Development of Quality Control Parameters and Electronic Data Recording for an Ambient Air Particle Inhalation Exposure System

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Research and Development at EPA

- 1,950 employees
- $700 million budget
- $100 million extramural research grant program
- 13 lab or research facilities across the U.S.
- Credible, relevant and timely research results and technical support that inform EPA policy decisions

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National Health and Environmental Effects Research Laboratory

- NHEERL is EPA's focal point for scientific research on the effects of contaminants and environmental stressors on human health and ecosystem integrity.
- NHEERL's Mission and goals help EPA identify and understand the processes that affect our health and environment, and evaluate the risks that pollution poses to humans and ecosystems.

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High Priority Research Areas

- Human Health
- Particulate Matter
- Drinking Water
- Clean Water
- Global Change
- Endocrine Disruptors
- Ecological Risk
- Pollution Prevention
- Homeland Security

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Experimental Toxicology Division

- ETD conducts multidisciplinary research to improve the scientific basis of risk assessment for pulmonary, cardiovascular, hepatic, renal, and immunotoxicity
- Research facilitates the use of pharmacokinetic data in the risk assessment process
- Animal Inhalation Exposure Facility allows researchers to study the health effects of gases, vapors, and aerosols

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Animal Inhalation Exposure Facility Team

- Performs inhalation exposure studies of gases, vapors, and aerosols including real world particulate matter (PM), and combustion emissions (e.g. fuel oil, natural gas, coal, diesel)
- Conducts air PM sampling, collection, and characterization
- Current projects include studies of concentrated real world PM air pollutants - and the role of size and components - on cardiopulmonary disease

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Inhalation Exposure Studies of Concentrated Air Particles

- Determine health effects of "real world, real time" PM on cardio-pulmonary systems of various animal models
- Simultaneous real time exposures using multiple modes of concentrated ambient air PM
  - UCAPs – Ultra-fine (µf) mode aerosols (< 0.3 µm)
  - CAPs - Fine mode aerosols (0.3<X< 2.5 µm)

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AIEF UCAPs/CAPs Small Animal Exposure Systems

- 0.3 m^3 stainless steel and glass chambers for Ultra-fine PM, fine PM, and control groups
- Exposure chamber atmosphere monitoring, characterization, and control
- "Real time, real world" ambient air particles (not resuspended or laboratory generated)
- State-of-the-art particle growth and Slit Virtual Impactor particle concentrating technology

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AIEF UCAPs/CAPs Small Animal Exposure Systems

- PM size fractionating eliminates incoming particles larger than PM_{10}, $PM_{2.5}$ and $PM_{0.3}$
- Specialized equipment concentrates remaining particles with minimal effect on particle chemistry
- Monitoring instruments measure and characterize atmosphere delivered to animals
- Repeated exposures, 6 hr/d, 5 d/wk, 13 wks
- Ambient weather station

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PM Delivery System

- 10,000 Lpm ambient air containing PM drawn into size selective inlet (SSI) impactors
- Entering ambient PM size fractionated by SSIs to <2.5 µm
- 5000 Lpm each delivered to 2 different particle concentrating systems
- Slit Virtual Impactor (SVI) technology used to concentrate PM for independent, simultaneous UCAPs and CAPs studies

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Ultra-fine PM Concentrating Equipment

- SVI technology is not directly effective on ultra-fine PM, therefore, requires particles <0.3 µm be grown to >1 µm for concentrating
- Concentrating effect optimized at vapor super saturation ratio, S_r ~3.0
- Supersaturated water vapor chamber grows µf PM to >1.5 µm in seconds
- Multistage SVIs concentrate grown PM >40 X
- Reshaper dries particles to original size and SSO eliminates PM > 0.3 µm prior to delivery to chamber

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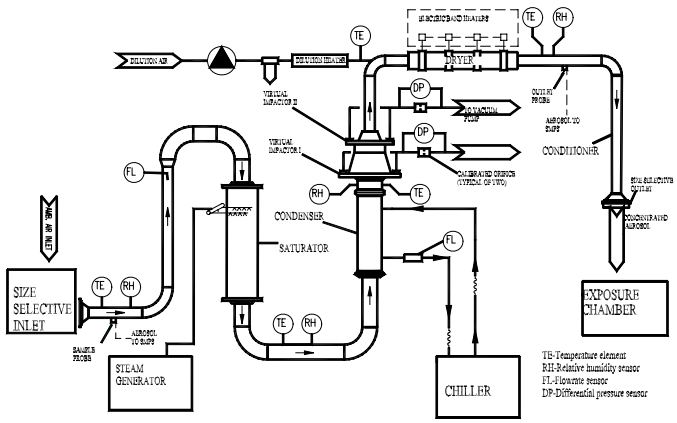
UCAPs Schematic



