and SO_2 channel and record the data logger time in the site logbook

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6.4.4 Changing Particulate Filters

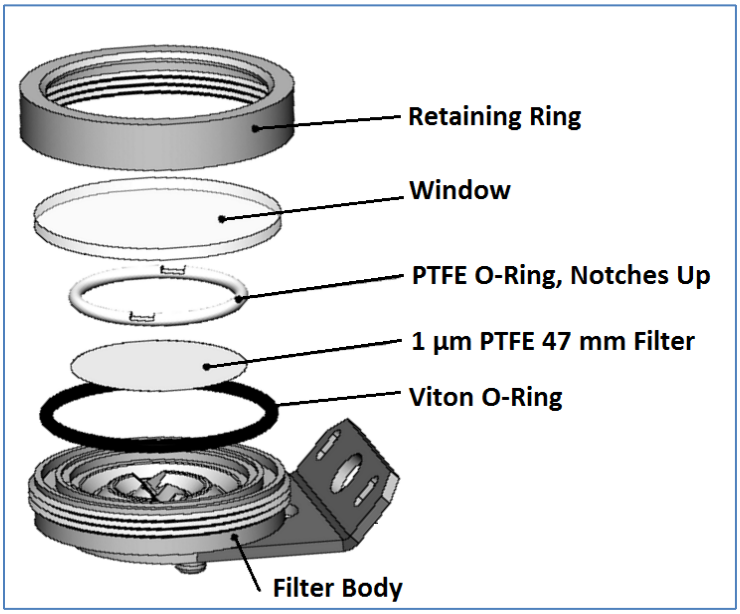
Change the external sample particulate filter every two weeks by completing the following steps:

- Using the data logger, ‘Down’ all parameters on the affected tower
- Lower the tower containing the external sample particulate filter
- Either remove or cap the CASTNET filter pack
- Unscrew the orange retaining ring. The green filter wrenches may be required.
- Install new 5 µm PTFE 47 mm diameter filter and discard the used filter
- Reinstall the retaining ring and tighten 1/8 turn using green filter wrenches
- Perform a sample train leak check as described in Section 6.7 of this SOP

Change the internal sample particulate filter (Figure 8) monthly by completing the following steps (Manual Section 11.3.1, pp. 224–225)

- ‘Down’ the SO_2 channel
- Turn off the analyzer to prevent particulates from being drawn into the sample line
- Open the hinged front panel and unscrew the knurled retaining ring on the filter assembly
- Replace the filter element with a 1 µm PTFE 47 mm diameter filter
- Reinstall the PTFE O-ring with the notches facing up, otherwise sample flow will be restricted
- Replace the glass window and hand-tighten the retaining ring
- Restart the analyzer
- Perform a vacuum leak check

Figure 8 Internal Sample Particulate Filter



6.5 T100U System Calibration

Audit system quarterly or as required for other reasons. Calibrate the zero and span if the relative percent difference (RPD) for any point is > 5%. All points must be < 1% of best fit line or else recalibration or other maintenance and troubleshooting are required. Estimate precision based on the procedures in Section 6.2.

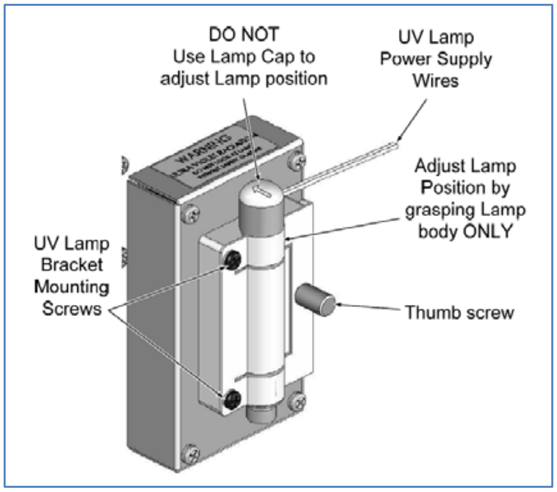
6.5.1 Calibrate subsystems

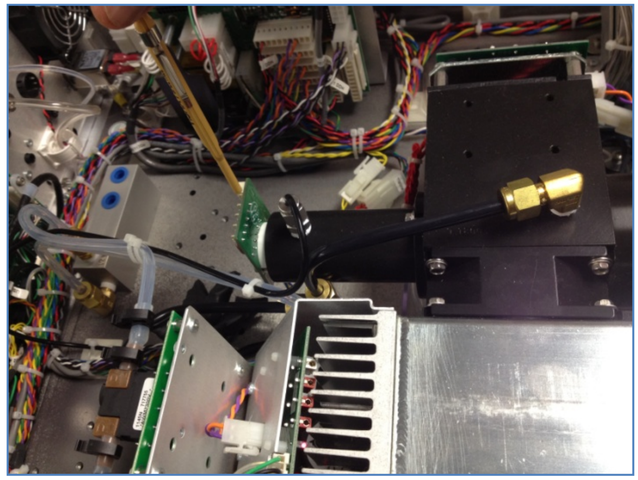
Lamp Adjustment and Calibration (Manual Section 5.9.6, p. 126)

Over a period of months, the UV energy will show a downward trend, usually 30% to 50% in the first 90 days, and then at a slower rate, until the end of the useful life of the lamp. Periodically running the UV lamp (Figure 9) adjustment and calibration routine will compensate for this until the lamp output becomes too low to function at all, approximately 2 to 3 years. The lamp adjustment should be performed according to the following eight steps whenever the UV LAMP reading falls below 3000 millivolts (mV) or is above 4800 mV. Between 3000 mV and 3800 mV, or between 4200 mV and 4800 mV, adjust only the detector adjustment potentiometer (begin at step 6 below).

1. Slightly loosen the brass thumbscrew located on the shutter housing so that the lamp can be moved.
2. Monitor the UV LAMP reading while adjusting the lamp position
3. Sample → Test → UV LAMP
4. Lower the UV reference detector adjustment potentiometer by turning clockwise until near the bottom
5. Adjust the UV lamp position by rotating the lamp body and moving it vertically until the UV LAMP reading is approximately 3800 mV. DO NOT USE the lamp cap to adjust the position as this can damage the power supply wires.
6. Adjust the UV reference detector adjustment potentiometer to raise the UV LAMP reading to 4000 mV by turning counter-clockwise
7. Finger-tighten the brass thumbscrew. DO NOT over tighten as this can break the UV lamp
8. Perform a UV lamp calibration

Figure 9 UV Lamp





Calibrating the UV lamp sets the peak output sampled by the reference detector and is stored in the LAMP_CAL parameter as the mV output. The UV lamp measurements recorded during sampling are divided by the LAMP_CAL factor to create a LAMP_RATIO that is used to correct the concentration calculation for variations in the UV lamp output. The lamp calibration should be performed before any instrument calibration activity.

Setup → More → Diag → 818 password; Entr → Lamp Calibration → ENTR

Pressure calibration (Manual Section 5.9.7, p. 127)
The sample pressure sensor is mounted below the flow sensor and is located pneumatically at the exit of the sample chamber. The measurement is used to compensate the raw PMT reading when temperature and pressure compensation (TPC) is enabled. First audit the sensor using either the lab or field procedure and calibrate the sensor if absolute difference is greater than 0.2 inches mercury absolute (inHg-A) for lab procedure or 0.5 inHg-A for field procedure.

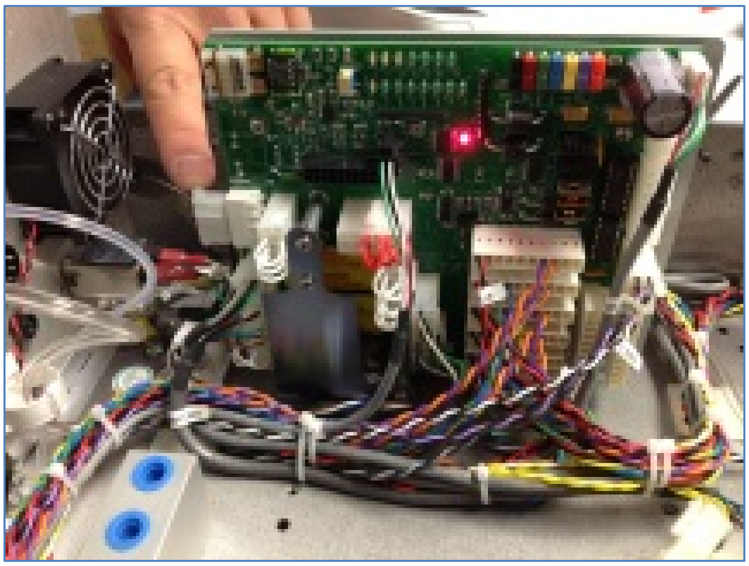
Pressure Sensor Audit - Lab Procedure

- Disconnect the clear, outer tubing directly from pressure sensor by loosening the back tubing clamp. The black tubing from the reaction chamber is also clamped inside the clear adapter tubing and is more difficult to reconnect.
- Connect pressure transfer standard directly to pressure sensor
- Record ambient pressure readings from transfer and analyzer
- Sample → Test → PRES
- Ensure the transfer pump is set to vacuum using the + - knob

- Close the vent of the pressure transfer using the • ◦ knob
- Press PUMP button on transfer to lower pressure to approximately 5 inHg-A and record readings.
- Slowly open the pressure transfer vent to adjust the pressure to approximately 15 inHg-A and record readings

Pressure Sensor Audit - Field Procedure

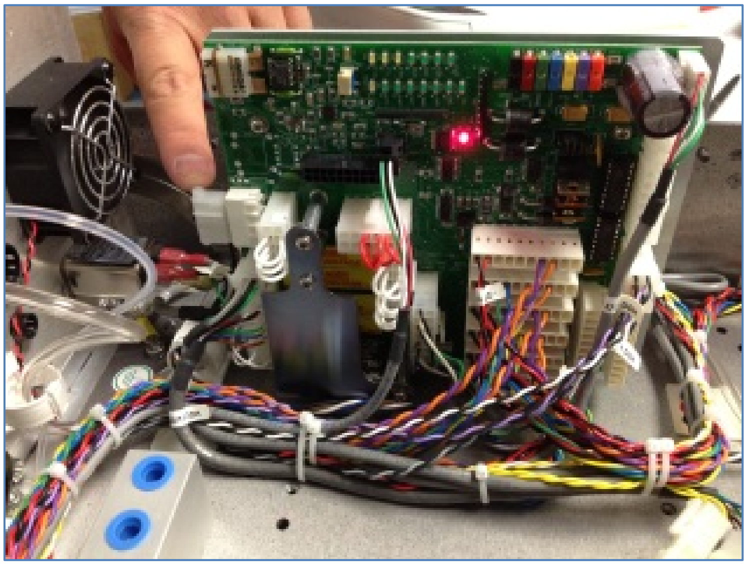
- Turn off instrument sample pump by disconnecting the pump power connector from the power supply board



- Record ambient pressure readings from transfer and analyzer
- Sample → Test → PRES
- Calibrate pressure sensor if absolute difference is greater than 0.5 inHg-A.

Adjustment of Pressure Sensor

- Turn off instrument sample pump by disconnecting the pump power connector from the power supply board

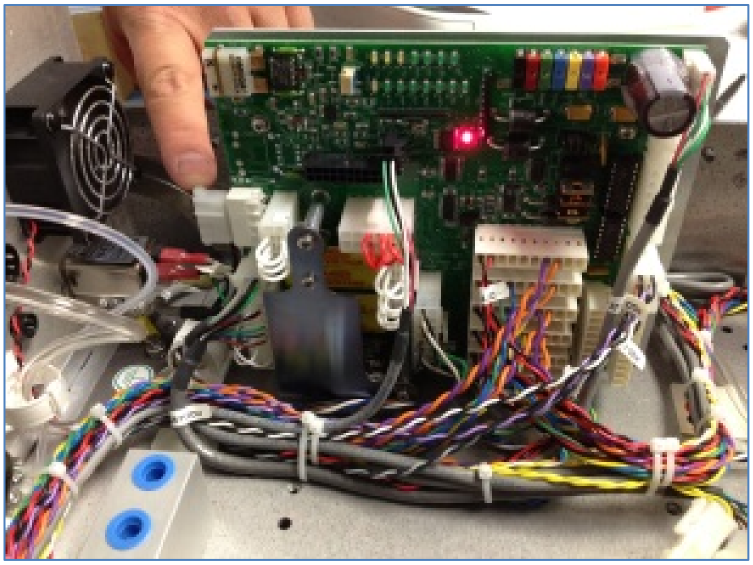


- Adjust pressure sensor measurement to transfer standard value at ambient pressure
  Setup → More → Diag → 818 password; Entr → Next…Pressure Calibration; Entr → CAL

ENTR must be pressed to save calibration changes. Pressing EXIT will leave the calibration unchanged and return to the previous menu.

Flow calibration (Manual Section 5.9.8, p. 126)
The flow sensor is mounted above the pressure sensor and is located pneumatically at the exit of the sample chamber. Calibrating the flow sensor reading does not change the hardware measurement, only the software calculated values.
To audit flow sensor:

- Connect flow transfer standard to sample inlet at the rear of the analyzer
- Record flow transfer reading and analyzer reading at nominal flow
- Sample → Test… SAMP FL
- Turn off instrument sample pump by disconnecting the pump power connector from the power supply board



- Record flow transfer reading and analyzer reading at zero flow

To Calibrate Flow Sensor

- Adjust flow sensor measurement to transfer standard value at nominal flow
  Setup → More → Diag → 818 password; Entr → Next…Flow Calibration; Entr → CAL

ENTR must be pressed to save calibration changes. Pressing EXIT will leave the calibration unchanged and return to the previous menu.

Photomultiplier Tube (PMT) Calibration (High Voltage Power Supply Adjustment)
The High Voltage Power Supply (HVPS) controls the gain of the PMT. Higher voltages provide a more sensitive signal, but also more noise (dark noise). In the T100U, the HVPS adjustment is controlled through software and there is no preamplification gain adjustment. Because the concentration measurement is used to adjust the HVPS and the HVPS affects the concentration measurement, the adjustment is iterative and usually must be performed at least twice.

- Manually reset the Slope and Offset values to 1.000 and 0.00 respectively
  - Setup → More → Vars → Next…SO2_SLOPE1 → Edit → Set to 1.000 ENTR
  - Setup → More → Vars → Next…SO2_OFFSET1 → Edit → Set to 0.000 ENTR

  ENTR must be pressed for both parameters even if they are already set to 1.0 and 0.0. Doing so is the only way to reset the Slope and Offset parameters.
- Perform a lamp calibration
- Generate SO_2 at 80% of full scale
- Once the concentration is stable (approximately 30 minutes or until the stability is less than 0.1 ppb, adjust the PMT target concentration to the 80% full scale value and press ENTR.
- Setup → More → Diag → 818 password; Entr → PMT Calibration; ENTR

- Wait two or three minutes until the ‘PMT Calibration Successful’ message is displayed
- Once the stability is less than 0.1 ppb, verify the NORM PMT value is approximately twice the concentration of span gas.
  Sample → Test → STABIL
  Sample → Test → NORM PMT
- Repeat the PMT Calibration to correct any over/under shoot of HVPS adjustment until the measurement remains within 2% of the target concentration with the stability less than 0.1 ppb
- Perform a zero and span calibration

Optic Test (Manual Section 5.9.4, p. 124)
The optic test turns on an LED on the PMT cooling block to verify the response of the PMT without using span gas. It is intended to be a coarse test of the photo-electric subsystem, including the PMT and current to voltage converter on the pre-amplifier board.

- Generate zero air
- Setup → More → Diag → 818 password; Entr → Optic Test ENTR
- Verify PMT signal is 2000 mV ± 200 mV (Manual specification is 2000 mV ± 1000 mV, p.124).

Electrical Test (Manual Section 5.9.4, p. 125)
The electrical test creates a simulated PMT output signal to the pre-amplifier board. The signal is generated on the pre-amplifier board itself and tests the filtering and amplification of that assembly and the analog-to-digital (A/D) conversion on the motherboard. It does not test the PMT itself and does not need to be run on zero air.

- Setup → More → Diag → 818 password; Entr → Optic Test ENTR
- Verify PMT signal is 2000 mV ± 200 mV (Manual specification is 2000 mV ± 1000 mV, p. 125)

Perform the LAMP CAL routine before any concentration calibration in order to adjust for lamp age.

6.5.2 Multipoint Audit and Calibration

Perform multipoint audit according to the following steps:

- Generate zero air and send to the sample train inlet
- Allow the concentration to stabilize until the stability reading is less than 0.5 ppb
- Record 5 minute concentration average and 5 minute expected concentration average
- Record the stability and expected value stability from the site laptop display

Repeat for each of the 5 concentration levels below

Audit Level	Concentration, ppb
Level 1	90
Level 2	40
Level 3	15
Level 4	7.5
Level 5	4

Calibrate zero (Manual Section 10.0, pp.207–216, also Manual Section 3.4.4, p.76)
Calibrate Zero

- Allow the instrument to sample zero air until a stable reading is obtained. Stability test parameter should be less than 0.5 ppb
- Cal→ Zero → ENTR
- ENTR must be pressed to save calibration changes. Pressing EXIT will leave the calibration unchanged and return to the previous menu
- If the ‘Zero’ option does not appear, the resulting calibration will be too extreme and there is most likely another problem.
- Verify the span concentration and adjustment as necessary
- Perform multipoint audit after final zero and span adjustment

Calibrate span (Manual Section 10.0, pp.207–216, also Manual Section 3.4.4, p.76)

- Allow the instrument to sample span gas until a stable reading is obtained. Stability test parameter should be less than 0.5 ppb
- Set SO_2 Span Gas Concentration. The concentration should be the expected concentration entered from the site laptop display. This may vary from the concentration set by the dynamic dilution system since the resolution of the entered tank concentrations in the calibration system is not always adequate
    - Sample → Cal → Conc → 0090.0 ENTR
- Calibrate Span
    - Cal → Span → ENTR
- ENTR must be pressed to save calibration changes. Pressing EXIT will leave the calibration unchanged and return to the previous menu
- If the ‘Span’ option does not appear, the resulting calibration will be too extreme and there is most likely another problem.
- Verify the zero concentration and adjustment as necessary
- Perform multipoint audit after final zero and span adjustment

6.6 Maintenance, Repair and Troubleshooting

Complete the following checks, tests, and calculations in order to maintain the T100U system.

Table 2 lists potential warning messages and their description (Manual Table 3–13, p. 69).

Table 2 Warning Messages

Message	Meaning
ANALOG CAL WARNING	The instrument's A/D circuitry or one of its analog outputs is not calibrated.
BOX TEMP WARNING	The temperature inside the T100 chassis is outside the specified limits.
CANNOT DYN SPAN[2]	Remote span calibration failed while the dynamic span feature was set to turned on.
CANNOT DYN ZERO[3]	Remote zero calibration failed while the dynamic zero feature was set to turned on.
CONFIG INITIALIZED	Configuration was reset to factory defaults or was erased.
DARK CAL WARNING	Dark offset above limit specified indicating that too much stray light is present in the sample chamber.
DATA INITIALIZED	DAS data storage was erased.
HVPS WARNING	High voltage power supply for the PMT is outside of specified limits.
PMT DET WARNING	PMT detector output is outside of operational limits.
PMT TEMP WARNING	PMT temperature is outside of specified limits.
RCELL TEMP WARNING	Sample chamber temperature is outside of specified limits.
REAR BOARD NOT DET	CPU unable to communicate with motherboard.
RELAY BOARD WARN	CPU is unable to communicate with the relay PCA.
SAMPLE FLOW WARN	The flow rate of the sample gas is outside the specified limits.
SAMPLE PRESS WARN	Sample gas pressure outside of operational parameters.
SYSTEM RESET[1]	The computer was rebooted.
UV LAMP WARNING	The UV lamp intensity measured by the reference detector reading too low or too high.

[1] Clears 45 minutes after power up.
[2] Clears the next time successful zero calibration is performed.
[3] Clears the next time successful span calibration is performed.

Table 3 lists the available test function parameters and their descriptions (Manual Table 4–2, p. 82).

Table 3 Test Function Parameters

DISPLAY	PARAMETER	UNITS	DESCRIPTION
RANGE	RANGE - - RANGE1 RANGE2	PPB, PPM, UGM & MGM	The Full Scale limit at which the reporting range of the analyzer's ANALOG OUTPUTS is currently set. THIS IS NOT the Physical Range of the instrument. Refer to Section 4.6 for more information. If DUAL or AUTO Range modes have been selected, two RANGE functions will appear, one for each range.
STABIL	STABILITY	mV	Standard deviation of SO_2 Concentration readings. Data points are recorded every ten seconds. The calculation uses the last 25 data points.
PRES	SAMPLE PRESSURE	in-Hg-A	The current pressure of the sample gas as it enters the sample chamber, measured between the SO_2 and Auto-Zero valves.
SAMP FL	SAMPLE FLOW	cm^3/min (cc/m)	The flow rate of the sample gas through the sample chamber. This value is not measured but calculated from the sample pressure.
PMT	PMT Signal	mV	The raw output voltage of the PMT.
NORM PMT	NORMALIZED PMT Signal	mV	The output voltage of the PMT after normalization for offset and temperature/pressure compensation (if activated).
UV LAMP	Source UV Lamp Intensity	mV	The output voltage of the UV reference detector.
LAMP RATIO	UV Source lamp ratio	%	The current output of the UV reference detector divided by the reading stored in the CPU's memory from the last time a UV Lamp calibration was performed.
STR. LGT	Stray Light	ppb	The offset due to stray light recorded by the CPU during the last zero-point calibration performed.
DRK PMT	Dark PMT	mV	The PMT output reading recorded the last time the UV source lamp shutter was closed.
DRK LMP	Dark UV Source Lamp	mV	The UV reference detector output reading recorded the last time the UV source lamp shutter was closed.
SLOPE	SO_2 measurement Slope	-	The sensitivity of the instrument as calculated during the last calibration activity. The slope parameter is used to set the span calibration point of the analyzer.
OFFSET	SO_2 measurement Offset	mV	The overall offset of the instrument as calculated during the last calibration activity. The offset parameter is used to set the zero point of the analyzer response.
HVPS	HVPS	V	The PMT high voltage power supply.
RCELL TEMP	SAMPLE CHAMBER TEMP	°C	The current temperature of the sample chamber.
BOX TEMP	BOX TEMPERATURE	°C	The ambient temperature of the inside of the analyzer case.
PMT TEMP	PMT TEMPERATURE	°C	The current temperature of the PMT.
IZS TEMP[1]	IZS TEMPERATURE[1]	°C	The current temperature of the internal zero/span option. Only appears when IZS option is enabled.
TEST[2]	TEST SIGNAL[2]	mV	Signal of a user-defined test function on output channel A4.
TIME	CLOCK TIME	hh:mm:ss	The current day time for DAS records and calibration events.

Table 4 lists the test function nominal values and possible failure causes (Addendum Table 4–1, p. 24).

Table 4 Test Function Nominal Values and Possible Causes

TEST FUNCTION	NOMINAL VALUE(S)	POSSIBLE CAUSE(S)
STABIL (STANDARD)	≤0.075 ppb with zero air	Faults that cause high stability values are: pneumatic leak; low or very unstable UV lamp output; light leak; faulty HVPS; defective preamp board; aging PMT; PMT recently exposed to room light; dirty/contaminated reaction cell.
STABIL2 (EPA DEF)	≤0.075 ppb with zero air	Same as STABIL
SAMPLE FL	650 cm^3/min ± 10%	Faults can be caused by: clogged critical flow orifice; pneumatic leak; faulty flow sensor; sample line flow restriction.
PMT	-20 TO 150 mV with zero air	High or noisy readings could be due to: calibration error; pneumatic leak; light leak (improper assembly); aging UV filter; low UV reference output; PMT recently exposed to room light; light leak in reaction cell; reaction cell contaminated; HVPS problem. *It takes 24-48 hours for a PMT exposed to ambient light levels to return to normal functioning.*
NORM PMT	- -	Noisy Norm PMT value (assuming unchanging SO_2 concentration of sample gas): Calibration error; HVPS problem; PMT problem; UV reference problem; UV lamp problem.
UV LAMP	2000 - 4400 mV	This is the instantaneous reading of the UV lamp intensity. Low UV lamp intensity could be due to: aging UV lamp; UV lamp position out of alignment; faulty lamp transformer; aging or faulty UV detector; dirty optical components. Intensity lower than 600 mV will cause **UV LAMP WARNING.**
UV STAB	0 to 100 mV	Unstable lamp or failed UV lamp driver.
LAMP RATIO	___	The current output of the UV reference detector divided by the reading stored in the CPU's memory from the last time a UV Lamp calibration was performed. Out of range lamp ratio could be due to: malfunctioning UV lamp; UV lamp position out of alignment; faulty lamp transformer; aging or faulty UV detector; dirty optical components; pin holes or scratches in the UV optical filters; light leaks.
STR LGT	<100 ppb	High stray light could be caused by: aging UV filter; contaminated reaction cell; light leak; pneumatic leak.
DRK PMT	200 - 325 mV	High dark PMT reading could be due to: light leak; high pmt temperature; high electronic offset.
DRK LMP	-50 - 200 mV	High dark UV detector could be caused by: light leak; high electronic offset.
HVPS	≈ 400 V to 900 V	Incorrect HVPS reading could be caused by; HVPS broken; preamp board circuit problems.
RCELL TEMP	50ºC ± 1ºC	Incorrect temperature reading could be caused by: malfunctioning heater; relay board communication (I^2C bus); relay burnt out
BOX TEMP	ambient + ~ 5ºC	Incorrect temperature reading could be caused by: Environment out of temperature operating range; broken thermistor; runaway heater
PMT TEMP	7ºC ± 2ºC constant	Incorrect temperature reading could be caused by: TEC cooling circuit broken; High chassis temperature; 12V power supply
PRESS	ambient ± 2 IN-HG-A	Incorrect SAMPLE pressure could be due to: pneumatic leak; malfunctioning valve; malfunctioning pump; clogged flow orifices; sample inlet overpressure; faulty pressure sensor
SLOPE	1.0 ± 0.3	Slope out of range could be due to: poor calibration quality ; span gas concentration incorrect; leaks; UV Lamp output decay.
OFFSET	< 250 mV	High offset could be due to: incorrect span gas concentration/contaminated zero air/leak; low-level calibration off; light leak; aging UV filter; contaminated reaction cell; pneumatic leak.
TIME OF DAY	Current time	Incorrect Time could be caused by: Internal clock drifting; move across time zones; daylight savings time?

Table 5 provides the preventative maintenance schedule (TAD Section 3, Table 3–4, p. 28 of 31).

Table 5 Preventative Maintenance Schedule

Maintenance Item	Schedule
Review test functions (Maintenance Forms)	Weekly
Replace External Filter	Every two weeks
Replace Internal Filter	Monthly
Pneumatic system leak check	After every filter change
Inspect internal and external tubing; replace as necessary	Semi-annually
Rebuild or replace pump	As needed to correct leak check failure
Replace UV lamp	As needed (typically 2–3 years)
Clean Optical bench	As needed (performed in lab)
Replace PMT	As needed (performed in lab)
Replace critical flow orifice and sintered filters	As needed

Table 6 lists common problems and possible causes and suggested solutions.

Table 6 Common Problems and Possible Causes and Suggested Solutions

Problem	Possible Cause	Possible Solution
Noisy Output	Defective DC power supply	Replace power supply
	Dirty optics	Clean optics bench
	PMT failure	Replace PMT
High positive zero drift	Defective bandpass filter	Replace filter
	PMT failure	Replace PMT
No or low response to span gas	UV source defective	Replace UV lamp
	UV power supply defective	Replace UV power supply
	PMT failure	Replace PMT
Zero output at ambient levels	Pump failure	Check pump
	UV lamp failure	Replace UV lamp
	UV power supply defective	Replace power supply
	PMT failure	Replace PMT
No or low flow	Pump failure	Replace/rebuild pump

6.7 Leak Checks

Complete the following checks and tests in order to check the system for leaks.

6.7.1 Sample Train Leak Check

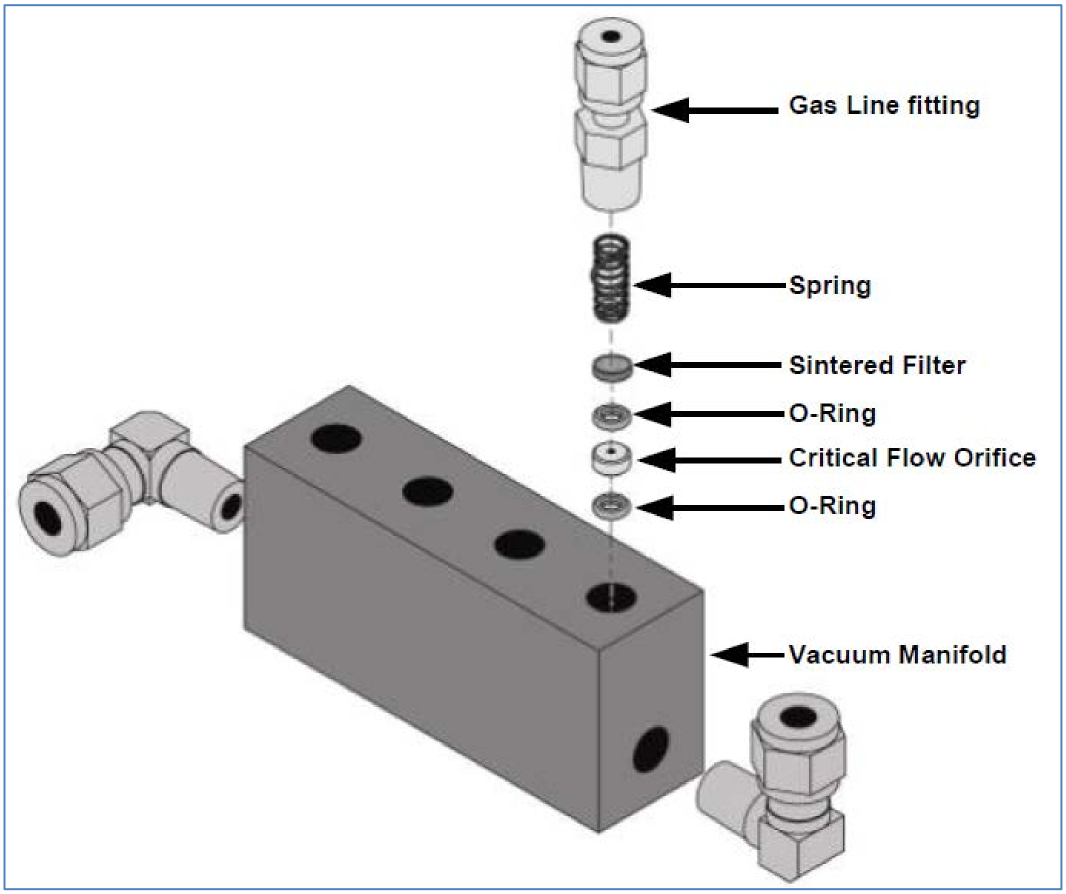
- Cap the inlet to the sample train, upstream of the particulate filter
- Wait approximately 5 minutes and verify the PRES is less than 10 inHg-A and the SAMP FL is less than 10 ccm
  Sample → Test → PRES
  Sample → Test → SAMP FL
  (Reference for Pressure and Flow specification is from the T300U CO Manual 12.2, pp. 267–273)
- If the SAMP FL is greater than 10 ccm, there is a leak in the pneumatic system.
- If the PRES is greater than 10 inHg-A and the SAMP FL is less than 10 ccm, the sample pump needs either rebuilding or replacement

6.7.2 Critical Flow Orifice Maintenance

A critical flow orifice is located in the exhaust vacuum manifold and is used to control the sample gas flow rate (Manual Section 11.3.4, pp. 226–227). Periodically, the sintered filter protecting the critical flow orifice from clogging and the O-rings in assembly require replacement. Replace any clogged filters via the following steps (Figure 10).

- Disconnect the pneumatic line from the exhaust vacuum manifold
- Unscrew the National Pipe Thread (NPT) fitting
- Remove the spring, sintered filter, two O-rings and the critical flow orifice
- Reassemble the parts as shown in the figure using a new sintered filter and O-rings. The jewel in the critical flow orifice must face up
- Reinstall the NPT fitting and connect all tubing
- Perform a leak check

Figure 10 Critical Flow Orifice Assembly



6.7.3 Check for Light Leaks

Occasionally, especially after being re-assembled, the reaction chamber assembly can develop small leaks (Manual Section 11.3.5, pp. 227–228) around the PMT, allowing stray light from the analyzer surroundings into the PMT housing. Check for light leaks using the following procedures:

- Generate zero air to the analyzer
- Shine a flashlight at the inlet and outlet fittings and at all the joints of the sample chamber as well as around the PMT housing.
- Monitor the PMT parameter to verify the reading does not respond to the light.
- Sample → Test → PMT
- If there is a PMT response to the external light, symmetrically tighten the sample chamber mounting screws or replace the 1/4” vacuum tubing with new, black PTFE tubing (this tubing will fade with time and become transparent). Often, light leaks are also caused by O-rings being left out of the assembly.
- If tubing was changed or fittings were separated, perform a leak check

6.7.4 Hydrocarbon Scrubber Leak Check

Leaks in the outer tubing of the scrubber are identified by the pressurized leak check procedures (Manual Section 11.3.8, pp. 229–230).

To check for leaks in the inner scrubber tubing:

- Turn off the analyzer
- Disconnect the tubing attached to both ends of the scrubber. One end is connected to the sample particulate filter assembly and the other end is connected to the reaction cell assembly. Both ends are 1/8" black Teflon tubing.
- Cap one end of the scrubber.
- Connect the pressure transfer standard to the other end of the inner tubing.
- Pressurize the inner tubing to 15 psia
- If the pressure drops more than 1 psi in 5 minutes, the scrubber has an internal leak and needs to be replaced.

6.8 Remote Communications

The following screenshot displays the available commands accessible using the Ethernet connection.

```
?
---------------------------------------------------------------------
|     T100U SO2 Analyzer, Software Rev 1.0.2 bld 74, Help Screen     |
|-------------------------------------------------------------------|
| TERMINAL MODE KEYS                                                 |
|     BS      Backspace                                              |
|     ESC     Abort line                                             |
|     CR      Execute command                                        |
|     Ctrl-C  Switch to computer mode                                |
| COMPUTER MODE KEYS                                                 |
|     LF      Execute command                                        |
|     Ctrl-T  Switch to terminal mode                                |
| COMMMANDS                                                          |
|     ? | HELP [id]                        (Display this help screen) |
|     LOGON [id] password        (Establish connection to instrument) |
|     LOGOFF [id]                (Terminate connection to instrument) |
|     T [id] SET ALL|name|hexmask                     (Display tests) |
|     T [id] LIST [ALL|name|hexmask] [NAMES|HEX]        (Print tests) |
|     T [id] name                                 (Print single test) |
|     T [id] CLEAR ALL|name|hexmask                   (Disable tests) |
|     W [id] SET ALL|name|hexmask                  (Display warnings) |
|     W [id] LIST [ALL|name|hexmask] [NAMES|HEX]     (Print warnings) |
|     W [id] name                              (Clear single warning) |
|     W [id] CLEAR ALL|name|hexmask                  (Clear warnings) |
|     C [id] ZERO|SPAN[|LOWSPAN] [<gas>1|2] (Enter calibration mode) |
|     C [id] ASEQ number                 (Execute automatic sequence) |
|     C [id] COMPUTE ZERO|SPAN             (Compute new slope/offset) |
|     C [id] EXIT                             (Exit calibration mode) |
|     C [id] ABORT                       (Abort calibration sequence) |
|     D [id] LIST ["pattern"]                     (Print I/O signals) |
|     D [id] name[=value]                 (Examine or set I/O signal) |
|     D [id] LIST NAMES         (Print names of all diagnostic tests) |
|     D [id] ENTER name                     (Execute diagnostic test) |
|     D [id] EXIT                              (Exit diagnostic test) |
|     D [id] RESET [DATA] [CONFIG] [exitcode]      (Reset instrument) |
|     D [id] PRINT ["name"] [SCRIPT]        (Print DAS configuration) |
|     D [id] RECORDS ["name"]   (Print number of DAS records stored) |
|     D [id] REPORT ["name"] [RECORDS=number] [FROM=<start date>]    |
|       [TO=<end date>] [VERBOSE|COMPACT|BASE64|HEX]                 |
|       (date format: MM/DD/YYYY(or YY) [HH:MM:SS])                  |
|                                                 (Print DAS records) |
|     D [id] CANCEL                       (Halt printing DAS records) |
|     DASBEGIN [<data channel definitions>] DASEND (Upload DAS cfg.) |
|     CHANNELBEGIN propertylist CHANNELEND (Upload single DAS chan.) |
|     CHANNELDELETE ["name"]       (Delete one or more DAS channels) |
|     V [id] LIST ["pattern"]               (Print setup variables) |
|     V [id] name[=value [warn_low [warn_high]]]    (Modify variable) |
|     V [id] name="value"                 (Modify enumerated variable) |
|     V [id] CONFIG                   (Print instrument configuration) |
|     V [id] MAINT ON|OFF              (Enter/exit maintenance mode) |
|     V [id] MODE                     (Print current instrument mode) |
|     V [id] CURR_TIME[=HH:MM]            (Print/set instrument time) |
|     V [id] CURR_DATE[=MM/DD/YYYY]       (Print/set instrument date) |
---------------------------------------------------------------------
```

The following screenshot lists the test parameters available and the names used to query the test function values.

```
t list
T  191:08:42  0000  RANGE=100.0 PPB
T  191:08:42  0000  STABIL=0.003 PPB
T  191:08:42  0000  STABIL2=0.009 PPB
T  191:08:42  0000  PRES=26.9 IN-HG-A
T  191:08:42  0000  SAMP FL=701 CC/M
T  191:08:42  0000  PMT=5.8 MV
T  191:08:42  0000  NORM PMT=6.4 MV
T  191:08:42  0000  UV LAMP=4444.5 MV
T  191:08:42  0000  UV STB=0.163 MV
T  191:08:42  0000  LAMP RATIO=100.6 %
T  191:08:42  0000  STR. LGT=3.083 PPB
T  191:08:42  0000  DRK PMT=228.3 MV
T  191:08:42  0000  DRK LMP=9.7 MV
T  191:08:42  0000  SLOPE=0.995
T  191:08:42  0000  OFFSET=6.2 MV
T  191:08:42  0000  HVPS=532 VOLTS
T  191:08:42  0000  RCELL TEMP=50.0 C
T  191:08:42  0000  BOX TEMP=30.0 C
T  191:08:42  0000  PMT TEMP=8.8 C
T  191:08:42  0000  TEST=5.8 MV
T  191:08:42  0000  TIME=08:42:12
t list names all
T  191:08:42  0000  RANGE
T  191:08:42  0000  RANGE1
T  191:08:42  0000  RANGE2
T  191:08:42  0000  STABILITY
T  191:08:42  0000  STABILITY2
T  191:08:42  0000  SAMPPRESS
T  191:08:42  0000  SAMPFLOW
T  191:08:42  0000  PMTDET
T  191:08:42  0000  NORMPMTDET
T  191:08:42  0000  UVDET
T  191:08:42  0000  STABILITYUV
T  191:08:42  0000  LAMPRATIO
T  191:08:42  0000  STRAYLIGHT
T  191:08:42  0000  DARKPMT
T  191:08:42  0000  DARKLAMP
T  191:08:42  0000  SLOPE
T  191:08:42  0000  OFFSET
T  191:08:42  0000  HVPS
T  191:08:42  0000  RCELLTEMP
T  191:08:42  0000  BOXTEMP
T  191:08:42  0000  PMTTEMP
T  191:08:42  0000  IZSTEMP
T  191:08:42  0000  SO2
T  191:08:42  0000  TESTCHAN
T  191:08:42  0000  XIN1
T  191:08:42  0000  XIN2
T  191:08:42  0000  XIN3
T  191:08:42  0000  XIN4
T  191:08:42  0000  XIN5
T  191:08:42  0000  XIN6
T  191:08:42  0000  XIN7
T  191:08:42  0000  XIN8
T  191:08:42  0000  CLOCKTIME
```

7.0 REFERENCES

Teledyne Advanced Pollution Instrumentation (API).2011. Addendum to T100U Operation Manual. Model T100 Trace Level Sulfur Dioxide Analyzer. 06840B DCN 6201.

Teledyne Advanced Pollution Instrumentation (API). 2011. Operation Manual. Model T100 UV Fluorescence SO_2 Analyzer. 06807B DCN6192.

Teledyne Advanced Pollution Instrumentation (API). 2012. Operation Manual. Model T300/T300M Carbon Monoxide Analyzer. 06864B DCN6314.

U.S. Environmental Protection Agency (EPA). 2005. Technical Assistance Document for NCore Monitoring. Version 4. EPA-454/R-05-003.

U.S. Environmental Protection Agency (EPA). 2008. QA Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program, Appendix D. EPA-454/B-08-003.

8.0 ATTACHMENTS

This SOP does not contain attachments.

9.0 ABBREVIATIONS

CAL	calibration
Comm	communications
Conc	concentration
Diag	diagnosis
ENTR	enter
ID	identification
INET	internet
LAMP CAL	lamp calibration routine
NORM PMT	SO_2 concentration associated with normal PMT value
PMT	photomultiplier
PRES	pressure
RNGE	range
SAMP FL	sample flow rate
SNGL	single
STABIL	stability

MODEL T200U NITROGEN OXIDE/TOTAL REACTIVE OXIDES OF NITROGEN (NO/NOY) ANALYZER STANDARD OPERATING PROCEDURE (SOP)

Effective Date: 7-7-16

Reviewed by: Kevin P. Mishoe, Field Operations Manager

Reviewed by: Marcus O. Stewart, QA Manager

Approved by: Holton K. Howell, Project Manager

TABLE OF CONTENTS

Annual Review			
Reviewed by:	Title:	Date:	Signature:

T200U SOP

1.0 PURPOSE

The purpose of this SOP is to provide consistent guidance for maintenance and handling of the Teledyne Advanced Pollution Instrumentation (API) Model T200U NO/NO_y Analyzer. This SOP is designed to be used by the Clean Air Status and Trends Network (CASTNET) field calibration laboratory and field personnel.

2.0 SCOPE

This SOP applies to all CASTNET sites operating trace level Teledyne API T200U NO/NO_y analyzers. The reader must also be familiar with five documents listed in Section 7.0 (References) of this SOP. The documents include the EPA (2005) Technical Assistance Document (TAD) for National Core (NCore) Monitoring, the API T200U Operation Manual (Manual), the T200U Addendum to the Manual, the NO_y Addendum and EPA (2008) Quality Assurance (QA) Handbook for Air Pollution Measurement Systems, Volume II, Appendix D (QA Handbook). The various sections throughout this SOP cross-reference the five documents.

CASTNET is mandated to use trace gas instruments that are based on Federal Equivalent Methods. The following settings and operational parameters must be used to maintain equivalency (Manual Section 2.2, pp. 28-29):

- Ambient temperature 5 degrees Celsius (°C) to 40°C
- 1 micrometer (µm) Teflon [polytetrafluoroethylene (PTFE)] filter in internal assembly
- Gas flow of 2 standard liters per minute (slpm) or greater supplied by external vacuum pump capable of 10 inches of mercury absolute (in Hg-A)
- Dynamic Span = OFF
- Dynamic Zero = OFF or ON
- CAL-ON-NO_2 = OFF
- Pressure/Temperature compensation = ON

3.0 SUMMARY

3.1 CASTNET Site Overview

Figure 1 CASTNET Site Overview

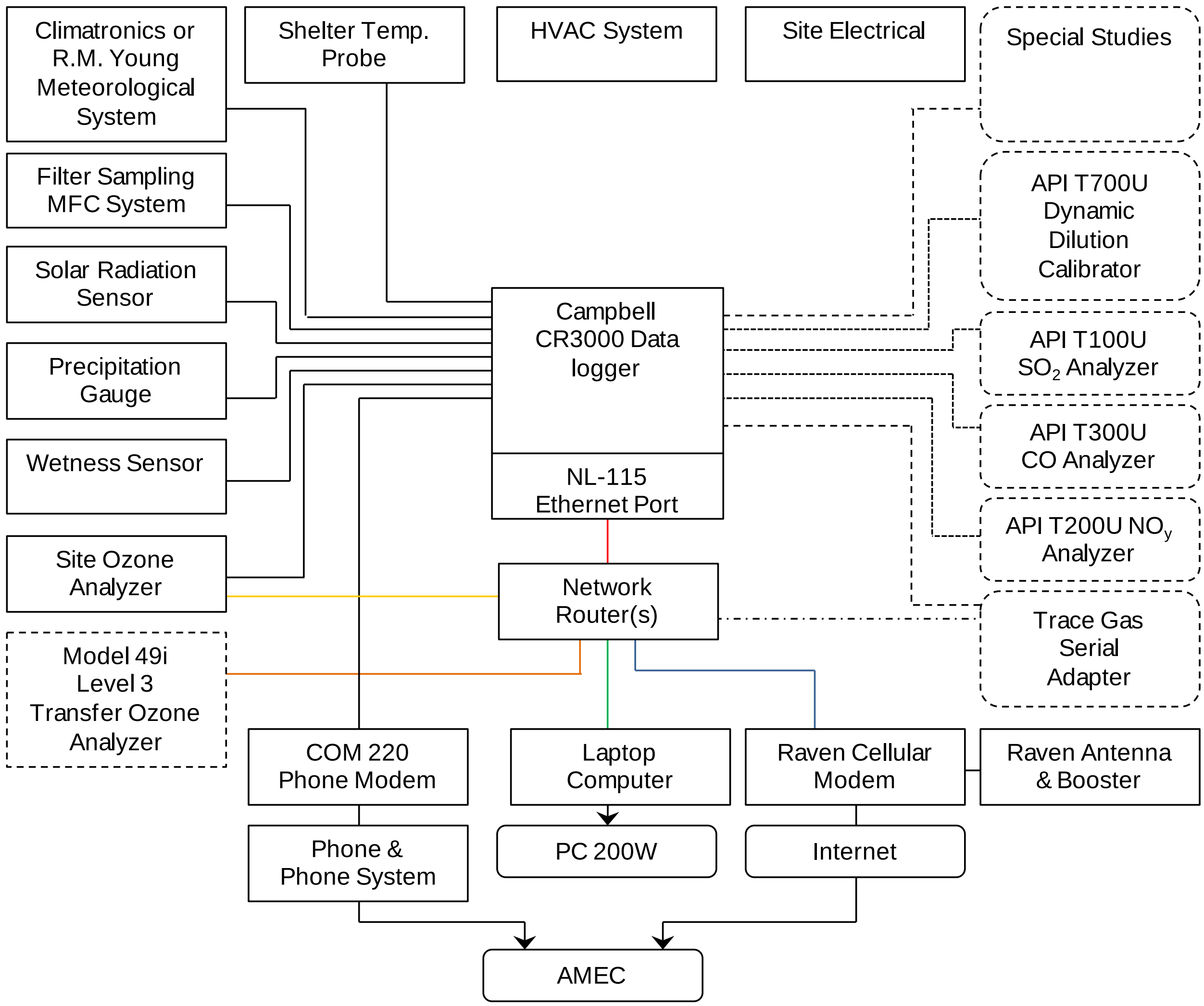


Figure 1 shows the instrument communication system at a CASTNET site. The instruments include the NCore trace gas analyzers and the standard CASTNET sensors. Flow Chart Figure 2 provides NO_2 validation criteria based on the tables in QA Handbook, Volume II, Appendix D.