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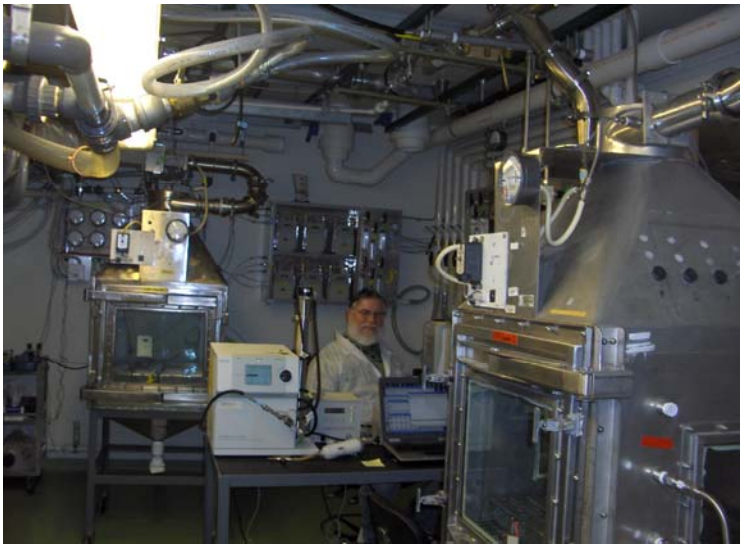

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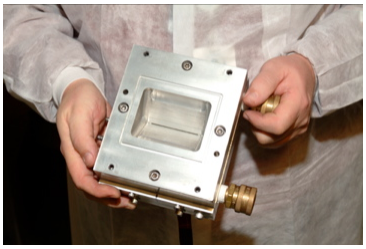
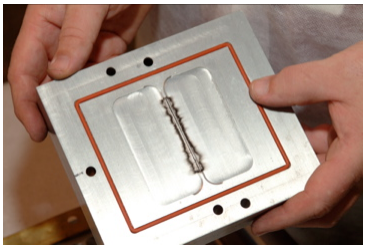
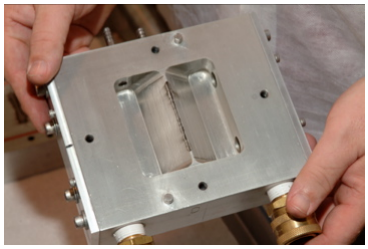
Slit Virtual Impactor







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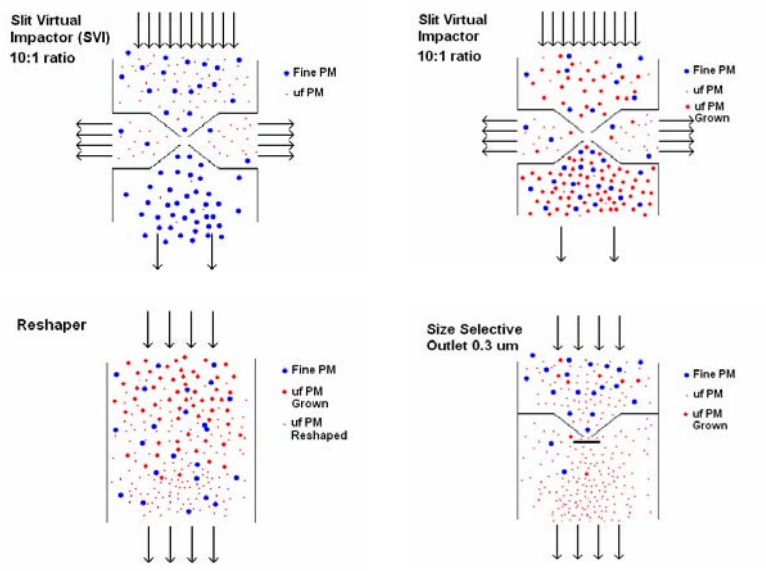
Slit Virtual Impactor



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System Monitoring

- Computerized electronic monitoring and data recording of ambient meteorological, process, system, and chamber variables
  - Ambient meteorological conditions for entering air
  - >80 critical conditions including temp., RH, pres., flow, and PM monitored in real time
  - >30 critical variables controlled either automatically or manually
  - Instrument data backed up to multiple locations daily
- Regular manual data entry as backup to electronic data monitoring
- >95% electronic records, moving towards 100%

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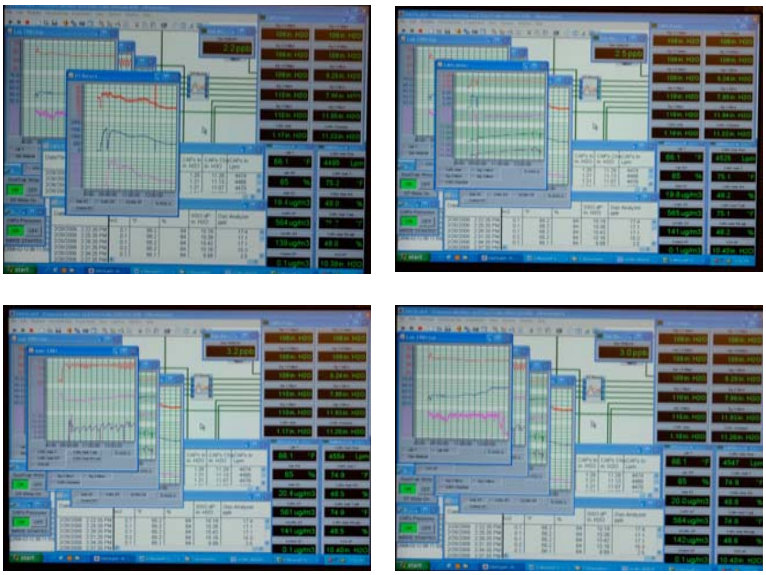
DASYLab Monitoring



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HUCAPs Monitoring

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Particle Monitoring

- Ambient and Chamber atmospheres monitored by continuous filter samples and electronic instruments for meteorological conditions and pollutant levels
- Filters provide mass concentration in µg/m^3
- SMPS, APS, DustTrak, P-Trak provide PM sizing (µm) and concentration (#/cc and µg/m^3)

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System Validation

- Devices including T, RH, flow, particle sizing and concentration monitors, and balances were audited and performance was routinely verified
- Chamber aerosol distribution testing insured consistent dosing of all test animals
- Certified weights, standard and field blank filters validated balances daily

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System Validation

- Instrument checks recommended by manufacturers performed daily to verify zero and span
- Collocated filters and chemical analysis procedures validate PM instruments
- Concentrating equipment was extensively characterized by preliminary testing

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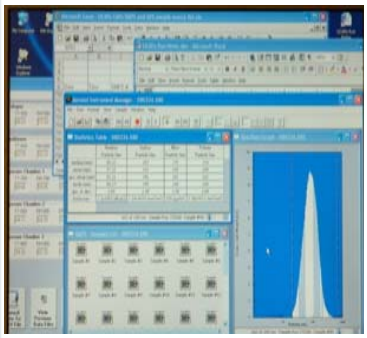
Electronic Records



- Electronic records developed where possible
- Notes and activities directly entered, recorded in files
- HUCAPs ADP controls allowed operators to monitor and adjust system parameters in real time to maintain optimal S_r and PM concentrating effects
- Process variables and chamber conditions recorded every 3 min.

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Electronic Records

- DASYLab process monitoring software tracked and recorded T, RH, flow, press, and PM concentrations at 24 locations
- 9 Aerosol instruments tracked and recorded chamber and inlet PM parameters every 3 min.
- All electronic files were backed up to multiple locations including network servers daily

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Redundancy

- Consistent exposures, reliable operations, minimal lost exposure time, equipment and process safeties, recoverable data
- Critical systems or measurements backed up with redundant equipment or alternative measurement techniques
- Examples include backup vacuum pumps, recoverable data such as chemical analysis of filters to backup balance measurements, DustTrak backup for filters, P-Trak backup for SMPS and APS
- Manual data entry as automatic data backup