Figure 2 Critical and Operational Criteria for NO_2 Measurements

Requirement	Frequency	Acceptance Criteria	Information /Action
		CRITICAL CRITERIA – NO/NO_y	
One Point QC Check Single analyzer	1/ 2 weeks	≤ ± 10% (percent difference)	0.01-0.10 parts per million (ppm) Relative to routine concentrations 40 CFR Part 58 Appendix (App) A, Section (Sec) 3.2
Zero/span check	1/ 2 weeks	Zero drift ≤ ± 1.5 ppb Span drift ≤ ± 10%	
		OPERATIONAL CRITERIA – NO/NO_y	
Shelter Temperature			
Temperature range	**Daily** (hourly values)	20 to 30° C. (Hourly average)	Generally the 20-30° C range will apply but the most restrictive operable range of the instruments in the shelter may also be used as guidance
Temperature Control	Daily (hourly values)	≤ ± 2° C standard deviation (SD) over 24 hours	
Temperature Device Check	2/year	± 2° C of standard	
Precision (using 1-point QC checks)	Calculated annually and as appropriate for design value estimates	90% CL CV ≤ 10%	90% Confidence Limit of Coefficient of Variation (CV) 40 CFR Part 58 App A, Sec 4.1.2
Bias (using 1-point QC checks)	Calculated annually and as appropriate for design value estimates	95% CL ≤ + 10%	95% Confidence Limit of absolute bias estimate. 40 CFR Part 58 App A, Sec 4.1.3
Annual Performance Evaluation			
Single analyzer	Every site 1/year 25 % of sites quarterly	Percent difference of each audit level ≤ 15%	3 consecutive audit concentration not including zero. 40 CFR Part 58 App A, Sec 3.2.2
Primary QA Organization (PQAO)	annually	95% of audit percent differences fall within the one point QC check 95% probability intervals at primary QA organization level of aggregation	40 CFR Part 58 App A, Sec 4.1.4
Federal Audits (NPAP)	1/year at selected sites 20% of sites audited	Mean absolute difference ≤ 15%	40 CFR Part 58 App A, Sec 2.4
State audits	1/year	State requirements	
Verification/Calibration	Upon receipt/adjustment/repair/ installation/moving 1/6 months if manual zero/span performed biweekly 1/year if continuous zero/span performed daily	Instrument residence time ≤ 2 min Dynamic parameter ≥ 2.75 ppm-min All points within ± 2 % of full scale of best-fit straight line	Multi-point calibration (0 and 4 upscale points) 40 CFR Part 50 App F
Converter Efficiency	During multi-point calibrations, span and audit 1/ 2 weeks	96%	
Gaseous Standards		Traceable to National Institute of Standards and Technology (NIST)	Vendor must participate in EPA Protocol Gas
Requirement	**Frequency**	**Acceptance Criteria**	**Information /Action**
		(e.g., EPA Protocol Gas)	Verification Program 40 CFR Part 58 App, A Sec 2.6.1
Zero Air/ Zero Air Check	1/year	Concentrations below lower detection level (LDL)	
Gas Dilution Systems	1/3 months	Accuracy ± 2 %	
Detection			
Noise	NA	0.005 ppm	40 CFR Part 53.20
Lower detectable level	1/year	0.01 ppm	40 CFR Part 53.20
		SYSTEMATIC CRITERIA – NO/NO_y	
Standard Reporting Units	All data	ppm [final units in EPA Air Quality System (AQS)]	
Completeness (seasonal)	Quarterly	75%	Annual standard (hourly data)
Sample Residence Times		< 20 seconds	
Sample Probe, Inlet, Sampling train		Borosilicate glass (e.g., Pyrex) or Teflon	40 CFR Part 58 App E
Siting		Un-obstructed probe inlet	40 CFR Part 58 App E

Notes: Guidance for the application of data flags is based on the validation template in Appendix D of volume II of the EPA Quality Assurance Handbook, Revision 1. No data adjustments will be made during routine procedures.

4.0 MATERIALS AND SUPPLIES

The operation of the T200U analyzer requires a sample inlet made of Teflon perfluoroalkoxy (PFA) (TAD Section 4.3.4.3, p. 24 of 40). The system utilizes a dynamic dilution gas calibrator (T700U) with a compressed nitric oxide (NO) gas cylinder with at least a ± 2% certification. The T200U system also requires:

- Assorted fittings comprised of Teflon or stainless steel
- gas lines comprised of Teflon [PTFE or fluorinated ethylene propylene (FEP)]
- 47 millimeter (mm), 1 µm Teflon inlet filler
- Zero air with concentrations lower than the lower detection limit (LDL) of NO, nitrogen dioxide (NO_2), and ammonia (NH_3).

5.0 SAFETY

The T200U is a heavy, high voltage instrument. With a weight of about 45 pounds with the pump, it is recommended that two people lift and carry the instrument. High voltages are present inside the instrument case. Consequently, the power connection must have a functioning ground connection. The power must be off before disconnecting subassemblies. The instrument must not be operated with the cover off. NO_2 is extremely toxic by inhalation. Consequently, the material safety data sheet (MSDS) for the NO cylinder must be posted onsite. Exhaust must be vented outside the shelter.

6.0 PROCEDURES

6.1 Set-Up/Installation

The first step is to unpack the analyzer from its shipping container and visually inspect the instrument for any damage. Then, identity loose fittings, screws, or items that may appear to be out of place. Internal damage to the analyzers and their components occurs occasionally during shipment.

6.1.1 Remove Shipping Screws

Remove the two red shipping screws from the top of the sensor base before operating the instrument.

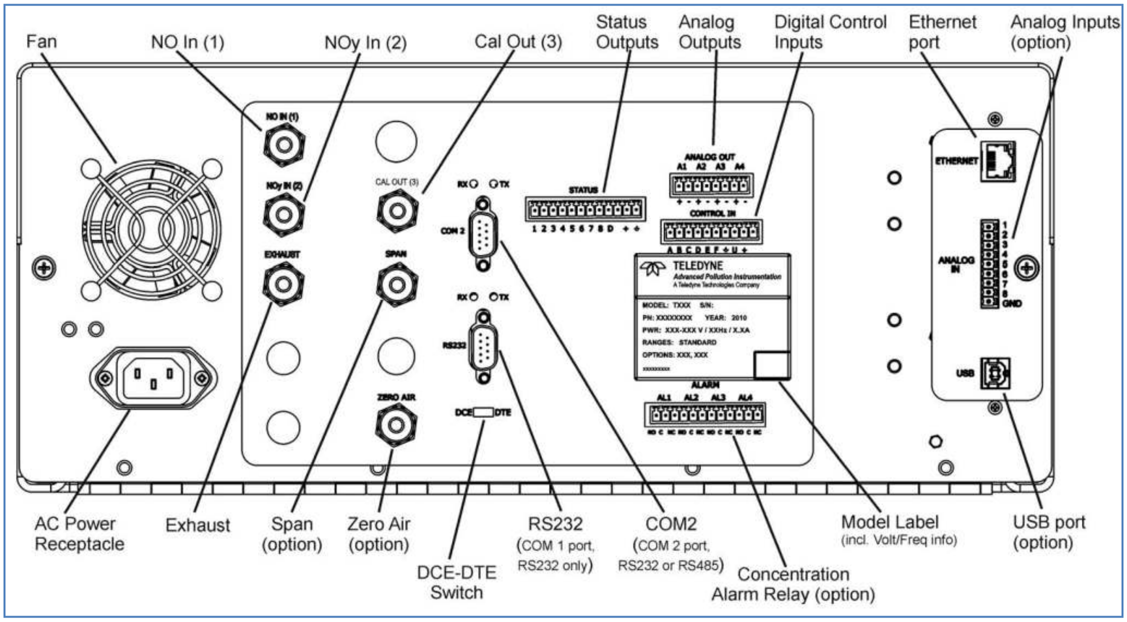
6.1.2 Ventilate Instrument

Before powering on the T200U, the instrument must be properly ventilated. Minimum ventilation clearances are as follows (Manual Section 3.3.1, p. 41):

- Back -- 4 inches
- Sides -- 1 inch
- Above and Below -- 1 inch

Figure 3 T200U Rear Panel

(a) Diagram



(b) Photo

6.1.3 Use Teflon Tubing and Fittings

Only FEP or PTFE tubing and fittings should be used for the T200U (TAD Section 4.3.2, p. 15 of 40). No stainless steel or brass fitting are allowed.

6.1.4 Implement Rear Panel Connections

- Connect Ethernet cable to Ethernet port (Figure 3)
- Connect the external exhaust pump to the exhaust port
- Connect the “NO In (1)” on the T200U to the “NO Out (1)” on the bypass box (Figure 3)
- Connect the “NOy In (2)” on the T200U to the “NOy Out (2)” on the bypass box

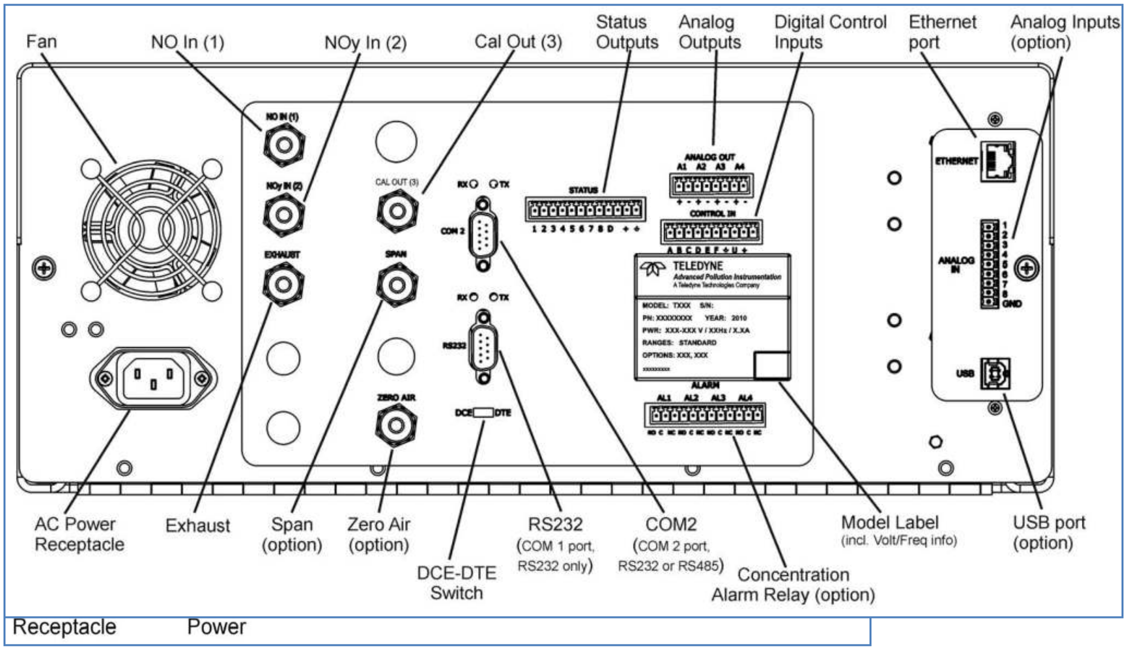
6.1.5 Connect Bypass and Converter Boxes

On the bypass box (Figure 3):

- Connect the power cord to the alternating current (AC) power receptacle
- Connect the converter power cable from the converter box
- Connect the thermocouple cable from the converter box
- Connect the “Cal In (3)” to the Output B on the Teledyne T700U gas calibrator, or equivalent source of calibration gas.
- Connect the “NO_y In (4)”, “NO In (5)”, and “Cal Out (6)” to their respective lines coming from the converter box

Figure 4 Bypass Box

(a) Diagram



(b) Photo

Figure 5 Converter box

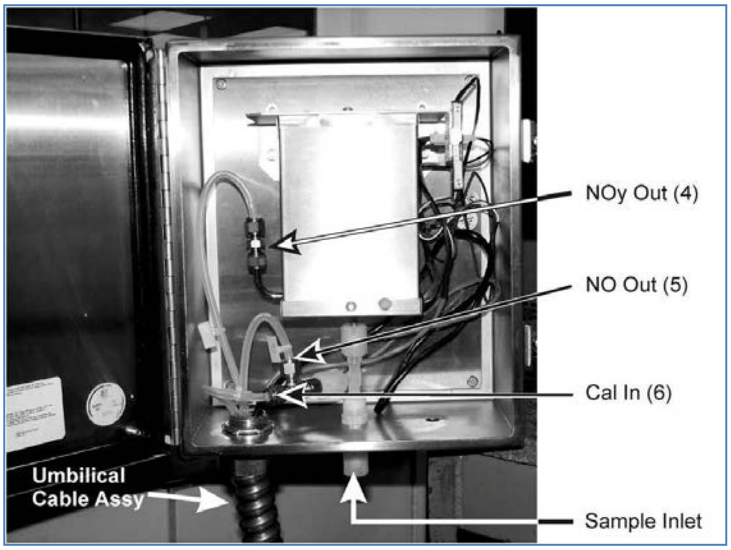


Figure 6 External sample pump

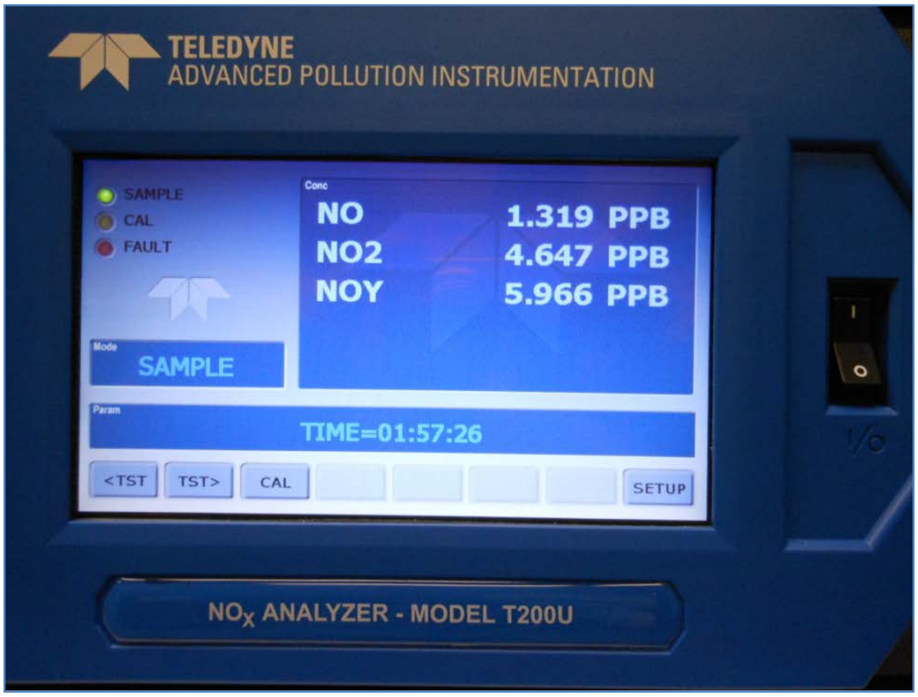
On the converter box

- Install additional 5µm filters on the inlet side of the NO and NO_y channels within the converter box (Figure 5).
- A leak check should be performed once pneumatic connections have all been made and the machine has been turned on (Manual Section 11.3.12, pp. 258-259).
  Cap sample inlet on the NO_y converter box, SAMP (sample pressure) and RCEL (reaction cell) on the T200U should fall below 4in-Hg

6.1.6 Complete Start-Up Procedures

- Pump (Figure 6) and exhaust fan should start immediately (Manual Section 3.4.1, p. 75))
- Allow 60 minutes of warm-up (Manual Section 3.4.1, pp. 75-76)
- Upon initial startup warning messages may appear on the display (Figure 7). If after 30 minutes of the warm-up period, warning messages still appear, their cause warrants further investigation.
- A list of common warning messages can be viewed in Table 3-12 of the Manual (p. 77)
- Check test functions using worksheet from Manual Appendix C, p. C-1, and Trace Gas Maintenance Forms 1 and 2 (Figure 6 and 7 in QAPP Appendix 11).

Figure 7 Operating Screen



6.2 Acceptance Testing

Complete the following checks, tests, and calculations as the bases for instrument acceptance.

- Perform vacuum leak check as described in SOP Section 6.10.
- Verify precision (also performed quarterly). Analyzer should have a 95% probability limit for precision of ± 15% or less (TAD Section 3.3.1.1, p. 5 of 31) based on Equations 1 and 2 in the TAD section.
- Verify bias (also performed quarterly). Analyzer should have an upper bound for average bias of ± 15% (TAD Section 3.3.1.2, p. 6 of 31)
- Calculate method detection limit (MDL) according to the procedure in 40 CFR 136 Appendix B. The MDL should be 0.2 parts per billion (ppb) or lower over an averaging time of no more than 5 minutes.
- Estimate LDL according to the procedure in 40 CFR 53.23 (c). The Addendum indicates the LDL is 50 parts per trillion (ppt).
- Verify linear range by demonstrating all points recorded during the multipoint audit are within 1% of full scale of the best fit straight line.
- Estimate zero/span drift (TAD Section 3.3.1.9, p. 10 of 31) over 12- and 24-hour periods of continuous unadjusted operation. Zero drift should be less than 0.1 ppb for 12 and 24 hours and less than 1% full scale for 24-hour span drift. The Addendum indicates span drift (24-hr) should be less than 0.5% of full scale or 50 ppt root mean square (RMS), whichever is greater.

- Test the conversion efficiency of the molybdenum converter (TAD Section 4.4.2, pp. 26-28).
- Verify test functioning using Forms 1 and 2 (Figures 6 and 7 in QAPP Appendix 11).

6.3 Configuration

- Set clock to current date and time of day (standard time) (Manual Section 5.6.1, p. 110) The clock will automatically be set by the site data logger and only needs to be set manually if the instrument is to be operated independently.
  Setup → Clk → Time → (Set to current local standard time) → ENTR*
  Setup → Clk → Date → (Set to current date) → ENTR

*The T200U uses abbreviations to show parameters on its display screen. The abbreviations are defined in Section 9.0 of this SOP.

- Analog range configuration is not applicable for digital communications.
- Range units = ppb (Manual Section 5.4.3.4, p. 105)
  To check:
  Sample → Test → RNGE
  To change:
  Setup → Rnge → Unit → PPB ENTR
- Range concentration = 0100.0
  To check:
  Sample → Test → RNGE
  To Change:
  Setup → Rnge → Set → 00100.0 ENTR
- Range mode = Single (SNGL) (Manual Section 5.4.3, p. 98)
  To check:
  Setup → Rnge → Mode → RANGE MODE
  To Change:
  Setup → Rnge → Mode → SNGL
- Set Machine ID (Manual Section 5.7.1, pp. 112-113)
  To check:
  Setup → More → Comm → ID
  To change:
  Setup → More → Comm → ID → (Set to desired value) → ENTR
- Set Ethernet settings (Manual Section 6.5.1, pp. 143-145)
  Setup → More → Comm → Inet
  - ➔ DHCP = Off
  - ➔ INST IP = 192.168.0.42
  - ➔ GATEWAY IP = 192.168.0.1
  - ➔ SUBNET MASK = 255.255.255.0

- → TCP PORT 1 = 3000
- → TCP PORT 2 = 502
- Set alarm limits
  The alarm limits will be set according to the list of acceptable values in Figures 6 and 7 of QAPP Appendix 11.

The API T200U NO/NO_y analyzer uses the temperature and pressure readings at the time of calibration as a reference for compensation. As such, there is no need to enter or confirm standard temperature and pressure conditions.

6.4 Operation

Figure 7 showed the normal operating screen. Descriptions of the various display components are listed in Table 1 (Manual Table 3-2, p. 35).

Table 1 Analyzer Display Functions

Field	Description/Function			
Status	LEDs indicating the states of Sample, Calibration and Fault, as follows:			
	Name	Color	State	Definition
	SAMPLE	Green	Off	Unit is not operating in sample mode, DAS is disabled.
			On	Sample Mode active; Front Panel Display being updated; DAS data being stored.
			Blinking	Unit is operating in sample mode, front panel display being updated, DAS hold-off mode is ON, DAS disabled
	CAL	Yellow	Off	Auto Cal disabled
			On	Auto Cal enabled
			Blinking	Unit is in calibration mode
	FAULT	Red	Off	No warnings exist
			Blinking	Warnings exist
Conc	Displays the actual concentration of the sample gas currently being measured by the analyzer in the currently selected units of measure			
Mode	Displays the name of the analyzer's current operating mode			
Param	Displays a variety of informational messages such as warning messages, operational data, test function values and response messages during interactive tasks.			
Control Buttons	Displays dynamic, context sensitive labels on each button, which is blank when inactive until applicable.			

Figure 8 illustrates the T200U Internal Layout (Manual Section 3.2.3, p. 39). A photograph of the internal layout is given in Figure 9. The internal layout of the bypass box is shown in Figure 10. Figure 11 provides an illustration of the T200U pneumatic layout (Addendum Section 3.0, p. 13.

6.4.1 Instrument Display Screen

Figure 7 displayed the normal operating screen (Manual Figure 3-2, p. 34). Descriptions of the display components are listed in Table 1 (Manual Table 3-2, p. 3-5). Recommended method performance criteria, e.g., precision, bias, representativeness, completeness, comparability, MDL, LDL, linear range, and zero/span drift are discussed in NCore TAD, Section 4.3.1, pp. 8-14 of 50).

6.4.2 Instrument Components

Figure 8 gives an image of the T200U internal layout and major instrument components (Manual Figure 3-5, p. 39).

Figure 8 T200U Internal Chassis Layout

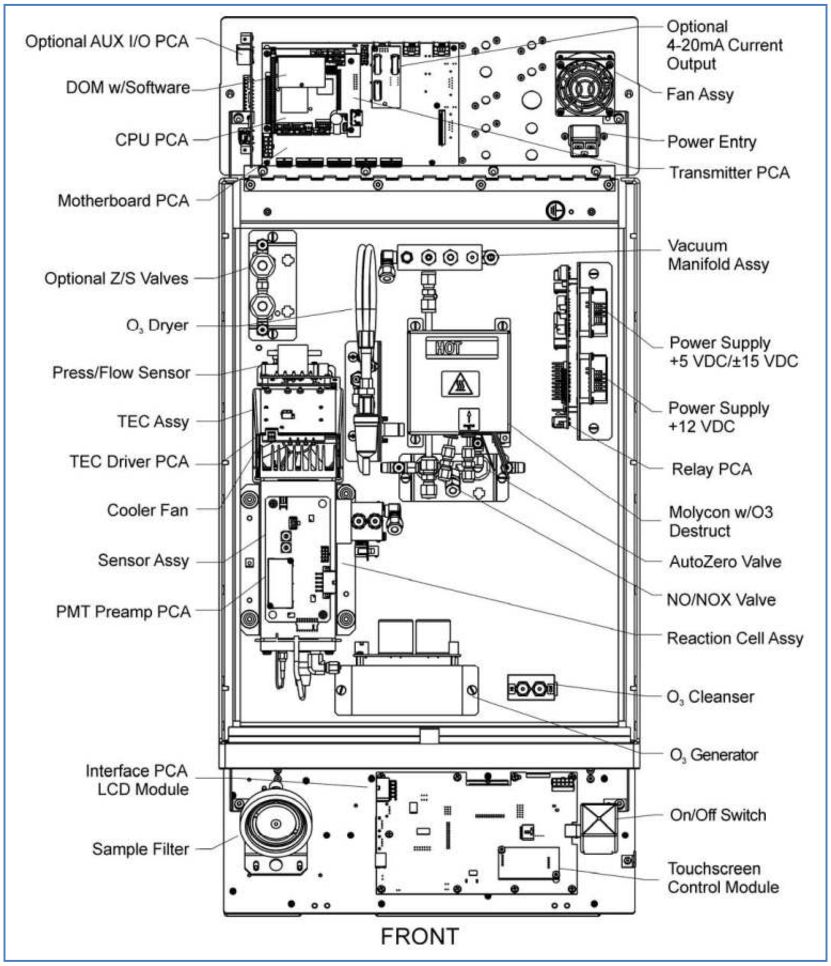


Figure 9 T200U Internal Layout

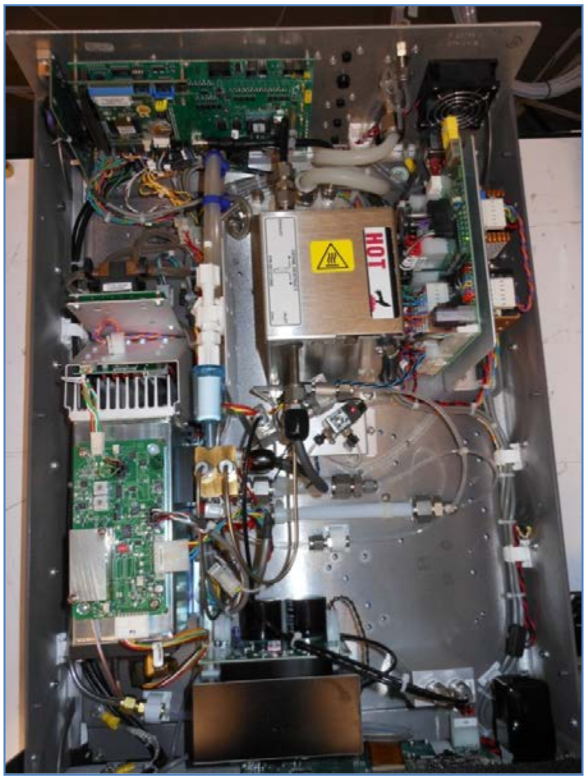


Figure 10 Bypass Box Internal Layout

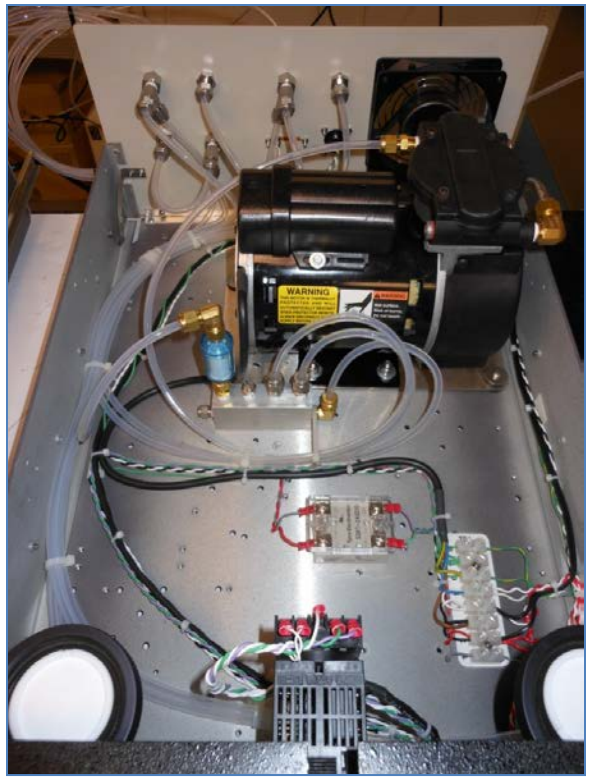
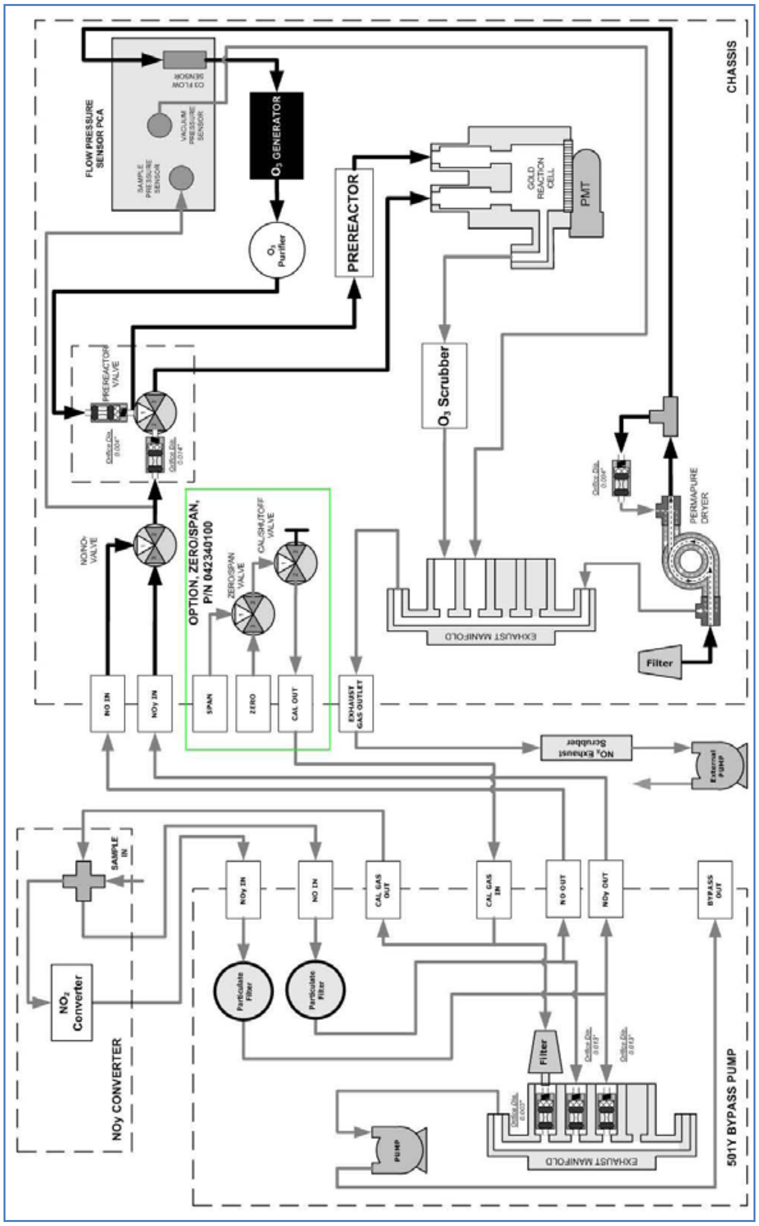


Figure 11 T200U Pneumatic Layout



6.4.3 Weekly Site Operator Activities

Weekly site operator activities are provided in Figure 12 (instrument suites may vary per site). They include:

- Leak checks
- Checking sample lines (moisture, dirt, and obstructions)
- Review of shelter temperature
- Review of operational settings and checks
- Site logbook entries

- Changing particulate filters
- Review of zero precision span (zps) results

Figure 12 Site Operator Trace Gas Checklist (Page 1 of 3)

Site Operator Trace Gas Checklist

- Record date, data logger time, site technicians present, and purpose of site visit in the site log book.
- Confirm that the analyzers are on. If not, contact AMEC.
- Are there any error messages on the analyzers? If so, record the messages on the Trace Gas Maintenance Forms and in site log book. Clear the messages and monitor the analyzer status. If an error message returns, contact AMEC immediately. If not, notify AMEC during call-in.
- Is the Gas Calibrator in Standby mode? If not, do not perform any maintenance or checks on the analyzers or equipment until it is in Standby mode.
- Complete Trace Gas Maintenance Forms 1 and 2. See Form 2 for analyzer filter change detail and schedule and for leak check procedure.
- Record any disturbance to the analyzers' sampling systems and the time of the disturbances in the site log book.
- If analyzer sampling system leak checks were performed, are leak checks within criteria? If not, contact AMEC for technical support.
- E-mail Trace Gas Maintenance Forms 1 and 2 to AMEC.
- Contact an AMEC Field Technician to report site visit findings and activities.
- Finish site log book documentation including site exit time.

Page 1 of 3

Figure 12 Site Operator Trace Gas Checklist (Page 2 of 3)

Site Operator Trace Gas Checklist

Note: Specific dates for changing particulate filters is found on the Trace Gas Maintenance Forms

Changing the external sample particulate filter every other week

- 'Down' all parameters on the affected tower and record the data logger time in the site logbook
- Lower the tower containing the external sample particulate filter
- Either remove or cap the CASTNET filter pack
- Unscrew the orange retaining ring. The green filter wrenches may be required
- Install new 5 µm PTFE 47 mm diameter filter and discard the used filter
- Reinstall the retaining ring and tighten 1/8 turn past hand tight using green filter wrenches

Changing the internal sample particulate filter once a month

- 'Down' the SO_2 channel and record the data logger time in the site logbook
- Turn off the analyzer to prevent particles from being drawn into the sample line
- Open the hinged front panel and unscrew the knurled retaining ring on the filter assembly
- Replace the filter element with a 1 µm PTFE 47 mm diameter filter
- Reinstall the PTFE O-ring with the notches facing up, otherwise sample flow will be restricted
- Replace the glass window and hand-tighten the retaining ring
- Restart the analyzer
- Repeat this procedure for the NO and NO_y filters inside the bypass box and for the CO filter on the back of the CO analyzer. Down the appropriate analyzer channel.

Page 2 of 3

Figure 12 Site Operator Trace Gas Checklist (Page 3 of 3)

Site Operator Trace Gas Checklist

Sampling system leak checks to be performed immediately after particulate filter change

Note: Specific criteria for leak checks are found on the Trace Gas Maintenance Forms

NO-NO_y

- With the analyzer's channel still down, cap the NO-NO_y sample inlet
- After 3 minutes, record the highest displayed pressure and flow over 30 second period in their appropriate boxes on the Trace Gas Maintenance Form 1
- Before the tower is raised make sure the cap is removed from the inlet
- Once the sampling system is returned to normal operation, 'Up' the channel and record the data logger time in the site logbook

SO_2

- With the analyzer's channel still down, remove the sample tubing from the back of the analyzer and cap the sample inlet port
- Once stable, record the displayed pressure and flow in their appropriate boxes on the Trace Gas Maintenance Form 1
- Remove the cap and reconnect the sample tubing to the back of the analyzer
- Leave the channel 'Down'

CO

- With the analyzer's channel still down, cap the CO/SO_2 sample inlet
- Once stable, record the displayed pressure and flow in their appropriate boxes on the Trace Gas Maintenance Form 1
- Before the tower is raised make sure the cap is removed from the inlet
- Once the sampling system is returned to normal operation, 'Up' the CO and SO_2 channel and record the data logger time in the site logbook

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6.4.4 Changing Particulate Filters

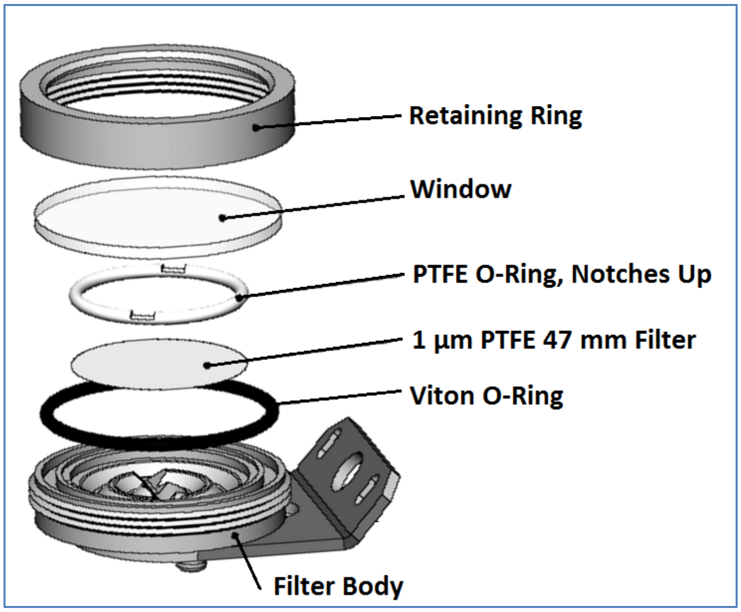
Change the external sample particulate filter every two weeks by completing the following steps:

- Using the data logger, ‘Down’ all parameters on the affected tower
- Lower the tower containing the external sample particulate filter
- Either remove or cap the CASTNET filter pack
- Unscrew the orange retaining ring. The green filter wrenches may be required
- Install new 5 µm, PTFE 47 mm diameter filter and discard the used filter
- Reinstall the retaining ring and tighten 1/8 turn past hand tight using green filter wrenches
- Perform a sample train leak check as described in Section 6.7 of this SOP

Change the internal sample particulate filter (Figure 13) monthly by completing the following steps (Manual Section 11.3.1, pp. 242-243)

- ‘Down’ the NO, NO_y, and NO_y diff channels
- Turn off the analyzer to prevent particulates from being drawn into the sample line
- Open the hinged front panel and unscrew the knurled retaining ring on the filter assembly
- Replace the filter element with a 1 µm, PTFE 47 mm diameter filter
- Reinstall the PTFE O-ring with the notches facing up, otherwise sample flow will be restricted
- Replace the glass window and hand-tighten the retaining ring
- Restart the analyzer
- Perform a vacuum leak check

Figure 13 Internal Sample Particulate Filter



6.5 Calibration

Audit the NO/NO_y monitoring system quarterly or if required for other reasons. A 4 to 5 hour warm-up period is recommended before any calibrations are performed. Calibrate the zero and span if the relative percent difference (RPD) for any point is > 5%. All points must be < 1% of best fit line or else recalibration or other maintenance and troubleshooting are required. Estimate precision based on the procedures in Section 6.2.

6.5.1 Calibrate Subsystems

Flow

Flow calibration is discussed in Manual Section 9.7, p. 218. Audit both channels before calibrating/adjusting either NO or NO_y flows.

Audit NO flow

Connect flow transfer standard to “NO In (1)” at the rear of the analyzer
→ SETUP → MORE → VARS → password “818” → NEXT until “MEASURE_MODE → EDIT → NO only → ENTR
Record flow transfer reading and analyzer SAMP flow reading

Audit NO_y flow

Connect flow transfer standard to “NO_y In (2) at the rear of the analyzer
→ SETUP → MORE → VARS → password “818” → NEXT until “MEASURE_MODE → EDIT → NO_y only → ENTR
Record flow transfer reading and the analyzer SAMP flow reading

Calibrate NO flow

Connect flow transfer standard to “NO In (1)” at the rear of the analyzer
→ SETUP → MORE → VARS → password “818” → NEXT until “MEASURE_MODE” → EDIT → NO only → ENTER → EXIT → DIAG → NEXT until “FLOW CALIBRATION” → ENTR → SAMP → Input the flow transfer average → ENTR

Calibrate NO_y flow

Connect flow transfer standard to “NO_y In (2)” at the rear of the analyzer
→ SETUP → MORE → VARS → password “818” → NEXT until “MEASURE_MODE” → EDIT → NOy only → ENTER → EXIT → DIAG → NEXT until “FLOW CALIBRATION” → ENTR → SAMP → Input the flow transfer average → ENTR

Optic Test

Follow the procedures in Manual Section 12.7.12.1, p. 301. See also Section 6.5.1 of SOP 100U.

Electrical Test
Follow the procedures in Manual Section 12.7.12.2, p. 301. See also Section 6.5.1 of SOP T100U.

Signal I/O
Follow the procedures in Manual Section 12.7.6.2, p. 287.

Return to VARS menu → NEXT until "MEASURE_MODE" → EDIT → NOY-NO → ENTR
Exit back to the main display

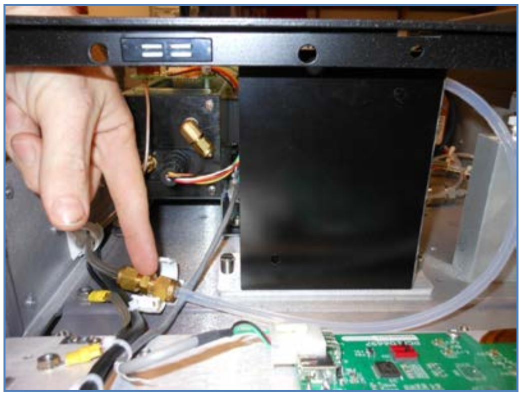
6.5.2 NO and NO_y Audits

NO audit
Connect the flow transfer to "NO In (1)"
→ SETUP → MORE → VARS → password "818" → NEXT until "MEASURE_MODE" → EDIT → NOY only → ENTR
Record flow transfer reading and the analyzer SAMP flow reading

NO_y audit
Connect the flow transfer to "NO_y In (2)"
→ SETUP → MORE → VARS → password "818" → NEXT until "MEASURE_MODE" → EDIT → NO only → ENTR
Record flow transfer reading and the analyzer SAMP flow reading

O_3 Generator Flow Audit
→ SETUP → MORE → DIAG → NEXT until "OZONE GEN OVERIDE" → ENTR → toggle to "OFF" → lower the front panel on the analyzer. Connect the flow transfer to the O_3 generator tubing at the union (Figure 14).
→ SETUP → MORE → DIAG → NEXT until "OZONE GEN OVERIDE" → ENTR → toggle to "ON" → EXIT to main screen → TEST to O_3 flow
Record the flow transfer reading and the analyzer O_3 flow reading
Return to "OZONE GEN OVERIDE" → Toggle to OFF → Disconnect flow transfer and reconnect O_3 generator union → Toggle to ON → EXIT to main screen

Figure 14 Union for Ozone Generator



O_3 Generator Flow Calibration
→ SETUP → MORE → DIAG → NEXT until “OZONE GEN OVERIDE” → ENTR → toggle to “OFF”

Lower the front panel on the analyzer. Connect the flow transfer to the O_3 generator tubing at the union (Figure 14).

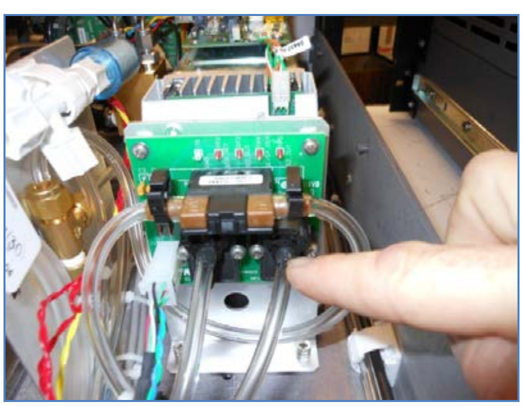
→ SETUP → MORE → DIAG → NEXT until “OZONE GEN OVERIDE” → ENTR → toggle to “ON” → EXIT → NEXT until “FLOW CALIBRATION” → ENTR → OZONE → Input average flow from flow transfer → ENTR

Return to “OZONE GEN OVERIDE” → Toggle to OFF → Disconnect flow transfer and reconnect O_3 generator union → Toggle to ON → EXIT to main screen

Pressure Audit
Disconnect the clear tubing (Figure 15) directly from the sample pressure sensor assembly

Connect the pressure transfer directly to the sample pressure sensor

Figure 15 Sample pressure transducer



SAMPLE → TEST → PRES
Record the ambient pressure readings from both the pressure standard and the analyzer's sample pressure

Set the pressure transfer standard to vacuum using the + - knob.

Close the vent of the pressure transfer using the • ◦ knob.

Press "PUMP" on the pressure transfer until the pressure is lowered to approximately 5 inches mercury absolute (inHg-A).

Record the readings from both the pressure standard and the analyzer's pressure sensor

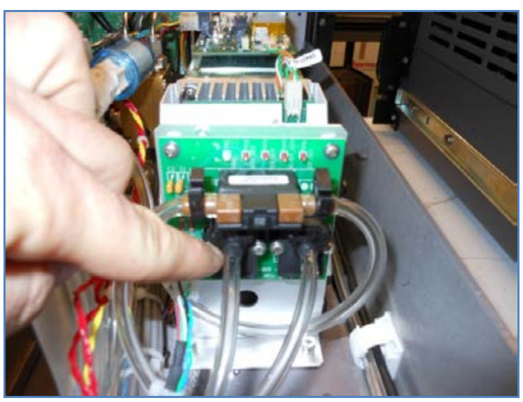
Slowly open the pressure transfer vent (the • ◦ knob) to adjust the pressure to approximately 15 inHg-A.

Record the readings from both the pressure standard and the analyzer's pressure standard. Disconnect the pressure transfer from the pressure sensor and reconnect the analyzer's tubing to the pressure sensor.

Calibrate pressure sensor if absolute difference of any reading is greater than 0.5 inHg-A. It is recommended to perform a leak check whenever any pneumatic connection is altered

Reaction Cell/Vacuum Pressure Sensor Audit
Repeat procedure for the reaction cell/vacuum pressure sensor (Figure 16). The reaction cell/vacuum pressure is listed as RCELL on the analyzer. Audit the reaction cell pressure sensor audit in the same manner as the sample pressure. The analyzer's external sample pump must be disconnected from the power supply to complete the audit.

Figure 16 RCELL pressure transducer



Pressure Calibration

Turn off instrument sample pump by disconnecting the pump power connector from the power supply.

→ SETUP → MORE → DIAG → password “929” → NEXT until “PRESSURE CALIBRATION” → ENTR → Input pressure transfer value for ambient pressure → ENTR

The T200U pressure calibration procedure calibrates both the sample pressure sensor and the reaction cell/vacuum pressure assembly simultaneously to ambient pressure. It is recommended to perform post calibration pressure audits to confirm proper calibration.

NO/NO_y Audit

Perform multi-point NO/NO_y audit using a Teledyne T700U gas calibrator or equivalent to produce concentrations of calibration gas. Calibration gases supplied to the T700U must be from a certified pressurized (28 to 32 psi) cylinder. Cylinders must be traceable to National Institute of Standards and Technology (NIST)-standard reference methods (SRM) and meet limits in traceability protocol for accuracy and stability (QA Handbook Section 12.1.2, pp. 3-6 of 11 and Manual Section 10.2, p. 221).

From the T700U

- Generate zero air and send to the sample inlet on the T200U
- Recommended flow rate supplied to T200U is 4.5 liters per minute (LPM) or greater
- Allow the concentration to stabilize until STABIL on the T200U reads less than 0.10
- Record 5 min concentration average and 5 minute expected concentration average
- Record the stability
- Repeat for each of the 5 levels below

Audit Level	Concentration, ppb
Level 1	90
Level 2	40
Level 3	15
Level 4	7.5
Level 5	4

If any point is greater than a RPD of 5%, then a zero/span calibration must be performed.

NO/NO_y Calibration

Record the analyzer’s original NO/NO_y slope and offset before calibration.

Zero Calibration
From T700U gas calibrator or equivalent, generate zero air at a flow of 4.5 LPM.