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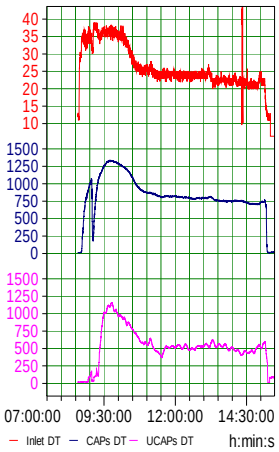
Exposure Results



- Completed 6 hr/d, 5 d/wk, 13wks of exposures with just 2 hrs of 1170 hrs scheduled exposure time lost
- UCAPs concentrations up to 5.0 x e^5 #/cc, 500 ug/m^3 , ~80 nm # size, ~170 nm mass size, Avg. Mass X factor ~42.6 X
- CAPs concentrations up to 600 ug/m^3 , ~900 nm, Avg. Mass X factor ~25.5 X
- Post exposure chemical analysis of ~1000 filter samples and health effects results pending

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Effective QC Practices

- Preliminary systems validation
- Survey of lab practices by QAM
- OPs backed up by detailed check lists completed daily
- Daily instrument QC checks
- Daily double checks of filter data sheets and activities entries
- Filter systems (sample port, holder, vacuum line, meter, valve, data sheet) color coded for location and sample ID

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Effective QC Practices

- Multiple alternative measurement techniques
- Daily file backups, multiple locations
- Ongoing routine systems maintenance based on system performance tracking
- Excellent staff communications and routine planning meetings/discussions
- Backup staffing coverage through cross training of staff in all critical areas and tasks

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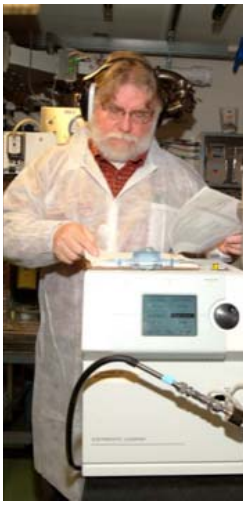
Check lists



- Operations Status – allowed staff to track when various processes were completed so exposures could start
- Filter Sampling – insured filter samples were properly setup, and documentation completed
- Instrument Setup and QC checks – verified instrument performance daily prior to exposures
- Exposure Operations - ensured all aspects of OPs were followed, completed, and data were properly recorded and backed up

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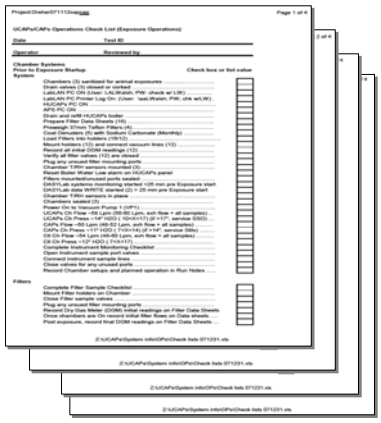
Exposure Operations



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Acknowledgements

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Operations Status

CAPS/UCAPS
DAILY EXPOSURE STATUS
CHECK LIST

DATE: _____ RUN DAY # _____

	COMPLETE (√)	TIME	INITIALS	COMMENTS
INSTR. DOWN LOAD				
BOILER FLUSH / FILL				
INSTRUMENTS				
FILTERS				
CHAMBERS				
ANIMALS LOADED				
EXPOSURE START				
EXPOSURE STOP				

NOTES:

Reviewed by: _____ Date: _____

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HUCAPs Boiler Service

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UCAPs/CAPs Operations Check List (HUCAPs Boiler)

Date Test ID

Operator Reviewed by

HUCAPs - Boiler Check box or record value

DI Water System Flow gage reading
Open floor drain valve (set timer to >12 min)
Route drain tubing
Close Boiler Feed Water valve (BFV) (DI supply loop)
Open Boiler Drain Valve (BDV)
Silence Boiler Low Water Alarm (Red PB)
Close BDV once drainage stops
Disconnect and drain tubing
Reconnect and store drain tubing
Open BFV about 1/3rd (flowing water sound)
Check DI Water Loop press. (if <45 psi, restrict flow)
Reset Boiler Low Water Alarm (Red PB, F1)
DI Water System Flow gage reading