Allow the analyzer reading to stabilize; STABIL should be less than 0.1

→ CAL → ZERO → ENTR

Span Calibration
From the T700U gas calibrator or equivalent, generate span gas at a concentration of 90 ppb NO

Flow rate should be 4.5 LPM at a minimum

Allow the analyzer reading to stabilize; STABIL should be less than 0.1

→ CAL → SPAN → ENTR

If the SPAN option is not displayed while sampling 90 ppb NO/NO_y, then the span range concentration must be changed on the analyzer.

To change the span range on the analyzer

→ CAL → CONC → NO_y → Input the desired span concentration, 90 ppb → ENTR

ENTER returns to the CONC MENU, now choose NO → Input the desired span concentration, 90 ppb → ENTER → EXIT returns to the CAL menu, SPAN should now be present

Record the new NO and NO_y slopes and offsets

Perform a post calibration NO/NO_y multipoint audit to confirm proper calibration

Note: If either slope or offset is outside the accepted range, then the potentiometer settings on the photomultiplier (PMT) preamplification printed circuit assembly (PCA) (Figure 17) must be adjusted

Parameter	Accepted Value
NO Slope	1.0 ± 0.3
NO Offset	50 to 150
NOy Slope	1.0 ± 0.3
NOy Offset	50 to 150

Adjusting Potentiometer Settings

Before adjusting the coarse or fine pot adjustments on the preamp board, the NO and NO_y slopes and offsets should be returned to 1.0 and 0.0, respectively.

To manually change NO_y slope

→ SETUP → MORE → VARS → password “929” → NEXT until NOy_SLOPE, or JUMP to “56” → EDIT → Input 1.0 for NOy_SLOPE → ENTR, “ENTR” returns to VARS menu

To manually change NOy offset

→ SETUP → MORE → VARS → password “929” → NEXT until NOy_OFFSET, or JUMP to “57” → EDIT → Input 0.0 for NOy_OFFSET→ENTR, “ENTR” returns to VARS menu

To manually change NO slope

→ SETUP → MORE → VARS → password “929” → NEXT until NO_SLOPE, or JUMP to “58” → EDIT → Input 1.0 for NO_SLOPE → ENTR, “ENTR” returns to VARS menu

To manually change NO offset

→ SETUP → MORE → VARS → password “929” → NEXT until NO_OFFSET, or JUMP to “59” → EDIT → Input 0.0 for NO_OFFSET → ENTR, “ENTR” returns to VARS menu

From the T700U gas calibrator or equivalent, generate span gas at a concentration of 90 ppb NO

Flow rate should be 4.5LPM at a minimum

Allow the analyzer reading to stabilize; STABIL should be less than 0.1

Remove the cover on the T200U

Locate the fine (Figure 18) and coarse (Figure 19) adjustments on the PMT preamp PCA (Figure 17).

Figure 17 PMT Preamp PCA

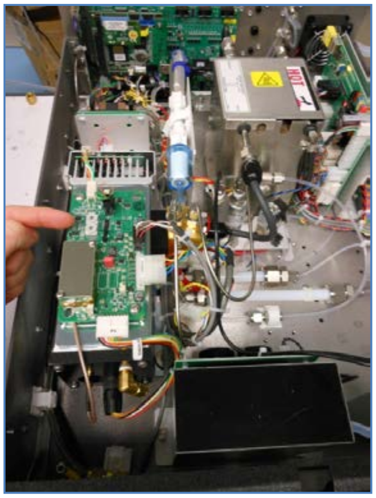


Figure 18 Fine Adjustment

Figure 19 Coarse Adjustment

Start with the fine adjustment. Using a small screw driver, turn the fine adjustment pot in increments of 1. With each adjustment allow the analyzer’s new reading to stabilize. Attempt to bring the analyzer’s readings as close as possible to the desired 90 ppb for NO and NO_y. Clockwise rotation will increase the analyzer’s reading. Counterclockwise rotation will decrease the analyzer’s reading. Do not leave the fine adjustment pot on the maximum settings.

If the fine adjustment pot is unable to bring the analyzer’s reading near the desired 90 ppb, then the coarse adjustment pot may need to be altered. The coarse adjustment can be made in the same manner as the fine adjustment. Clockwise rotation will raise the analyzer response, and counterclockwise will lower the analyzer response. After coarse adjustment, it is recommended to perform a fine adjustment.

After adjusting either of the fine or coarse adjustments, a NO/NO_y zero and span calibration should be performed.

GPT/GPTZ Audit

Gas Phase Titration (GPT) determines the amount of NO_2 generated by titration using the analyzer’s NO channel. The principle of the GPT is based on the rapid reaction that occurs between NO and O_3 to produce NO_2. With known NO and O_3 concentrations and known residence time, a known NO_2 concentration can be determined. The GPTZ is the same as GPT except the O_3 generator is off. The Teledyne gas calibrator model T700U is designed to perform a GPT/GPTZ.

From the T700U or equivalent gas calibrator perform a multi-point audit on the following points

Audit Level	GPT/GPTZ	NO ppb	O_3 ppb
Level 1	GPT	90	80
Level 2	GPTZ	90	0
Level 3	GPT	50	40
Level 4	GPTZ	50	0
Level 5	GPT	20	15
Level 6	GPTZ	20	0
Level 7	GPT	20	7
Level 8	GPTZ	20	0
Level 9	GPT	20	4
Level 10	GPTZ	20	0

Record the NO, NO_y, and resulting NO_2 concentrations.
Calculated NO_2 responses are obtained using the following equation

$$[NO_2]_{OUT} = [NO]_{ORIG} \quad - [NO]_{REM} \quad + \frac{F_{NO} * [NO_2]_{IMP}}{F}$$

[NO]ORIG= NO concentration analyzer response during the GPTZ
[NO]REM= NO concentration analyzer response during the GPT

Plot the NO_2 analyzer response concentration against the calculated NO_2 concentration. The plot should yield a straight line. All analyzer response concentrations should be within 2% of the best-fit line. If the plot does not yield a straight line, the converter should be inspected or replaced.

N-Propyl Nitrate (NPN) Audit
A multipoint NPN audit is required to determine the NO_y converter efficiency.

An NPN audit should not be performed on a “new” converter. Converters should be allowed to “burn in” for a period of up to 3 days before performing an NPN audit. The NPN standard cannot be certified to better than ±5%. Therefore, record the conversion over time and use 95% of the original efficiency as the performance cutoff (TAD Section 4.4.2, pp. 26-28 of 40).

For the purpose of NO_y monitoring, the conversion efficiency must be 95% or greater. Converters with efficiencies less than 95% should be replaced.

From the T700U gas calibrator or equivalent, generate NPN concentrations for the following points:

Audit Level	NPN ppb
Level 1	90
Level 2	40
Level 3	15
Level 4	7
Level 5	4
Zero	Zero

Record the analyzer response for NO, NO_y, and NO_2 at each audit level.

6.6 Maintenance, Repair and Troubleshooting

Complete the following checks, tests, and calculations in order to maintain the T200U system. Table 2 lists potential warning messages and their descriptions (Manual Table 3-12, p. 77).

Table 2 Warning Messages

MESSAGE	MEANING
SYSTEM RESET[1]	The computer has rebooted.
ANALOG CAL WARNING	The A/D or at least one D/A channel have not been calibrated.
BOX TEMP WARNING	The temperature inside the T200 chassis is outside the specified limits.
CANNOT DYN SPAN[2]	Contact closure span calibration failed while *DYN_SPAN* was set to *ON*.
CANNOT DYN ZERO[3]	Contact closure zero calibration failed while *DYN_ZERO* was set to *ON*.
CONFIG INITIALIZED	Configuration storage was reset to factory configuration or erased.
DATA INITIALIZED	DAS data storage was erased before the last power up occurred.
OZONE FLOW WARNING	Ozone gas flow is too high or too low for accurate NO_x, NO and NO_2 readings.
OZONE GEN OFF[4]	Ozone generator is off. This is the only warning message that automatically clears itself. It clears itself when the ozone generator is turned on. Upon power up the Ozone generator will remain off for 30 minutes. This allows the perma-pure dryer to reach its working dew point.

[1] Clears 45 minutes after power up.
[2] Clears the next time successful zero calibration is performed.
[3] Clears the next time successful span calibration is performed.
[4] Clears 30 minutes after power up.

MESSAGE	MEANING
RCELL PRESS WARN	Reaction cell pressure is too high or too low for accurate NO_x, NO and NO_2 readings.
RCELL TEMP WARNING	Reaction cell temperature is too high or too low for accurate NO_x, NO and NO_2 readings.
IZS TEMP WARNING[5]	IZS temperature is too high or too low for efficient O_3 production.
CONV TEMP WARNING	NO_2 to NO Converter temperature too high or too low to efficiently convert NO_2 to NO.
PMT TEMP WARNING	PMT temperature outside of warning limits specified by *PMT_SET* variable.
AZERO WARN *[XXXX]* MV	AutoZero reading too high. The value shown in message indicates auto-zero reading at time warning was displayed.
HVPS WARNING	High voltage power supply output is too high or too low for proper operation of the PMT.
REAR BOARD NOT DET	CPU unable to communicate with motherboard..
RELAY BOARD WARN	CPU is unable to communicate with the relay PCA.
SAMPLE FLOW WARN	The flow rate of the sample gas is outside the specified limits.

Table 3 lists available test functions and their descriptions (Manual Table 4.2, p. 89).

Table 3 Available Test Functions

DISPLAY	PARAMETER	UNITS	DESCRIPTION
RANGE	RANGE	PPB, PPM, UGM & MGM	The Full Scale limit at which the reporting range of the analyzer's ANALOG OUTPUTS is currently set. **THIS IS NOT** the Physical Range of the instrument. See Section 5.4.1 for more information.
RANGE1 RANGE2			If **AUTO** Range mode has been selected, two **RANGE** functions will appear, one for each range: • **RANGE1**: The range setting for all analog outputs. • **RANGE2**: The **HIGH** range setting for all analog outputs.
RANGE1 RANGE2 RANGE3			If the **IND** Range mode has been selected, three **RANGE** functions will appear, one for each range:

[5] Only Appears if the IZS option is installed.

DISPLAY	PARAMETER	UNITS	DESCRIPTION
			• **RANGE1**: NO_x concentration output on **A1**. • **RANGE2**: NO concentration output on **A2.** • **RANGE2**: NO_2 concentration output on **A3.**
NOX STB	STABILITY	PPB	The standard deviation of concentration readings of the selected gas. • Data points are recorded every ten seconds. The calculation uses the last 25 data points.
SAMP FLW	SAMPFLOW	CC/M	Gas flow rate of the sample gas into the reaction cell.
OZONE FL	OZONEFLOW	CC/M	Gas flow rate of O_3 gas into the reaction cell.
PMT	PMT	MV	The raw signal output of the PMT.
NORM PMT	NORMPMT	MV	The signal output of the PMT after is has been normalized for temperature, pressure, auto-zero offset, but not range.
AZERO	AUTOZERO	MV	The PMT signal with zero NO_x, which is usually slightly different from 0 V. This offset is subtracted from the PMT signal and adjusts for variations in the zero signal.
HVPS	HVPS	V	The output power level of the high voltage power supply.
RCELL TEMP	RCELLTEMP	C	The temperature of the gas inside the reaction cell temperature.
BOX TEMP	BOXTEMP	C	The temperature inside the analyzer chassis.
PMT TEMP	PMTTEMP	C	The temperature of the PMT .
IZS TEMP[1]	IZSTEMP	C	The temperature of the internal span gas generator's permeation tube.
MOLY TEMP	CONVTEMP	C	The temperature of the analyzer's NO_2 → NO converter.
RCEL	RCELLPRESS	IN-HG-A	The current pressure of the sample gas in the reaction cell as measured at the vacuum manifold.
SAMP	SAMPPRESS	IN-HG-A	The current pressure of the sample gas as it enters the reaction cell, measured between the NO/NO_x and Auto-Zero valves.
NOX SLOPE	NOXSLOPE		The slope calculated during the most recent NO_x zero/span calibration.

DISPLAY	PARAMETER	UNITS	DESCRIPTION
NOX OFFS	NOXOFFSET	MV	The offset calculated during the most recent NO_x zero/span calibration.
NO SLOPE	NOSLOPE		The slope calculated during the most recent NO

[1] Only appears if Internal Span Gas Generator option is installed.

DISPLAY	**PARAMETER**	**UNITS**	**DESCRIPTION**
			zero/span calibration.
NO OFFS	NOOFFSET	MV	The offset calculated during the most recent NO zero/span calibration.
DISPLAY	**PARAMETER**	**UNITS**	**DESCRIPTION**
TEST	TESTCHAN	MV	Displays the signal level of the Test Function that is currently being produced by the Analog Output Channel **A4**.
TIME	CLOCKTIME	HH:MM:SS	The current time. This is used to create a time stamp on DAS readings, and by the AutoCal feature to trigger calibration events.

Table 4 lists common warning messages (Manual Table 4.3, p. 91).

Table 4 Common Warning Messages

MESSAGE	**MEANING**
ANALOG CAL WARNING	The A/D or at least one D/A channel has not been calibrated.
AZERO WARN	Auto-zero reading above limit specified by *AZERO_LIMIT* variable. Value shown in message indicates auto-zero reading at time warning was displayed.
BOX TEMP WARNING	The temperature inside the T200 chassis is outside the specified limits.
CANNOT DYN SPAN	Contact closure span calibration failed while *DYN_SPAN* was set to *ON*.
CANNOT DYN ZERO	Contact closure zero calibration failed while *DYN_ZERO* was set to *ON*.
CONFIG INITIALIZED	Configuration storage was reset to factory configuration or erased.
CONV TEMP WARNING	NO_2^- → NO converter temperature outside of warning limits specified by *CONV_SET* variable.
DATA INITIALIZED	DAS data storage was erased before the last power up occurred.
HVPS WARNING	High voltage power supply output outside of warning limits specified by *HVPS_SET* variable.
IZS TEMP WARNING[1]	IZS temperature outside of warning limits specified by *IZS_SET* variable.
OZONE FLOW WARNING	Ozone flow outside of warning limits specified by *OFLOW_SET* variable.
OZONE GEN OFF	Ozone generator is off. This warning message clears itself when the ozone generator is turned on.
PMT TEMP WARNING	PMT temperature outside of warning limits specified by *PMT_SET* variable.

[1] Only Appears if the Internal Span Gas Generator option is installed.

MESSAGE	MEANING
RCELL PRESS WARN	Reaction cell pressure outside of warning limits specified by *RCELL_PRESS_SET* variable.
RCELL TEMP WARNING	Reaction cell temperature outside of warning limits specified by *RCELL_SET* variable.
REAR BOARD NOT DET	Motherboard was not detected during power up.
RELAY BOARD WARN	CPU is unable to communicate with the relay PCA.
SAMPLE FLOW WARN	The flow rate of the sample gas is outside the specified limits.
SYSTEM RESET	The computer has rebooted.

Table 5 provides the maintenance schedule (Addendum Table 6, p. 21).

Table 5 Maintenance Schedule

Item	Maintenance Interval
Zero/Span Calibration	Annually or after maintenance or repairs
Zero/Span Checks	Daily
Particulate Filter	Weekly as needed
Ozone Flow	Check every year and replace o-ring and orifice in reaction cell
Ozone Dryer Filter-DFU	Replace every year
Sample Flow	Check every 2 months
Converter	Check efficiency every 2 months
Pneumatic Lines	Check every 3 months
Factory Calibration	Calibrate each year or after repairs
Leak Check	Check every 6 months
Replace bypass flow orifices	Every year / as needed
Rebuild 501Y bypass pump	Every year (check part number on pump label)
Maintain air dryer	As needed
Replace particle filter	Weekly
Perform pneumatic system leak check	At least quarterly
Inspect internal, external tubing; replace if necessary	Inlet, weekly; other, quarterly
Clean optical bench	As needed
Monitor NO_2^- conversion efficiency	At least every 6 months
Monitor NPN conversion efficiency	At least every month

Table 6 provides the preventative maintenance schedule (Manual Table 11-1, p. 240).

Table 6 Preventative Maintenance Schedule

ITEM	ACTION	FREQ	CAL CHECK REQ'D
TEST functions	Review and evaluate	Weekly	No
Particulate filter	Change particle filter	Weekly	No

ITEM	ACTION	FREQ	CAL CHECK REQ'D
Zero/span check	Evaluate offset and slope	Weekly	No
Zero/span calibration	Zero and span calibration	Every 3 months	Yes
External zero air scrubber option	Exchange chemical	Every 3 months	No
External dryer option	Replace chemical	When indicator color changes	No
Ozone cleanser	Change chemical	Annually	Yes
Reaction cell window	Clean	Annually or as necessary	Yes
DFU filters	Change particle filter	Annually	No
Pneumatic sub-system	Check for leaks in gas flow paths	Annually or after repairs involving pneumatics	Yes if a leak is repaired
Reaction cell O-rings and sintered filters	Replace	Annually	Yes
PMT Sensor Hardware Calibration	Low-level hardware calibration	On PMT/preamp changes or if slope is outside of 1.0±0.3	Yes
Pump	Rebuild head	When RCELL pressure exceeds 10in-Hg	Yes
Inline Exhaust Scrubber	Replace	Annually	No
NO_2 converter	Replace Converter	Every 3 years or if conversion efficiency drops below 96%	Yes
Desiccant bags	Replace	Any time PMT housing is opened for maintenance	N/A

6.7 Leak Check and Other Tests

Complete the following checks and tests.

6.7.1 Sample Train Leak Check

- Cap the sample inlet located on the bottom of the converter
- Wait approximately 5 minutes and verify the SAMP and RCELL pressures are less than 4 in Hg-A for both NO and NO_y channels
  Sample → Test → SAMP
  Sample → Test → RCELL
- If the PRES is greater than 4 in Hg-A, there is most likely a pneumatic leak in the system

6.7.2 Leak Check Pressure

Follow the procedures in Manual Section 11.3.12.1, p. 258.

6.7.3 Checking for Light Leaks

Occasionally, especially after being re-assembled, the reaction chamber assembly can develop small leaks around the PMT, allowing stray light from the analyzer surroundings into the PMT housing (Manual 11.3.11, pp. 257-258).

- Generate zero air to the analyzer
- Shine a flashlight at the inlet and outlet fittings and at all the joints of the sample chamber as well as around the PMT housing.
- Monitor the PMT parameter to verify the reading does not respond to the light.
- Sample → Test → PMT
- If there is a PMT response to the external light, symmetrically tighten the sample chamber mounting screws or replace the 1/4" vacuum tubing with new, black PTFE tubing (this tubing will fade with time and become transparent). Often, light leaks are also caused by O-rings being left out of the assembly.
- If tubing was changed or fittings were separated, perform a leak check

6.7.4 Other Tests

Complete the following additional tests according to the referenced Manual sections.

- Changing the O_3 dryer particulate filter (Manual Section 11.3.2, pp. 243-244)
- Changing the O_3 cleanser chemical (Manual Section 11.3.3, pp. 244-246)
- Rebuilding the external sample pump (Manual Section 11.3.4, p. 247)
- Cleaning the reaction cell (Manual Section 11.3.9, pp. 254-255)
- Replacing the critical flow orifices (Manual 11.3.10, pp. 256-257)

6.8 Remote Communications

```
t list
T  188:12:17  0000  NO=0.789 NOY=2.379
T  188:12:17  0000  RANGE=100.0 PPB
T  188:12:17  0000  NOY STB=0.018 PPB
T  188:12:17  0000  SAMP FLW=1042 CC/M
T  188:12:17  0000  OZONE FL=84 CC/M
T  188:12:17  0000  PMT=5.9 MV
T  188:12:17  0000  NORM PMT=4.6 MV
T  188:12:17  0000  PREREACT=2.4 MV
T  188:12:17  0000  HVPS=559 V
T  188:12:17  0000  RCELL TEMP=40.0 C
T  188:12:17  0000  BOX TEMP=27.6 C
T  188:12:17  0000  PMT TEMP=5.4 C
T  188:12:17  0000  MF TEMP=40.0 C
T  188:12:17  0000  O3KL TEMP=199.6 C
T  188:12:17  0000  RCEL=2.6 IN-HG-A
T  188:12:17  0000  SAMP=27.6 IN-HG-A
T  188:12:17  0000  NOY SLOPE=1.059
T  188:12:17  0000  NOY OFFS=0.1 MV
T  188:12:17  0000  NO SLOPE=1.067
T  188:12:17  0000  NO OFFS=-0.0 MV
T  188:12:17  0000  TIME=12:17:45
t list names all
T  188:12:17  0000  NONOYCONC
T  188:12:17  0000  RANGE
T  188:12:17  0000  RANGE1
T  188:12:17  0000  RANGE2
T  188:12:17  0000  RANGE3
T  188:12:17  0000  STABILITY
T  188:12:17  0000  SAMPFLOW
T  188:12:17  0000  OZONEFLOW
T  188:12:17  0000  PMT
T  188:12:17  0000  NORMPMT
T  188:12:17  0000  PREREACT
T  188:12:17  0000  HVPS
T  188:12:17  0000  RCELLTEMP
T  188:12:17  0000  BOXTEMP
T  188:12:17  0000  PMTTEMP
T  188:12:17  0000  MANIFOLDTEMP
T  188:12:17  0000  CONVTEMP
T  188:12:17  0000  RCELLPRESS
T  188:12:17  0000  SAMPPRESS
T  188:12:17  0000  NOYSLOPE
T  188:12:17  0000  NOYOFFSET
T  188:12:17  0000  NOSLOPE
T  188:12:17  0000  NOOFFSET
T  188:12:17  0000  NO2
T  188:12:17  0000  NOY
T  188:12:17  0000  NO
T  188:12:17  0000  TESTCHAN
T  188:12:17  0000  XIN1
T  188:12:17  0000  XIN2
T  188:12:17  0000  XIN3
T  188:12:17  0000  XIN4
T  188:12:17  0000  XIN5
T  188:12:17  0000  XIN6
T  188:12:17  0000  XIN7
T  188:12:17  0000  XIN8
T  188:12:17  0000  CLOCKTIME
```

```
?
----------------------------------------------------------------------
|   T200U_NOY NOY Analyzer, Software Rev 1.0.3 bld 79, Help Screen   |
|--------------------------------------------------------------------|
| TERMINAL MODE KEYS                                                 |
|     BS      Backspace                                              |
|     ESC     Abort line                                             |
|     CR      Execute command                                        |
|     Ctrl-C  Switch to computer mode                                |
| COMPUTER MODE KEYS                                                 |
|     LF      Execute command                                        |
|     Ctrl-T  Switch to terminal mode                                |
| COMMMANDS                                                          |
|     ? | HELP [id]                        (Display this help screen) |
|     LOGON [id] password       (Establish connection to instrument) |
|     LOGOFF [id]               (Terminate connection to instrument) |
|     T [id] SET ALL|name|hexmask                     (Display tests) |
|     T [id] LIST [ALL|name|hexmask] [NAMES|HEX]        (Print tests) |
|     T [id] name                                 (Print single test) |
|     T [id] CLEAR ALL|name|hexmask                   (Disable tests) |
|     W [id] SET ALL|name|hexmask                  (Display warnings) |
|     W [id] LIST [ALL|name|hexmask] [NAMES|HEX]     (Print warnings) |
|     W [id] name                              (Clear single warning) |
|     W [id] CLEAR ALL|name|hexmask                  (Clear warnings) |
|     C [id] ZERO|SPAN [1|2]                 (Enter calibration mode) |
|     C [id] ASEQ number                (Execute automatic sequence) |
|     C [id] COMPUTE ZERO|SPAN             (Compute new slope/offset) |
|     C [id] EXIT                             (Exit calibration mode) |
|     C [id] ABORT                      (Abort calibration sequence) |
|     D [id] LIST ["pattern"]                     (Print I/O signals) |
|     D [id] name[=value]                  (Examine or set I/O signal) |
|     D [id] LIST NAMES        (Print names of all diagnostic tests) |
|     D [id] ENTER name                    (Execute diagnostic test) |
|     D [id] EXIT                             (Exit diagnostic test) |
|     D [id] RESET [DATA] [CONFIG] [exitcode]      (Reset instrument) |
|     D [id] PRINT ["name"] [SCRIPT]        (Print DAS configuration) |
|     D [id] RECORDS ["name"]    (Print number of DAS records stored) |
|     D [id] REPORT ["name"] [RECORDS=number] [FROM=<start date>]    |
|        [TO=<end date>] [VERBOSE|COMPACT|BASE64|HEX]                |
|        (date format: MM/DD/YYYY(or YY) [HH:MM:SS])                 |
|                                                 (Print DAS records) |
|     D [id] CANCEL                        (Halt printing DAS records) |
|     DASBEGIN [<data channel definitions>] DASEND (Upload DAS cfg.) |
|     CHANNELBEGIN propertylist CHANNELEND (Upload single DAS chan.) |
|     CHANNELDELETE ["name"]        (Delete one or more DAS channels) |
|     V [id] LIST ["pattern"]                (Print setup variables) |
|     V [id] name[=value [warn_low [warn_high]]]    (Modify variable) |
|     V [id] name="value"                (Modify enumerated variable) |
|     V [id] CONFIG                  (Print instrument configuration) |
|     V [id] MAINT ON|OFF              (Enter/exit maintenance mode) |
|     V [id] MODE                     (Print current instrument mode) |
|     V [id] CURR_TIME[=HH:MM]             (Print/set instrument time) |
|     V [id] CURR_DATE[=MM/DD/YYYY]        (Print/set instrument date) |
----------------------------------------------------------------------
```

7.0 REFERENCES

Teledyne Advanced Pollution Instrumentation (API). 2012. Manual Addendum. Ultra Sensitivity Model T200U NO/NO_2/NO_x. 06861B DCN6275.

Teledyne Advanced Pollution Instrumentation (API). 2012. Operation Manual. Model T200 Nitrogen Oxide Analyzer. 06858C DCN6213.

Teledyne Advanced Pollution Instrumentation (API). 2013. T200U–NO_y Analyzer. 07303C DCN6646.

U.S. Environmental Protection Agency (EPA). 2005. Technical Assistance Document for NCore Monitoring. Version 4. EPA-454/R-05-003.

U.S. Environmental Protection Agency (EPA). 2008. QA Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program, Appendix D. EPA-454/B-08-003.

8.0 ATTACHMENTS

This SOP does not contain attachments.

9.0 ABBREVIATIONS

CAL	calibration
COMM	communications
CONC	concentration
DIAG	diagnosis
ENTR	enter
GEN	generator
ID	identification
INET	internet
PMT	photomultiplier tube
PRES	pressure
RCELL	reaction cell
RNGE	range
SAMP	sample
SNGL	single
STABIL	stability
VARS	variables

MODEL T300U CARBON MONOXIDE (CO) ANALYZER STANDARD OPERATING PROCEDURE (SOP)

Effective Date: 7-7-16

Reviewed by: Kevin P. Mishoe, Field Operations Manager

Reviewed by: Marcus O. Stewart, QA Manager

Approved by: Holton K. Howell, Project Manager

TABLE OF CONTENTS

Annual Review			
Reviewed by:	Title:	Date:	Signature:

T300U SOP

1.0 PURPOSE

The purpose of this SOP is to provide consistent guidance for maintenance and handling of the Teledyne Advanced Pollution Instrumentation (API) Model T300U CO Analyzer. This SOP is designed to be used by the Clean Air Status and Trends Network (CASTNET) field calibration laboratory and field personnel.

2.0 SCOPE

This SOP applies to all CASTNET sites operating trace level Teledyne API T300U CO analyzers. The reader must also be familiar with the four documents listed in Section 7.0 (References) of this SOP. The documents include the EPA (2005) Technical Assistance Document (TAD) for National Core (NCore) Monitoring, the API T300U Operation Manual (Manual), the Addendum to the Manual, and EPA (2008) Quality Assurance (QA) Handbook for Air Pollution Measurement Systems, Volume II, Appendix D (QA Handbook). The various sections throughout this SOP cross-reference the four documents.

CASTNET is mandated to use trace gas instruments that are based on Federal Equivalent Methods. The following settings and operational parameters must be used to maintain equivalency:

- Concentration range 0.1 to 5.0 parts per million (ppm)
- Ambient Temperature 10 to 40 degrees Celsius (°C)
- 1 micrometer (µm) Teflon [polytetrafluoroethylene (PTFE)] filter in internal filler assembly (TAD Section 2.3.4.3, p. 20)
- Dynamic Span = OFF
- Temp/Pressure Compensation = ON

3.0 SUMMARY

Figure 1 shows the instruments, including API trace gas analyzers and standard CASTNET sensors, and communication system at a CASTNET site. Figure 2 provides validation criteria based on the tables in Appendix D of the QA Handbook (Volume II).

Figure 1 CASTNET Site Overview

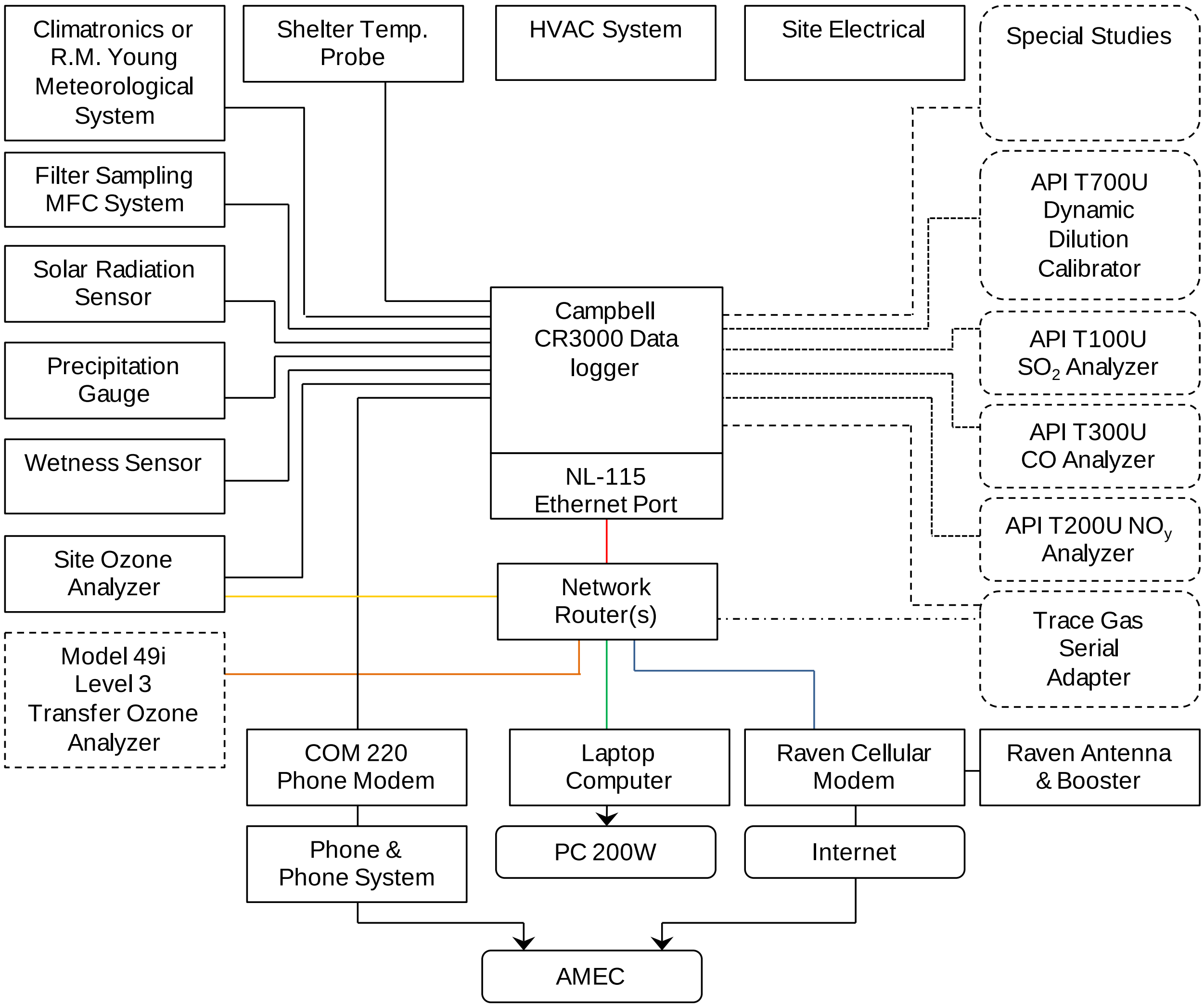


Figure 2 Critical and Operational Criteria for CO Measurements

Requirement	Frequency	Acceptance Criteria	Information /Action
		CRITICAL CRITERIA-CO	
One Point QC Check **Single analyzer**	1/ 2 weeks	≤ ± 10% (percent difference)	1-10 parts per million (ppm) Relative to routine concentrations 40 CFR Part 58 Appendix (App) A, Section (Sec) 3.2
Zero/span check	1/ 2 weeks	Zero drift ≤ ± 30 ppb Span drift ≤ ± 10 %	
		OPERATIONAL CRITERIA-CO	
Shelter Temperature			
Temperature range	**Daily** (hourly values)	10 to 40° C. (Hourly average)*	Generally the 10 to 40° C range will apply but the most restrictive operable range of the instruments in the shelter may also be used as guidance
Temperature Control	Daily (hourly values)	≤ ± 2° C standard deviation (SD) over 24 hours	
Temperature Device Check	2/year	± 2° C of standard	
Precision(using 1-point QC checks)	Calculated annually and as appropriate for design value estimates	90% CL CV ≤ 10%	90% Confidence Limit (CL) of Coefficient of Variation (CV). 40 CFR Part 58 App A, Sec 4.1.2
Bias (using 1-point QC checks)	Calculated annually and as appropriate for design value estimates	95% CL ≤ + 10%	95% Confidence Limit of absolute bias estimate; 40 CFR Part 58 App A, Sec 4.1.3
Annual Performance Evaluation			
Single analyzer	Every site 1/year 25 % of sites quarterly	Percent difference of each audit level ≤ 15%	3 consecutive audit concentration not including zero. 40 CFR Part 58 App A, Sec 3.2.2
Primary QA Organization (PQAO)	annually	95% of audit percent differences fall within the one point QC check 95% probability intervals at Primary QA Organization level of aggregation	40 CFR Part 58 App A, Sec 4.1.4
Federal Audits (NPAP)	1/year at selected sites 20% of sites audited	Mean absolute difference ≤ 15%	40 CFR Part 58 App A, Sec 2.4
State audits	1/year	State requirements	
Verification/Calibration	Upon receipt/adjustment/repair/installation/moving 1/6 months if manual zero/span performed biweekly 1/year if continuous zero/span performed daily	All points within ± 2% of full scale of best-fit straight line	Multi-point calibration (0 and 4 upscale points)
Gaseous Standards		Traceable to National Institute of Standards and Technology (NIST) (e.g., EPA Protocol Gas)	Vendor must participate in EPA Protocol Gas Verification Program 40 CFR Part 58 App A, Sec 2.6.1
Zero Air/Zero Air Check	1/year	Concentrations below lower detection limit (LDL)	
Requirement	**Frequency**	**Acceptance Criteria**	**Information /Action**
Gas Dilution Systems	1/3 months	Accuracy ± 2 %	
Detection			
Noise	NA	0.50 ppm	40 CFR Part 53.20
Lower detectable level	1/year	1.0 ppm	40 CFR Part 53.20
		SYSTEMATIC CRITERIA-CO	
Standard Reporting Units	All data	ppm [final units in EPA Air Quality System (AQS)]	
Completeness (seasonal)	Hourly	75% of hourly averages for the 8-hour period	8-Hour average
Sample Residence Times		< 20 seconds	
Sample Probe, Inlet, Sampling train		Borosilicate glass (e.g., Pyrex) or Teflon	40 CFR Part 58, App E
Siting		Un-obstructed probe inlet	40 CFR Part 58, App E

Notes: Guidance for the application of data flags is based on the validation template in Appendix D of volume II of the EPA Quality Assurance Handbook, Revision 1. No data adjustments will be made during routine procedures.
*As per EPA Automated Reference Method RFCA-1093-093.

4.0 MATERIALS AND SUPPLIES

Gas lines to/from analyzer should be Teflon PTFE, Teflon fluorinated ethylene propylene (FEP), glass, stainless steel or brass. Sample tubing is limited to PTFE or FEP (TAD Section 2.3.4.3, p. 20 of 33). The system utilizes a dynamic dilution gas calibrator such as T700U or equivalent with a compressed CO gas cylinder with between 50 ppm and 90 ppm. For cylinders stored in the field, a minimum of 300 pounds per square inch (psi) + 25 psi/month/additional analyzer is required if the same cylinder is used for quality control (QC) checks. For example, a blended cylinder of NO and CO supplying two analyzers should have at least 600 psi for the cylinder to be stored for 6 months.

The T300U system also requires

- 47 millimeter (mm), 5 µm Teflon inlet filter (used at sample inlet to extend life of inlet tubing)
- 47 mm, 1 µm Teflon inlet filter
- Zero air supply capable of at least 6 standard liters per minute (slpm) with a concentration lower than the lower detection limit (LDL) of CO
- Zero air source with greater than 5% molecular oxygen (O_2), such as API 701H, and with a dew point < -5ºC ± 2% (Manual Section 9.1.1.1, p.198).
- Assorted fittings and tools

5.0 SAFETY

The T100U is a heavy, high voltage instrument. With a weight of about 45 pounds with the pump, it is recommended that two people lift and carry the instrument. High voltages are present inside the instrument case. The power connection must have a functioning ground connection. The power must be off before disconnecting subassemblies. The instrument must not be operated with the cover off. CO is a poisonous gas. Consequently, the material safety data sheet (MSDS) for cylinder must be posted onsite.

The infrared (IR) source is a filament resistor and can become very hot. When troubleshooting, allow the instrument to cool. Avoid electrical contact with jewelry.

6.0 PROCEDURES

6.1 Set-up/ Installation

The first step is to unpack the analyzer from its shipping container and visually inspect the instrument for any damage. Then, identity loose fittings, screws, or items that may appear to be out of place. Loose fittings and screws should be tightened in place if practical and noted in the Remarks section of the specific iForm. The CASTNET Field Operations Manager (FOM) or his designee should be notified about any remaining loose pieces.

6.1.1 Remove Shipping Screws

Remove the two red shipping screws from the top of the sensor base before operating the instrument.

6.1.2 Ventilate Instrument

Before powering on the T100U, the instrument must be properly ventilated. Minimum ventilation clearances are as follows (Manual Section 3.3.1, p. 36):

- Back -- 4 inches
- Sides --1 inch
- Above and below -- 1 inch

6.1.3 Use Teflon Tubing and Fittings

Only FEP or PTFE tubing and fittings should be used for the T300U (TAD Section 3.3.4.3, p. 17 of 31). No stainless steel or brass fittings are allowed.

6.1.4 Implement Rear Panel Connections

Complete the following rear panel connections (Manual Section 3.2.2, pp. 41-42):

- Connect Ethernet cable to Ethernet port
- Connect sample tubing to sample port
- Connect exhaust tubing to exhaust port and direct tubing outside the shelter. Total exhaust tubing length should be less than 10 meters. (Manual Section 3.3.2, p. 64)
- Connect instrument power cord to alternating current (AC) power connector.

6.1.5 Verify Teflon Filter is Installed

Verify clean 47 mm 1 µm Teflon filter is installed inside internal filter assembly. If filter is visibly dirty or status is unknown, replace filter before operation. See SOP Section 6.7 for internal sample filter replacement procedure (TAD Section 3.3.4.3, p. 17 of 31).

6.1.6 Complete Start-up Procedures and Complete Leak Checks

Complete the following steps:

- Pump and exhaust fan should be turned on immediately and allowed a 2-hour warm up

- Check the instrument for vibration. When pumps get old, they sometimes will vibrate more than normally, causing cracks if the tubing is touching another surface. Verify the tubing inside the analyzer is not showing signs of wear (cracks or worn surfaces) or resting against another surface. Replace any damaged tubing. Rebuild or replace the pump if the vibration causes any other components in the analyzer to move.

- Perform leak checks as described in SOP Section 6.7.

6.2 Acceptance Testing

- Pre-calibration stabilization: allow the instrument to operate for more than 12 hours before calibrating (Addendum 3.5.1, p. 20) and performing initial acceptance testing.

- After stabilization is complete, manually initiate an auto-reference measurement by following the procedures in Addendum 6.4.2, pp. 38-39.

- Verify precision (also performed quarterly). Analyzer should have a 95% probability limit for precision of ± 15% or less (TAD Section 3.3.1.1, p. 5 of 31) based on Equations 1 and 2 in the TAD section.

- Verify bias (also performed quarterly). Analyzer should have an upper bound for average bias of ± 15% (TAD Section 3.3.1.2, p. 6 of 31)

- Calculate method detection limit (MDL) according to the procedure in 40 CFR 136 Appendix B. The MDL should be 80 parts per billion (ppb) or lower over an averaging time of no more than 5 minutes.

- Estimate LDL according to the procedure in 40 CFR 53.23 (c). The Addendum indicates the LDL is less than 20 ppb.

- Verify linear range is <1% full scale (Addendum p.11) or 20 ppb for concentrations below 1 ppm.
  Verify all points recorded during the multipoint audit are within 1% of full scale of the best fit straight line of about 1 ppm and within 20 ppb below 1 ppm.
  (**Note:** Using the standard operating range of 0-2 ppm, 1% of full scale is 20 ppb).

- Zero/span drift (TAD Section 2.3.1.9, pp. 12-13 of 33)
  Should be less than 100 ppb for 12- to 24-hour zero drift and less than 1% full scale for 24-hour span drift The Addendum indicates 24-hour zero drift should be less than 20 ppb; and 24-hour span drift <0.5% of reading or 20 ppb.

- Verify CO scrubber efficiency
  - Generate 1000 ppb CO
  - Activate the scrubber reference solenoid
    - Setup -> More -> Diag -> 818 password; Entr -> Signal I/O; Entr -> 29) ZERO_SCRUB_VALVE = ON
  - Do not exit the diagnostic menu. Doing so will turn off the scrubber solenoid.
  - Record a 5-minute CO concentration average from the data logger interface once the stability is less than 10 ppb. Scrubber Efficiency is defined as
    [1 – (Actual Concentration / Target Concentration)] * 100%

- Verify Test functions using Trace Gas Maintenance Forms 1 and 2 (Figures 6 and 7 in QAPP Appendix 11)

- Complete the following tests according to the cited Manual sections:
  - – Electrical test (Manual Section 5.9.4, p. 137),
  - o See Electrical Test in Section 6.5 of SOP
  - – Dark calibration (Manual Section 5.9.5, p. 137 and also Section 9.6.1, p. 219)
  - o See Dark Calibration in Section 6.5 of SOP
  - – Pressure calibration (Manual Section 5.9.6, p. 137 and also Section 9.6.2, p. 220)
  - o See Pressure Calibration in Section 6.5 of SOP
  - – Flow calibration (Manual Section 5.9.7, p.138 and also Section 9.6.3, p. 222)
  - o See Flow Calibration is Section 6.5 of SOP

6.3 Configuration

Complete the following steps to configure the T300U.

- Set clock to current date and time of day (standard time) (Manual Section 5.6, p. 111) The clock will automatically be set by the site data logger and only needs to be set manually if the instrument is to be operated independently.
  Setup → Clk → Time → (Set to current local standard time) → ENTR*
  Setup → Clk → Date → (Set to current date) → ENTR

*The T300U uses abbreviations to show parameters on its display screen. The abbreviations are defined in Section 9.0 of this SOP.

- Analog range configuration
  This step is not applicable for digital communications

- Range units (Addendum Section 6.3.6, p.35) = ppb
  Note: Changing units from Mass to Volume (e.g., μg/m^3 → ppb) requires a recalibration of the analyzer
  To check:
  Sample → Test → RNGE
  To change:
  Setup → Rnge → Unit → PPB ENTR

- Range concentration = 2000.0 (Addendum Section 6.3.3, p. 31)
  To check:
  Sample → Test → RNGE
  To Change:
  Setup → Rnge → Set → 02000.0 ENTR

- Range mode = Single (SNGL) (Addendum Section 6.3.3, pp. 31-32)
  To check:
  Setup → Rnge → Mode → RANGE MODE
  To Change:
  Setup → Rnge → Mode → SNGL

- Set Machine ID (Manual 5.7.1 pg 113)
  To check:
  Setup → More → Comm → ID
  To change:
  Setup → More → Comm → ID → (Set to desired value) → ENTR

- Set Ethernet settings (Manual Section 6.5.1, pg 149)
  Setup → More → Comm → Inet
  - ➔ DHCP = Off
  - ➔ INST IP = 192.168.0.48
  - ➔ GATEWAY IP = 192.168.0.1
  - ➔ SUBNET MASK = 255.255.255.0
  - ➔ TCP PORT 1 = 3000
  - ➔ TCP PORT 2 = 502

- Set alarm limits
  The alarm limits will be set according to the list of acceptable values in Figure 6 and 7 of QAPP Appendix 11.

- Adjust A-Ref mod cycle time (Addendum Section 6.4.1, pp. 37-38) = 4 hours
  The default Auto-Reference cycle time is four hours

- Verify DYN_ZERO + DYN_SPAN are OFF (Addendum Section 6.5, p.40)
  Setup → More → Vars → 818 password; Entr → 2) DYN_ZERO = OFF
  Setup → More → Vars → 818 password; Entr → 3) DYN_SPAN = OFF

- Set standard Temp to 25°C
  Setup → More → Vars → 929 password; Entr -> 32) STD_TEMP = 298.2K

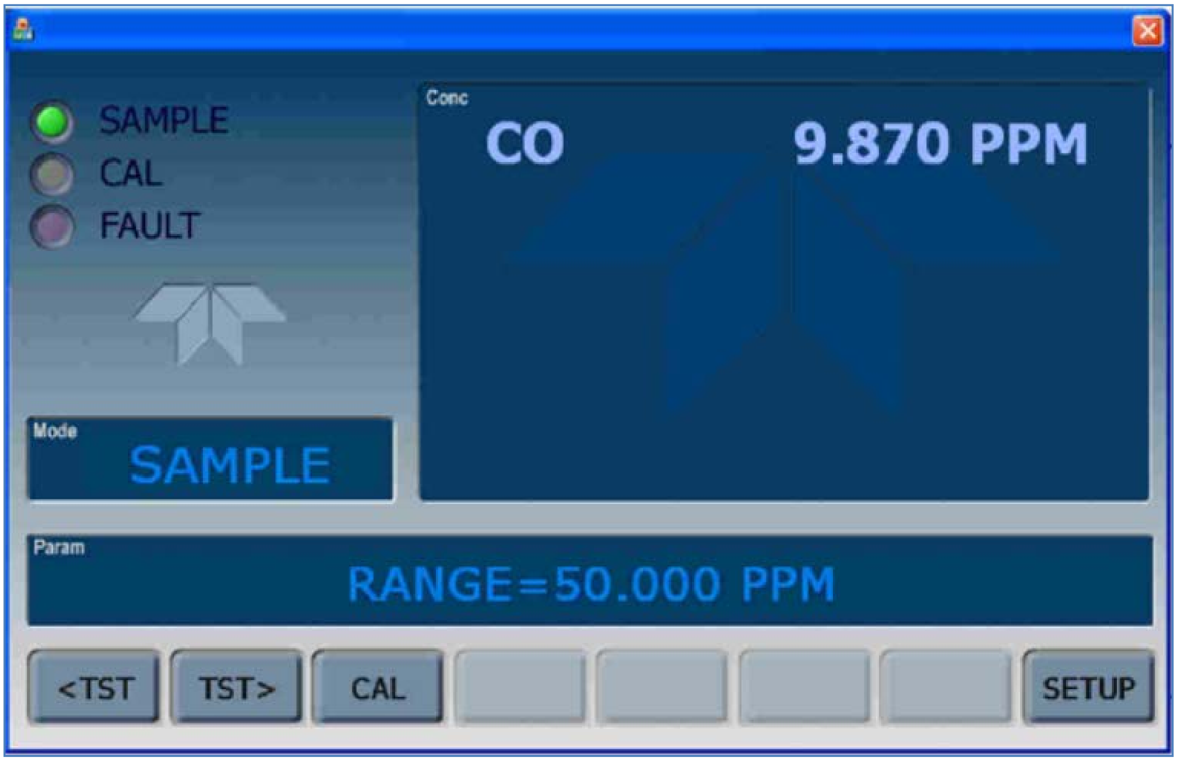
- Set standard pressure to 29.92 in Hg
  Setup -> More -> Vars -> 929 password; Entr -> 33) STD_PRESS = 29.92 inHg

6.4 Operation

6.4.1 Instrument Display Screen

Figure 3displays the normal operating screen (Manual Figure 3-2, pp. 38-39).

Figure 3 Normal Operating Screen



Descriptions of the various display components are listed in Table 1.

Table 1 Analyzer Display Functions

Field	Description/Function			
Status	LEDs indicating the states of Sample, Calibration and Fault, as follows:			
	Name	Color	State	Definition
	SAMPLE	Green	Off	Unit is not operating in Sample Mode, DAS is disabled.
			On	Sample Mode active; Front Panel Display being updated; DAS data being stored.
			Blinking	Unit is operating in Sample Mode, front panel display being updated, DAS hold-off mode is ON, DAS disabled
	CAL	Yellow	Off	Auto Cal disabled
			On	Auto Cal enabled
			Blinking	Unit is in calibration mode
	FAULT	Red	Off	No warnings exist
			Blinking	Warnings exist
Conc	Displays the actual concentration of the sample gas currently being measured by the analyzer in the currently selected units of measure			
Mode	Displays the name of the analyzer's current operating mode			
Param	Displays a variety of informational messages such as warning messages, operational data, test function values and response messages during interactive tasks.			
Control Buttons	Displays dynamic, context sensitive labels on each button, which is blank when inactive until applicable.			

Recommended method performance criteria, e.g., precision, bias, representativeness, completeness, comparability, MDL, LDL, linear range, and zero/span drift are discussed in the NCore TAD, Section 3.3.1, pp. 4-12.

6.4.2 Instrument Components

Figure 4 is an image of the T300U internal layout and major instrument components (Addendum Figure 3-1, p. 14).

Figure 4 T300U Internal Layout

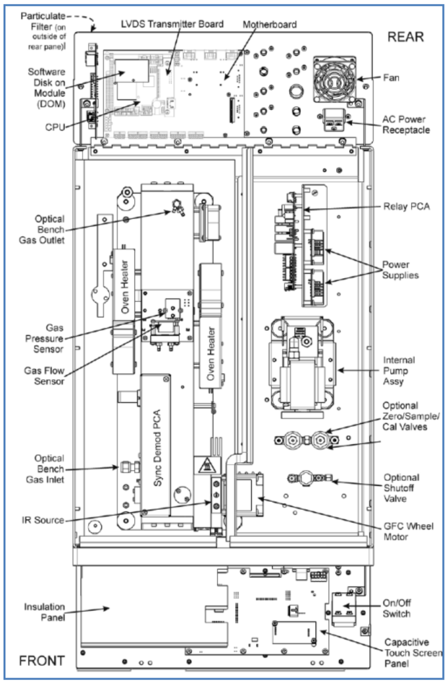
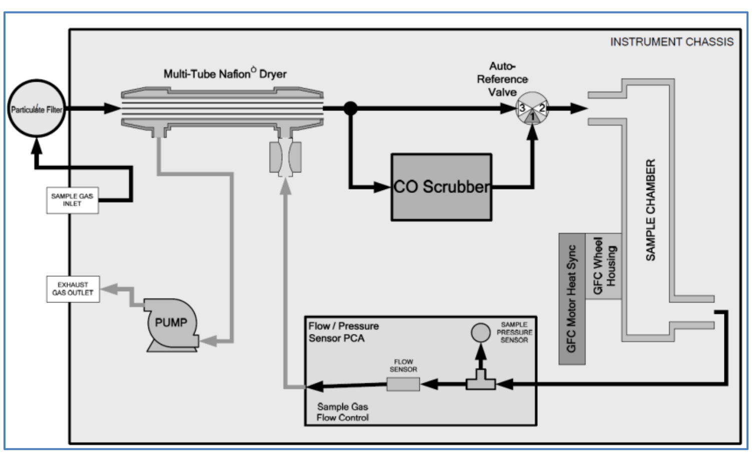


Figure 5 shows the pneumatic layout of the analyzer (Addendum Figure 3-2, p.15).

Figure 5 Pneumatic Layout



6.4.3 Weekly Site Operator Checks

Weekly site operator activities are provided in Figure 6 (instrument suites may vary per site). They include:

- Leak checks
- Checking sample lines (moisture, dirt, and obstructions)
- Site logbook entries
- Changing particulate filters
- Review of zero/precision/span (zps) results

Figure 6 Site Operator Trace Gas Checklist (Page 1 of 3)

Site Operator Trace Gas Checklist

- Record date, data logger time, site technicians present, and purpose of site visit in the site log book.
- Confirm that the analyzers are on. If not, contact AMEC.
- Are there any error messages on the analyzers? If so, record the messages on the Trace Gas Maintenance Forms and in site log book. Clear the messages and monitor the analyzer status. If an error message returns, contact AMEC immediately. If not, notify AMEC during call-in.
- Is the Gas Calibrator in Standby mode? If not, do not perform any maintenance or checks on the analyzers or equipment until it is in Standby mode.
- Complete Trace Gas Maintenance Forms 1 and 2. See Form 2 for analyzer filter change detail and schedule and for leak check procedure.
- Record any disturbance to the analyzers' sampling systems and the time of the disturbances in the site log book.
- If analyzer sampling system leak checks were performed, are leak checks within criteria? If not, contact AMEC for technical support.
- E-mail Trace Gas Maintenance Forms 1 and 2 to AMEC.
- Contact an AMEC Field Technician to report site visit findings and activities.
- Finish site log book documentation including site exit time.

Page 1 of 3

Figure 6 Site Operator Trace Gas Checklist (Page 2 of 3)

Site Operator Trace Gas Checklist

Note: Specific dates for changing particulate filters is found on the Trace Gas Maintenance Forms

Changing the external sample particulate filter every other week

- 'Down' all parameters on the affected tower and record the data logger time in the site logbook
- Lower the tower containing the external sample particulate filter
- Either remove or cap the CASTNET filter pack
- Unscrew the orange retaining ring. The green filter wrenches may be required
- Install new 5 µm PTFE 47 mm diameter filter and discard the used filter
- Reinstall the retaining ring and tighten 1/8 turn past hand tight using green filter wrenches

Changing the internal sample particulate filter once a month

- 'Down' the SO_2 channel and record the data logger time in the site logbook
- Turn off the analyzer to prevent particles from being drawn into the sample line
- Open the hinged front panel and unscrew the knurled retaining ring on the filter assembly
- Replace the filter element with a 1 µm PTFE 47 mm diameter filter
- Reinstall the PTFE O-ring with the notches facing up, otherwise sample flow will be restricted
- Replace the glass window and hand-tighten the retaining ring
- Restart the analyzer
- Repeat this procedure for the NO and NO_y filters inside the bypass box and for the CO filter on the back of the CO analyzer. Down the appropriate analyzer channel.

Page 2 of 3

Figure 6 Site Operator Trace Gas Checklist (Page 3 of 3)

Site Operator Trace Gas Checklist

Sampling system leak checks to be performed immediately after particulate filter change

Note: Specific criteria for leak checks are found on the Trace Gas Maintenance Forms

NO-NO_y

- With the analyzer's channel still down, cap the NO-NO_y sample inlet
- After 3 minutes, record the highest displayed pressure and flow over 30 second period in their appropriate boxes on the Trace Gas Maintenance Form 1
- Before the tower is raised make sure the cap is removed from the inlet
- Once the sampling system is returned to normal operation, 'Up' the channel and record the data logger time in the site logbook

SO_2

- With the analyzer's channel still down, remove the sample tubing from the back of the analyzer and cap the sample inlet port
- Once stable, record the displayed pressure and flow in their appropriate boxes on the Trace Gas Maintenance Form 1
- Remove the cap and reconnect the sample tubing to the back of the analyzer
- Leave the channel 'Down'

CO

- With the analyzer's channel still down, cap the CO/SO_2 sample inlet
- Once stable, record the displayed pressure and flow in their appropriate boxes on the Trace Gas Maintenance Form 1
- Before the tower is raised make sure the cap is removed from the inlet
- Once the sampling system is returned to normal operation, 'Up' the CO and SO_2 channel and record the data logger time in the site logbook

Page 3 of 3

6.4.4 Changing Particulate Filters

Changing the external sample particulate filter

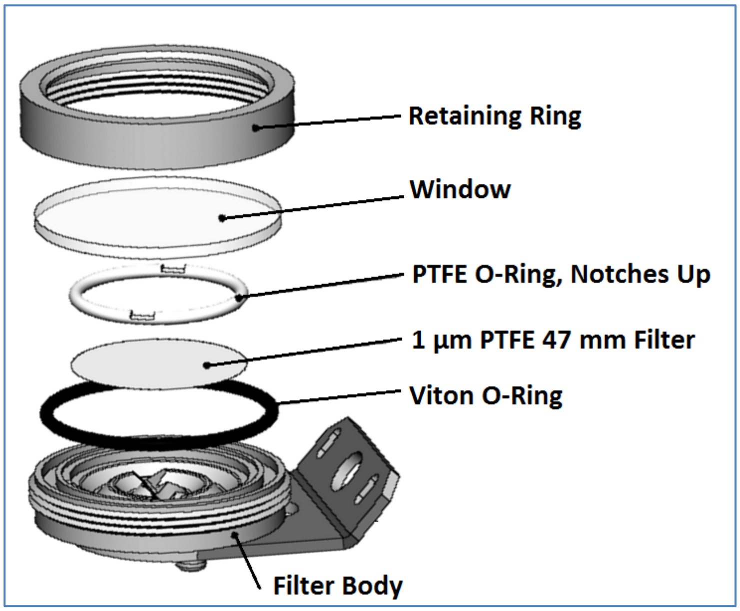
- Using the data logger, 'Down' all parameters on the affected tower
- Lower the tower containing the external sample particulate filter
- Either remove or cap the CASTNET filter pack
- Unscrew the orange retaining ring. The green filter wrenches may be required
- Install new 5 µm, PTFE 47 mm diameter filter and discard the used filter

- Reinstall the retaining ring and tighten 1/8 turn past hand tight using green filter wrenches
- Perform a sample train leak check as described in Section 6.7 of this SOP

Change the internal sample particulate filter (Figure 7) monthly by completing the following steps (Manual Section 11.3.1, p.250).

- 'Down' the CO channel
- Turn off the analyzer to prevent particulates from being drawn into the sample line
- Unscrew the knurled retaining ring on the filter assembly at the rear of the analyzer. The sample particulate filter on the T300U is external to the instrument so that the front panel does not have to be opened for maintenance, in order to avoid impacting the temperature stability
- Replace the filter element with a 1 µm, PTFE 47 mm diameter filter
- Reinstall the PTFE O-ring with the notches facing up, otherwise sample flow will be restricted
- Replace the glass window and hand-tighten the retaining ring
- Restart the analyzer
- Perform a vacuum leak check

Figure 7 Internal Sample Particulate Filter



6.5 T300U System Calibration

Audit system quarterly or as required for other reasons. Calibrate the zero and span if the relative percent difference (RPD) for any point is > 5%. All points must be < 1% of best fit line or recalibration or other maintenance or troubleshooting are required. Estimate precision based on the procedures in Section 6.2.

6.5.1 Calibrate subsystems

Pressure Calibration (Manual Section 9.6.2, pp. 220-221)

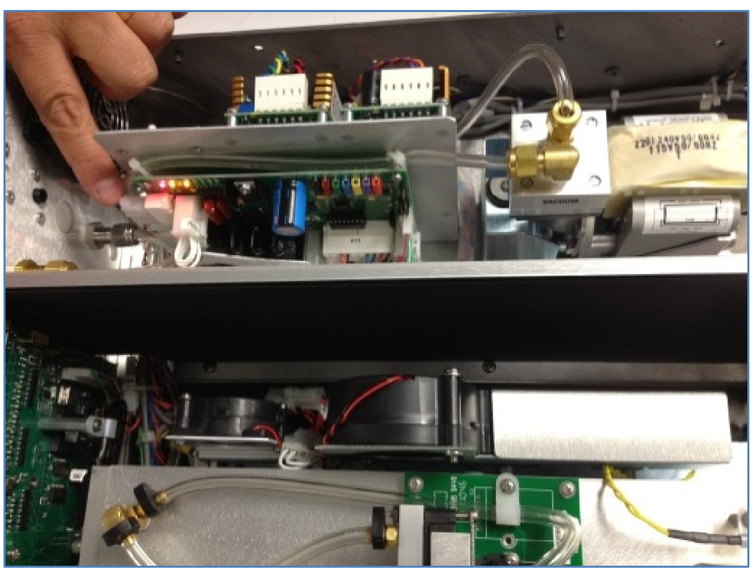
The sample pressure sensor is mounted next the flow sensor on top of the optical bench and is located pneumatically at the exit of the sample chamber. The measurement is used to compensate the raw detector reading when temperature and pressure compensation (TPC) is enabled.

Pressure Sensor Audit – Lab Procedure

- Disconnect the clear tubing from pressure sensor by loosening the back tubing clamp.
- Connect pressure transfer standard directly to pressure sensor
- Record ambient pressure readings from transfer and analyzer
- Sample -> Test -> PRES
- Ensure the transfer pump is set to vacuum using the + - knob
- Close the vent of the pressure transfer using the • ◦ knob
- Press PUMP button on transfer to lower pressure to approximately 5 inHg-A and record readings.
- Slowly open the pressure transfer vent to adjust the pressure to approximately 15 inHg-A and record readings
- Perform Pressure Calibration if error is greater than ± 0.2 inHg

Pressure Sensor Audit - Field Procedure

- Turn off instrument sample pump by disconnecting the pump power connector from the power supply board



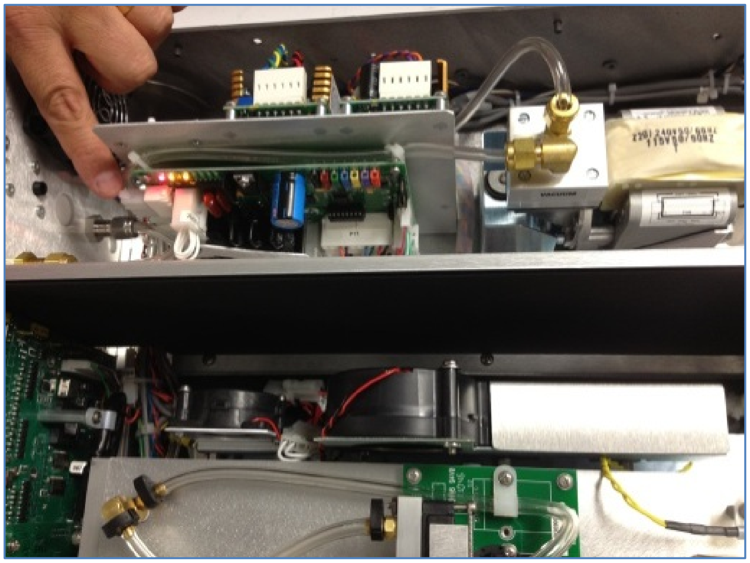
- Record ambient pressure readings from transfer and analyzer

  Sample -> PRES

- Calibrate pressure sensor if absolute difference is greater than 0.5 inHg

To Calibrate Pressure Sensor

- Turn off instrument sample pump by disconnecting the pump power connector from the power supply board



- Adjust pressure sensor measurement to transfer standard value at ambient pressure
  Setup → More → Diag → 818 password; Entr → Next…Pressure Calibration; Entr → CAL
  ENTR must be pressed to save calibration changes. Pressing EXIT will leave the calibration unchanged and return to the previous menu

Dark calibration (Manual Section 9.6.1, pp. 219-220)

The dark calibration test interrupts the signal path between the IR photo-detector and the rest of the synchronous demodulation circuitry. This allows the instrument to compensate for any voltage levels inherent in the circuitry that might affect the CO concentration.

- Record current dark calibration levels
  Setup → More → Diag → 818 password; Entr → Next… Dark Calibration → Entr → View → REF DARK OFFSET
  Exit → MEAS DARK OFFSET

  To calibrate dark offset:
- Initiate calibration and wait for 100% completion (approximately 2 minutes)
  Setup → More → Diag → 818 password; Entr → Next… Dark Calibration → Entr → CAL
- Record updated dark calibration levels
  Setup → More → Diag → 818 password; Entr → Next… Dark Calibration →

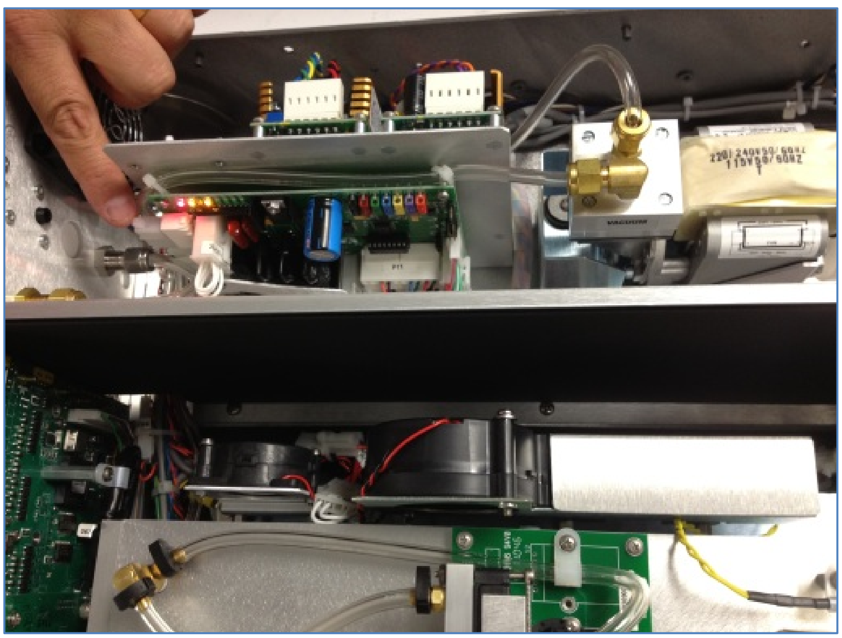
Entr → View → REF DARK OFFSET
Exit → MEAS DARK OFFSET

Temperature Calibration – NONE

Flow calibration (Manual Section 9.6.3, p.222)
The flow sensor is mounted next to the pressure sensor on top of the optical bench and is located pneumatically at the exit of the sample chamber. Calibrating the flow sensor reading does not change the hardware measurement, only the software calculated values.

To Audit Flow Sensor:

- Connect flow transfer standard to sample inlet at the rear of the analyzer
- Record flow transfer reading and analyzer reading at nominal flow
  Sample → Test… SAMP FL
- Turn off instrument sample pump by disconnecting the pump power connector from the power supply board



- Record flow transfer reading and analyzer reading at zero flow
- Calibrate flow sensor if error is greater than 5%

To Calibrate Flow Sensor:

- Adjust flow sensor measurement to transfer standard value at nominal flow
  Setup → More → Diag → 818 password; Entr → Next…Flow Calibration;
  Entr → CAL

ENTR must be pressed to saves calibration changes. Pressing EXIT will leave the calibration unchanged and return to the previous menu

Electrical Test (Manual Section 5.9.4, p.137)

The electric test function substitutes simulated signals for CO MEAS and CO REF, generated by circuitry on the synchronous/demodulation board, for the output of the IR photo-detector. When the test is running, the concentration reported on the front panel display should be 40.0 ppm.

- Initiate the electrical test from the diagnostic menu
  Setup → More → Diag → 929 password; Entr → Next…Electrical Test → ENTR
- Once the concentration has stabilized, press CAL → ENTR if the concentration is not 40 ppm ± 1 ppm

6.5.2 Multipoint Audit and Calibration

Calibrate zero (Addendum Section 7.0, pp.49-51)

The analyzer must be continually operating with an adequate flow of sample gas for 2 hours prior to performing a calibration (12 hours is recommended for the initial calibration).

- Generate zero air and send to the sample train inlet
- Allow the concentration to stabilize until the stability reading is less than 10 ppb
  - Calibrate Offset
  - Cal → Zero → ENTR
  - ENTR must be pressed to save calibration changes. Pressing EXIT will leave the calibration unchanged and return to the previous menu
  - If the 'Zero' option does not appear, the resulting calibration will be too extreme and there is most likely another problem.
- Verify the Offset is 0 ± 0.1
  Sample → Test → OFFSET

Calibrate span (Addendum Section 7.0, p.49-51)

The analyzer must be continually operating with an adequate flow of sample gas for 2 hours prior to performing a calibration (12 hours is recommended for the initial calibration).

- Generate Span gas at 80% of full scale (for a range of 0–2000 ppb, 80% of full scale is 1600 ppb)

Set CO Span Gas Concentration

- Sample → Cal → Conc → 1600.0 ENTR
- Allow the concentration to stabilize until the stability reading is less than 10 ppb
- Cal → Span → ENTR
- ENTR must be pressed to save calibration changes. Pressing EXIT will leave the calibration unchanged and return to the previous menu

- If the 'Span' option does not appear, the resulting calibration will be too extreme and there is most likely another problem.
- Verify the Slope is 1 ± 0.1
  Sample → Test → SLOPE

Perform Multipoint audit.

- Generate zero air and send to the sample train inlet
- Allow the concentration to stabilize until the stability reading is less than 10 ppb
- Record 5 min concentration average and 5 minute expected concentration average
- Record the stability and expected value stability from the site laptop display
- Repeat for each of the 5 levels below

Audit Level	Concentration, PPB
Level 1	1800
Level 2	800
Level 3	300
Level 4	150
Level 5	80

Note: The concentrations may be approximate if concentration targets are selected for CO.

6.6 Maintenance, Repair and Troubleshooting

Perform the appropriate checks, tests, and evaluations in order to maintain the T300U system.

Table 2 lists the potential warning messages and their description (Manual Table 12-1, pp. 257-258).

Table 2 Warning Messages

MESSAGE	MEANING
ANALOG CAL WARNING	The instrument's A/D circuitry or one of its analog outputs is not calibrated.
AZERO WARN 1.001	Auto-reference ratio below the specified limits.
BENCH TEMP WARNING	Optical bench temperature is outside the specified limits.
BOX TEMP2 WARNING	**The temperature inside the T300U chassis is outside the specified limits (Replaces BOX TEMP WARNING)**
CANNOT DYN SPAN	Remote span calibration failed while the dynamic span feature was set to turned on
CANNOT DYN ZERO	Remote zero calibration failed while the dynamic zero feature was set to turned on
CONFIG INITIALIZED	Configuration was reset to factory defaults or was erased.
DATA INITIALIZED	DAS data storage was erased.
OVEN TEMP WARNING	**The temperature of the insulated convection oven area of the analyzer is outside the specified limits.**
PHOTO TEMP WARNING	Photometer temperature outside of warning limits specified by PHOTO_TEMP_SET variable.
REAR BOARD NOT DET	The CPU is unable to communicate with the motherboard.
RELAY BOARD WARN	The firmware is unable to communicate with the relay board.
SAMPLE FLOW WARN	The flow rate of the sample gas is outside the specified limits.
SAMPLE PRESS WARN	Sample pressure outside of operational parameters.
SAMPLE TEMP WARN	The temperature of the sample gas is outside the specified limits.
SOURCE WARNING	The IR source may be faulty.
SYSTEM RESET	The computer was rebooted.
WHEEL TEMP WARNING	The Gas Filter Correlation wheel temperature is outside the specified limits.

Table 3 lists the available test function parameters and their descriptions (Manual Table 12-2, pp. 259-260).

Table 3 Test Function Parameters

TEST FUNCTIONS (As Displayed)	INDICATED FAILURE(S)
TIME	Time of day clock is too fast or slow To adjust, see Section 5.6 of the T300/T300M Operators Manual (P/N 06864). Battery in clock chip on CPU board may be dead.
RANGE	Incorrectly configured measurement range(s) could cause response problems with a Data logger or chart recorder attached to one of the analog output. If the Range selected is too small, the recording device will over range. If the Range is too big, the device will show minimal or no apparent change in readings.
STABIL	Indicates noise level of instrument or CO concentration of sample gas (See Section 12.4.2 of the T300/T300M Operators Manual for causes).
CO MEAS & CO REF	If the value displayed is too high the IR Source has become brighter. Adjust the variable gain potentiometer on the sync/demod board (See Section 12.5.7.1 of the T300/T300M Operators Manual) If the value displayed is too low or constantly changing and the **CO REF** is OK: ○ Failed multiplexer on the mother board ○ Failed sync/demod board ○ Loose connector or wiring on sync/demod board If the value displayed is too low or constantly changing and the **CO REF** is BAD: ○ GFC wheel stopped or rotation is too slow ○ Failed sync/demod board IR source ○ Failed IR source ○ Failed relay board ○ Failed I^2C bus ○ Failed IR photo-detector
MR RATIO	When the analyzer is sampling zero air and the ratio is too low: ○ The reference cell of the GFC wheel is contaminated or leaking. ○ The alignment between the GFC wheel and the segment sensor, the M/R sensor or both is incorrect. ○ Failed sync/demod board When the analyzer is sampling zero air and the ratio is too high: ○ Zero air is contaminated ○ Failed IR photo-detector
PRES	See Table 9-1 for **SAMPLE PRES WARN**
SAMPLE FL	Check for gas flow problems. (See Section 12.2 of the T300/T300M Operators Manual)
SAMPLE TEMP	SAMPLE TEMP should be close to BENCH TEMP. Temperatures outside of the specified range or oscillating temperatures are cause for concern
BENCH TEMP	Bench temp control improves instrument noise, stability and drift. Temperatures outside of the specified range or oscillating temperatures are cause for concern. See Table 9-1 for **BENCH TEMP WARNING**
WHEEL TEMP	Wheel temp control improves instrument noise, stability and drift. Outside of set point or oscillating temperatures are causes for concern. See Table 9-1 for **WHEEL TEMP WARNING**
BOX TEMP	If the **box** temperature is out of range: ○ Check the motherboard stabilization fan (see Figure 3-1). ○ See Table 9-1 for **BOX TEMP WARNING**.
OVEN TEMP	If the oven is temperature is out of range, check both of the oven heater fans in the power supply module. Areas to the side and rear of instrument should allow adequate ventilation. ○ Check the both of the oven fans (see Figure 3-1). ○ Check both of the oven heaters. See Table 9-1 for **OVEN TEMP WARNING.**
PHT DRIVE	If this drive voltage is out of range it may indicate one of several problems: - A poor mechanical connection between the various components in inside the detector housing - An electronic failure of the IR Photo-Detector's built-in cooling circuitry, or; - A temperature problem inside the analyzer chassis. In this case other temperature warnings would also be active such as **OVEN TEMP WARNING, BENCH TEMP WARNING** or **BOX TEMP WARNING**.
SLOPE	Values outside range indicate Contamination of the zero air or span gas supply Instrument is miscalibrated Blocked gas flow Contaminated or leaking GFC wheel (either chamber) Faulty IR photo-detector Faulty sample faulty IR photo-detector pressure sensor (P1) or circuitry Invalid M/R ratio (see above) Bad/incorrect span gas concentration due.
OFFSET	Values outside range indicate Contamination of the zero air supply Contaminated or leaking GFC wheel (either chamber) Faulty IR photo-detector

Table 4 provides the preventative maintenance schedule (TAD, Section 2.8, pp. 29-32 of 33)

Table 4 Preventative Maintenance Schedule

Maintenance Item	Schedule
Review test functions (Maintenance Sheet)	Weekly
Replace External Filter	Every two weeks
Replace Internal Filter	Monthly
Pneumatic system leak check	After every filter change
Inspect internal and external tubing; replace as necessary	Semi-annually
Rebuild or replace pump	As needed to correct leak check failure

Maintenance Item	Schedule
Clean Optical bench	As needed (performed in lab)
Replace critical flow orifice and sintered filters	As needed
Replace IR Source	As needed
Replace wheel motor	As needed
Replace gases in correlation wheel	As needed

Table 5 lists common problems and suggested causes and solutions.

Table 5 Common Problems and Suggested Causes and Solutions

Problem	Possible Cause	Possible Solution
Noisy Output	Defective DC power supply	Replace power supply
	Dirty optics	Clean optics bench
High positive zero drift	Defective bandpass filter	Replace filter
No or low response to span gas	IR source is defective	Replace IR source
	IR power supply is defective	Replace IR power supply
Differential Signal at Zero	IR source is defective	Replace IR source
	IR power supply is defective	Replace IR power supply
	CO leak from correlation wheel	Replace wheel
Zero output at ambient levels	IR source is defective	Replace IR source
	IR power supply is defective	Replace IR power supply
	Pump failure	Check pump
No or low flow	Pump failure	Replace/rebuild pump
Reference signal at zero	N_2 leak from correlation wheel	Replace wheel

6.7 Leak Checks

Sample Train Leak Check (Manual Section 11.3.3, pp. 251-252)

- Cap the inlet to the sample train, upstream of the particulate filter
- Wait approximately 5 minutes and verify the PRES is less than 10 inHg-A and the SAMP FL is less than 10 ccm

  Sample -> Test -> PRES

  Sample -> Test -> SAMP FL
- If the SAMP FL is greater than 10 ccm, there is a leak in the pneumatic system.
- If the PRES is greater than 10 inHg-A and the SAMP FL is less than 10 ccm, the sample pump needs either rebuilding or replacement

Internal analyzer leak check

- Cap the sample inlet on the rear of the analyzer

- Wait approximately 5 minutes and verify the PRES is less than 10 inHg-A and the SAMP FL is less than 10 ccm
  Sample -> Test -> PRES
  Sample -> Test -> SAMP FL
- If the SAMP FL is greater than 10 ccm, there is a leak in the pneumatic system.
- If the PRES is greater than 10 inHg-A and the SAMP FL is less than 10 ccm, the sample pump needs either rebuilding or replacement

Leak check - Thorough pressure check (Manual Section 11.3.3, pp. 251-252)

- Turn off the analyzer
- Open the analyzer and plug the inlet side of the sample pump
- Attach pressure transfer to sample inlet port and pressurize to 20 psia
- The leak rate should be less than 0.4 psi over 5 minutes

Rebuilding the sample pump (Manual Section 11.3.2, p.251)

- Rebuild the sample pump using the rebuild kit and instructions
- Perform flow rate check and vacuum check

6.8 Checking, Replacing IR Source

The expected life of the IR Source (Manual Section 12.5.7.5, p. 282) is 2 to 3 years.

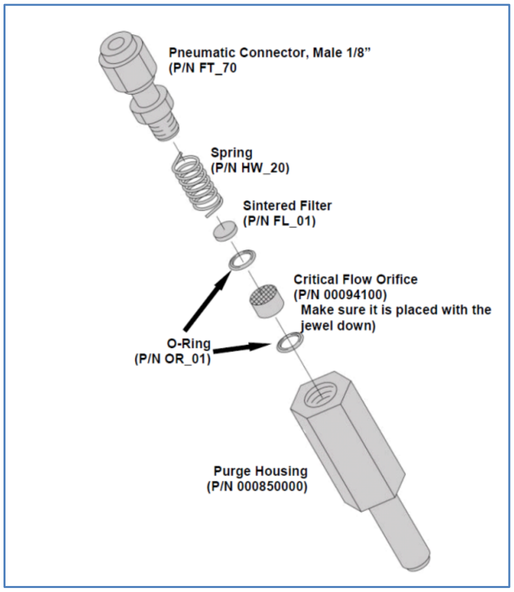
- Disconnect the source and check its resistance when cold.
  - When new, the source should have a cold resistance of more than 1.5 Ohms but less than 3.5 Ohms.
  - If not, then the source is bad.
- With the source disconnected, energize the analyzer and wait for it to start operating.
  - Measure the drive voltage between pins 1 and 2 on the jack to which the source is normally connected; the voltage should be 11.5 ± 0.25 volts direct current (VDC).
  - If not, then the problem is with the wiring, the relay board, or the +12 volt (V) power supply.
- If the drive voltage is correct as discussed above, then remove the source from the heat sink assembly (2 screws on top) and connect to its mating connector.
  - Observe the light being emitted from the source.
  - It should be centered at the bottom of the U-shaped element.
  - If there is either no emission or a badly centered emission, then the source is bad.

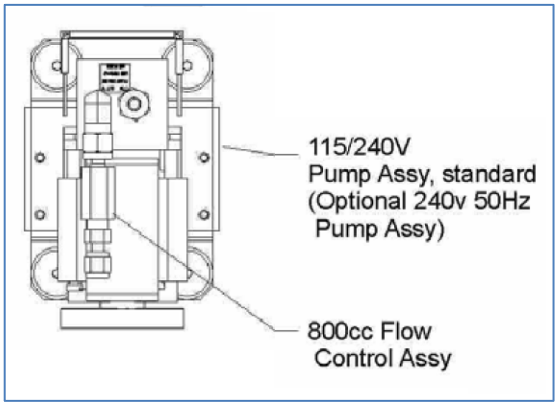
6.9 Cleaning/Replacing Critical Flow Orifices/Sintered Filter (Manual 12.6.1, p. 289)

The critical flow orifice is housed in the flow control assembly (Manual Section 12.6.1, p. 289) located on the top of the optical bench (Figure 6). A sintered filter protects the jewel orifice so it is unusual for the orifice to need replacing. The sintered filter and O-rings should be replaced periodically at a frequency specified in the maintenance schedule.

- Turn off power to the analyzer.
- Locate the flow control assembly attached to the sample pump.
- Disconnect the pneumatic connection from the flow assembly and the assembly from the pump.
- Remove the fitting and the components as shown in the exploded view below.
- Replace the O-rings and the sintered filter
- If replacing the critical flow orifice itself, ensure that the side with the colored window (usually red) is facing upstream to the flow gas flow.
- Apply new Teflon tape to the male connector threads.
- Re-assemble in reverse order.
- After reconnecting the power and pneumatic lines, flow check the instrument.

Figure 6 Critical Flow Restrictor Assembly/Disassembly





6.10 Remote Communications

The following screenshot displays the available commands accessible using the Ethernet connection.

```
?
----------------------------------------------------------------------
|     T300U2 CO Analyzer, Software Rev 1.0.3 bld 75, Help Screen     |
|--------------------------------------------------------------------|
| TERMINAL MODE KEYS                                                 |
|     BS      Backspace                                              |
|     ESC     Abort line                                             |
|     CR      Execute command                                        |
|     Ctrl-C  Switch to computer mode                                |
| COMPUTER MODE KEYS                                                 |
|     LF      Execute command                                        |
|     Ctrl-T  Switch to terminal mode                                |
| COMMMANDS                                                          |
|     ? | HELP [id]                       (Display this help screen) |
|     LOGON [id] password       (Establish connection to instrument) |
|     LOGOFF [id]               (Terminate connection to instrument) |
|     T [id] SET ALL|name|hexmask                     (Display tests) |
|     T [id] LIST [ALL|name|hexmask] [NAMES|HEX]        (Print tests) |
|     T [id] name                                 (Print single test) |
|     T [id] CLEAR ALL|name|hexmask                   (Disable tests) |
|     W [id] SET ALL|name|hexmask                  (Display warnings) |
|     W [id] LIST [ALL|name|hexmask] [NAMES|HEX]     (Print warnings) |
|     W [id] name                              (Clear single warning) |
|     W [id] CLEAR ALL|name|hexmask                  (Clear warnings) |
|     C [id] ZERO|SPAN [1|2]                  (Enter calibration mode) |
|     C [id] ASEQ number                  (Execute automatic sequence) |
|     C [id] COMPUTE ZERO|SPAN              (Compute new slope/offset) |
|     C [id] EXIT                              (Exit calibration mode) |
|     C [id] ABORT                        (Abort calibration sequence) |
|     D [id] LIST ["pattern"]                      (Print I/O signals) |
|     D [id] name[=value]                   (Examine or set I/O signal) |
|     D [id] LIST NAMES          (Print names of all diagnostic tests) |
|     D [id] ENTER name                      (Execute diagnostic test) |
|     D [id] EXIT                               (Exit diagnostic test) |
|     D [id] RESET [DATA] [CONFIG] [exitcode]       (Reset instrument) |
|     D [id] PRINT ["name"] [SCRIPT]         (Print DAS configuration) |
|     D [id] RECORDS ["name"]    (Print number of DAS records stored) |
|     D [id] REPORT ["name"] [RECORDS=number] [FROM=<start date>]     |
|       [TO=<end date>] [VERBOSE|COMPACT|BASE64|HEX]                 |
|       (date format: MM/DD/YYYY(or YY) [HH:MM:SS])                  |
|                                                (Print DAS records) |
|     D [id] CANCEL                       (Halt printing DAS records) |
|     DASBEGIN [<data channel definitions>] DASEND (Upload DAS cfg.) |
|     CHANNELBEGIN propertylist CHANNELEND (Upload single DAS chan.) |
|     CHANNELDELETE ["name"]        (Delete one or more DAS channels) |
|     V [id] LIST ["pattern"]                  (Print setup variables) |
|     V [id] name[=value [warn_low [warn_high]]]     (Modify variable) |
|     V [id] name="value"               (Modify enumerated variable) |
|     V [id] CONFIG                    (Print instrument configuration) |
|     V [id] MAINT ON|OFF               (Enter/exit maintenance mode) |
|     V [id] MODE                       (Print current instrument mode) |
|     V [id] CURR_TIME[=HH:MM]               (Print/set instrument time) |
|     V [id] CURR_DATE[=MM/DD/YYYY]          (Print/set instrument date) |
----------------------------------------------------------------------
```

The following figure lists the test parameters available and the names used to query the test function values.

10.38.60.1 - PuTTY

```
t list
T  188:11:25  0000  RANGE=2000.0 PPB
T  188:11:25  0000  STABIL=2.597 PPB
T  188:11:25  0000  CO MEAS=4475.1 MV
T  188:11:25  0000  CO REF=3771.3 MV
T  188:11:25  0000  MR RATIO=1.176
T  188:11:25  0000  AZERO RATIO=1.197
T  188:11:25  0000  PRES=28.7 IN-HG-A
T  188:11:25  0000  SAMP FL=1832 CC/M
T  188:11:25  0000  BENCH TEMP=48.0 C
T  188:11:25  0000  WHEEL TEMP=62.0 C
T  188:11:25  0000  OVEN TEMP=46.0 C
T  188:11:25  0000  PHT DRIVE=2763.1 MV
T  188:11:25  0000  SLOPE=0.931
T  188:11:25  0000  OFFSET=-0.03101
T  188:11:25  0000  TIME=11:25:04
t list names all
T  188:11:25  0000  RANGE
T  188:11:25  0000  RANGE1
T  188:11:25  0000  RANGE2
T  188:11:25  0000  STABILITY
T  188:11:25  0000  COMEAS
T  188:11:25  0000  COREF
T  188:11:25  0000  MRRATIO
T  188:11:25  0000  AUTOZERO
T  188:11:25  0000  SAMPPRESS
T  188:11:25  0000  SAMPFLOW
T  188:11:25  0000  BENCHTEMP
T  188:11:25  0000  WHEELTEMP
T  188:11:25  0000  BOXTEMP
T  188:11:25  0000  OVENTEMP
T  188:11:25  0000  PHOTOTEMP
T  188:11:25  0000  COSLOPE
T  188:11:25  0000  COSLOPE1
T  188:11:25  0000  COSLOPE2
T  188:11:25  0000  COOFFSET
T  188:11:25  0000  COOFFSET1
T  188:11:25  0000  COOFFSET2
T  188:11:25  0000  CO
T  188:11:25  0000  TESTCHAN
T  188:11:25  0000  XIN1
T  188:11:25  0000  XIN2
T  188:11:25  0000  XIN3
T  188:11:25  0000  XIN4
T  188:11:25  0000  XIN5
T  188:11:25  0000  XIN6
T  188:11:25  0000  XIN7
T  188:11:25  0000  XIN8
T  188:11:25  0000  CLOCKTIME
```

7.0 REFERENCES

Teledyne Advanced Pollution Instrumentation (API). 2010. Manual Addendum to Model. T300U CO Analyzer with Auto-Reference. 06867 Rev A DCN5871.

Teledyne Advanced Pollution Instrumentation (API) Operation Manual. 2012. Model T300/T300M Carbon Monoxide Analyzer. 06864 DCN6314.

U.S. Environmental Protection Agency (EPA). 2005. Technical Assistance Document for NCore Monitoring. Version 4. EPA-454/R-05-003.

U.S. Environmental Protection Agency (EPA). 2008. QA Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program, Appendix D. EPA-454/B-08-003.

8.0 ATTACHMENTS

This SOP does not contain attachments.

9.0 ABBREVIATIONS

CAL	calibration
CO MEAS	measured CO level
CO REF	referenced CO level
COMM	communication
DIAG	diagnosis
DYN_ZERO	dynamic zero
DYN_SPAN	dynamic span
ENTR	enter
ID	identification
INET	internet
inHG-A	inches mercury absolute
MEAS	measured
PRES	pressure
REF	reference
RNGE	range
SAMP	sample
SNGL	single
STABIL	stability
STD_PRESS	standard pressure
STD TEMP	standard temperature
VARS	variables

MODEL T700U DYNAMIC DILUTION CALIBRATOR STANDARD OPERATING PROCEDURE (SOP)

Effective Date: 6-1-13

Reviewed by: Kevin P. Mishoe, Field Operations Manager

Reviewed by: Marcus O. Stewart, QA Manager

Approved by: Holton K. Howell, Project Manager

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Annual Review			
Reviewed by:	Title:	Date:	Signature:
MS	QA Mgr	10/30/14	[signature]
MS	QA Mgr	10/22/15	[signature]

T700U SOP

1.0 PURPOSE

The purpose of this SOP is to provide consistent guidance for maintenance and handling of the Teledyne Advanced Pollution Instrumentation (API) Model T700U Dynamic Dilution Calibrator. This SOP is designed to be used by the Clean Air Status and Trends Network (CASTNET) Field Calibration Laboratory personnel.

2.0 SCOPE

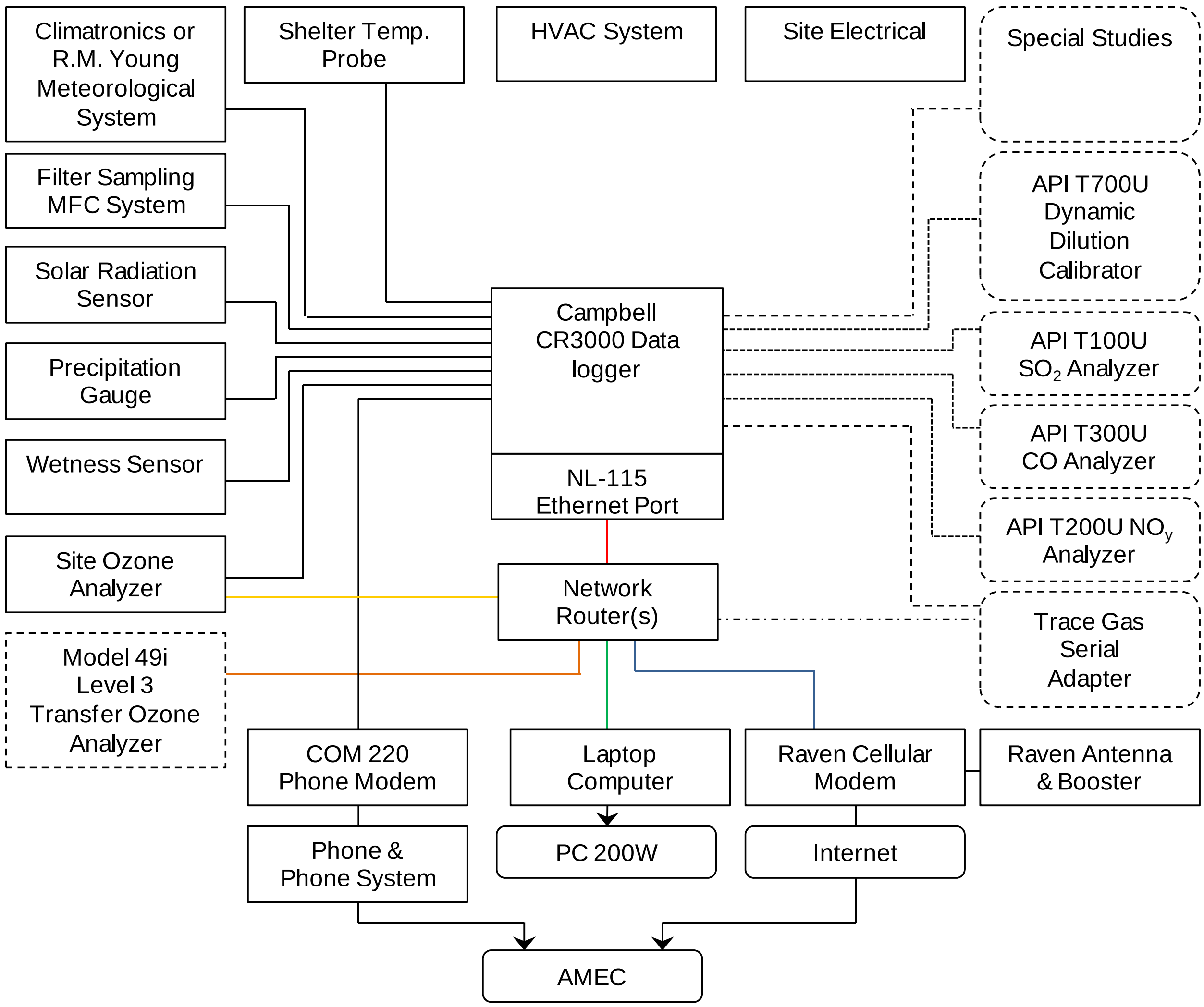
This SOP applies to all CASTNET sites using the Teledyne API Model 700U Dynamic Dilution Calibrator. The reader must also be familiar with six documents listed in Section 7.0 (References) of this SOP. The documents include the EPA (2005) Technical Assistance Document (TAD) for National Core (NCore) monitoring, the Transfer Standards for Calibration of Air Monitoring Analyzers for Ozone Technical Assistance Document (O_3 TAD), Title 40 Code of Federal Regulations Part 50 (40 CFR 50), the Technical Assistance Document for the Chemiluminescence Measurement of Nitrogen Dioxide (NO_2 TAD), the API T700U Operation Manual (Manual), and the Addendum to the Manual (Addendum). The various sections throughout this SOP cross-reference the documents.