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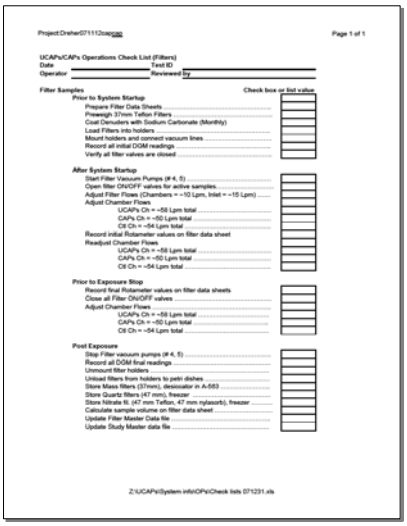
Filter Samples



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UCAPs/CAPs Operations Check List (Filters)

Date Test ID

Operator Reviewed by

Filter Samples	Check box or list value
Prior to System Startup	
Prepare Filter Data Sheets	
Preweigh 37mm Teflon Filters	
Coat Denuders with Sodium Carbonate (Monthly)	
Load Filters into holders	
Mount holders and connect vacuum lines	
Record all initial DGM readings	
Verify all filter valves are closed	
After System Startup	
Start Filter Vacuum Pumps (# 4, 5)	
Open filter ON/OFF valves for active samples	
Adjust Filter Flows (Chambers = ~10 Lpm, Inlet = ~16 Lpm)	
Adjust Chamber Flows	
UCAPs Ch = ~58 Lpm total	
CAPs Ch = ~50 Lpm total	
Ctl Ch = ~54 Lpm total	
Record initial Rotameter values on filter data sheet	
Readjust Chamber Flows	
UCAPs Ch = ~58 Lpm total	
CAPs Ch = ~50 Lpm total	
Ctl Ch = ~54 Lpm total	
Prior to Exposure Stop	
Record final Rotameter values on filter data sheets	
Close all Filter ON/OFF valves	
Adjust Chamber Flows	
UCAPs Ch = ~58 Lpm total	
CAPs Ch = ~50 Lpm total	
Ctl Ch = ~54 Lpm total	
Post Exposure	
Stop Filter vacuum pumps (# 4, 5)	
Record all DGM final readings	
Unmount filter holders	
Unload filters from holders to petri dishes	
Store Mass filters (37mm), desiccator in A-583	
Store Quartz filters (47 mm), freezer	
Store Nitrate fil. (47 mm Teflon, 47 mm nylasorb), freezer	
Calculate sample volume on filter data sheet	
Update Filter Master Data file	
Update Study Master data file	

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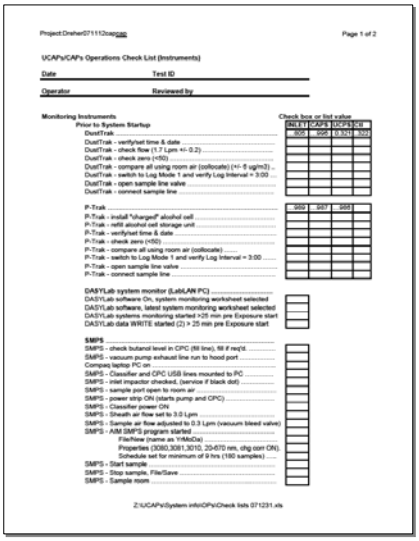
Instrument Operations



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UCAPs/CAPs Operations Check List (Instruments)

Date Test ID

Operator Reviewed by

Monitoring Instruments	Check box or list value			
Prior to System Startup	INLET	CAPS	UCPS	CTR
DustTrak	805	806	0.3/1	803
DustTrak - verify/set time & date				
DustTrak - check flow (1.7 Lpm +/- 0.2)				
DustTrak - check zero (<50)				
DustTrak - compare all using room air (collocate) (+/- 5 ug/m3)				
DustTrak - switch to Log Mode 1 and verify Log Interval = 3:00				
DustTrak - open sample line valve				
DustTrak - connect sample line				
P-Trak	800	807	802	
P-Trak - install "charged" alcohol cell				
P-Trak - refill alcohol cell storage unit				
P-Trak - verify/set time & date				
P-Trak - check zero (<50)				
P-Trak - compare all using room air (collocate)				
P-Trak - switch to Log Mode 1 and verify Log Interval = 3:00				
P-Trak - open sample line valve				
P-Trak - connect sample line				
DASYLab system monitor (LabLAN PC)				
DASYLab software On, system monitoring worksheet selected				
DASYLab software, latest system monitoring worksheet selected				
DASYLab systems monitoring started >25 min pre Exposure start				
DASYLab data WRITE started (2) > 25 min pre Exposure start				
SMPS				
SMPS - check butanol level in CPC (fill line), fill if req'd.				
SMPS - vacuum pump exhaust line run to hood port				
Compaq laptop PC on				
SMPS - Classifier and CPC USB lines mounted to PC				
SMPS - inlet impactor checked, (service if black dot)				
SMPS - sample port open to room air				
SMPS - power strip ON (starts pump and CPC)				
SMPS - Classifier power ON				
SMPS - Sheath air flow set to 3.0 Lpm				
SMPS - Sample air flow adjusted to 0.3 Lpm (vacuum bleed valve)				
SMPS - AIM SMPS program started				
File/New (name as YrMoDa)				
Properties (3080,3081,3010, 20-670 nm, chg corr ON)				
Schedule set for minimum of 9 hrs (180 samples)				
SMPS - Start sample				
SMPS - Stop sample, File/Save				
SMPS - Sample room				