The ozone photometer of the T700U can be certified as an ozone transfer standard if required. Most CASTNET sites do not use the T700U for this purpose, but the optional procedures are included in this SOP when needed.

3.0 SUMMARY

Figure 1 provides a flow chart that shows the instrument communication system at a CASTNET site. The instruments encompass the NCore trace gas analyzers, including the T700U dynamic gas calibrator, and the standard CASTNET sensors. The specifications for the T700U are given in Manual Table 2.1.

Figure 1 CASTNET Site Overview



4.0 MATERIALS AND SUPPLIES

The operation of the T700U gas calibrator requires the following materials and supplies:

- Teflon [fluorinated ethylene propylene (FEP) or polytetrafluoroethylene (PTFE)] is the recommended material for all components and lines throughout the calibration system, and all tubing and connections from the gas standard cylinders (TAD Section 5.3.1.1, p. 3 of 10).
- Appropriate National Institute of Standards Technology (NIST)-traceable gas blend cylinders for analyte being measured.
    - CO concentration range of 200 to 250 parts per million (ppm), certified to ± 2% (TAD Section 2.6.1, p. 25 of 33).
    - Sulfur dioxide (SO_2) concentration range of 10 to 20 ppm, certified to ± 2% (TAD Section 3.6.1, p. 23 of 31).
    - Nitric oxide (NO) concentration range of 5 to 20 ppm (with less than 1 ppm NO_2), certified to ± 2% (TAD Section 4.6.1, p. 30 of 40).
- NPN cylinder certified to ± 5% (TAD Section 4.6.1, p. 30 of 40)
- A Zero Air Generator capable of at least 1.1 liters per minute (lpm) continuous flow and meets the minimum specifications described in the 701H Zero Air Generator SOP
- Regulators: stainless steel regulators with internal diaphragms that are coated with Teflon® or other inert material should be used with all calibration and audit cylinders (TAD Section 5.3.1.1, p. 2 of 10).
- ¼” outer diameter (O.D.) FEP or PTFE Teflon tubing
- Assorted fittings and tools
- Flow meter traceable to NIST
- NIST-traceable pressure gauge with vacuum/pressure pump
- Level 2 ozone photometer for transfer standard certification (only required if the T700U is to be used as a site transfer standard for ozone)
- Documentation
    - Cylinder concentration certification
    - Cylinder MSDS
    - Flow meter transfer standard certification
    - Pressure gauge transfer standard certification
    - Level 2 ozone photometer certification (if used)

5.0 SAFETY

The T700U is a heavy, high voltage instrument. With a weight of about 40 lb with the options installed, it is recommended that two people lift and carry the instrument. High voltages are present inside the instrument case. The power connection must have a functioning ground connection. The power must be off before disconnecting subassemblies. The instrument must not be operated with the cover off. Exhaust must be vented outside the shelter. Exposure to the ultraviolet (UV) light could cause eye damage if the cover is off. The use of safety glasses with UV blocking material is mandatory in this situation.

6.0 PROCEDURE

6.1 Set-up/ Installation

Visually inspect the instrument for any damage. Be sure to look for loose fittings, screws, or items that may appear to be out of place. Loose fittings and screws should be tightened in place if practical and noted in the Remarks section of the specific iForm. The CASTNET Field Operations Manager (FOM) or his designee should be notified about any remaining loose pieces.

6.1.1 Ventilate Instrument

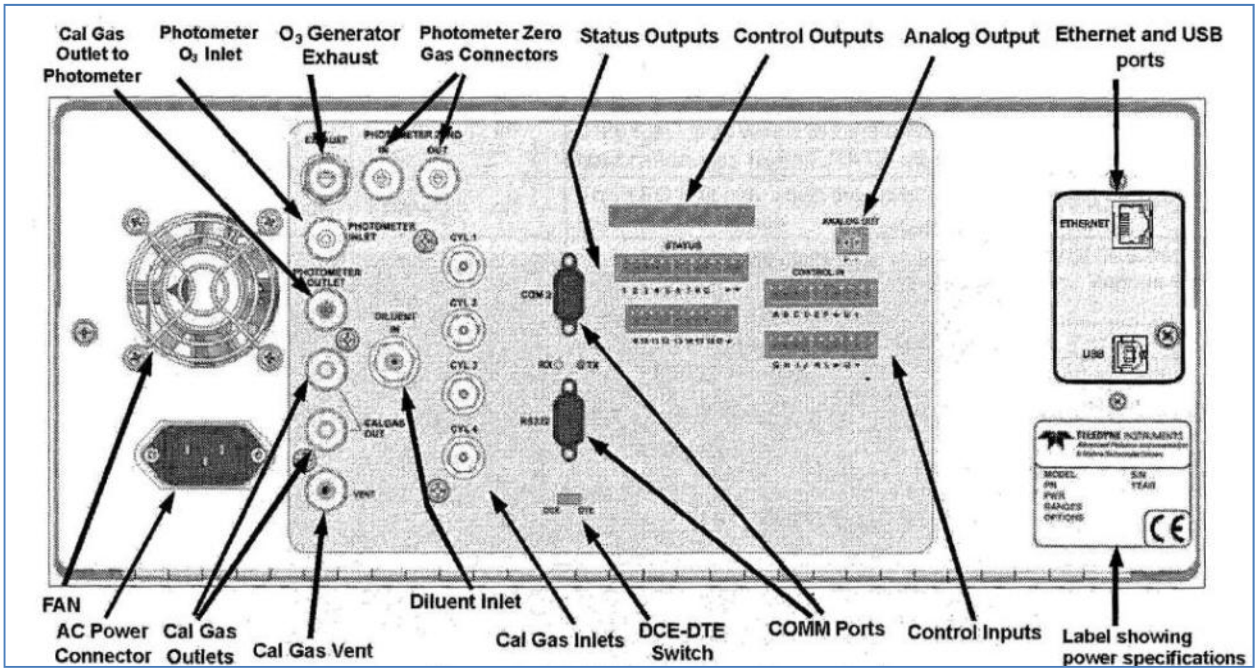
Before powering on the T700U, be sure that the instrument is properly ventilated. Minimum ventilation clearances are as follows (Manual Section 3.1, p. 28):

- Back – 10 cm/4 inches
- Sides – 2.5 cm/1 inch
- Above and below – 2.5 cm/1 inch

6.1.2 Implement Gas Cylinder Connections

Connect the two stage regulator to the gas cylinder and purge the regulator. See TAD Section 4.3.2, pp. 15-16 of 40 and TAD Section 5.3.1.1, p. 3 of 10 for regulator purge procedures. 1/4" FEP Teflon tubing will be used to connect the regulator to the T700U. Tools should not be used to loosen or tighten the main cylinder valve.

Figure 2 T700U Rear Panel



6.1.3 Implement Rear Panel Connections

Complete the following rear panel connections:

- With the power switch off, connect power cable to the alternating current (AC) power connector (Manual Section 3.1.3.1, p. 37)
- Connect Ethernet cable to Ethernet port (Manual Section 3.3.1.7, p. 47)
- Attach a zero air source to the port labeled diluent inlet (Figure 2). Zero air should be supplied at 25-35 pounds per square inch (psi).
- Using a stainless steel (SS) tee fitting and tubing, connect the DILUENT IN port to the CYL1 port (Figure 3). This connection will eliminate the need to move the zero air tubing during the Mass Flow Controller (MFC) calibration.

Figure 3 DILUENT IN and CYL1 Connection

- Connect the exhaust tubing to the EXHAUST port (Figure 3). The exhaust must be vented to atmospheric pressure with a maximum of 10 m of tubing (Manual Section 3.3.2.6, p. 67). In the lab, the loose end will be connected to a charcoal/Purafil mix canister. In the field, the loose end will be run outside the shelter.
- Connect OUTPUT A and OUTPUT B to the sample inlet or manifold of a gas analyzer. If a NO_y analyzer is used, it should be connected to OUTPUT B. If only one output port is used, the other must be capped. Output B [reactive oxides of nitrogen (NO_y)] cannot be used for ozone generation with photometer feedback (Manual Figure 3-28, p. 76). Ozone is highly destructive to the molybdenum NO_y converter.

- Connect gas cylinder regulator tubing to port CYL2, CYL3, or CYL4. Gas delivery pressure should be regulated between 30 PSI and 35 PSI. Any unused port must be capped. Note that if more than one cylinder containing the same gas is connected to the T700U, the T700U is programmed to automatically choose the first CYL# port which carries that particular gas.

6.1.4 Startup

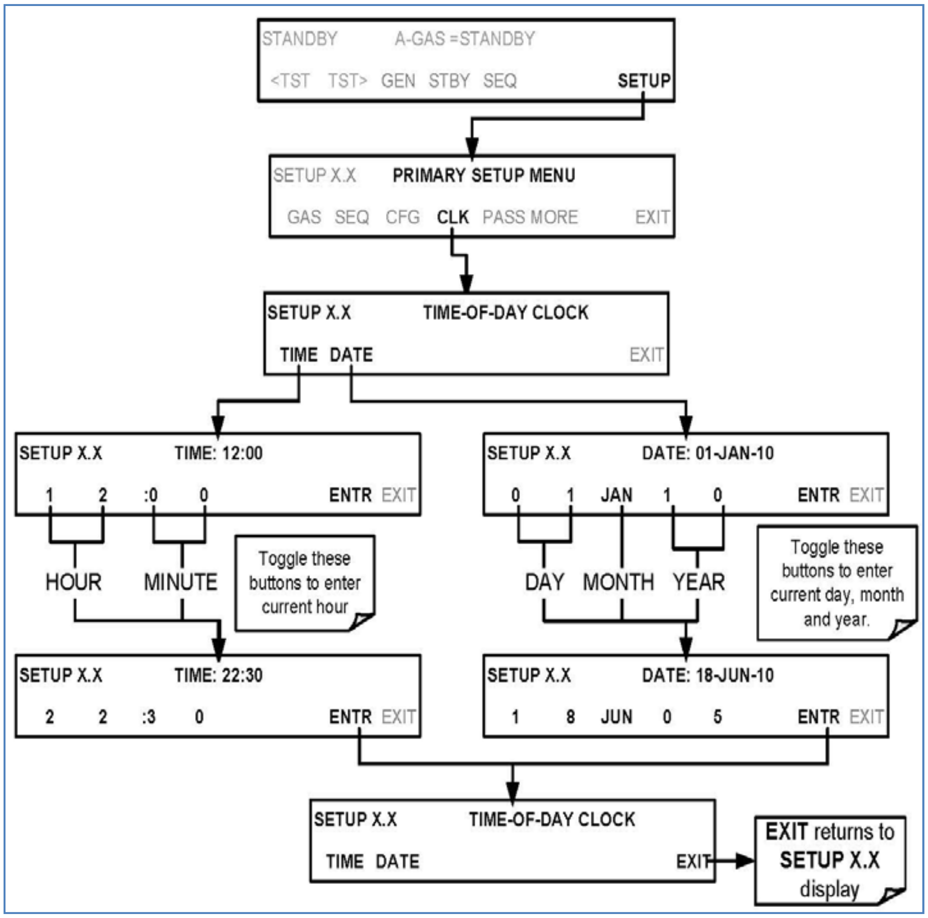
Complete the following steps:

- Power the T700U. The exhaust fan and photometer pump should start immediately and the instrument should automatically switch to STANDBY mode after boot-up (Manual Section 3.4.1, p. 77)
- Allow a minimum of 30 minutes of warm-up
- After warm-up, clear warning messages (Manual Section 3.4.2, p. 77). See Manual Table 3-16 for a list of possible warning messages.
- Check test functions using worksheet from Manual Appendix C.

6.2 Configuration

6.2.1 Set Clock

Set clock to current date and time of day (standard time) (Manual Section 4.5.1, p. 143). The clock will automatically be set by the site data logger and only needs to be set manually if the instrument is to be operated independently. Daylight saving time adjustment should be OFF. The abbreviations used in touch screen sequences are generally self-explanatory. See also Section 9.0 of the SOP.

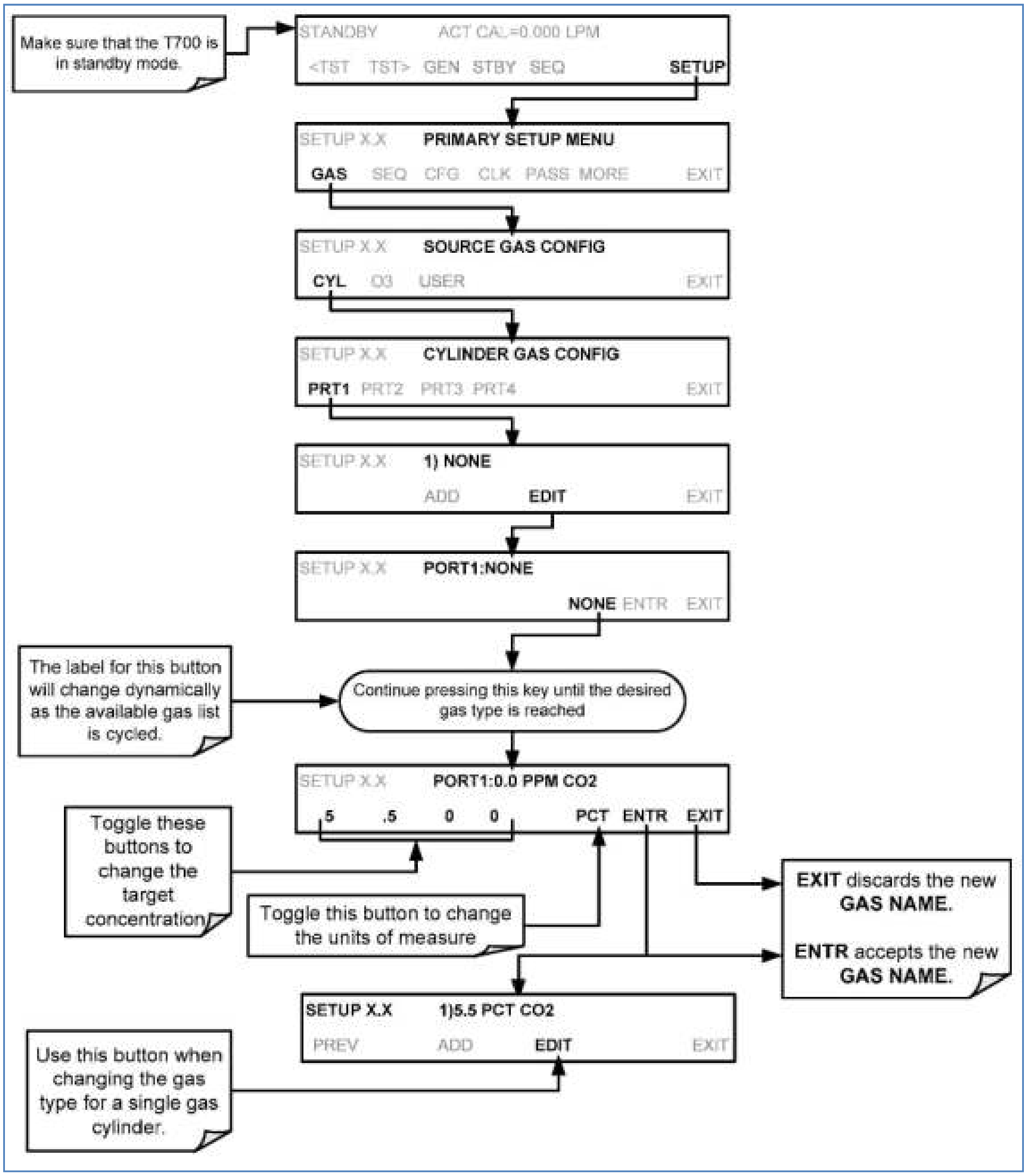


6.2.2 Set Calibration Gas Inlet Ports

Set the calibrator's input ports according to the instructions in the next three subsections.

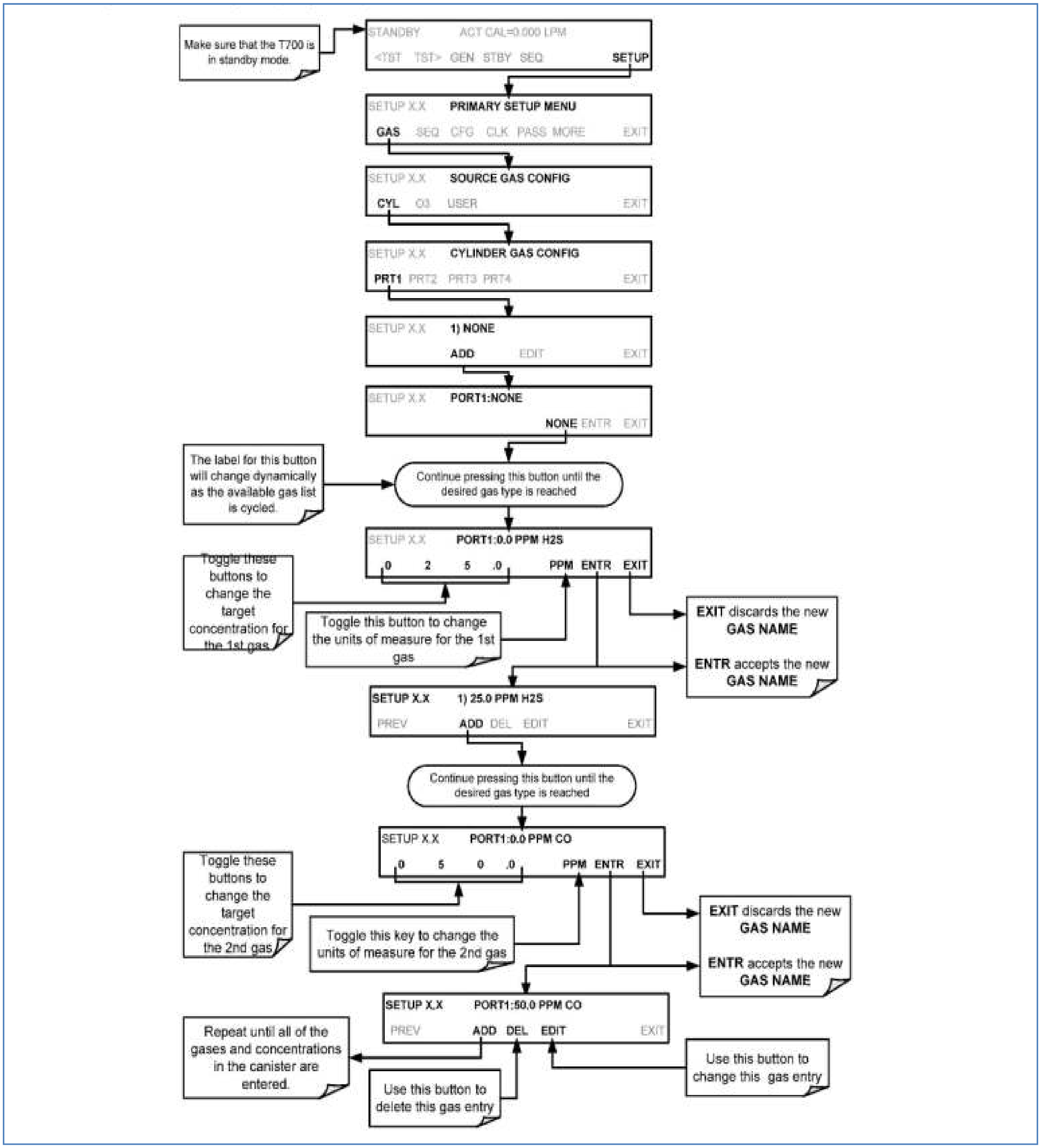
6.2.2.1 Single Gas Cylinder

To program the T700U calibrator's source gas input ports for a single gas cylinder, use the touch screen sequence below (Manual Section 3.4.6.2, p. 83).



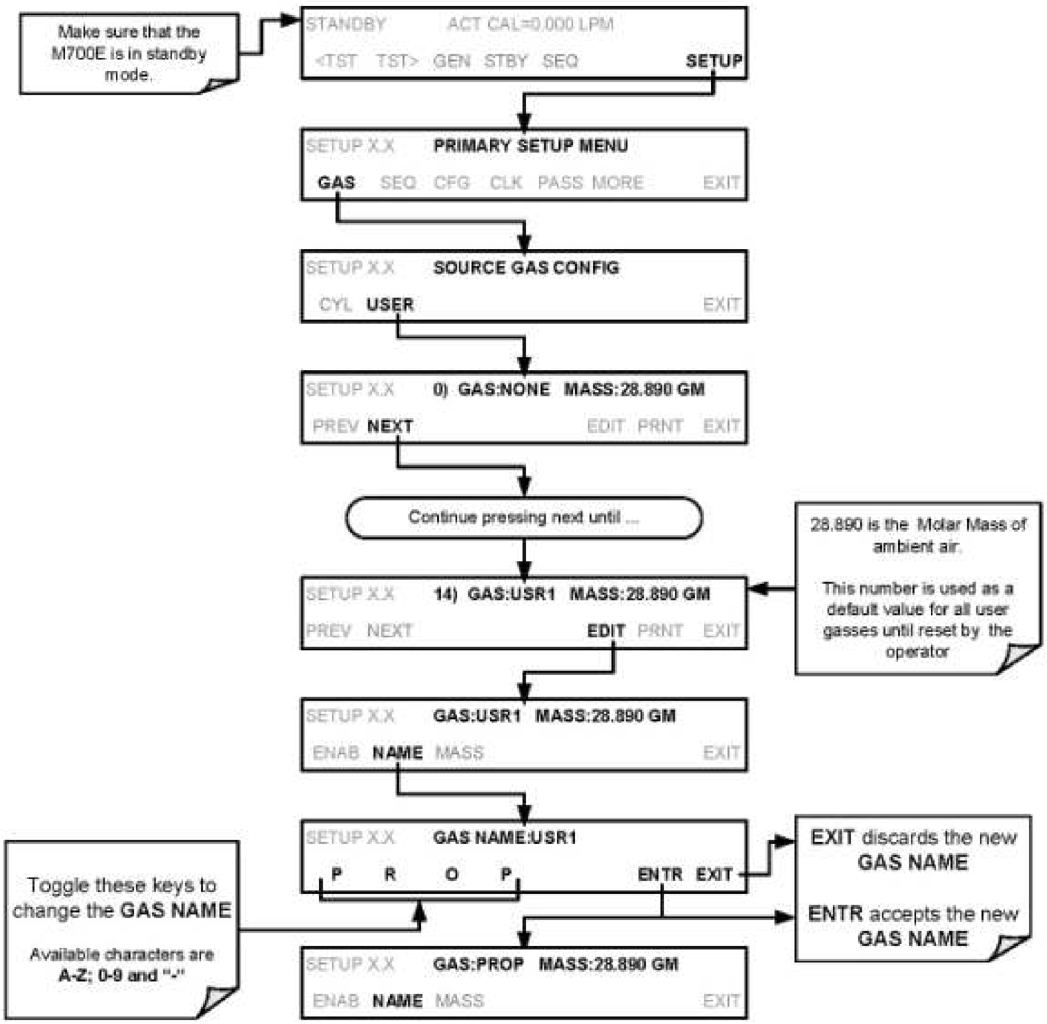
6.2.2.2 Multiple Gas Cylinder

To program the T700U calibrator's source gas input ports for a cylinder containing multiple gases, use the touch screen sequence below (Manual Section 3.4.7.1, p. 87).



6.2.2.3 User Defined Gas Cylinder

To program the T700U calibrator's source gas input ports for a gas that is not listed in the T700U gas library, use the touch screen sequence below (Manual Section 3.4.6.2, p. 83). To define a USER GAS you must first define the GAS NAME and then set the MOLAR MASS. PROPANE (C_2H_8) is used in this example.

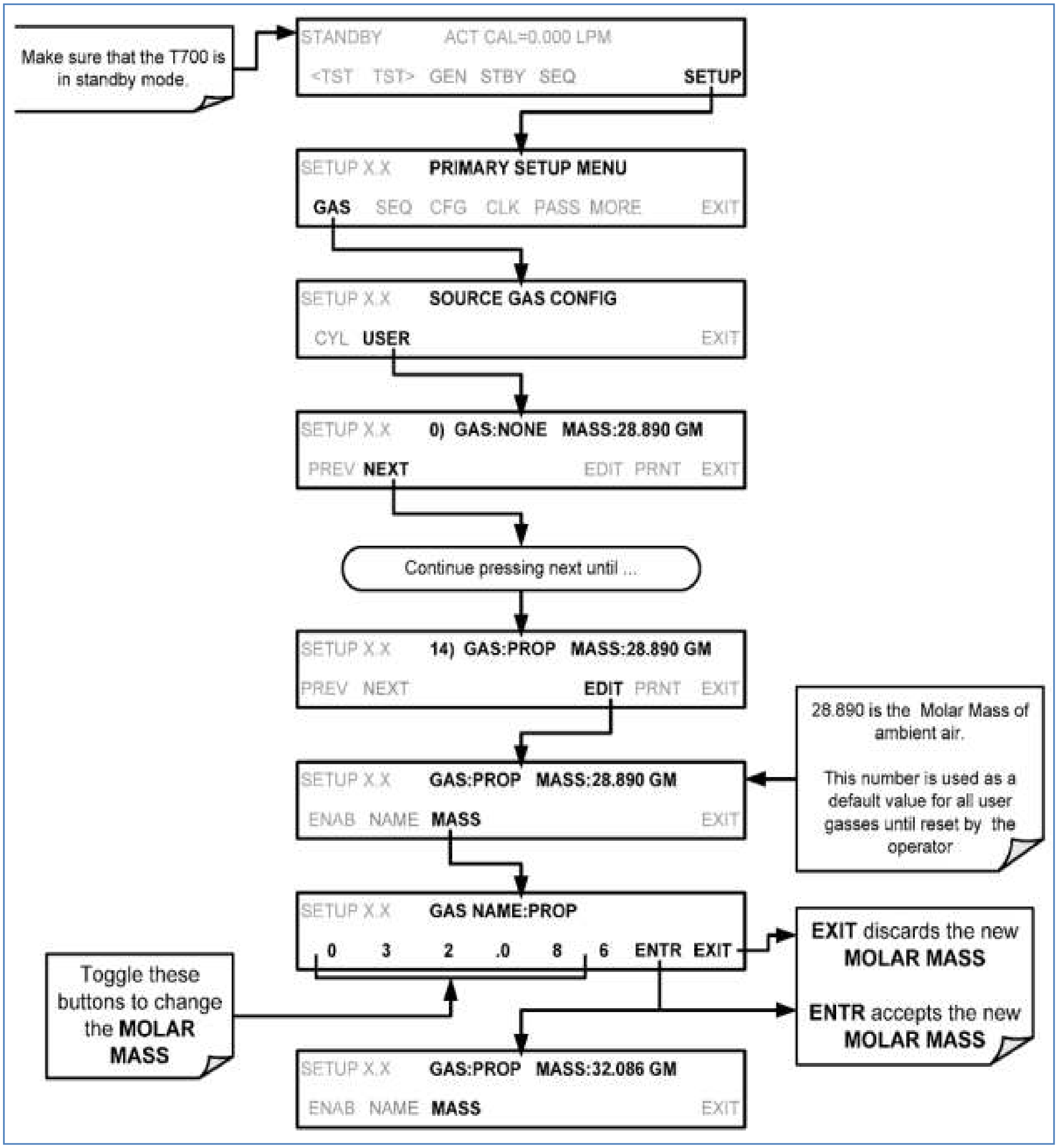


Alternatively, one could use the chemical formula for this gas, $\mathbf{C_2H_8}$ or any other 4-letter name (e.g. PRPN, MY-1, etc.)

NOTE

If you have the same type of gas, but two different concentrations (for example, two concentrations of CO_2), assign the second concentration to one of the user defined gases (e.g. CO2 {default name} and CO2B {user defined}).

To determine the Molar mass of a gas, add together the atomic weights of the elements that make up the gas. EXAMPLE: The chemical formula for propane is C_2H_8. Therefore the molecular mass of propane is: (12.011 x 2) + (1.008 x 8) = 24.022 + 8.064 = 32.086. To enter the MOLAR MASS, use the touch screen sequence below (Manual Section 3.4.6.3, p. 85).

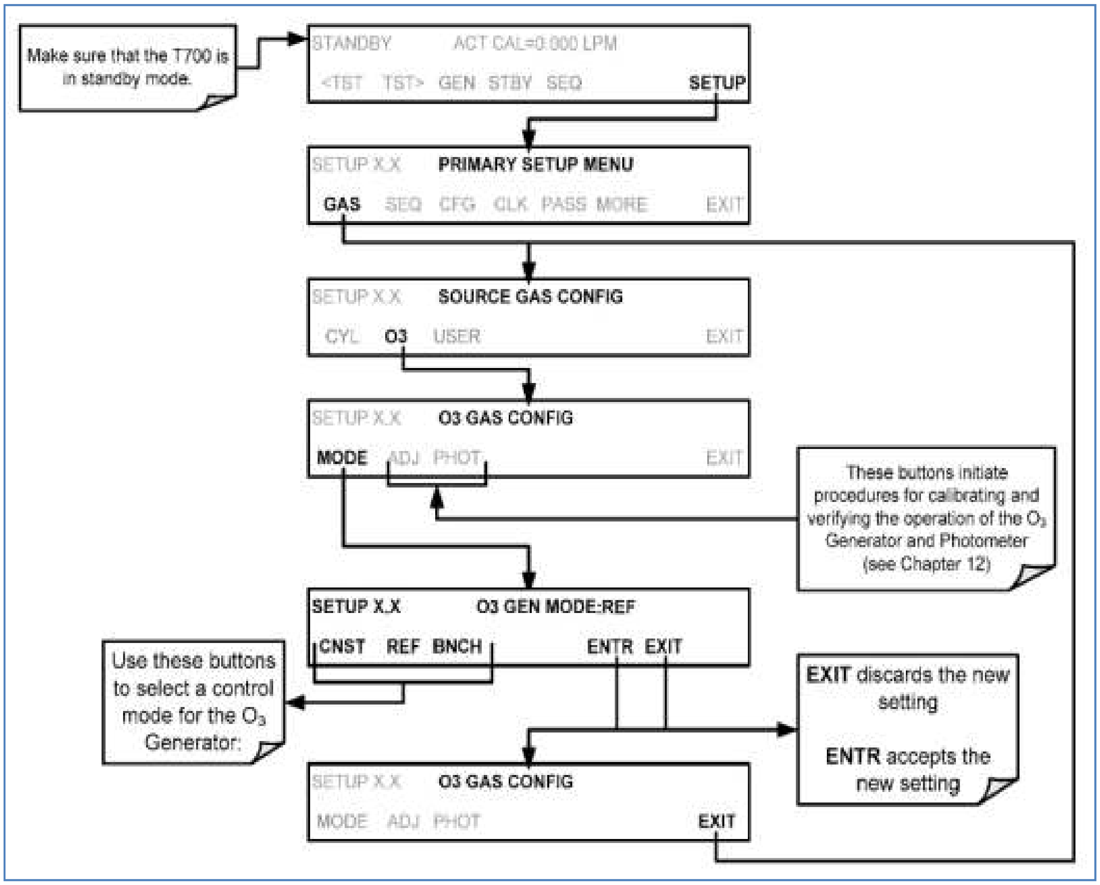


The following user defined gases should be added:

Name	Molar Mass
Zer2 (zero air)	28.89
NPN	105.1

6.2.3 Select Bench Feedback for internal ozone generator

To select a default photometer generation mode, use the touch screen sequence below (Manual Section 3.4.8.3, p. 90).



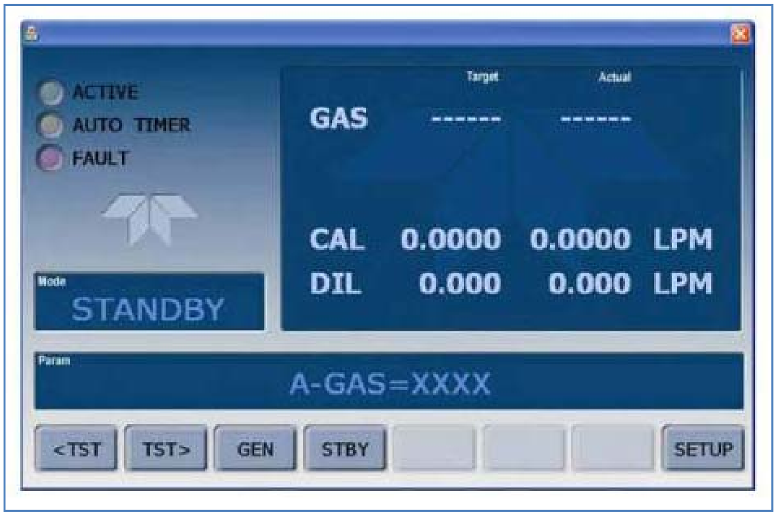
6.3 Acceptance Testing

Upon receipt, verify proper operation using all tests described in SOP Section 6.5.

6.4 Operation

6.4.1 Instrument Display Screen

Figure 4 Normal Operating Screen



Descriptions of the various display components are listed in Table 1 (Manual Table 3-1, p. 34)

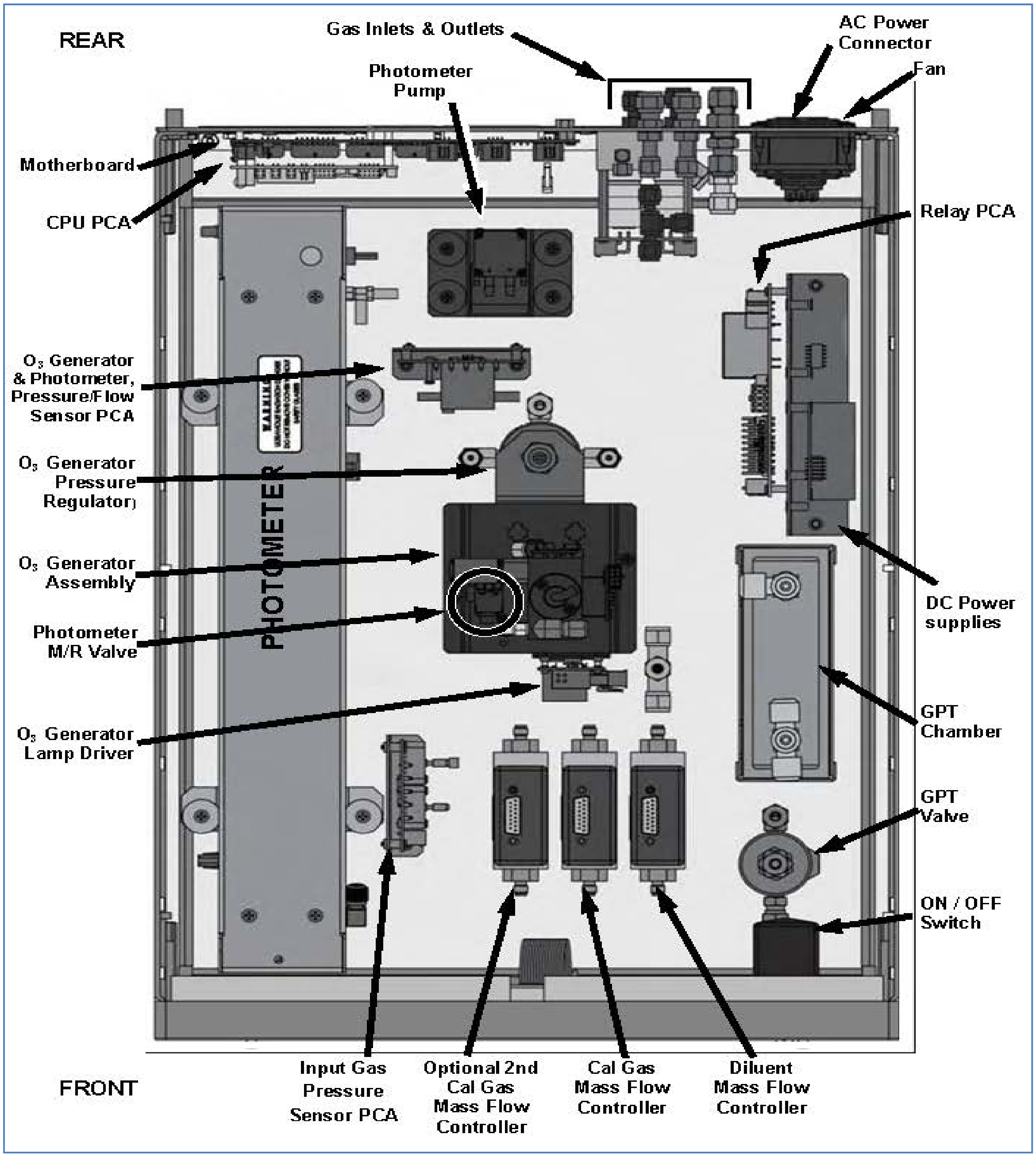
Table 1 Instrument Display Functions

Field	Description/Function			
LEDs indicating the states of the calibrator:				
	Name	Color	State	Definition
	Active	Green	off	Unit is operating in STANDBY mode.
			on	This LED is lit when the instrument is actively producing calibration gas (GENERATE mode).
	Auto Timer	Yellow	off	This LED is lit only when the calibrator is performing an automatic calibration sequence.
	Fault	Red	blinking	The calibrator is warming up and therefore many of its subsystems are not yet operating within their optimum ranges. Various warning messages may appear in the Param field.
Target/ Actual	Gas concentrations, Cal gas MFC and Diluent MFC values with unit of measure			
Mode	Displays the name of the calibrator's current operating mode (default is STANDBY at initial startup).			
Param	Displays a variety of informational messages such as warning messages, operational data, test function values and response messages during interactive tasks.			
Touchscreen control: row of eight buttons with dynamic, context sensitive labels; buttons are blank when inactive/inapplicable.				

6.4.2 Instrument Components

Figure 5 is an image of internal layout and major instrument components (Manual Figure 3-6, p. 39) of the T700U.

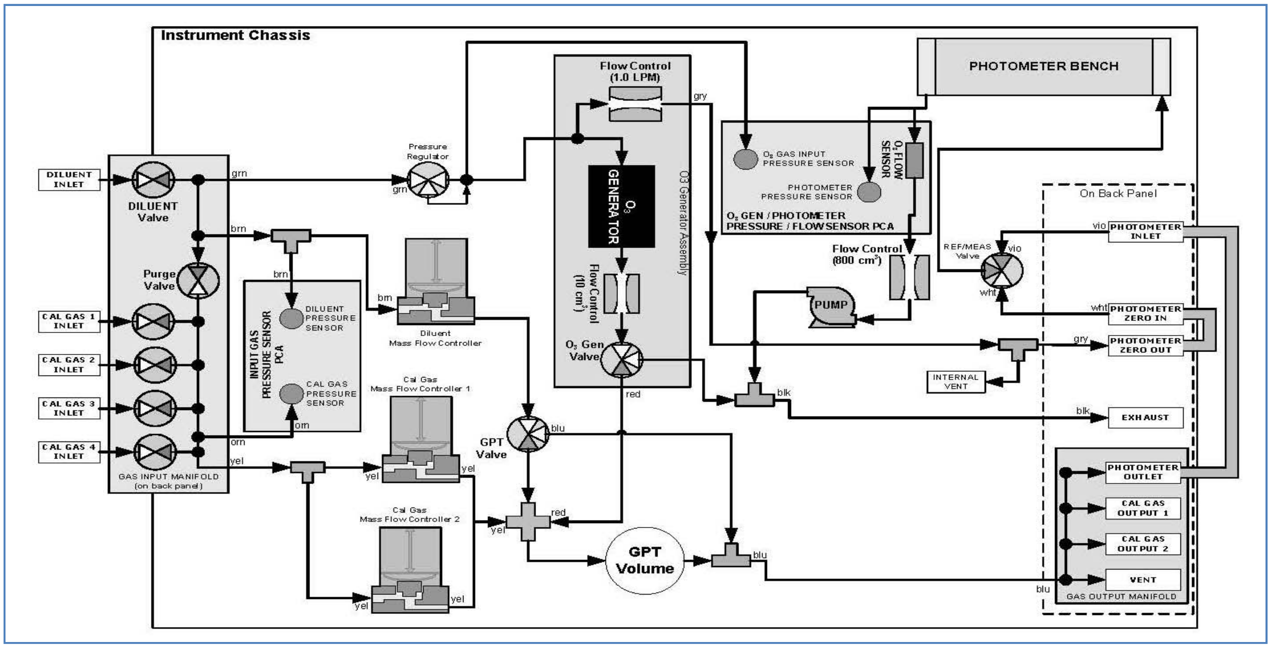
Figure 5 Instrument Components



6.4.3 Pneumatic Diagram

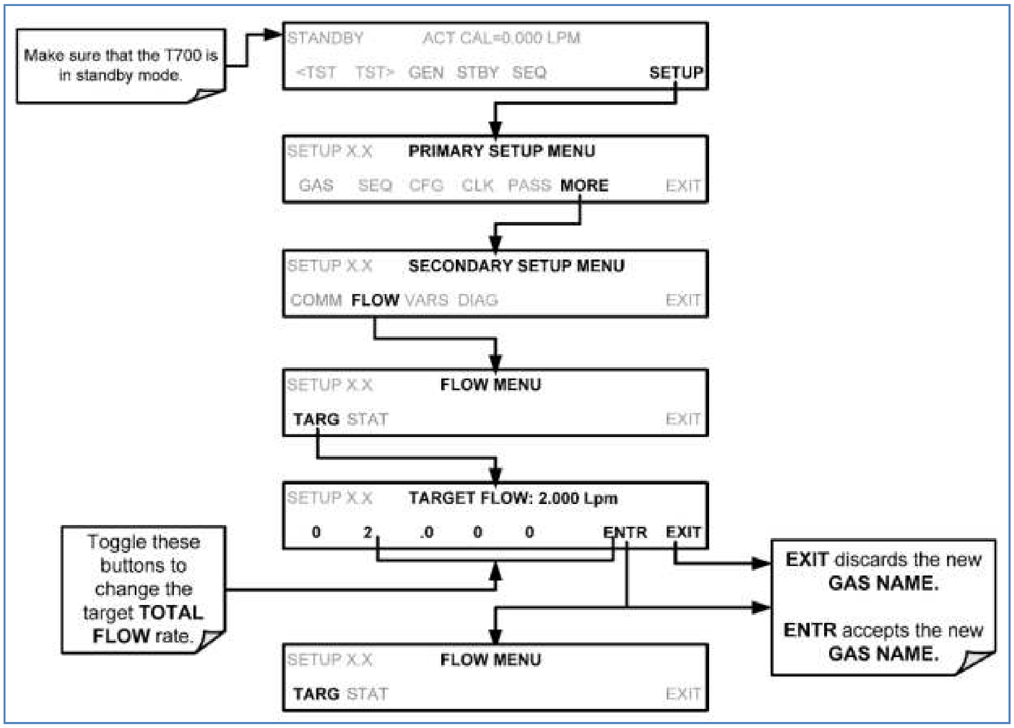
Figure 6 shows the pneumatic layout of the analyzer (Manual Figure 3-23, p. 66 and Addendum Figure 3, p. 16).

Figure 6 Pneumatic Layout



6.4.4 Set the Total Gas Flow Rate

The default total gas flow rate is 2 lpm. The minimum total flow should equal 150% of the flow requirements of all of the instruments to which the T700U will be supplying calibration gas (Manual Section 3.4.9, p. 91). The O_3 photometer flow [800 cubic centimeters per minute (ccm)] must be accounted for in the calculation: (max analyzer demand) x 1.5 + 0.8 for O_3 photometer.



6.4.5 Operating Modes

Descriptions of available Operating Modes are listed in Table 2 (Manual Table 4-1, p. 97).

Table 2 Operating Modes

MODE	MEANING
DIAG	One of the calibrator's diagnostic modes is being utilized. When the diagnostic functions that have the greatest potential to conflict with generating concentrations are active, the instrument is automatically placed into standby mode.
GENERATE	In this mode, the instrument is engaged in producing calibration gas mixtures.
GPT[1]	The calibrator is using the O_3 generator and source gas inputs to mix and generate calibration gas using the gas phase titration method.
GPTPS[2]	Stands for Gas Phase Titration Preset. In this mode the T700 determines the precise performance characteristics of the O_3 generator at the target values for an upcoming GPT calibration.
MANUAL	In this mode, the instrument is engaged in producing calibration gas mixtures.
PURGE	The calibrator is using diluent (zero air) to purge its internal pneumatics of all source gas and previously created calibration mixtures.
SETUP[3]	**SETUP** mode is being used to configure the calibrator.
STANDBY	The calibrator and all of its subsystems are inactive.

[1] This mode is not available in units without O_3 generators installed.

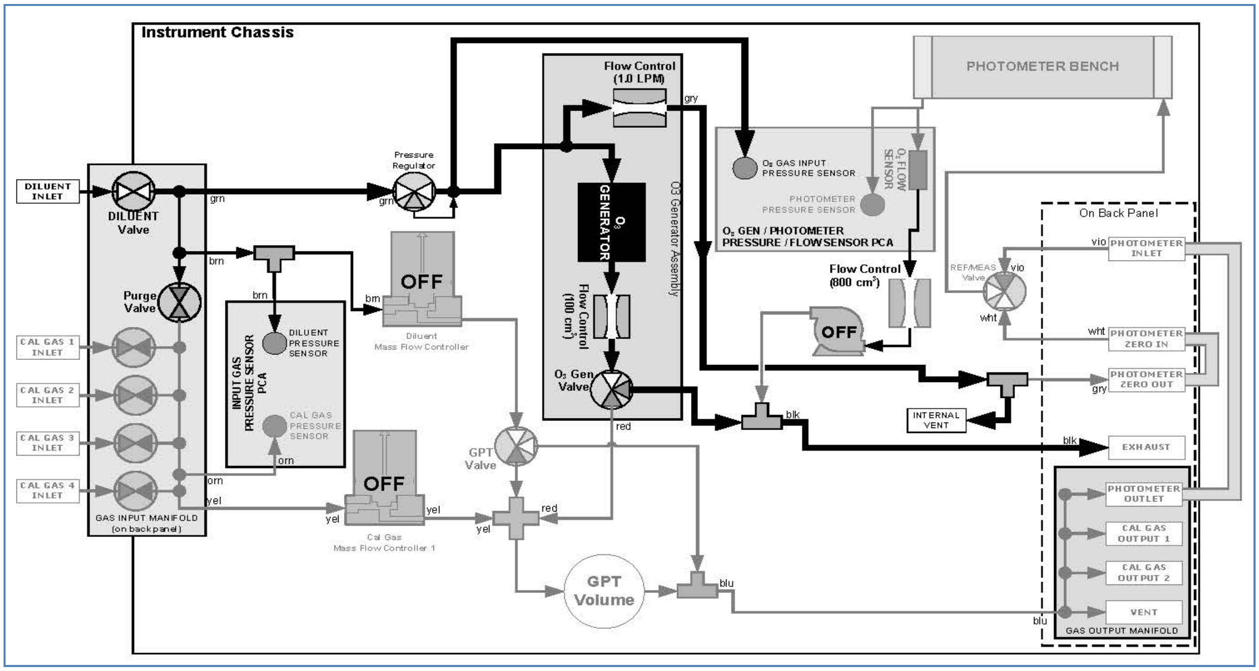
[2] This mode is not available in units without internal photometers installed.