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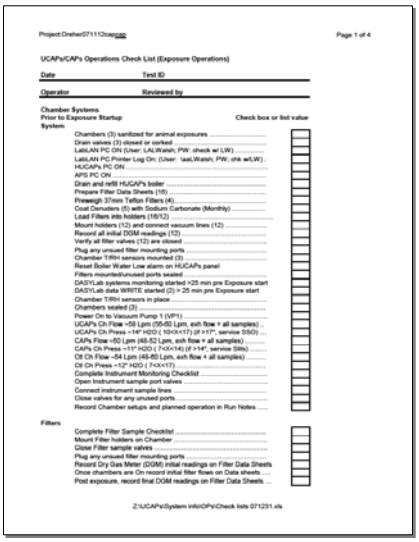
Exposure Operations



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UCAPs/CAPs Operations Check List (Exposure Operations)

Date Test ID

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Chamber Systems
Prior to Exposure Startup Check box or list value
System

- Chambers (3) sanitized for animal exposures
- Drain valves (3) closed or corked
- LabLAN PC ON (User: LAL/Walsh; PW: check w/ LW)
- LabLAN PC Printer Log On: (User: \aaLWalsh; PW: chk w/LW)
- HUCAPs PC ON
- APS PC ON
- Drain and refill HUCAPs boiler
- Prepare Filter Data Sheets (16)
- Preweigh 37mm Teflon Filters (4)
- Coat Denuders (5) with Sodium Carbonate (Monthly)
- Load Filters into holders (16/12)
- Mount holders (12) and connect vacuum lines (12)
- Record all initial DGM readings (12)
- Verify all filter valves (12) are closed
- Plug any unused filter mounting ports
- Chamber T/RH sensors mounted (3)
- Reset Boiler Water Low alarm on HUCAPs panel
- Filters mounted/unused ports sealed
- DASYLab systems monitoring started >25 min pre Exposure start
- DASYLab data WRITE started (2) > 25 min pre Exposure start
- Chamber T/RH sensors in place
- Chambers sealed (3)
- Power On to Vacuum Pump 1 (VP1)
- UCAPs Ch Flow =56 Lpm (55-60 Lpm, exh flow + all samples)
- UCAPs Ch Press ~14" H2O (10<X<17) (if >17", service SSO)
- CAPs Flow =50 Lpm (48-52 Lpm, exh flow + all samples)
- CAPs Ch Press ~11" H2O (7<X<14) (if >14", service SSh)
- Ot Ch Flow ~54 Lpm (48-60 Lpm, exh flow + all samples)
- Ot Ch Press ~12" H2O (7<X<17)
- Complete Instrument Monitoring Checklist
- Open Instrument sample port valves
- Connect instrument sample lines
- Close valves for any unused ports
- Record Chamber setups and planned operation in Run Notes

Filters

- Complete Filter Sample Checklist
- Mount Filter holders on Chamber
- Close Filter sample valves
- Plug any unused filter mounting ports
- Record Dry Gas Meter (DGM) initial readings on Filter Data Sheets
- Once chambers are On record initial filter flows on Data sheets
- Post exposure, record final DGM readings on Filter Data Sheets