[3] The revision of the Teledyne API software installed in this calibrator will be displayed following the word **SETUP**. E.g. "**SETUP G.4**"

GPTZ (Gas Phase Titration Zero) is another operating mode for this instrument (Addendum Section 3.3, p. 11). The GPTZ mode is used for obtaining the baseline NO and NO_y readings for calculating the NO_y converter efficiency. GPTZ is identical to GPT, except the ozone generation lamp is off and ozone is not created. All flow rates and paths are the same.

Figure 7 is a schematic of gas flow while in STANDBY mode (Manual Figure 4-2, p. 99).

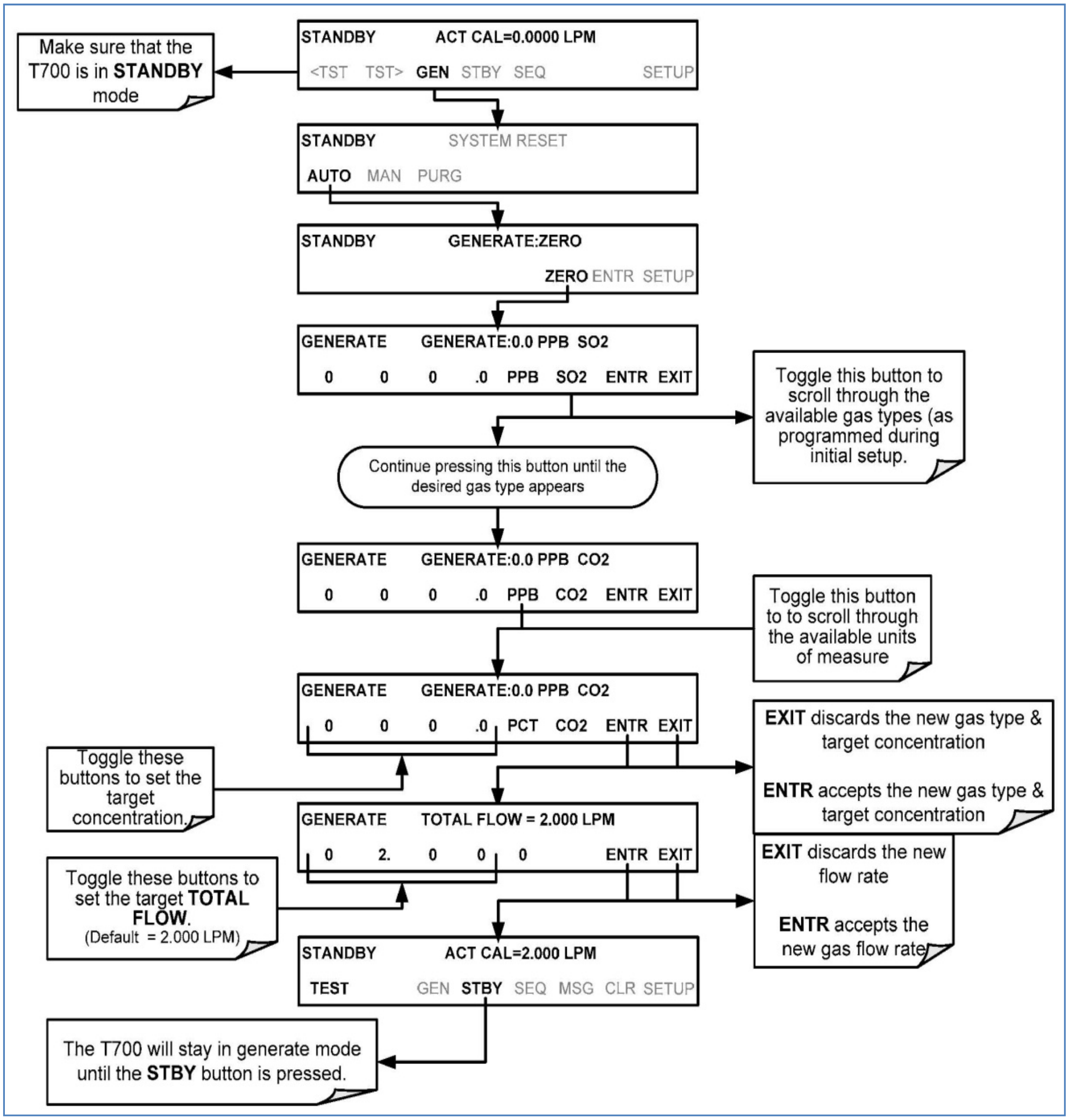
Figure 7 Pneumatic Layout in Standby Mode



6.4.5.1 Generate Mode

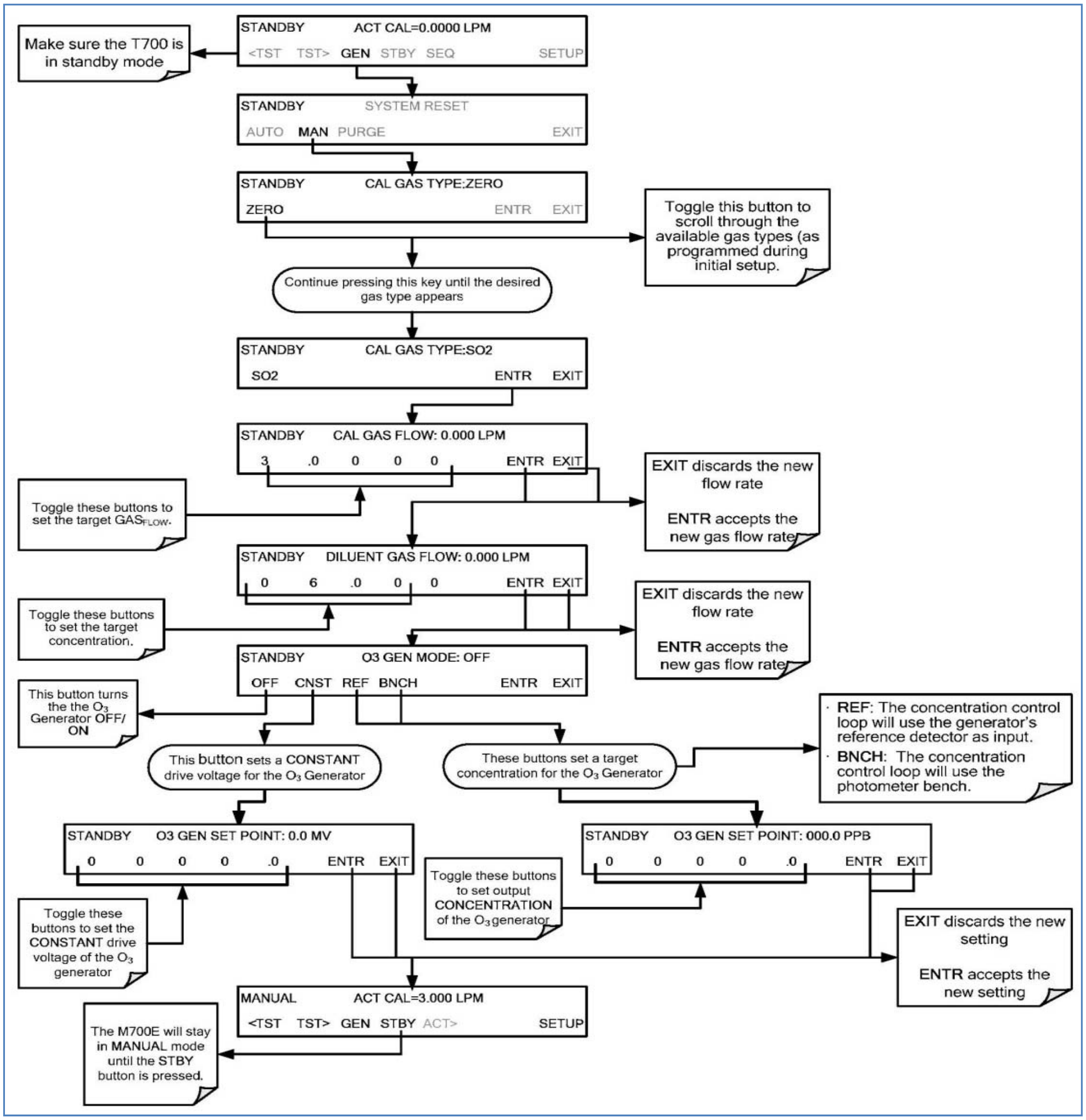
Automatic

- Auto generate a single concentration (Manual Section 4.2.1, p. 105)
  After selecting AUTO, select output port A or B before selecting gas type.



Manual

- Manually generate a concentration (Manual Section 4.2.2.4, p. 108)
  After selecting MAN, select output port A or B before selecting gas type.



The output concentration from this procedure is given by:

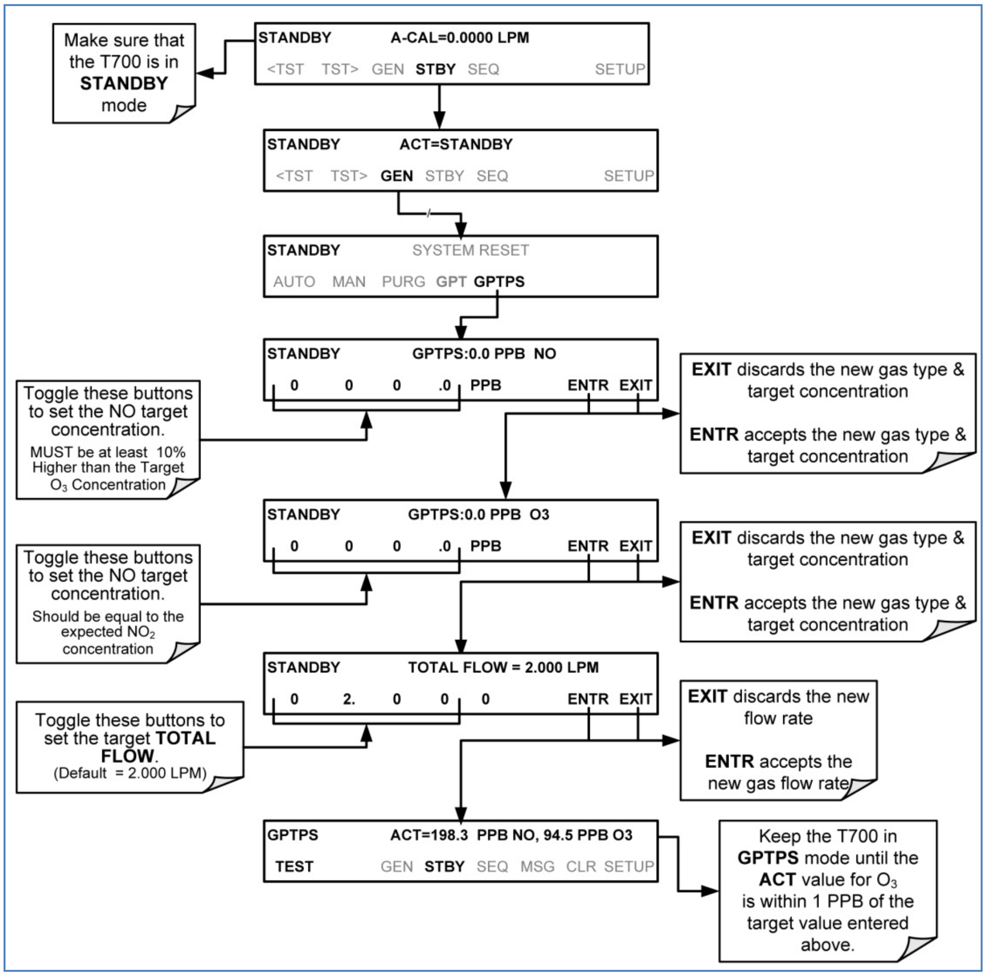
$$\text{Output concentration} = \frac{[\text{Tank}] \times \text{Gas Flow}}{[\text{Diluent flow} + O_3 \text{ flow (constant} \sim 20 \text{ sccm)} + \text{Cal Gas flow}]}$$

Note: sccm is standard cubic centimeters per minute.

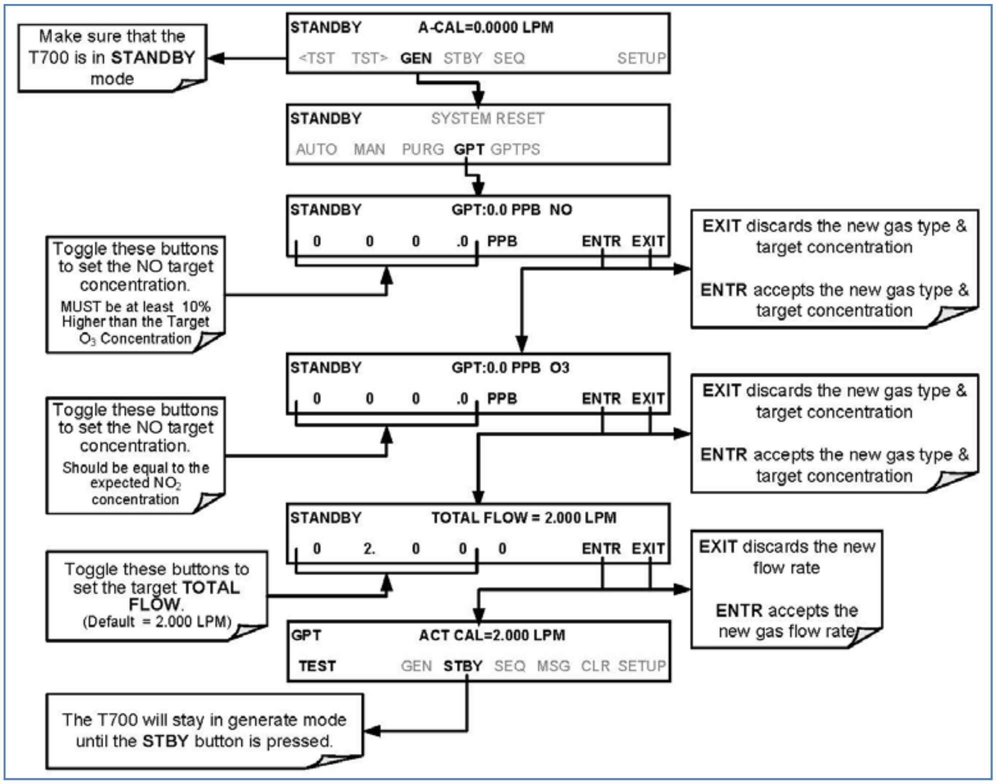
6.4.5.2 NO_y Convertor Efficiency Check Modes

Manual Sections 4.2.3 and 4.2.4 discuss performing a gas phase titration calibration.

- GPTPS (Manual Section 4.2.4.2, p.115)



- GPT (Manual Section 4.2.3.5, p.112



For GPT, EPA requires a flow for NO of no more than 10% > O_3 (40 CFR 50 App F; and, Manual Section 4.2, pp. 106-107).
Output flow must be chosen to keep the O_3 generator output > 30 ppb*lpm

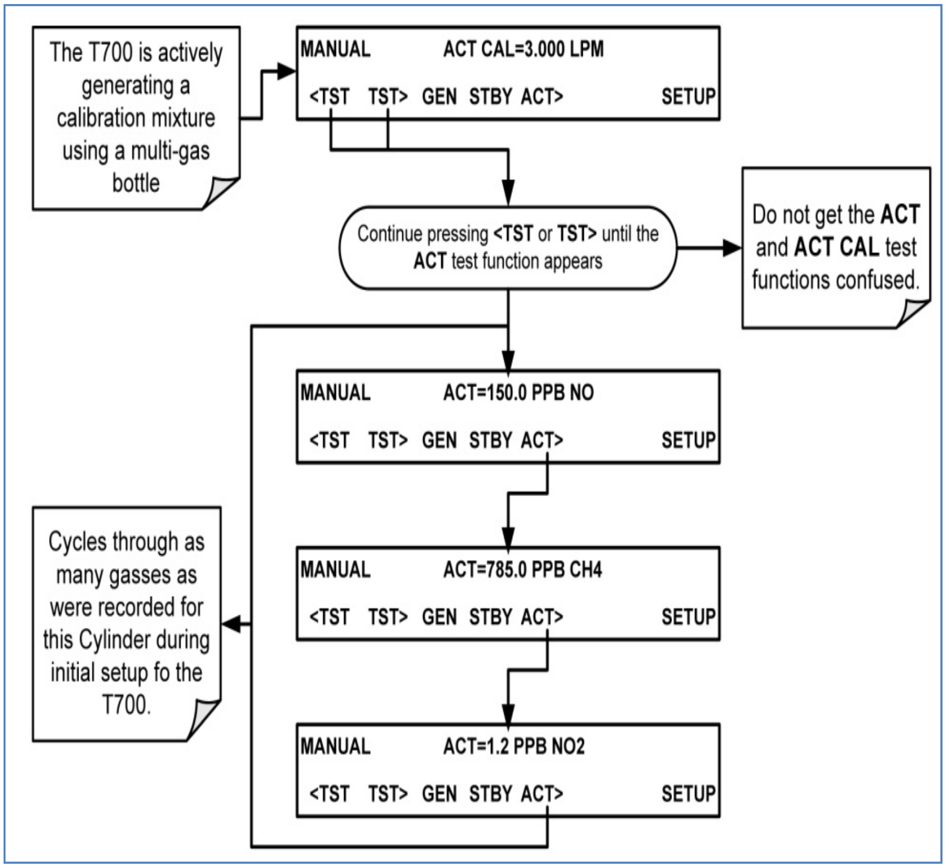
$$F_T \geq \frac{200\ \text{ppb*lpm}}{[O_3]}$$

Residence time in reaction chamber must be < 2 minutes (40 CFR 50 App F; and TAD Section 4.4, pp. 24-37 of 40).
NO flow must be > 45 cc/m (Addendum Section 4.1, p. 12).

- GPTZ
  Use the same touch screen sequence as the GPT, but choose GPTZ (Addendum Section 3.2, p. 10) instead of GPT. The GPTZ must be performed just before or just after the first GPT point and after every GPT. The NO concentration change will determine the original NO and NO_y levels.

6.4.5.3 Other Concentrations Generated from Gas Blend Cylinders

When a concentration mixture is being generated using a multiple-gas cylinder as a source (Manual Section 4.2.6, p. 118), the software uses the Diluent and Cal gas flow rates to calculate the actual concentration for each gas in the cylinder so that it is possible to see the concentrations of all of the gases output by the T700U calibrator. To view these concentrations follow the sequence below.



The <ACT> button only appears if the T700 is generating gas from a multiple-gas cylinder.

6.5 T700U System Calibration

The system must be audited and, if necessary, adjusted to establish NIST-traceability (TAD Section 5.3.1.1, p. 3 of 10) before it can be used as a gas dilution calibration system or as a certified photometer.

6.5.1 Pressure Sensors

The T700U Dynamic Dilution Calibrator has several sensors that monitor the pressure of the gases flowing through the instrument. The data collected by these sensors are used to compensate the final concentration calculations for changes in atmospheric pressure and are stored in the central processing unit (CPU)'s memory as various test functions. Table 3 lists the pressure sensors and instrument units. Figures 8, 9, 10, and 11 show the location of the pressure sensors. First audit the sensors and then calibrate the sensors if absolute difference is greater than 0.2. The pressure sensors will only be audited and calibrated in the lab unless a problem is indicated.

Table 3 Pressure Sensors

SENSOR	ASSOCIATED TEST FUNCTION	UNITS
Diluent Pressure Sensor	DIL PRESSURE	PSIG
Cal Gas Pressure Sensor	CAL PRESSURE	PSIG
O_3 Regulator Pressure Sensor (Optional O_3 Generator)	REG PRESSURE	PSIG
Sample Gas Pressure Sensor (Optional O_3 Photometer)	PHOTO SPRESS	IN-HG-A

Figure 8 Diluent Pressure Sensor

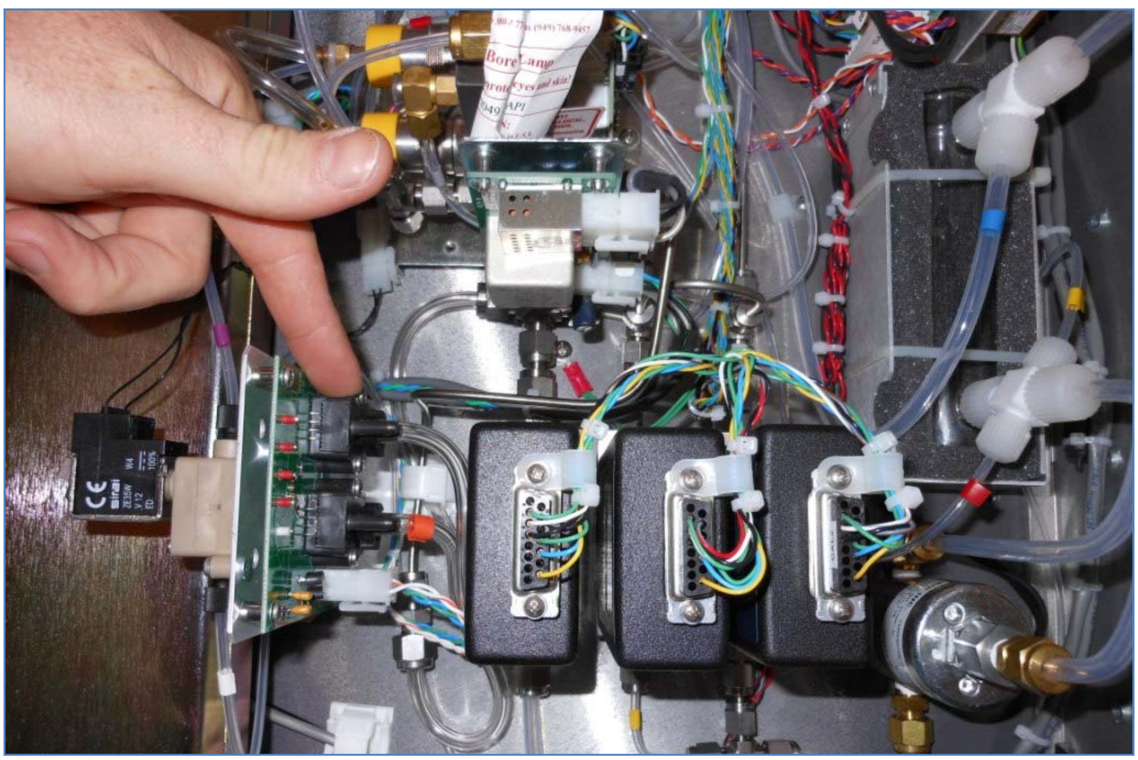


Figure 9 Calibration Gas Pressure Sensor

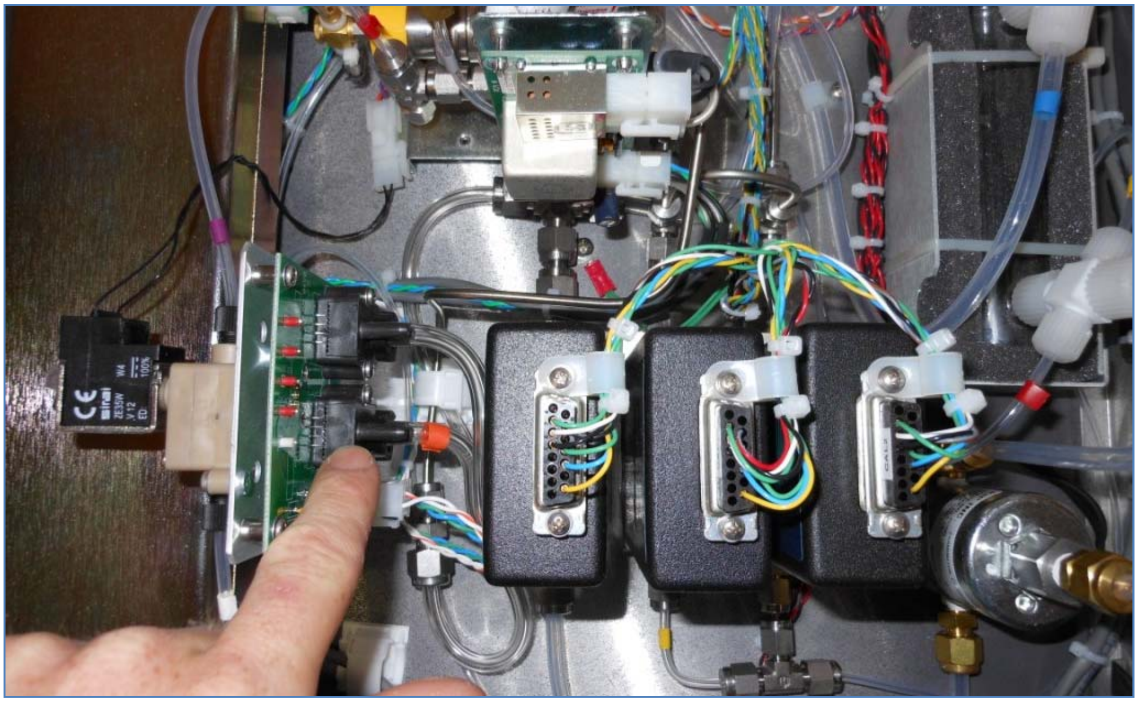


Figure 10 O_3 Regulator Pressure Sensor

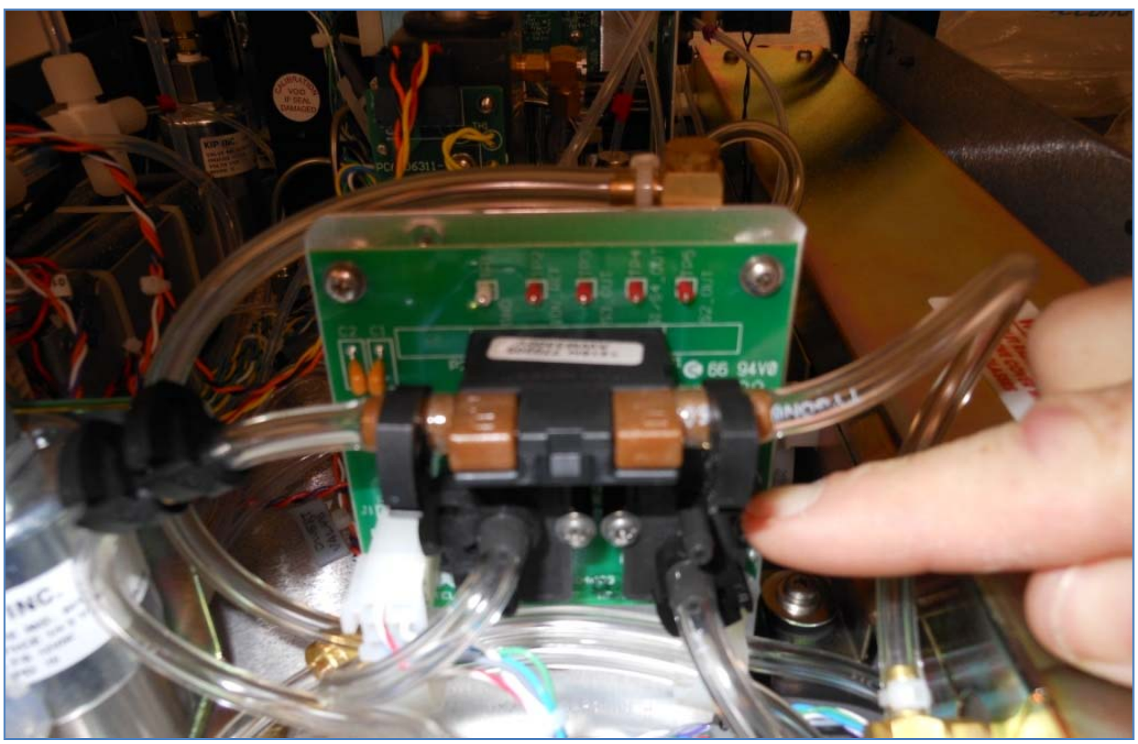
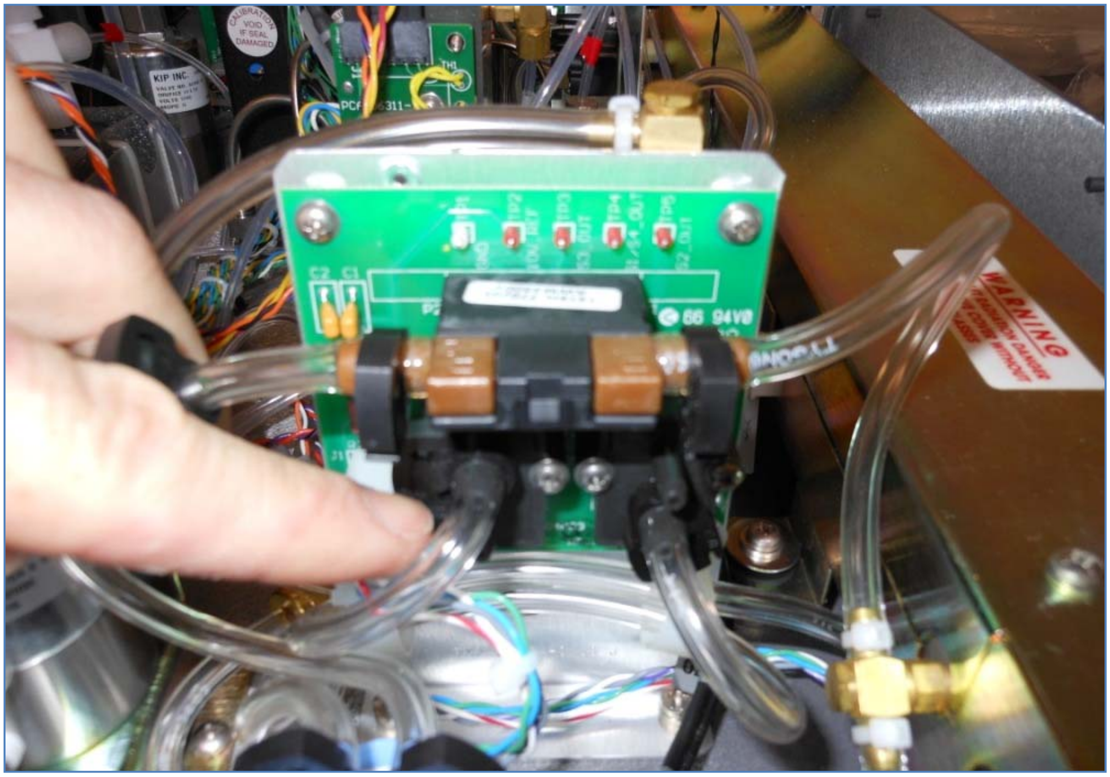


Figure 11 Sample Gas Pressure Sensor



6.5.1.1 Pressure Sensor Audit

Diluent, Calibration Gas, and O_3 Regulator Pressure Sensors

- Disconnect the clear outer tubing directly from pressure sensor by loosening the black tubing clamp.
- Connect pressure transfer standard directly to pressure sensor
- Record ambient pressure readings from transfer and calibrator
- Sample → Test → (select correct pressure for sensor under test)
- Ensure the transfer pump is set to pressure using the + - knob
- Close the vent of the pressure transfer using the • ◦ knob
- Press PUMP button on transfer to raise pressure to approximately 30 pounds per square inch absolute (psia) and record readings.
- Slowly open the pressure transfer vent to adjust the pressure to approximately 22 psia and record readings

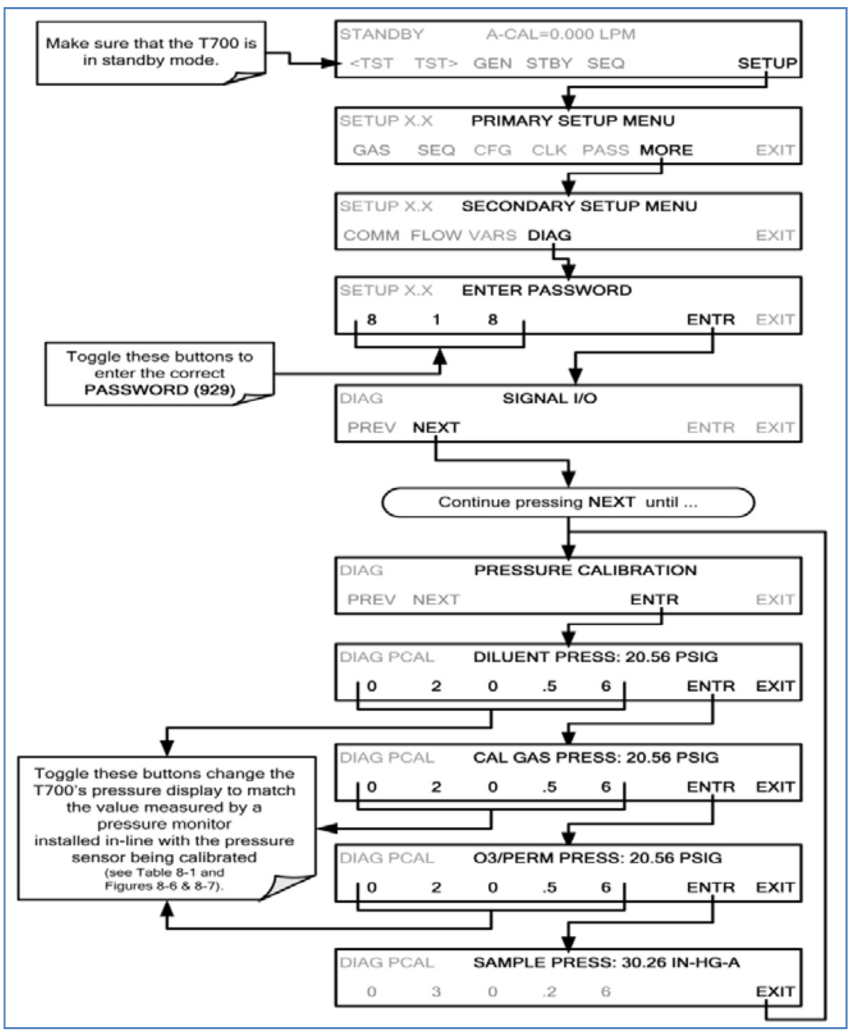
O_3 Sample Gas Pressure Sensor

- Disconnect the clear, outer tubing directly from pressure sensor by loosening the back tubing clamp. The black tubing from the reaction chamber is also clamped inside the clear adapter tubing and is more difficult to reconnect.
- Connect pressure transfer standard directly to pressure sensor

- Record ambient pressure readings from transfer and calibrator
- Sample → Test → PRES
- Ensure the transfer pump is set to vacuum using the + - knob
- Close the vent of the pressure transfer using the • ◦ knob
- Press PUMP button on transfer to lower pressure to approximately 5 inHg-A and record readings.
- Slowly open the pressure transfer vent to adjust the pressure to approximately 15 inHg-A and record readings

6.5.1.2 Pressure Sensor Calibration

Calibrate the pressure sensors according to the procedures in Manual Section 7.5, pp. 218-221. Adjust pressure sensor measurement to transfer standard value at ambient pressure. All four pressure sensors can be calibrated using the touch screen sequence below. If a calibration is required, the sensor must be re-audited.

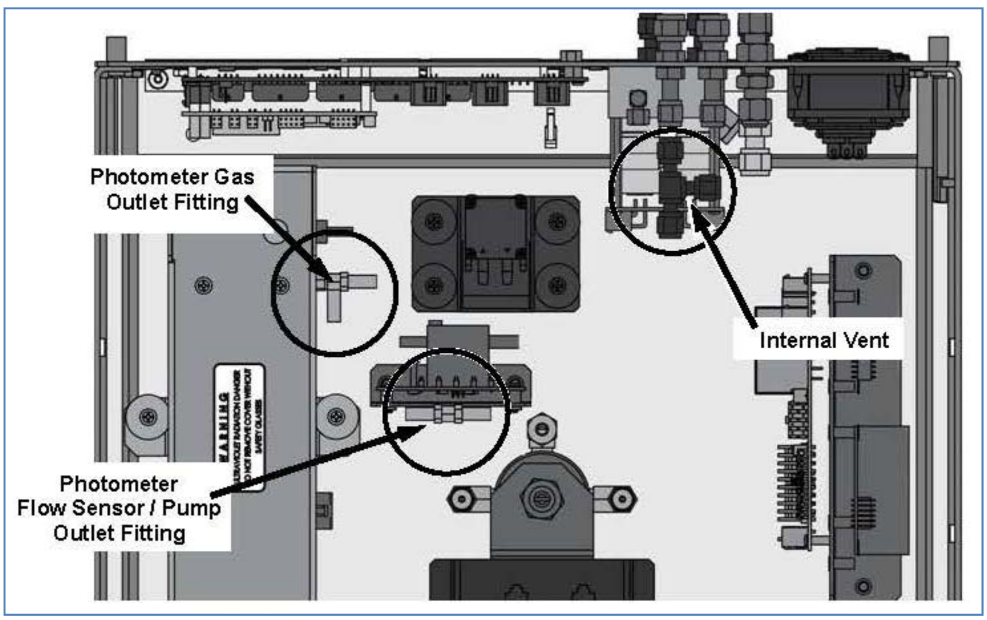


6.5.2 System Leak Check

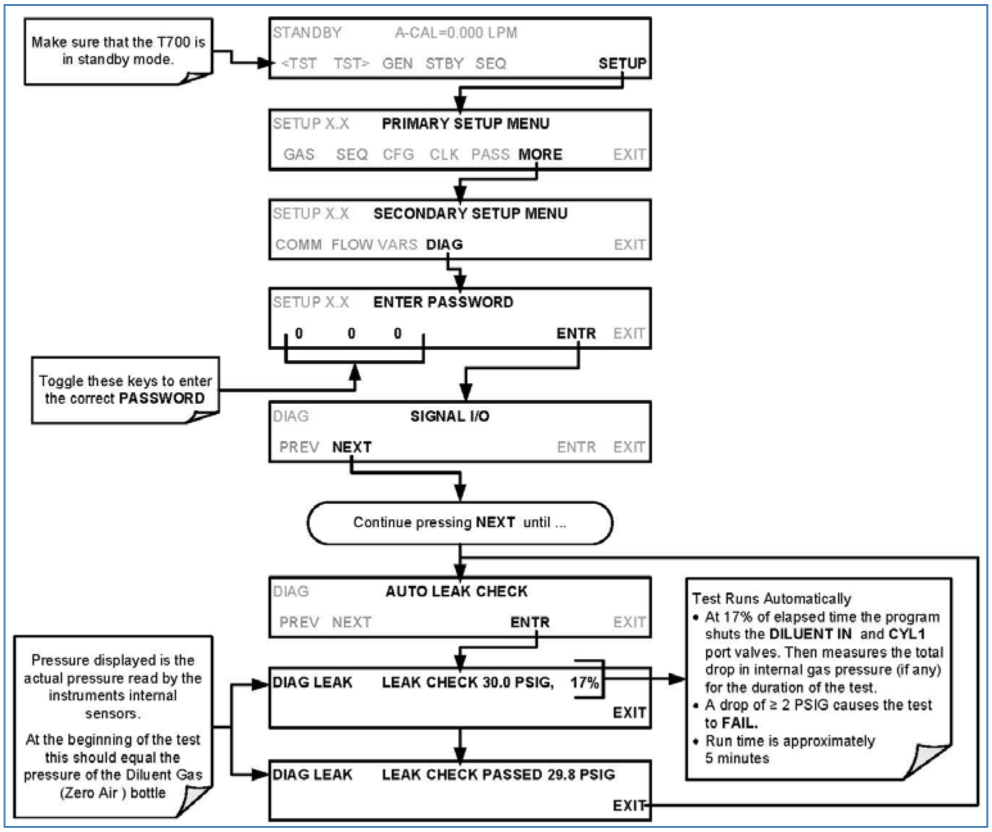
Follow the procedures in Manual Section 8.2, pp. 227-230, to complete the leak check. These procedures must be performed before the MFC Calibration (Section 7.2), the Ozone Photometer Gas Flow Calibration (Section 7.3), or the Ozone Generator Calibration (Section 7.4).

- Remove the cover from the calibrator
- Using a #6 nut driver, remove the hexagonal nut located at the top of the gas outlet of the photometer (see Figure 12)
- Using a #6 nut driver, remove the hexagonal nut located on the fitting on the back side of the Flow/Pressure sensor board (see Figure 12)
- Connect the end of the line removed from the Sensor PCA to the Photometer Outlet Fitting
- Using the 1/8" cap, securely cover the outlet of the internal vent located just behind the valve relay PCA (see Figure 12)

Figure 12 Bypassing the Photometer Sensor PCA and Pump



- Cap the EXHAUST port, OUTPUT A port, and OUTPUT B port on the back of the T700 (see Figure 2)
- After the above steps are complete, use the touch-screen sequence below to initiate the Auto Leak Check (Manual Section 8.2.1.3, p. 230)



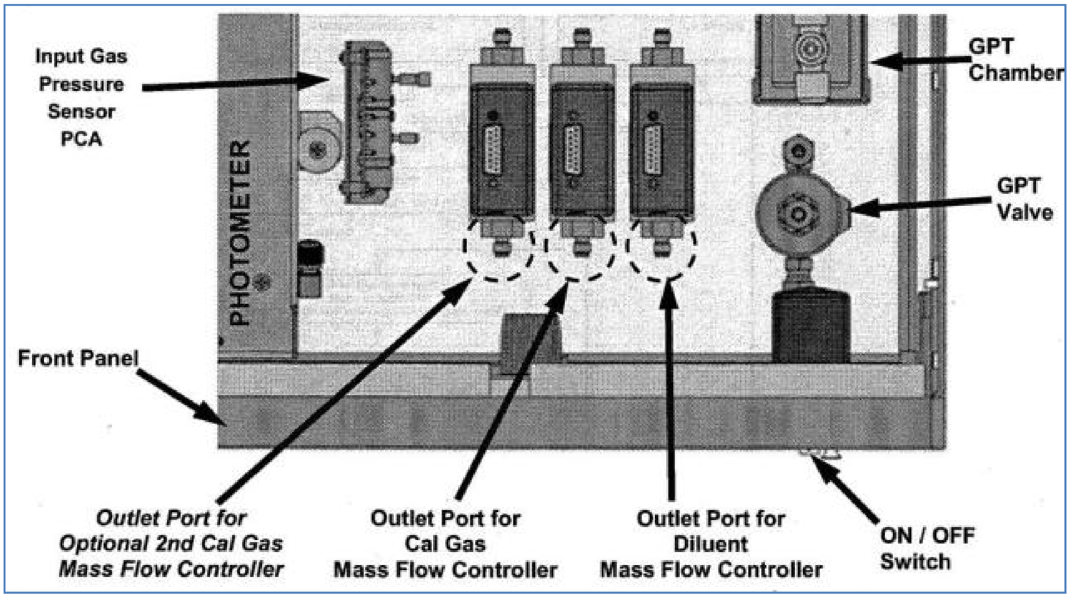
6.5.3 MFC Calibration, Manual Section 8.2, p. 196-198

The T700U Dynamic Dilution Calibrator has three MFCs: a 20 ccm calibration (cal) gas MFC, a 200 ccm cal MFC, and a 10 lpm MFC. A table exists in the memory of the T700 for each MFC. Each table sets the output of the MFC at each of 20 equally spaced control points along its entire performance range. First audit the sensor using either the Lab or Field procedure and adjust the flow rate if the percent difference is greater than 2% (40 CFR 50) or if the absolute difference is greater than 1% of full scale of the MFC being audited. Repeat the Lab or Field Procedure, and if necessary, the Adjustment Procedure for each MFC. If an MFC is adjusted, the MFC must be re-audited.

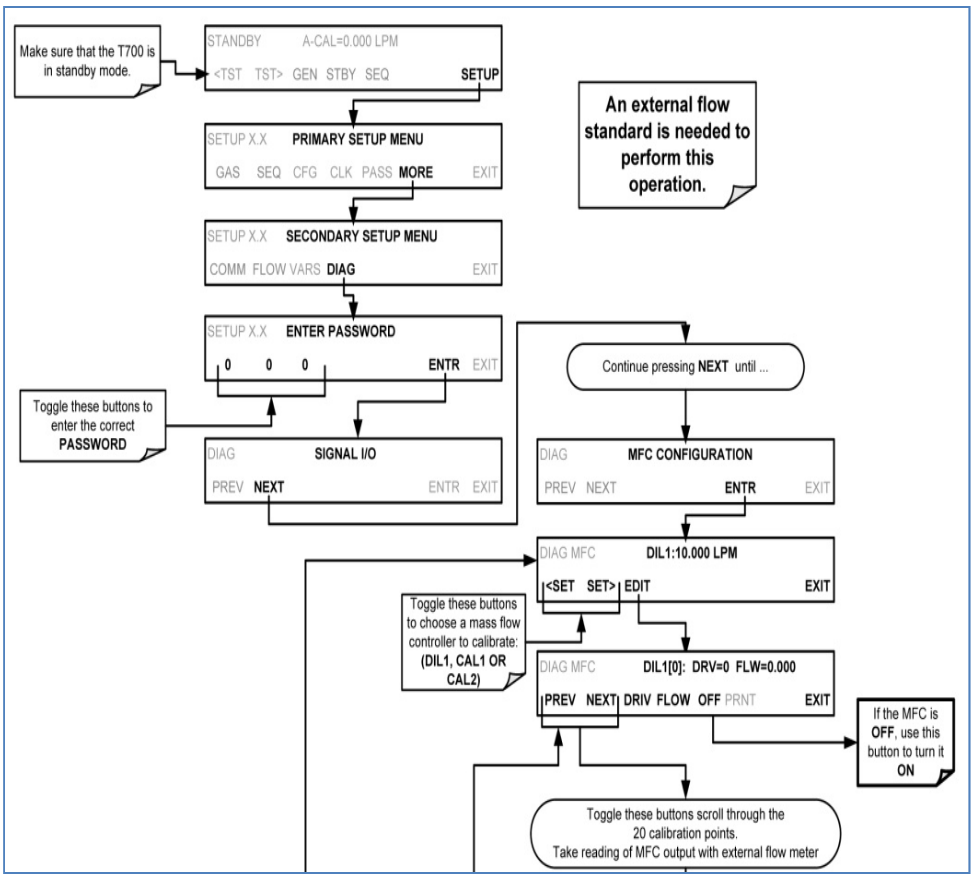
6.5.3.1 MFC Audit - Lab Procedure

- Open the front panel to the T700 calibrator and attach the flow transfer standard directly to the output port of the MFC to be audited/adjusted as shown in Figure 13 (Manual Figure 7-1, p. 200).