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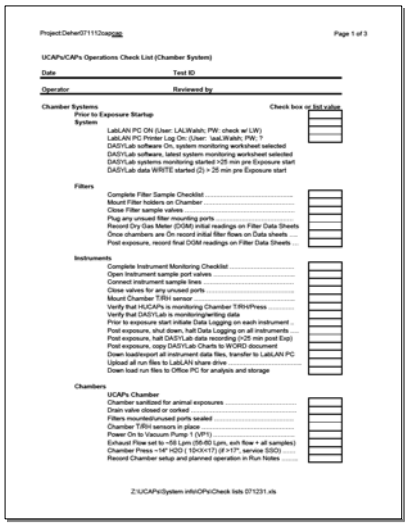
Chamber Systems



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UCAPs/CAPs Operations Check List (Chamber System)

Date Test ID

Operator Reviewed by

Chamber Systems Check box or list value
Prior to Exposure Startup
System

- LabLAN PC ON (User: LAL/Walsh; PW: check w/ LW)
- LabLAN PC Printer Log On: (User: \aaLWalsh; PW: ?
- DASYLab software On, system monitoring worksheet selected
- DASYLab software, latest system monitoring worksheet selected
- DASYLab systems monitoring started >25 min pre Exposure start
- DASYLab data WRITE started (2) > 25 min pre Exposure start

Filters

- Complete Filter Sample Checklist
- Mount Filter holders on Chamber
- Close Filter sample valves
- Plug any unused filter mounting ports
- Record Dry Gas Meter (DGM) initial readings on Filter Data Sheets
- Once chambers are On record initial filter flows on Data sheets
- Post exposure, record final DGM readings on Filter Data Sheets

Instruments

- Complete Instrument Monitoring Checklist
- Open Instrument sample port valves
- Connect instrument sample lines
- Close valves for any unused ports
- Mount Chamber T/RH sensor
- Verify that HUCAPs is monitoring Chamber T/RH/Press
- Verify that DASYLab is monitoring/writing data
- Prior to exposure start initiate Data Logging on each instrument
- Post exposure, shut down, halt Data Logging on all instruments
- Post exposure, halt DASYLab data recording (>25 min post Exp)
- Post exposure, copy DASYLab Charts to WORD document
- Down load/export all instrument data files, transfer to LabLAN PC
- Upload all run files to LabLAN share drive
- Down load run files to Office PC for analysis and storage

Chambers
UCAPs Chamber

- Chamber sanitized for animal exposures
- Drain valve closed or corked
- Filters mounted/unused ports sealed
- Chamber T/RH sensors in place
- Power On to Vacuum Pump 1 (VP1)
- Exhaust Flow set to ~56 Lpm (56-60 Lpm, exh flow + all samples)
- Chamber Press ~14" H2O (10<X<17) (if >17", service SSO)
- Record Chamber setup and planned operation in Run Notes

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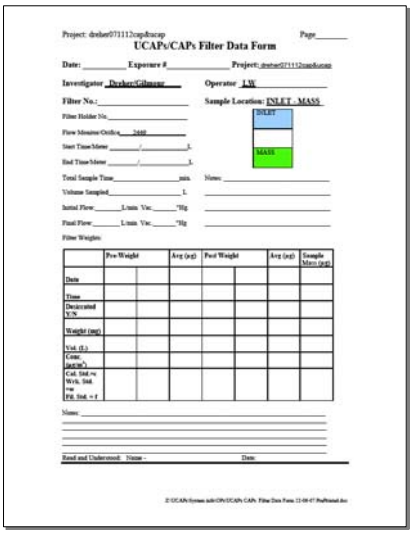
Filter Sample Data Form



Project: dreher071112cap&ucap Page_____

UCAPs/CAPs Filter Data Form

Date: _____ Exposure #_____ Project: dreher071112cap&ucap

Investigator Dreher/Gilmour Operator LW

Filter No.:_____ Sample Location: INLET - MASS

Filter Holder No._____

Flow Monitor/Orifice 2440

Start Time/Meter _____/_____L

End Time/Meter _____/_____L

Total Sample Time_____min. Notes: _____

Volume Sampled_____L _____

Initial Flow_____L/min Vac_____"Hg _____

Final Flow_____L/min Vac_____"Hg _____

Filter Weights:

	Pre-Weight		Avg (ug)	Post Weight		Avg (ug)	Sample Mass (ug)
Date							
Time							
Desiccated Y/N							
Weight (mg)							
Vol. (L)							
Cond. (µg/m³)							
Cal. Std /w Wrk. Std /w Fil. Std. + F							

Notes: _____

Read and Understood: Name - Date:

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