Figure 13 MFC Top View



- Audit the 20 flow control points in memory using the touch screen sequence below
- Allow a point to stabilize for at least 10 minutes
- Record an average transfer reading using at least 10 measurements

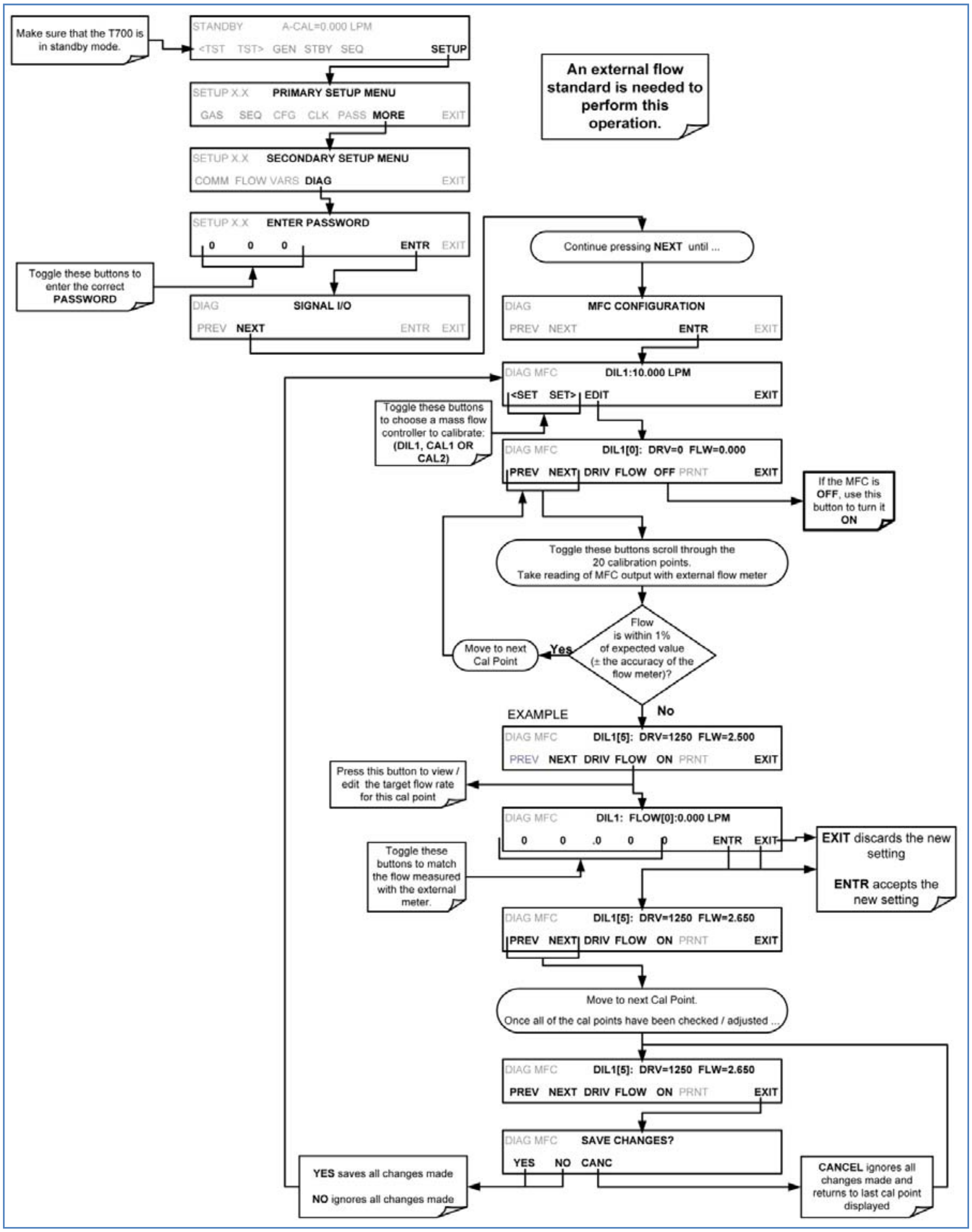


6.5.3.2 MFC Audit - Field Procedure

- Use the same procedures as the lab procedures, but only auditing every other flow control point.

6.5.3.3 Adjustment of Mass Flow Controllers

- Using the touch screen sequence below, adjust the MFC flow rate to flow transfer standard at each control point that was not within criteria.



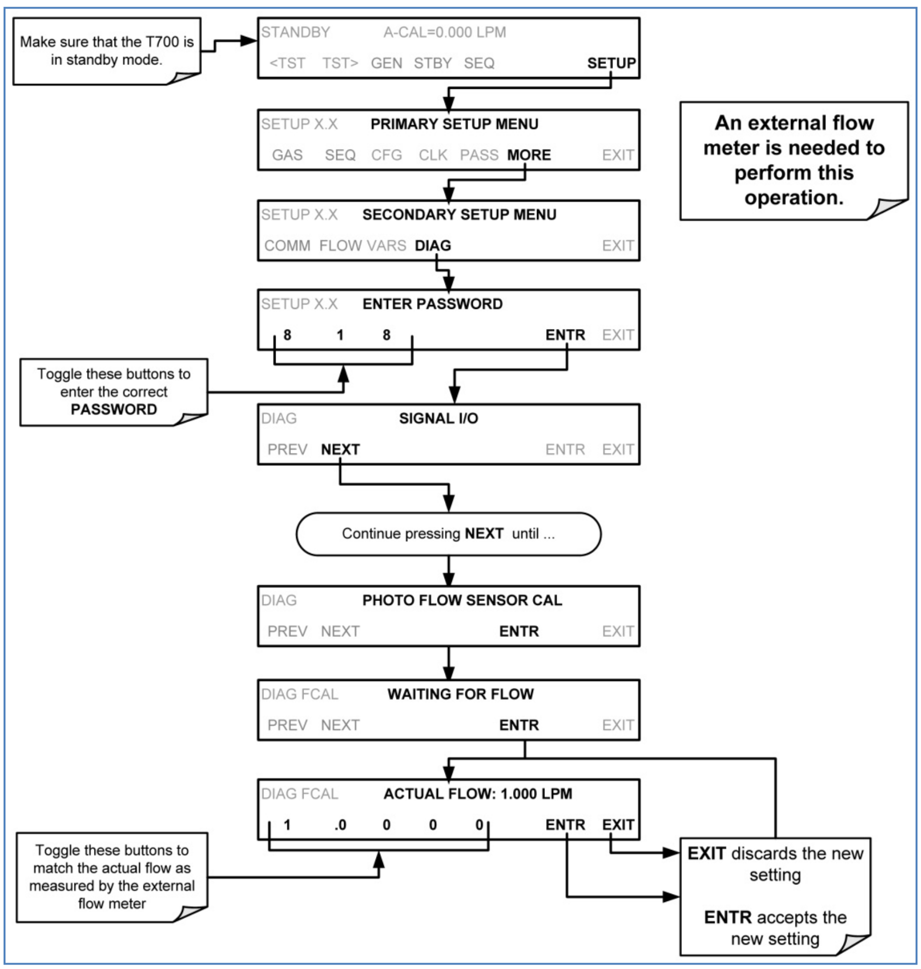
6.5.4 Ozone Photometer

The accuracy of calibration mixtures involving O_3 produced by the T700U depends entirely on the accuracy of the photometer; therefore, it is very important that the photometer is operating properly and accurately (Manual Sections 7.3.1 through 7.3.5, pp. 202-206). First, perform the Photometer Gas Flow Sensor Calibration (Manual Section 7.5). Next, perform the Photometer Dark Calibration procedure (Manual Section 7.3.5). Then perform the Photometer Calibration (Manual Section 7.3.4) or the Photometer Level 3 (L3) certification (Manual Section 7.4).

6.5.4.1 Photometer Gas Flow Sensor Calibration

Follow the procedure in Manual Section 7.3.6, p. 209. This procedure must be performed before any other ozone procedure. First, audit the sensor and then adjust the sensor if absolute difference is greater than 0.02 lpm. This procedure will be performed only in the lab unless a problem is identified.

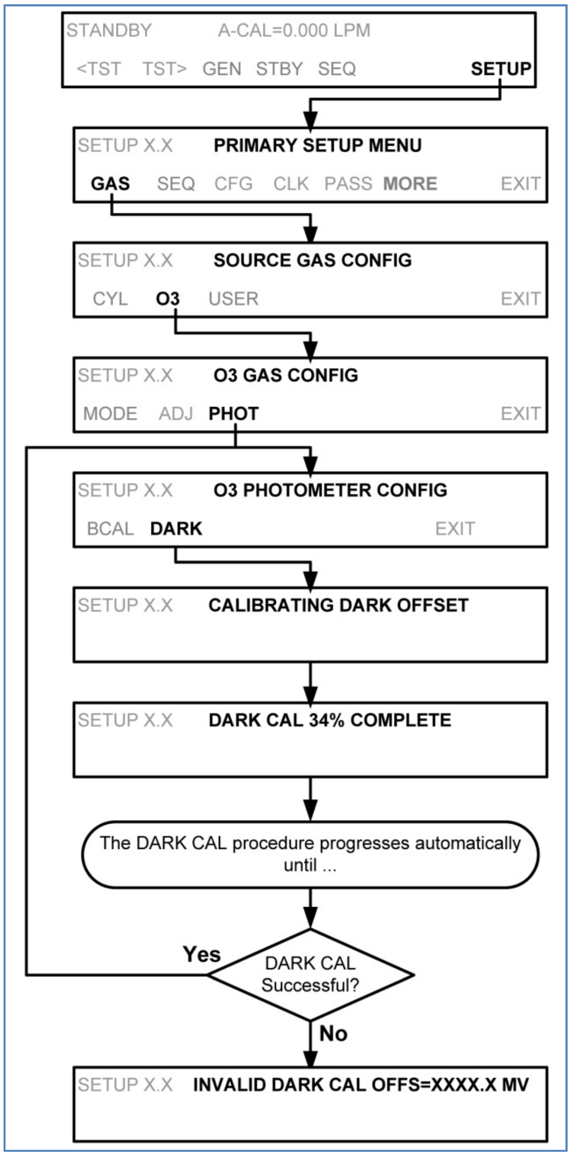
- Connect flow transfer standard to the EXHAUST port on the rear of the calibrator
- Using the touch-screen sequence below, record the readings from transfer and calibrator at nominal flow and then adjust if necessary



6.5.4.2 Photometer Dark Calibration

The Dark Calibration Test (Manual Section 7.3.5, p. 208) turns off the photometer UV lamp and records any offset signal level of the UV Detector-Preamp-Voltage to Frequency Converter circuitry. This allows the instrument to compensate for any voltage levels inherent in the Photometer detection circuit that might affect the output of the detector circuitry and therefore the calculation of O_3 concentration.

To activate the Dark Calibration feature use the touch screen sequence below.



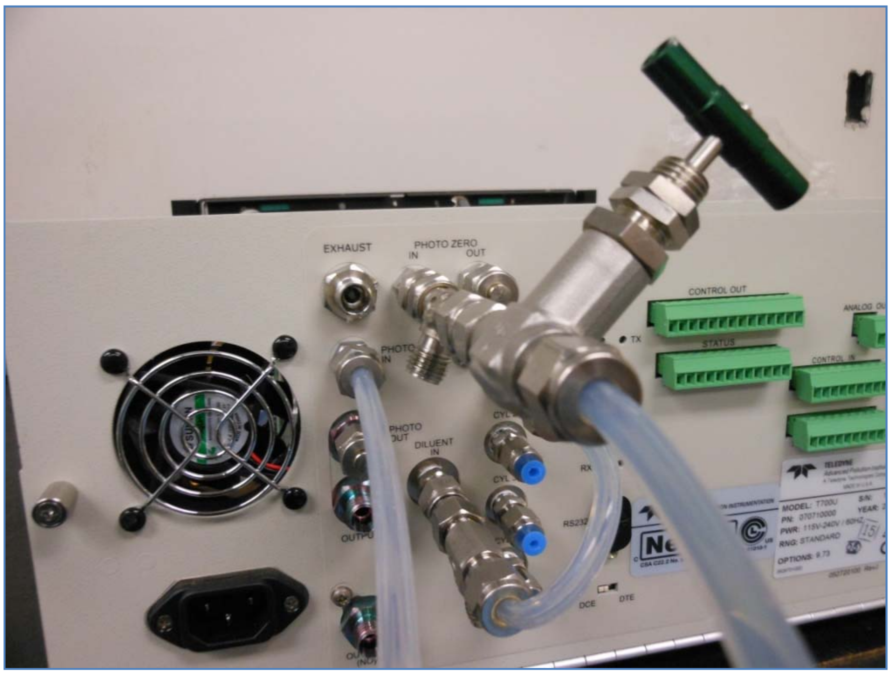
6.5.4.3 Photometer Calibration Procedure

First audit the photometer and then calibrate the photometer (Manual Section 7.3.4) if the absolute difference is greater than 1%.

Photometer Audit Procedure

- Cap the PHOTOMETER OUTLET and PHOTOMETER ZERO OUT ports on the rear of the calibrator
- Connect tubing from a certified level 2 ozone transfer standard to the calibrator PHOTOMETER INLET port
- Using the same zero air source as the ozone generator, connect tubing, with inline valve and vent (Figure 14), from the zero air source to the PHOTOMETER ZERO IN port on the calibrator

Figure 14 Zero Air Line with Vent and Valve



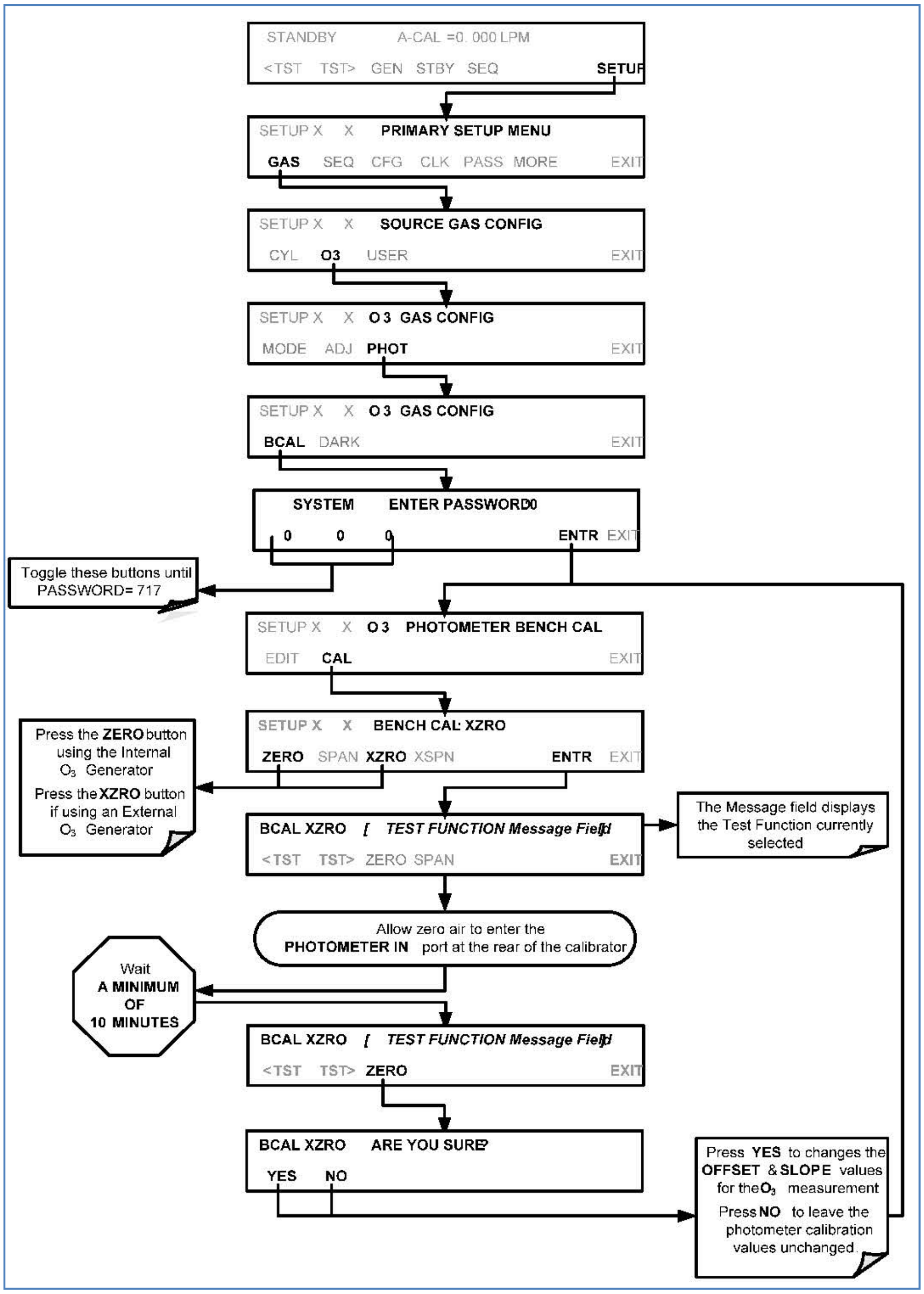
- Adjust the inline valve so there is positive pressure coming from the vent
- Generate 450 ppb from the ozone transfer standard, make sure to account for the slope and intercept correction for the transfer standard concentration
- To view calibrator ozone reading, use the touch-screen sequence in Section 7.3.4.1 selecting output A, 0 ppb of ozone, and 2 lpm
- Wait a minimum of 10 minutes and record the stable ozone reading from the transfer standard and calibrator
- Repeat the audit for the following concentrations: 200 ppb, 90 ppb, 40, ppb, 15 ppb, 7 ppb, and 0 ppb

Photometer Calibration Procedure

This procedure sets values held in the calibrator's memory for zero point OFFSET and SLOPE. When this procedure is complete, another photometer audit must be performed.

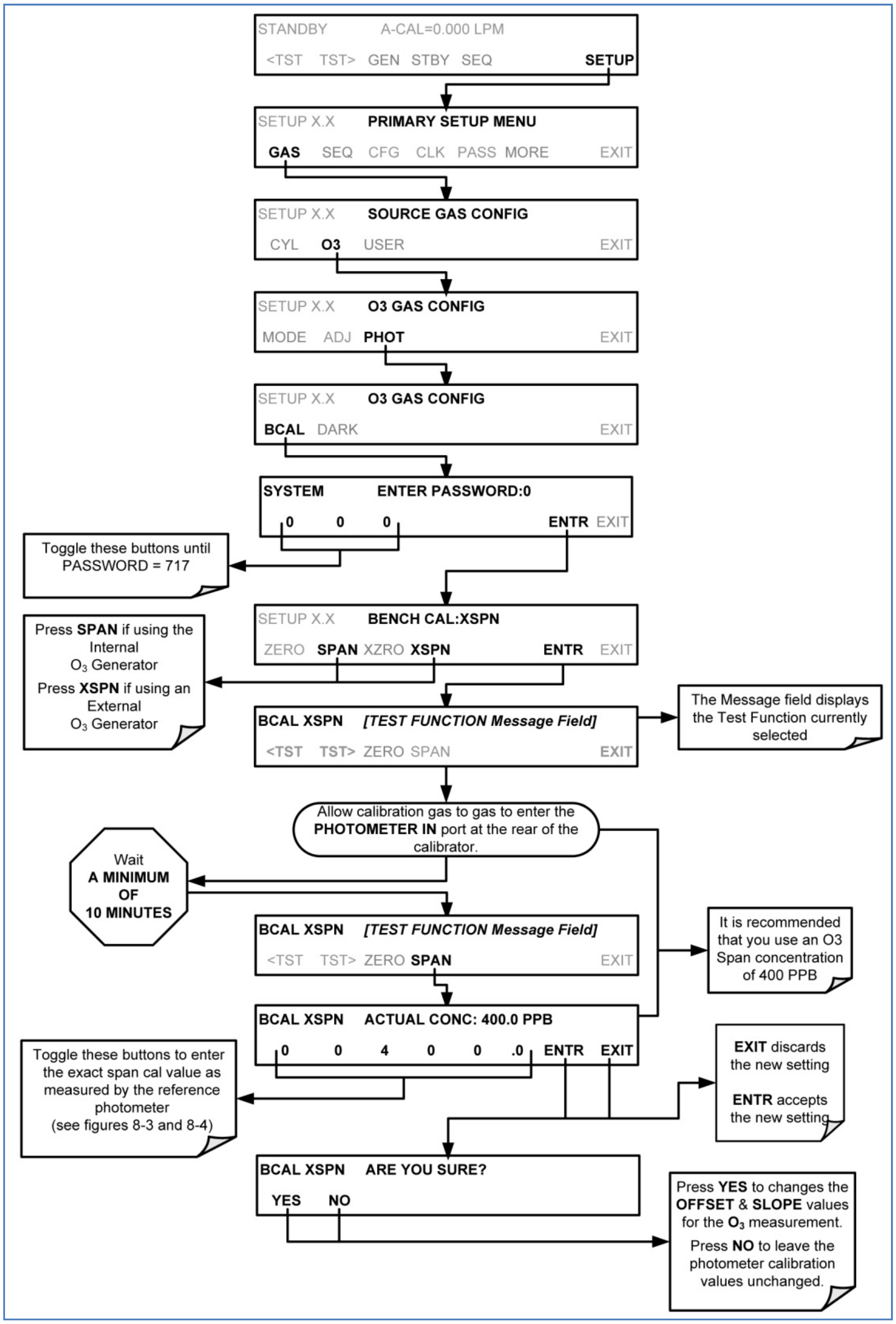
Photometer Zero

- Use the same pneumatic setup as in Section 7.3.4.1.
- Generate 0 ppb from the transfer standard, make sure to account for the slope and intercept correction for the transfer standard concentration
- Once stable (10 minutes minimum), use the touch-screen sequence below to set the zero point offset



Photometer Span

- Use the same pneumatic setup as in Section 7.3.4.2.
- Generate 450 ppb from the primary standard (PS), make sure to account for the slope and intercept correction for the PS concentration
- Once stable (10 minutes minimum), use the touch-screen sequence below to set the response slope



6.5.4.4 Photometer L3 Certification

All photometers used as transfer standards are calibrated and certified in accordance with the EPA document titled "Transfer Standards for Calibration of Air Monitoring Analyzers for Ozone", EPA-600/4-79-056 and O_3 TAD. Initial certification requires 6 comparison runs (6x6) between transfer and PS that include 6 concentration levels including zero and 85 percent to 95 percent of upper range. This procedure is to be performed on 6 separate days. Ongoing recertification of the L3 transfer standard requires that the L3 standard be compared to a Level 2 (L2) traveling transfer standard (a 1x6 verification). This comparison can take place either at the beginning and end of the designated ozone season or at six-month intervals, whichever is less frequent. A record of the most recent six calibrations of the transfer standard is kept as part of the certification process. The average of the six slopes and the average of the six intercepts are used as the correction factor for the transfer standard. Transfer standard certifications and traceability documents are maintained in the network coordination center files. First, the offset and slope of the photometer must be set to 0 and 1, respectively. Next, perform the initial 6x6 lab certification procedure. Then, perform the ongoing 1x6 field verification procedure.

Photometer Offset Procedure

Use the touch screen sequence below to manually set the offset to 0.

- Standby→Setup→More→VARS→929(password)→Next (continue pressing next until O3_OFFSET is displayed)→Edit→(Enter 0 or desired value)→ENTR (to accept value) or EXIT (to disregard value)

Photometer Slope Procedure

Use the touch screen sequence below to manually set the slope to 1.

- Standby→Setup→More→VARS→929(password) →Next (continue pressing next until O3_SLOPE is displayed)→Edit →(Enter 1 or desired value)→ENTR (to accept value) or EXIT (to disregard value)

6x6 Lab Certification Procedure

- Perform the Photometer Audit Procedure in SOP Section 6.5.4.3 using the following concentrations: 450 ppb, 300 ppb, 200 ppb, 90 ppb, 60 ppb, and 0 ppb

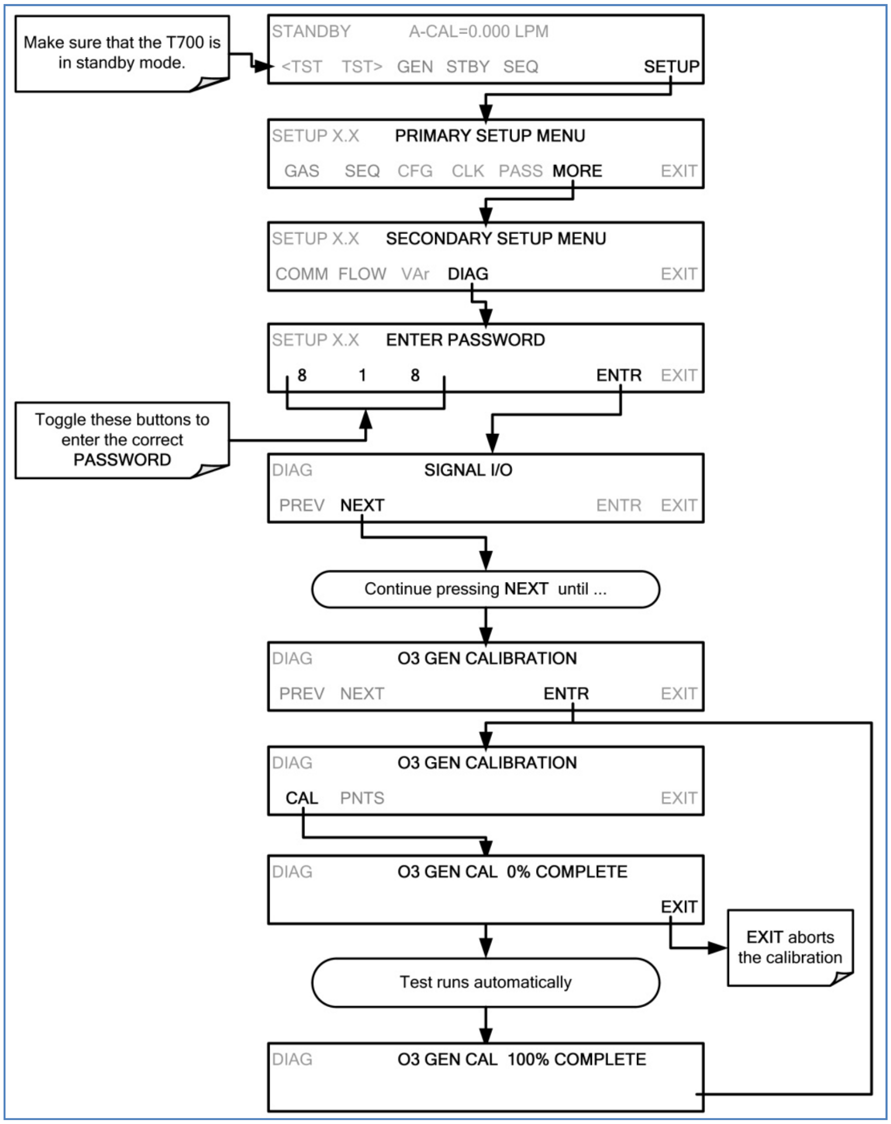
1x6 Field Verification Procedure

- Connect the Level 2 Traveling Transfer (L2) sample tubing to the Level 3's calibration gas line calibration fitting
- Power the L2 and establish communication between it and the data logger
- Generate 450 ppb from the calibrator, use the touch-screen sequence in section 6.4.5.1 selecting output A, 450 ppb of O_3, and 4 lpm
- Perform the back pressure compensation calibration in SOP Section 6.5.6
- Allow the traveling transfer to warm-up at least one hour

- After warm-up, record the L2 and calibrator five minute averages from the data logger
- Repeat the audit for the following concentrations: 300 ppb, 200 ppb, 90 ppb, 60 ppb, and 0 ppb
- The following concentrations can be audited for GPT considerations, but are not to be included into the L3 certification: 40 ppb, 15 ppb, and 7 ppb

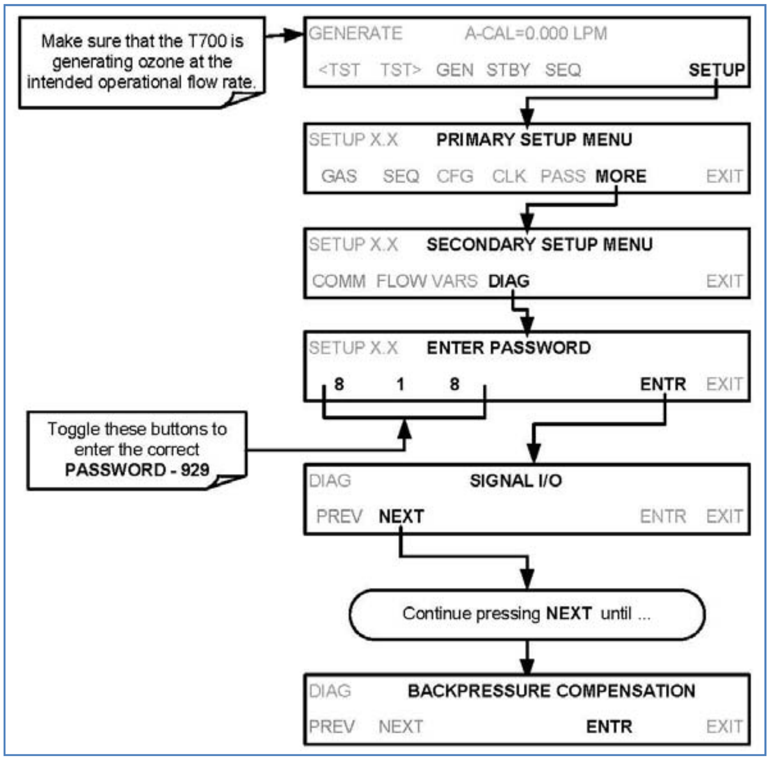
6.5.5 Ozone Generator Calibration

The T700 calibrator's software includes a routine for automatically calibrating the O_3 generator (Manual Section 7.4.2.5, p. 217). A table of drive voltages stored in the T700 memory is the basis for this calibration. Use the touch-screen sequence below to initiate the calibration.



6.5.6 Ozone Photometer Back Pressure Compensation

Any time there is a pneumatic configuration change; there is risk of impacting the internal measure/reference pressure (Manual Section 7.3.7, p. 210). This procedure must be performed before a photometer field audit. Set the calibrator to generate ozone at the flow rate intended for operation. While the instrument is generating ozone, use the touch-screen sequence below to initiate.



6.6 Maintenance, Repair and Troubleshooting

Complete the following checks, tests, and calculations in order to maintain the T700U calibration system.

Table 4 lists potential warning messages and their description (Manual Table 3-16, pp. 78-79).

Table 4 Warning Messages

MESSAGE	MEANING
ANALOG CAL WARNING	The calibrator's A/D converter or at least one analog input channel has not been calibrated.
CONFIG INITIALIZED	Stored Configuration information has been reset to the factory settings or has been erased.
DATA INITIALIZED	The calibrator's data storage was erased.
LAMP DRIVER WARN[1, 2]	The firmware is unable to communicate with either the O_3 generator or photometer lamp I^2C driver chips.[1, 2]
MFC CALIBRATION WARNING	The flow setting for one of the calibrator's mass flow controllers is less than 10% or greater than 100% of the flow rating for that controller.
MFC COMMUNICATION WARNING	Firmware is unable to communicate with any MFC.
MFC FLOW WARNING[3]	One of the calibrator's mass flow controllers is being driven at less than 10% of full scale or greater than full scale.
MFC PRESSURE WARNING	One of the calibrator's mass flow controllers internal gas pressure is outside of allowable limits.
O3 GEN LAMP TEMP WARNING[1]	The O_3 generator lamp temperature is outside of allowable limits.[1]
O3 GEN REFERENCE WARNING[1]	The O_3 generator's reference detector has dropped below the minimum allowable limit.[1]
O3 PUMP WARNING[1]	The pump associated with the O_3 photometer has failed to turn on.[1]
PHOTO LAMP TEMP WARNING[2]	The photometer lamp temperature is outside of allowable limits.[2]
PHOTO LAMP STABILITY WARNING	Photometer lamp reference step changes occur more than 25% of the time.
PHOTO REFERENCE WARNING[2]	The photometer reference reading is outside of allowable limits.[2]
REAR BOARD NOT DET	The calibrator's motherboard was not detected during power up. - THIS WARNING only appears on Serial I/O COMM Port(s). - The Front Panel Display will be frozen, blank or will not respond.
REGULATOR PRESSURE WARNING	The gas pressure regulator associated with the internal O_3 generator option is reporting a pressure outside of allowable limits.
RELAY BOARD WARN	The firmware is unable to communicate with the calibrator's relay PCA.
SYSTEM RESET	The calibrator has been turned off and on or the CPU was reset.
VALVE BOARD WARN	The firmware is unable to communicate with the valve controller board.

[1] Only applicable for calibrators with the optional the O_3 generator installed.
[2] Only applicable for calibrators with the optional photometer installed.
[3] On instrument with multiple Cal Gas MFCs installed, the **MFC FLOW WARNING** occurs when the flow rate requested is <10% of the range of the lowest rated MFC (i.e. all of the cal gas MFC are turned off).

Table 5 lists the warning message fault condition and possible causes (Manual Table 9–1, p. 243-244).

Table 5 Warning Message Fault Conditions and Possible Causes

WARNING	FAULT CONDITION	POSSIBLE CAUSES
CONFIG INITIALIZED	Configuration and Calibration data reset to original Factory state.	- Failed Disk-on-Module - User has erased configuration data
DATA INITIALIZED	Data Storage in DAS was erased.	- Failed Disk-on-Module. - User cleared data.
LAMP DRIVER WARN[1, 2]	The CPU is unable to communicate with either the O_3 generator or photometer lamp I^2C driver chip.	- I^2C has failed
MFC COMMUNICATION WARNING	Firmware is unable to communicate with any MFC.	- I^2C has failed - One of the MFCs has failed - Cabling loose or broken between MFC and Motherboard
MFC PRESSURE WARNING	One of the calibrator's mass flow controllers internal gas pressure is <15 PSIG or > 36 PSIG	- Zero or source air supply is incorrectly set up or improperly vented. - Leak or blockage exists in the T700's internal pneumatics - Failed CAL GAS or DUILUENT pressure sensor
O3 GEN LAMP TEMP WARNING[1]	IZS Ozone Generator Temp is outside of control range of 48°C ± 3°C.	- No IZS option installed, instrument improperly configured - O_3 generator heater - O_3 generator temperature sensor - Relay controlling the O_3 generator heater - Entire Relay PCA - I^2C Bus
O3 GEN REFERENCE WARNING[1]	The O_3 generator's reference detector output has dropped below 50 mV.[1]	Possible failure of: - O_3 generator UV Lamp - O_3 generator reference detector - O_3 generator lamp power supply - I^2C bus
O3 PUMP WARNING[1]	The photometer pump failed to turn on within the specified timeout period (default = 30 sec.).	- Failed Pump - Problem with Relay PCA - 12 VDC power supply problem
PHOTO LAMP TEMP WARNING[2]	The photometer lamp temp is < 51°C or >61°C.	Possible failure of: - Bench lamp heater - Bench lamp temperature sensor - Relay controlling the bench heater - Entire Relay PCA - I^2C Bus - Hot Lamp
PHOTO LAMP STABILITY WARNING	Value output during the Photometer's reference cycle changes from measurements to measurement more than 25% of the time.	- Faulty UV source lamp - Noisy UV detector - Faulty UV lamp power supply - Faulty ± 15 VDC power supply
PHOTO REFERENCE WARNING[2]	Occurs when Ref is <2500 mVDC or >4950 mVDC.	Possible failure of: - UV Lamp - UV Photo-Detector Preamp

Table 6 lists the available test function parameters and their descriptions (Manual Table 4-3, p. 101).

Table 6 Test Function Parameters

DISPLAY	UNITS	DESCRIPTION
A-CAL	LPM	The actual gas flow rate of source gas being output by the calibrator.
T-CAL	LPM	Target source gas flow rate for which the calibrator output is set.
A-DIL	LPM	The actual gas flow rate of diluent (zero) gas being output by the calibrator.
T-DIL	LPM	Target diluent (zero) gas flow rate for which the calibrator output is set.
O3GENREF[1]	mV	The voltage being output by the O_3 generator reference detector.
O3FLOW[1]	LPM	The gas flow rate for which the O_3 generator is set.
O3GENDRV[1]	mV	The drive voltage of the O_3 generator UV lamp.
O3LAMPTMP[1]	°C	O_3 generator UV lamp temperature.
CAL PRES	PSIG	The gas pressure of the source gas being supplied to the calibrator.
DIL PRES	PSIG	The gas pressure of the Diluent gas being supplied to the calibrator Diluent pressure.
REG PRES[2]	PSIG	The gas pressure at the pressure regulator on the O_3 generator supply line.
A-GAS		Actual concentration, and in some modes the actual flow rate, of the source gas in the calibration mixture being generated is displayed.
T-GAS		The Target concentration, and in some modes the target flow rate, of the source gas in the calibration mixture being generated is displayed.
BOX TMP	°C	Internal chassis temperature.
PH MEAS[2]	mV	The average UV Detector output during the SAMPLE PORTION of the optional photometer's measurement cycle.
PH REF[2]	mV	The average UV Detector output during the REFERENCE portion of the optional photometer's measurement cycle.
PH FLW[2]	LPM	The gas flow rate as measured by the flow sensor located between the optical bench and the internal pump.
PH LTEMP[2]	°C	The temperature of the UV lamp in the photometer bench.
PH PRES[2]	In-hg-A	The pressure of the gas inside the photometer's sample chamber as measured by a solid-state pressure sensor located downstream of the photometer.
PH STEMP[2]	°C	The temperature of the gas inside the sample chamber of the photometer.
PH SLOPE[2]	1.000	Photometer slope computed when the photometer was calibrated at the factory.
PH OFFST[2]	ppb	Photometer offset computed when the photometer was calibrated at the factory.
TEST[3]	mV	Displays the analog signal level of the **TEST** analog output channel.
TIME	HH:MM:SS	Current time as determined by the calibrator's internal clock.

[1] Only appears when the optional O_3 generator is installed.
[2] Only appears when the optional O_3 photometer is installed.
[3] Only appears when the **TEST** channel has been activated.

Table 7 lists the test functions and possible causes of nominal range failure (Manual Table 9-2, pp. 245-246).

Table 7 Test Functions and Possible Causes of Nominal Range Failure

TEST FUNCTION	DIAGNOSTIC RELEVANCE AND CAUSES OF FAULT CONDITIONS.
O3GENREF[1]	Particularly important in calibrators without the optional O_3 photometer since the reference detector is the primary input for controlling O_3 concentration. Possible causes of faults are the same as **O3 GEN REFERENCE WARNING** from Table 11-1.
O3FLOW[1]	Gas flow problems directly affect the concentration accuracy of the T700's calibration gas mixtures. - Check for Gas Flow problems.
O3GENDRV[1]	Check the O_3 generator heater and temperature sensors. Possible causes of faults are the same as **O3 GEN LAMP TEMP WARNING** from Table 11-1.
O3LAMPTMP[1]	Incorrect Lamp temperature can affect the efficiency and durability of the O_3 generators UV lamp. Possible causes of faults are the same as **O3 GEN LAMP TEMP WARNING** from Table 11-1.
CAL PRES	Affects proper flow rate of Cal gas MFCs. Possible causes of faults are the same as **MFC PRESSURE WARNING** from Table 11-1.
DIL PRES	Affects proper flow rate of Diluent gas MFCs. Possible causes of faults are the same as **MFC PRESSURE WARNING** from Table 11-1.
REG PRES	Same as **REGULATOR PRESSURE WARNING** from Table 11-1.
BOX TMP	If the Box Temperature is out of range, ensure that the: Box Temperature typically runs ~7°C warmer than ambient temperature. - The Exhaust-Fan is running. - Ensure there is sufficient ventilation area to the side and rear of instrument to allow adequate ventilation.
PH MEAS[2] & PH REF[2]	If the value displayed is too high the UV Source has become brighter. Adjust the variable gain potentiometer on the UV Preamp Board in the optical bench. If the value displayed is too low: - < 200mV – Bad UV lamp or UV lamp power supply. - < 2500mV – Lamp output has dropped, adjust UV Preamp Board or replace lamp. If the value displayed is constantly changing: - Bad UV lamp. - Defective UV lamp power supply. - Failed I^2C Bus. If the PHOTO REFERENCE value changes by more than 10mV between zero and span gas: - Defective/leaking switching valve.
PH FLW[2]	Gas flow problems directly affect the accuracy of the photometer measurements and therefore the concentration accuracy of cal gas mixtures involving O_3 and GPT mixtures. - Check for Gas Flow problems.
PH LTEMP[2]	Poor photometer temp control can cause instrument noise, stability and drift. Temperatures outside of the specified range or oscillating temperatures are cause for concern. Possible causes of faults are the same as **PHOTO LAMP TEMP WARNING from** Table 11-1.
PH PRES[2]	The pressure of the gas in the photometer's sample chamber is used to calculate the concentration of O_3 in the gas stream. Incorrect sample pressure can cause inaccurate readings. - Check for Gas Flow problems. See Section Table 11-1.

TEST FUNCTION	DIAGNOSTIC RELEVANCE AND CAUSES OF FAULT CONDITIONS.
PH STEMP[2]	The temperature of the gas in the photometer's sample chamber is used to calculate the concentration of O_3 in the gas stream. Incorrect sample temperature can cause inaccurate readings. Possible causes of faults are: - Bad bench lamp heater - Failed sample temperature sensor - Failed relay controlling the bench heater - Failed Relay PCA - I^2C Bus malfunction - Hot Lamp
PH SLOPE[2]	Values outside range indicate: ▪ Contamination of the Zero Air or Span Gas supply. ▪ Instrument is miss-calibrated. ▪ Blocked Gas Flow. ▪ Faulty Sample Pressure Sensor or circuitry. ▪ Bad/incorrect Span Gas concentration.
PH OFFST[2]	Values outside range indicate: ▪ Contamination of the Zero Air supply.
TIME	Time of Day clock is too fast or slow. ▪ To adjust see Section 6.7. ▪ Battery in clock chip on CPU board may be dead.
[1] Only appears when the optional O_3 generator is installed. [2] Only appears when the optional O_3 photometer is installed	

6.6.1 Cleaning or Replacing the Absorption Tube

Follow the instructions in Manual Section 8.2.2, p. 231:

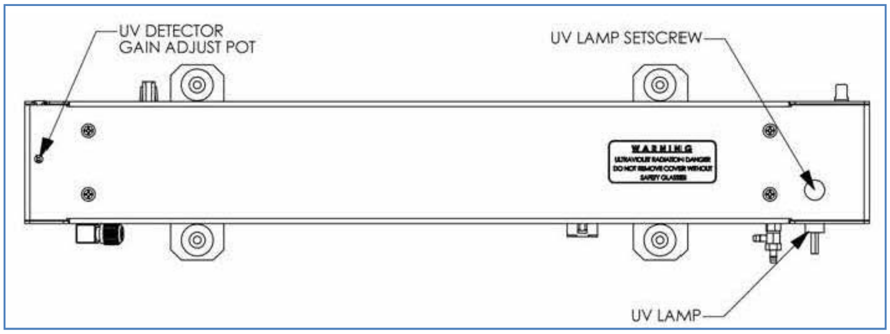
- Remove the center cover from the optical bench
- Unclip the sample thermistor from the tube
- Loosen the two screws on the round tube retainers at either end of the tube
- Using both hands, carefully rotate the tube to free it
- Slide the tube towards the lamp housing and the tube can now be slid past the detector block and out of the instrument
- Clean the tube by rinsing with de-ionized water
- Air dry the tube
- Check the cleaning job by looking down the bore of the tube. It should be free from dirt and lint
- Inspect the O-rings that seal the ends of the optical tube (these O-rings may stay seated in the manifolds when the tube is removed), if there is any noticeable damage to these O-rings, they should be replaced
- Re-assemble the tube into the lamp housing and perform the System Leak Check (Section 6.5.2)

6.6.2 UV Source Lamp Adjustment

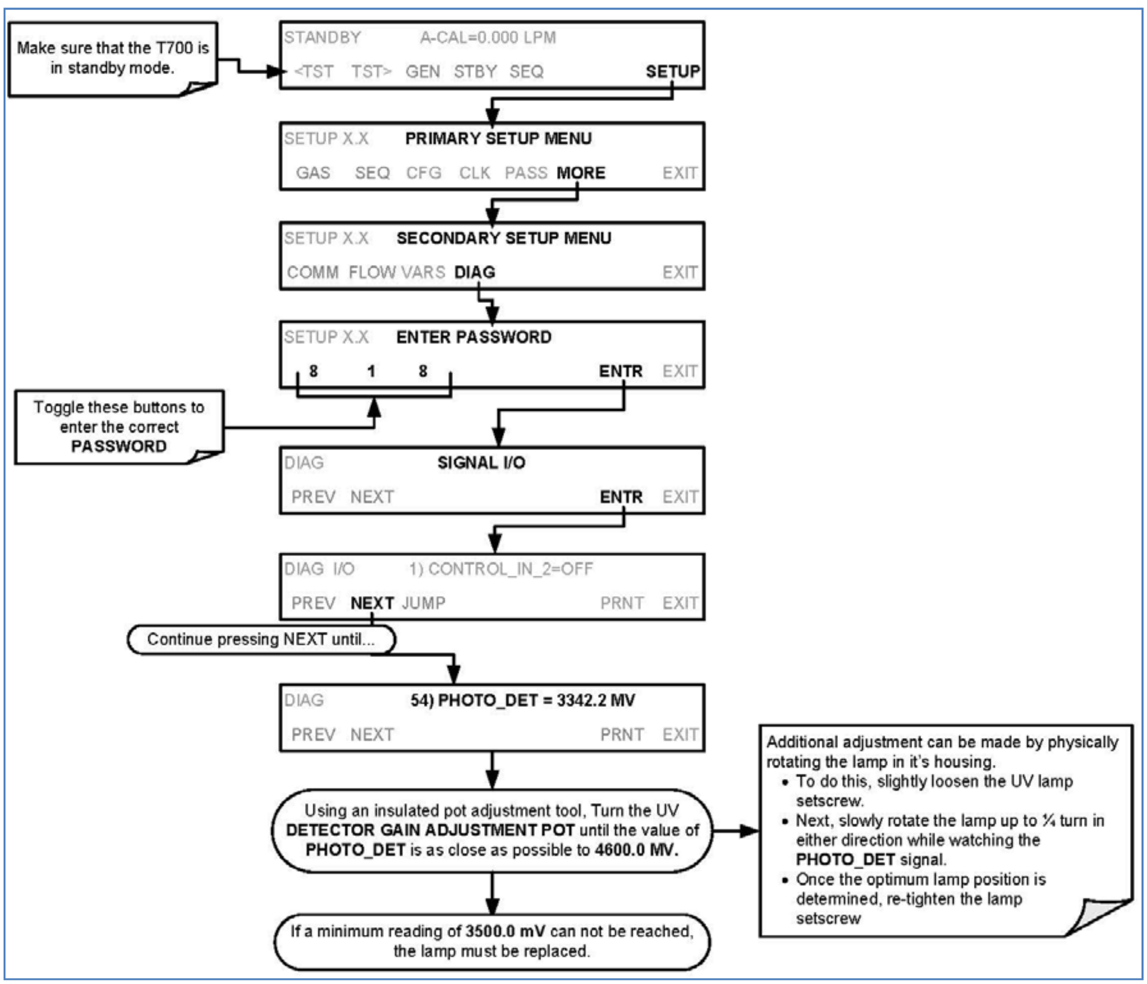
This procedure should be done whenever the PHOTO REFERENCE test function value drops below 3000 mV (Manual Section 8.2.3, pp. 232-233).

- Ensure that the calibrator is warmed-up and has been running for at least 30 minutes before proceeding
- Remove the cover from the calibrator
- Locate the optional Photometer (see Figure 5)
- Locate the UV DETECTOR GAIN ADJUST POT on the photometer assembly (see Figure 15)

Figure 15 Photometer Assembly – Lamp Adjustment/Installation



- Perform the following touch screen sequence and procedure



6.6.3 UV Source Lamp Replacement

This procedure (Manual Section 8.2.4, pp. 233-234) should be done whenever the lamp can no longer be adjusted as described in Section 6.6.2.

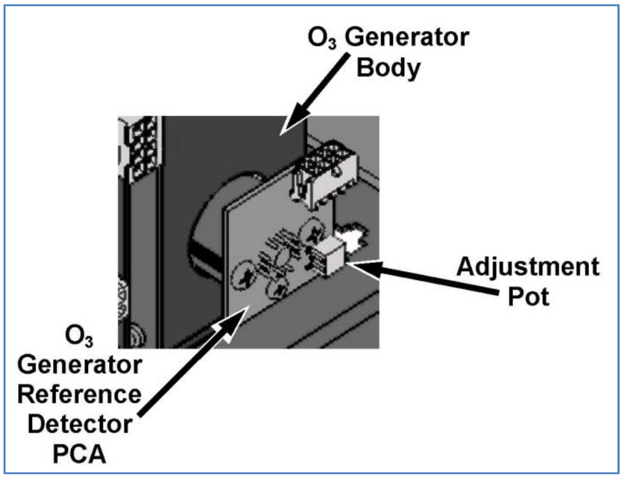
- Turn the calibrator off
- Remove the cover from the calibrator
- Locate the Optical Bench Assembly (see Figures 5 and 6)
- Locate the UV lamp at the front of the optical bench assembly (see Figure 15)
- Unplug the lamp cable from the power supply connector on the side of the optical bench
- Slightly loosen (do not remove) the UV lamp setscrew and pull the lamp from its housing
- Install the new lamp in the housing, pushing it all the way in. Leave the UV lamp setscrew loose for now
- Turn the calibrator back on and allow it to warm up for at least 30 minutes
- Turn the UV detector gain adjustment pot (See Figure 15) clockwise to its minimum value. The pot may click softly when the limit is reached
- Perform the UV Lamp Adjustment procedure described in SOP Section 6.6.2, with the following exceptions:
  - Slowly rotate the lamp in its housing (up to ¼ turn in either direction) until a MINIMUM value is observed
    - Ensure the lamp is pushed all the way into the housing while performing this rotation
    - If the PHOTO_DET will not drop below 5000 mV while performing this rotation, contact Teledyne API'S Customer Service for assistance
  - Once a lamp position is found that corresponds to a minimum observed value for PHOTO_DET, tighten the lamp setscrew at the approximate minimum value observed
  - Adjust PHOTO_DET within the range of 4400 – 4600 mV
- Replace the cover on the calibrator

6.6.4 Adjustment or Replacement of Ozone Generator UV Lamp

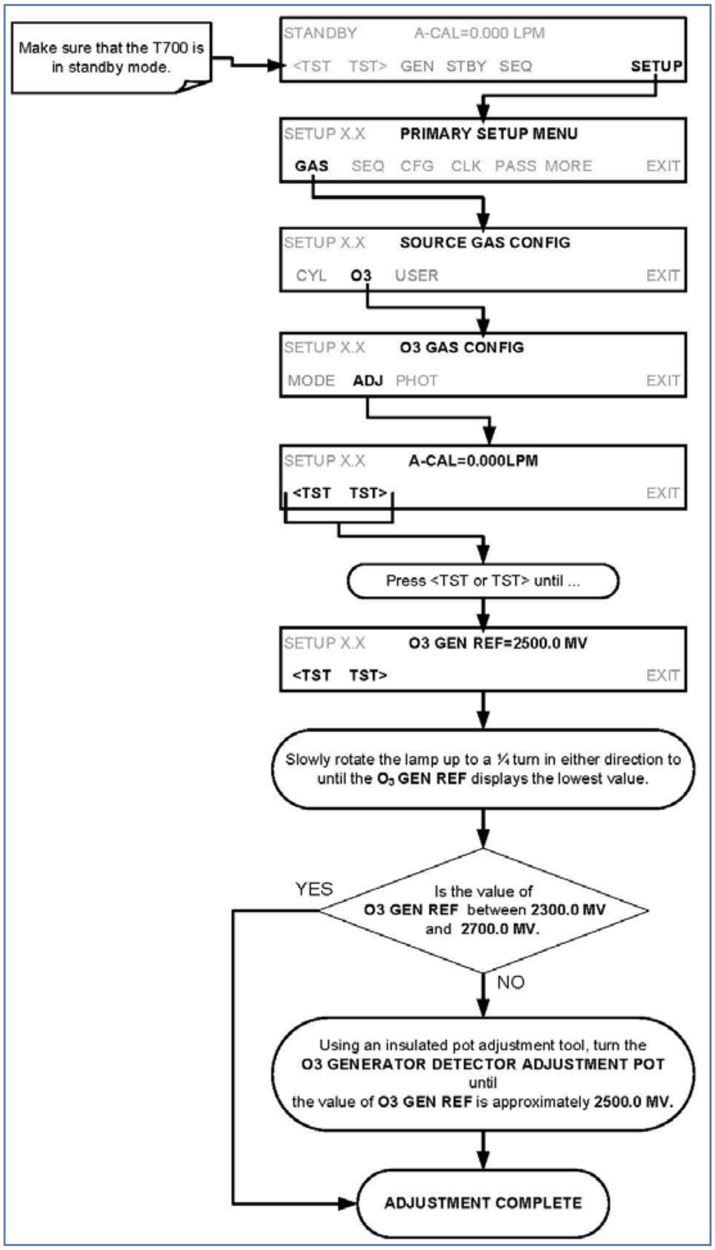
Adjust or replace the ozone generator UV lamp (Manual Section 8.2.5, pp. 234-235)

- Turn off the calibrator
- Remove the cover from the calibrator
- Locate the O_3 generator (see Figure 5)
- Remove the two setscrews on the top of the O_3 generator and gently pull out the old lamp
- Inspect the O-ring beneath the nut and replace if damaged
- Install the new lamp in O_3 generator housing, but do not fully tighten the setscrews; the lamp should be able to be rotated in the assembly by grasping the lamp cable
- Turn on calibrator and allow it to stabilize for at least 30 minutes
- Locate the potentiometer used to adjust the O_3 generator UV output (see Figure 16)

Figure 16 Location of O_3 Generator Reference Detector Adjustment Pot



- Perform the touch-screen sequence below



- Tighten the two setscrews
- Replace the calibrator's cover
- Perform an System Leak Check (see Section 6.5.2)
- Perform an Ozone Generator calibration (see Section 6.5.5)

7.0 REFERENCES

Teledyne Advanced Pollution Instrumentation (API). 2012. Operation Manual. Model T700 Dynamic Dilution Calibrator. 06873B DCN6388.

Teledyne Advanced Pollution Instrumentation (API). 2012. Addendum. Model T700U Calibrator. 06876B DCN6403.

U.S. Environmental Protection Agency (EPA). 2010. Transfer Standards for Calibration of Air Monitoring Analyzers, Ozone Technical Assistance Document (O_3 TAD). EPA-454/B-10-001.

Code of Federal Regulations Title 40 Part 50 (40 CFR 50). National Primary and Secondary Ambient Air Quality Standards

U.S. Environmental Protection Agency (EPA). 1975. Technical Assistance Document for the Chemiluminescence Measurement of Nitrogen Dioxide (NO_2 TAD). EPA-600/4-75-003.

U.S. Environmental Protection Agency (EPA). 2005. Technical Assistance Document for NCore Monitoring. Version 4. EPA-454/R-05-003.

U.S. Environmental Protection Agency (EPA). 2008. QA Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program, Appendix D. EPA-454/B-08-003.

8.0 ATTACHMENTS

This SOP does not contain attachments.

9.0 ABBREVIATIONS

CLK	clock
ENTR	enter
InHG-A	inches mercury absolute
MASS	molar mass
POT	potentiometer
PSIG	pounds per square inch
PRES	pressure
PRT1	port # 1

MODEL 701H ZERO AIR GENERATOR STANDARD OPERATING PROCEDURE (SOP)

Effective Date: 6-1-13

Reviewed by: Kevin P. Mishoe, Field Operations Manager — Kevin Mishoe by Michael J. Smith with permission

Reviewed by: Marcus O. Stewart, QA Manager — [signature]

Approved by: Holton K. Howell, Project Manager — Holton K Howell

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Reviewed by:	Title:	Date:	Signature:
MS	QA Mgr	10/30/14	[signature]
MS	QA Mgr	10/22/15	[signature]

TELEDYNE API 701H ZERO AIR GENERATOR SOP

1.0 PURPOSE

The purpose of this SOP is to provide consistent guidance for maintenance and handling of the Teledyne Advanced Pollution Instrumentation (API) Model 701H High Performance Zero Air System. This SOP is designed to be used by the Clean Air Status and Trends Network (CASTNET) field calibration laboratory and field personnel.

2.0 SCOPE

This SOP applies to all CASTNET sites operating a Teledyne API 701H zero air source, which typically supports trace level pollutant monitoring equipment. The reader must also be familiar with the three documents listed in Section 7.0 (References) of this SOP. The documents include the EPA (2005) Technical Assistance Document (TAD) for NCore monitoring, the API 701H Operation Manual (Manual), and EPA (2008) QA Handbook for Air Pollution Measurement Systems, Volume II, Appendix D (QA Handbook). The various sections throughout this SOP cross-reference the three documents.

3.0 SUMMARY

The Teledyne API Model 701H dries and scrubs ambient air of the appropriate pollutants and interferants in order to produce zero air. This zero air is supplied to the T700U Dilution Gas Calibrator, which is then used to calibrate and verify trace level pollutant analyzers.

Figure 1 provides a schematic of the API 701H. The compressor draws ambient air in from the rear panel bulkhead union and inlet filter. At the compressor outlet, the air is under pressure and hot from the compression. The relative humidity is high as a result of the high pressure. The air is conducted through the cooling coil where heat is removed by transfer to the cooling fan air. With the pressure still high but the temperature reduced to ambient, the relative humidity is at its highest. At this point, the air is usually supersaturated.

From the coil, the wet air passes through a coalescing filter where the excess water is separated and settles in the bottom of the filter. The controller periodically opens the solenoid drain valve allowing the water to be expelled through a rear panel bulkhead union (drain).

The partially dried air then passes a pressure relief valve, set to open at 90 pounds per square Inch (psig), and enters the regenerative drier which removes essentially all the remaining water and a portion of the other contaminants. The dry air then passes through a check-valve to the on demand storage tank.

For a final clean-up, the dry, regulated air enters the specific scrubbers that remove sulfur dioxide (SO_2), nitrogen oxides (NO), nitrogen dioxide (NO_2), ozone (O_3), hydrogen sulfide (H_2S), carbon monoxide (CO), and hydrocarbons (THC). The air finally passes through a fine particulate filter before it enters the ¼” Teflon fluorinated ethylene propylene (FEP) tubing that runs to the T700U Gas Dilution System (Figure 2).

Figure 1 Schematic of 701H Operation

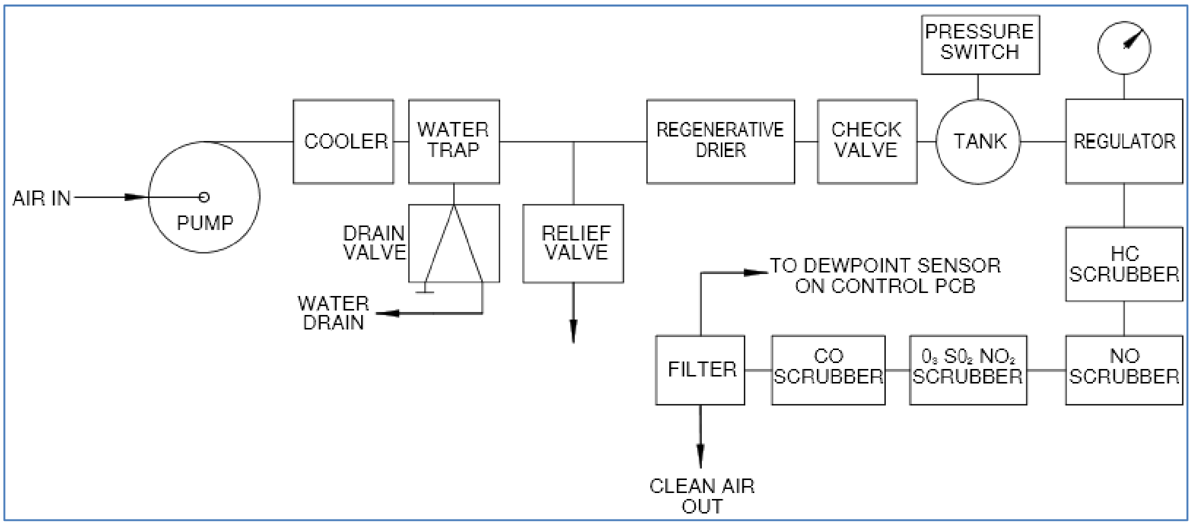


Figure 2 Scrubber Canisters Accessed from Front Panel

4.0 MATERIALS AND SUPPLIES

The operation of the API 701H requires:

- inlet air filter
- ¼" stainless nut and compression ferrule set
- ¼" FEP Teflon tubing
- power cord
- charcoal
- purafil
- rack mounts

The API 701H is utilized with a dynamic dilution gas system (API 700U) with an Ultra-Pure Zero Air Cylinder with certified concentrations less than lower detection limit (LDL) of analyzers that are supported. Current specifications from Scott-Marrin are THC <0.01 ppm, CO < 0.01 ppm, NO_x < 0.001 ppm, and SO_2 < 0.001 ppm. The API 701H supports the T100U SO_2 Analyzer, T200U NO_y analyzer, and the T300U CO monitor.

5.0 SAFETY

According to Manual, the weight of the 701H system is 55 lb. Consequently, it is recommended that two persons lift and carry the 701H. The system operates with high voltages and the instrument must have properly grounded power. The water storage vessel may need to be emptied periodically, or line vented outside.

6.0 PROCEDURES

6.1 Set-Up/Installation

6.1.1 Remove Shipping Screws

Remove the 701H from shipping carton. Remove cover by taking out the screw on front upper center and two screws on each side of 701H (Manual Figures 3-2 and 3-3). Slide cover back 1 inch and then lift. Remove 4 red shipping screws on compressor base (Manual Section 5.1, Figure 5-2). Perform a visual inspection of the machine. Look for any loose connections or things that appear out of place. Internal damage to the generator and its components can occur during shipment. Loose fittings and screws should be tightened in place if practical and noted in the Remarks section of the specific iForm. The field operations manager (FOM) or his designee should be notified about any remaining loose pieces and/or any damage to the 701H.

6.1.2 Ventilate Instruments

Install rack slides onto each side of 701H and install into rack. Use the following ventilation/clearance guidance to properly operate equipment:

Ventilation/ clearance (Manual 3.2, p. 3-1).

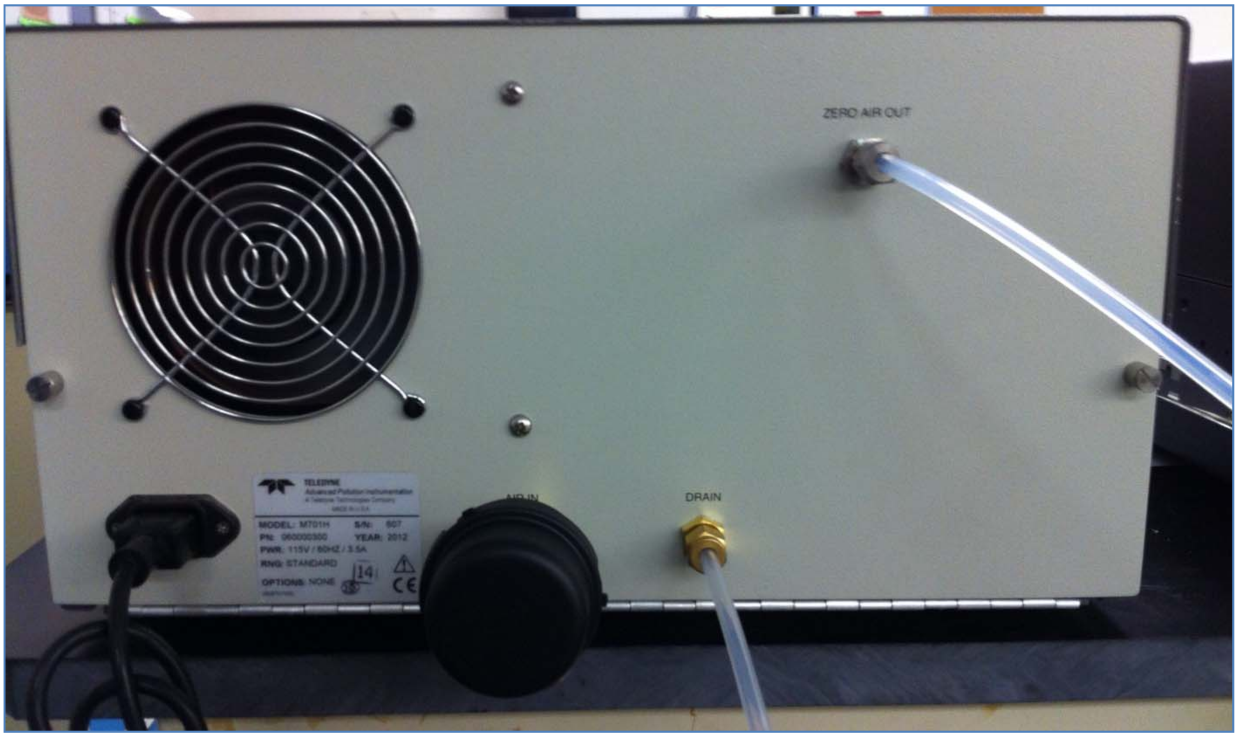
– Back 6 inches

- Sides 3 inches
- Access to front and rear (Figure 3) of machine.

6.1.3 Implement Connections

Implement the following electrical and pneumatic connections (Manual Section 5.1, Figures 5-1 and 5-2).

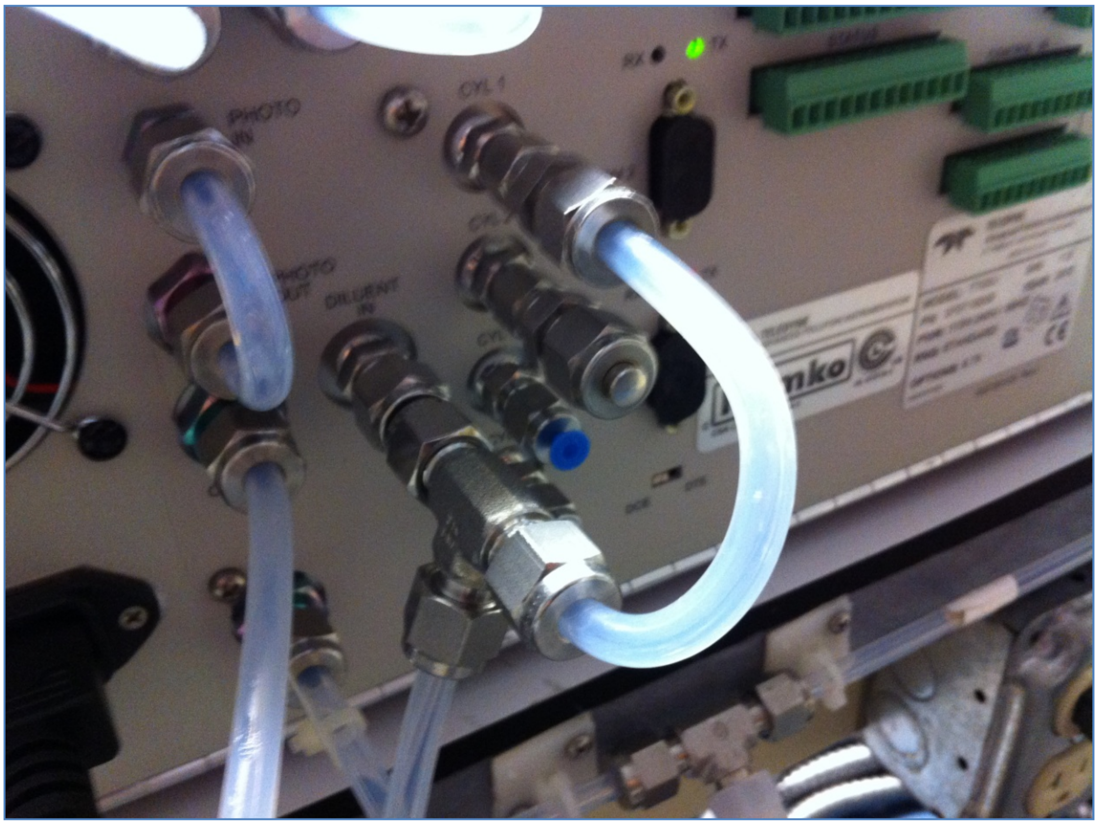
Figure 3 Rear of 701H



1. "AIR IN" (1/4" female pipe thread).
   a. Screw the inlet filter into the "AIR IN" port. Hand-tight is sufficient.
   NOTE: Operation without filter will cause premature wear.
2. "WATER DRAIN" (1/4" swage-type bulkhead union).
   a. Connect 1/4" outside diameter tubing to the WATER DRAIN to conduct the occasional spurts of water away from the instrument rack. Connect the tubing to a drain or, alternatively, the water may be collected in a tray or bucket and dispersed by normal evaporation.

3. “ZERO AIR OUT” (1/4” swage-type bulkhead union).
   a. Connect the AIR OUT (Figure 4) port of the 701H to the equipment requiring zero air. For the Model T700U Calibrator, connect the AIR OUT port to the “Diluent In” and “CYL1” fittings using a stainless steel or Teflon Tee and clean 1/4” FEP Teflon tubing. The pressure in this line will normally be 30 PSIG, but may be as high as 80 psig.
   b. Keep this line as short as possible to minimize pressure drops.

Figure 4 Zero Air Connected to Model T700U Calibrator



   c. POWER. Connect the power cord to the proper power source. At 115 VAC, 60 Hz, the 701H draws 3.5 Amps. At 230 VAC, 50 Hz, the 701H draws 2.0 Amps.
4. “COOLING FAN” The rear panel cooling fan draws air in and requires at least 6” (150 mm) of clearance for proper operation.

6.2 Powering Up

- Turn on the front panel POWER SWITCH. (Manual Figure 3-2, p. 3-3).
- The front panel POWER light should come on.
- The cooling fan should start immediately.

- The compressor should start after a few seconds delay. The delay is to allow the control board to measure the local line frequency.
- After 30 to 60 seconds, the front panel pressure gauge should read 30 psig. If it does not, use pressure adjust dial until it reads 30 psig.
- Make sure that the green dew point sensor on front panel is lit, if not, troubleshoot. If the panel is lit green, the Model 701H is now producing clean, dry air.

If the 701H has been unused for several days, it may take 30-60 minutes to achieve final purity and dryness.

6.3 Acceptance Testing

Using a certified cylinder of Ultra-Pure air, calibrate the zero of the analyzers that are supported. Then deliver zero air to the analyzers using the 701H as described in Sections 6.1 (Set-Up), 6.2 (Configuration) and 6.4 (Operation) of the T700U SOP. Verify that the stable instrument readings, using a minimum of a five-minute average, are below the specifications in the table below.

SO_2	0.5 ppb
NO	0.5 ppb
NO_2	0.5 ppb
O_3	0.5 ppb
CO	0.025 ppm
HC	0.02 ppm

6.4 Powering Down

Standing water will cause corrosion. If the 701H will be out of use for an extended period or if it will be shipped/transported, the following procedures are recommended in order to prolong the life of the equipment.

- Turn OFF the 701H.
- Wait approximately 1 minute.
- Turn the 701H ON and vent any accumulated water through the water drain.
- Turn the 701H OFF.

These procedures will vent any water that has accumulated in the coalescing filter, which not only helps to avoid corrosion, but also prevents that water from passing into the 701H in the event that the instrument is inverted during storage or transportation.

Figure 5 Front Panel

6.5 Maintenance, Repair and Troubleshooting

6.5.1 Periodic Maintenance

Periodic Maintenance is essential to proper operation of 701H., The charcoal, purafil and particulate filters will be replaced annually (Manual Section 6.1, Table 6-1) while performing site calibrations during the period July through December. The filter replacements will be documented using Manual Table 6-1 and recorded in site log book.

- During the July through December calibration visits the inside of the 701H will be checked for excessive dirt or dust.
- In particular, the cooling fan, cooling coil and compressor fan inlet will be checked.
- Any dirt or dust will be removed with a vacuum cleaner, not an air jet (which will only redistribute the dirt and will not remove it).
- The results will be noted in site log book.

6.5.2 Line Checks

During any vibration of the compressor, some parts of the Teflon tubing may abrade against nearby objects. This is most likely to occur when the tubing is directly attached to the compressor.

- Check to see if any signs of abrasion are present, and, if so, adjust the tubing to prevent rubbing.
- If any section of tubing appears to be heavily abraded, remove and replace it. Rebuild or replace the pump if the vibration causes any other components in the generator to move.

7.0 REFERENCES

Teledyne Advanced Pollution Instrumentation (API). 2011. Operation Manual. Model T701 Zero Air Generator. 01671H DCN6051.

U.S. Environmental Protection Agency (EPA). 2005. Technical Assistance Document for NCore Monitoring. Version 4. EPA-454/R-05-003.

U.S. Environmental Protection Agency (EPA). 2008. QA Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program, Appendix D. EPA-454/B-08-003.

8.0 ATTACHMENTS

This SOP does not contain attachments.

REMOTE CALIBRATION

Effective Date: 6-1-13

Reviewed by: Kevin P. Mishoe
Field Operations Manager

Reviewed by: Marcus O. Stewart
QA Manager

Approved by: Holton K. Howell
Project Manager

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MS	QA Mgr	10/30/14	[signature]
MS	QA Mgr	10-22-15	[signature]

REMOTE CALIBRATION

1.0 PURPOSE

The purpose of this document is to provide consistent guidance for the remote calibration of continuous gas analyzers.

2.0 SCOPE

CASTNET sites operating remotely accessible continuous gas analyzers and a certified, on-site calibration transfer standard. For example, a site operating an API T200U NO_y analyzer and an API T700U Dynamic Dilution Gas Calibrator.

3.0 OVERVIEW

Performing frequent calibration adjustments to an analyzer is undesirable. The consistency of the data record is reduced and the difficulty in maintaining clear, transparent quality control documentation is increased. As such, the use of remote calibration adjustments should be minimized whenever possible. When required, a root cause preventing the analyzer from operating within established criteria until a routinely scheduled visit should be investigated.

4.0 PROCEDURE

4.1 Prepare data record for adjustment

4.1.1 Connect remotely to the site data logger using LoggerNet or PC200 on the site laptop

4.1.2 Set the Calibrator to Service mode by changing Enable_Calibrator_Service_Mode to True.

4.1.3 Enable remote communication to the analyzers by setting Enable_APICom(*Index*) to True for the analyzer to be adjusted. ***Note:*** APICom is always enabled for the Dynamic Calibrator. The indexes are as follows:
1 = Ozone Site Analyzer
2 = Level 3 Onsite Transfer Standard
3 = Level 2 Travelling Transfer Standard
4 = SO_2 Analyzer
5 = CO Analyzer
6 = NO Analyzer
7 = Dynamic Dilution Calibrator

4.1.4 Down the data channel for the analytes affected (e.g. SO_2 for the T100U; NO, NO_y and NOy_Diff for the T200U)

4.2 Connect directly to the Analyzer and perform the Calibration

4.2.1 Connect remotely to the Dynamic calibrator and the analyzer to be adjusted. The TCP/IP configuration to connect to an analyzer is the public IP address of the site, and the port chosen from the following table

3043 – SO_2 Analyzer
3048 – CO Analyzer
3042 – NO Analyzer
3146 – Dynamic Dilution Calibrator

4.2.2 Perform multipoint As Found audit as described in the relevant SOP

4.2.3 Record the results using the iForms and clearly state in the Remarks section that the adjustment was done remotely.

4.2.4 Perform a calibration adjustment as described in the relevant SOP

4.2.5 Perform a final As Left audit as described in the relevant SOP

4.2.6 Disconnect from remote communication to free the data logger to resume normal data collection (e.g. close APICom)

4.3 Return all instruments to normal operational mode.

4.3.1 Enable_APICom = False for each analyzer calibrated

4.3.2 Enable_APICom = False for the Dynamic Dilution Calibrator

4.3.3 Enable_Calibrator_Service_Mode = False

4.4 Complete documentation

4.4.1 Initiate an automated on-demand ZPS check

4.4.2 Record final results using the iForms

4.4.3 Place a PDF copy of the iForms in the calibration folder on the desktop of the site laptop

4.4.4 Send the original iForms and a PDF copy to the calibration folder reviewer

HANDLING AND STORAGE OF COMPRESSED GASES

Effective Date: 6-1-13

Reviewed by: Kevin P. Mishoe, Field Operations Manager

Reviewed by: Marcus O. Stewart, QA Manager

Approved by: Holton K. Howell, Project Manager

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Reviewed by:	Title:	Date:	Signature:
MS	QA Mgr	10/30/14	[signature]
MS	QA Mgr	10/22/15	[signature]

HANDLING AND STORAGE OF COMPRESSED GASES

1.0 PURPOSE

Cylinders of compressed gases can be extremely hazardous if misused. Besides the hazard associated with high pressure, the chemical hazard of the cylinder contents must be considered. In addition, some of these materials are extremely cold when released. Certain precautions must be observed in storage, handling, and use of these materials in order to minimize these hazards. The purpose of this procedure is to delineate guidelines for the use, handling, and storage of compressed gas cylinders for the Clean Air Status and Trends Network (CASTNET) project.

2.0 SCOPE

This procedure applies to all employees, temporary workers and contractors who work with or around compressed gases at AMEC facilities involved with the CASTNET project.

This procedure does not cover the U.S. Department of Transportation regulations pertaining to the transportation of compressed gases.

3.0 PROCEDURE

Supervisors in areas where compressed gas cylinders are used or stored are responsible for:

- Verifying that the guidelines for their use, handling and storage are followed in areas under their supervision.
- Notifying the Project Manager of any new processes which will change the current inventory, including but not limited to increases in amount and/or types of gases.

3.1 STORAGE of COMPRESSED GASES

Chemical inventories are used to determine if a hazard class of gas must be reported to the State Fire Marshal.

CO	=	Flammable
NO	=	Corrosive/Oxidizer
NPN	=	Flammable/Irritant
SO_2	=	Irritant

Aggregate use or storage of compressed gases exceeding the amounts listed below must be permitted (Article 1 Uniform Fire Code, Section 105, Permits).

UFC Table 105-A–Permit Amounts for Compressed Gases[1]

Type of Gas	Amount (ft^3)[2]
Corrosive	200
Flammable (except cryogenic fluids and LPG)	200
Highly Toxic	Any Amount
Inert and Simple Asphyxiant	6,000
Irritant	200
Other Health Hazards	650
Oxidizing (including oxygen)	504
Pyrophoric	Any Amount
Radioactive	Any Amount
Sensitizer	200
Toxic	Any Amount
Unstable (reactive)	Any Amount

Notes: [1] See UFC Articles 49, 52, 63, 74, 80 and 82 for additional requirements
[2] Cubic feet measured at standard temperature and pressure

3.2 GENERAL SAFETY REQUIREMENTS

- A cylinder should always carry a legible label or stencil identifying its contents. Do not use the cylinder if the contents are not properly identified.
- Labels or identifying markings on cylinders should face out such that they are clearly visible.
- Ensure cylinders are stored and used in a dry, well ventilated area.
- All cylinders, whether full or empty, must be secured in an upright position by a chain or strap system made for this purpose.
- Cylinders should be stored out of direct sunlight and away from other heat sources.
- Cylinders should be stored at temperatures above freezing and below 125 degrees F.
- Cylinder valves should be closed except when the cylinder is in active use.
- Always use an appropriate pressure regulator with each cylinder.
- Open cylinder valves and regulators slowly.
- The main cylinder valve should always be opened before opening the downstream regulator valve.
- Once the cylinder is installed, test for leaks. If gas leaks are detected, shut down the system, relieve pressure and tighten connections until leaks are corrected. If you cannot correct the problem, lock and tag out the system until repairs can be made by trained personnel.
- Do not vent any gas inside a building without adequate ventilation.
- Never bleed a cylinder below 25 pounds per square inch (psi).

- If a cylinder valve leaks and it can be safely moved, take it outdoors and slowly empty the bottle.
- Any and all repairs and refilling shall be made only by qualified individuals.
- Do not place a cylinder where it might become part of an electric circuit.
- Cylinders that are not connected or in use, must be fitted with a valve protection cap.
- Valve protection caps should be in place when cylinders are moved.
- No tools, including wrenches and hammers shall be used to open or close cylinder valves.
- Cylinder valves must be verified closed before moving the cylinder.
- Larger cylinders, which cannot be easily carried, shall be moved using a wheeled cart.
- Cylinders shall never be rolled or dragged, nor lifted by the valve cap.
- Cylinders must never be violently struck or allowed to strike another object.

3.3 PERSONAL PROTECTIVE EQUIPMENT REQUIRED

- Foot protection meeting the most current American National Standards Institute (ANSI) Z41 standard for safety shoes is required when moving gas cylinders.
- Safety glasses or other face and eye protection should be employed when installing or removing regulators.

4.0 REFERENCES

National Safety Council (NSC). 2009. *Accident Prevention Manual for Business and Industry*. American National Standards Institute (ANSI). 1994. Guide to Protective Footwear Requirements.

5.0 ATTACHMENTS

This SOP does not contain attachments.

ATTACHMENT C

NCore Instrument Acceptance Criteria and Procedures for Instrument Calibration

Critical and Operational Criteria for CO Measurements

Requirement	Frequency	Acceptance Criteria	Information /Action
CRITICAL CRITERIA-CO			
One Point QC Check Single analyzer	1/ 2 weeks	≤ ± 10% (percent difference)	1-10 parts per million (ppm) Relative to routine concentrations 40 CFR Part 58 Appendix (App) A, Section (Sec) 3.2
Zero/span check	1/ 2 weeks	Zero drift ≤ ± 30 ppb Span drift ≤ ± 10 %	
OPERATIONAL CRITERIA-CO			
Shelter Temperature			
Temperature range	**Daily** (hourly values)	10 to 40° C. (Hourly average)*	Generally the 10 to 40° C range will apply but the most restrictive operable range of the instruments in the shelter may also be used as guidance
Temperature Control	Daily (hourly values)	≤ ± 2° C standard deviation (SD) over 24 hours	
Temperature Device Check	2/year	± 2° C of standard	
Precision(using 1-point QC checks)	Calculated annually and as appropriate for design value estimates	90% CL CV ≤ 10%	90% Confidence Limit (CL) of Coefficient of Variation (CV). 40 CFR Part 58 App A, Sec 4.1.2
Bias (using 1-point QC checks)	Calculated annually and as appropriate for design value estimates	95% CL ≤ + 10%	95% Confidence Limit of absolute bias estimate; 40 CFR Part 58 App A, Sec 4.1.3
Annual Performance Evaluation			
Single analyzer	Every site 1/year 25 % of sites quarterly	Percent difference of each audit level ≤ 15%	3 consecutive audit concentration not including zero. 40 CFR Part 58 App A, Sec 3.2.2
Primary QA Organization (PQAO)	annually	95% of audit percent differences fall within the one point QC check 95% probability intervals at Primary QA Organization level of aggregation	40 CFR Part 58 App A, Sec 4.1.4
Federal Audits (NPAP)	1/year at selected sites 20% of sites audited	Mean absolute difference ≤ 15%	40 CFR Part 58 App A, Sec 2.4
State audits	1/year	State requirements	
Verification/Calibration	Upon receipt/adjustment/repair/installation/moving 1/6 months if manual zero/span performed biweekly 1/year if continuous zero/span performed daily	All points within ± 2% of full scale of best-fit straight line	Multi-point calibration (0 and 4 upscale points)
Gaseous Standards		Traceable to National Institute of Standards and Technology (NIST) (e.g., EPA Protocol Gas)	Vendor must participate in EPA Protocol Gas Verification Program 40 CFR Part 58 App A, Sec 2.6.1
Zero Air/Zero Air Check	1/year	Concentrations below lower detection limit (LDL)	
Requirement	**Frequency**	**Acceptance Criteria**	**Information /Action**
Gas Dilution Systems	1/3 months	Accuracy ± 2 %	
Detection			
Noise	NA	0.50 ppm	40 CFR Part 53.20
Lower detectable level	1/year	1.0 ppm	40 CFR Part 53.20
SYSTEMATIC CRITERIA-CO			
Standard Reporting Units	All data	ppm [final units in EPA Air Quality System (AQS)]	
Completeness (seasonal)	Hourly	75% of hourly averages for the 8-hour period	8-Hour average
Sample Residence Times		< 20 seconds	
Sample Probe, Inlet, Sampling train		Borosilicate glass (e.g., Pyrex) or Teflon	40 CFR Part 58, App E
Siting		Un-obstructed probe inlet	40 CFR Part 58, App E

Notes: Guidance for the application of data flags is based on the validation template in Appendix D of volume II of the EPA Quality Assurance Handbook, Revision 1. No data adjustments will be made during routine procedures.
*As per EPA Automated Reference Method RFCA-1093-093.

Critical and Operational Criteria for NO/NO_y Measurements

Requirement	Frequency	Acceptance Criteria	Information /Action
CRITICAL CRITERIA – NO/NO_y			
One Point QC Check **Single analyzer**	1/ 2 weeks	≤ ± 10% (percent difference)	0.01-0.10 parts per million (ppm) Relative to routine concentrations 40 CFR Part 58 Appendix (App) A, Section (Sec) 3.2
Zero/span check	1/ 2 weeks	Zero drift ≤ ± 1.5 ppb Span drift ≤ ± 10%	
OPERATIONAL CRITERIA – NO/NO_y			
Shelter Temperature			
Temperature range	**Daily** (hourly values)	20 to 30° C. (Hourly average)	Generally the 20-30° C range will apply but the most restrictive operable range of the instruments in the shelter may also be used as guidance
Temperature Control	Daily (hourly values)	≤ ± 2° C standard deviation (SD) over 24 hours	
Temperature Device Check	2/year	± 2° C of standard	
Precision (using 1-point QC checks)	Calculated annually and as appropriate for design value estimates	90% CL CV ≤ 10%	90% Confidence Limit of Coefficient of Variation (CV) 40 CFR Part 58 App A, Sec 4.1.2
Bias (using 1-point QC checks)	Calculated annually and as appropriate for design value estimates	95% CL ≤ + 10%	95% Confidence Limit of absolute bias estimate. 40 CFR Part 58 App A, Sec 4.1.3
Annual Performance Evaluation			
Single analyzer	Every site 1/year 25 % of sites quarterly	Percent difference of each audit level ≤ 15%	3 consecutive audit concentration not including zero. 40 CFR Part 58 App A, Sec 3.2.2
Primary QA Organization (PQAO)	annually	95% of audit percent differences fall within the one point QC check 95% probability intervals at primary QA organization level of aggregation	40 CFR Part 58 App A, Sec 4.1.4
Federal Audits (NPAP)	1/year at selected sites 20% of sites audited	Mean absolute difference ≤ 15%	40 CFR Part 58 App A, Sec 2.4
State audits	1/year	State requirements	
Verification/Calibration	Upon receipt/adjustment/repair/ installation/moving 1/6 months if manual zero/span performed biweekly 1/year if continuous zero/span performed daily	Instrument residence time ≤ 2 min Dynamic parameter ≥ 2.75 ppm-min All points within ± 2 % of full scale of best-fit straight line	Multi-point calibration (0 and 4 upscale points) 40 CFR Part 50 App F
Converter Efficiency	During multi-point calibrations, span and audit 1/ 2 weeks	96%	
Gaseous Standards		Traceable to National Institute of Standards and Technology (NIST)	Vendor must participate in EPA Protocol Gas
Requirement	**Frequency**	**Acceptance Criteria**	**Information /Action**
		(e.g., EPA Protocol Gas)	Verification Program 40 CFR Part 58 App, A Sec 2.6.1
Zero Air/ Zero Air Check	1/year	Concentrations below lower detection level (LDL)	
Gas Dilution Systems	1/3 months	Accuracy ± 2 %	
Detection			
Noise	NA	0.005 ppm	40 CFR Part 53.20
Lower detectable level	1/year	0.01 ppm	40 CFR Part 53.20
SYSTEMATIC CRITERIA – NO/NO_y			
Standard Reporting Units	All data	ppm [final units in EPA Air Quality System (AQS)]	
Completeness (seasonal)	Quarterly	75%	Annual standard (hourly data)
Sample Residence Times		< 20 seconds	
Sample Probe, Inlet, Sampling train		Borosilicate glass (e.g., Pyrex) or Teflon	40 CFR Part 58 App E
Siting		Un-obstructed probe inlet	40 CFR Part 58 App E

Notes: Guidance for the application of data flags is based on the validation template in Appendix D of volume II of the EPA Quality Assurance Handbook, Revision 1. No data adjustments will be made during routine procedures.

Critical and Operational Criteria for SO_2 Measurements

Requirement	Frequency	Acceptance Criteria	Information /Action
		CRITICAL CRITERIA – SO_2	
One Point QC Check **Single analyzer**	1/ 2 weeks	≤ +10% (percent difference)	0.01-0.10 parts per million (ppm) Relative to routine concentrations 40 CFR Part 58 Appendix (App) A, Section (Sec) 3.2
Zero/span check	1/ 2 weeks	Zero drift ≤ ± 1.5 ppb Span drift ≤ ± 10%	
		OPERATIONAL CRITERIA – SO_2	
Shelter Temperature			
Temperature range	**Daily** (hourly values)	5 to 40° C. (Hourly average)*	Generally the 5 to 40° C range will apply but the most restrictive operable range of the instruments in the shelter may also be used as guidance
Temperature Control	Daily (hourly values)	≤ ± 2° C SD over 24 hours	
Temperature Device Check	2/year	± 2° C of standard	
Precision (using 1-point QC checks)	Calculated annually and as appropriate for design value estimates	90% CL CV ≤ 10%	90% Confidence Limit of Coefficient of Variation (CV), 40 CFR Part 58 App A, Sec 4.1.2
Bias (using 1-point QC checks)	Calculated annually and as appropriate for design value estimates	95% CL ≤ + 10%	95% Confidence Limit of absolute bias estimate, 40 CFR Part 58 App A, Sec 4.1.3
Annual Performance Evaluation			
Single analyzer	Every site 1/year 25 % of sites quarterly	Percent difference of each audit level ≤ 15%	3 consecutive audit concentrations not including Zero, 40 CFR Part 58 App A, Sec 3.2.2
Primary QA Organization (PQAO)	annually	95% of audit percent differences fall within the one point QC check 95% probability intervals at primary QA organization level of aggregation	40 CFR Part 58 App A, Sec 4.1.4
Federal Audits (NPAP)	1/year at selected sites 20% of sites audited	Mean absolute difference ± 15%	40 CFR Part 58 App A, Sec 2.4
State audits	1/year	State requirements	
Verification/Calibration	Upon receipt/adjustment/repair/installation/moving 1/6 months if manual zero/span performed biweekly 1/year if continuous zero/span performed daily	All points within ± 2 % of full scale of best-fit straight line	Multi-point calibration (0 and 4 upscale points)
Zero Air		Concentrations below lower detection limit (LDL)	
Gaseous Standards		Traceable to National Institute of Standards and Technology (NIST) (e.g., EPA Protocol Gas)	Vendor must participate in EPA Protocol Gas Verification Program 40 CFR Part 58 App A, Sec 2.6.1
Requirement	**Frequency**	**Acceptance Criteria**	**Information /Action**
Zero Air/ Zero Air Check	1/year	Concentrations below LDL	
Gas Dilution Systems	1/3 months	Accuracy ± 2 %	
Detection			
Noise	NA	0.005 ppm	40 CFR Part 53.20
Lower detectable level	1/year	0.01 ppm	40 CFR Part 53.20
		SYSTEMATIC CRITERIA- SO_2	
Standard Reporting Units	All data	ppm [final units in EPA Air Quality System (AQS)]	
Completeness (seasonal)	Quarterly	75%	Annual standard
	24 hours	75%	24-hour standard
	3 hours	75%	3-hour standard
Sample Residence Times		< 20 seconds	
Sample Probe, Inlet, Sampling train		Borosilicate glass (e.g., Pyrex) or Teflon	40 CFR Part 58 App E
Siting		Un-obstructed probe inlet	40 CFR Part 58 App E

Notes: Guidance for the application of data flags is based on the validation template in Appendix D of volume II of the EPA Quality Assurance Handbook, Revision 1. No data adjustments will be made during routine procedures.
*As per EPA Automated Equivalent Method EQSA-0495-100.