

Ascent Particle Filter Molecular Conductance Study

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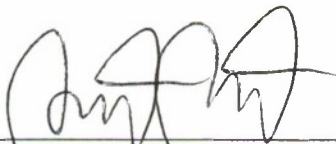
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This report has been reviewed by the Public Affairs Office (PAS) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nationals.

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 for DD

David E. Davis
SMC/EA

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14. ABSTRACT Ascent particle filters on enclosures containing space hardware, such as electronics boxes, regulate venting of these enclosures during launch and ascent. While allowing venting to occur, these filters prevent the transport of particles into and out of the enclosures. Particle filters are primarily characterized with respect to the flow of gas through the filter; the conductance of out-gassed molecules is not quantified. This report documents a series of tests performed at The Aerospace Corporation's Space Materials Laboratory to measure the conductance of outgassed molecular contamination from a model contaminant across a typical particle filter as a function of outgassing arrival rate. The results herein show that a typical ascent particle filter significantly limits the conductance of molecular contamination.					
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Ascent Particle Filter Molecular Conductance Study

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Ascent Particle Filter Molecular Conductance Study

Introduction

- Particle filters on enclosures containing space hardware (electronics boxes, etc.) provide venting during launch and ascent
- Filters are typically sized in the 5 to 10 μm effective filtration range
 - *Prevent the ingestion of particles into the assembly*
 - *Prevent the release of particles from the interior of the enclosure*
- Filters are most often characterized with respect to the flow of gas through the filter
 - *Conductance of outgassed molecules is not quantified*

Question to Answer: To what extent does a typical ascent particle filter limit the conductance of molecular contamination?



Ascent Particle Filter Molecular Conductance Study

Experiment Design

- Molecular conductance through a filter can be thought of in two ways:
 - **Effective Aperture Size:** *Size of the obstruction-free aperture that will pass molecules at the same rate as the filter*
 - **Mass Throughput:** *Percentage of mass per unit time that the filter can pass relative to an unobstructed target*
- Molecular conductance is considered to be a function of:
 - *Filter parameters (design, effective filtration size, material, etc.)*
 - *Macro dimensions of the filter (length, width, thickness)*
 - *Temperature of the filter*
 - *Rate of outgassing arrival*
- **Objective:** Measure the molecular conductance* across a typical filter as a function of outgassing arrival rate for a model contaminant (Diocetyl Phthalate)

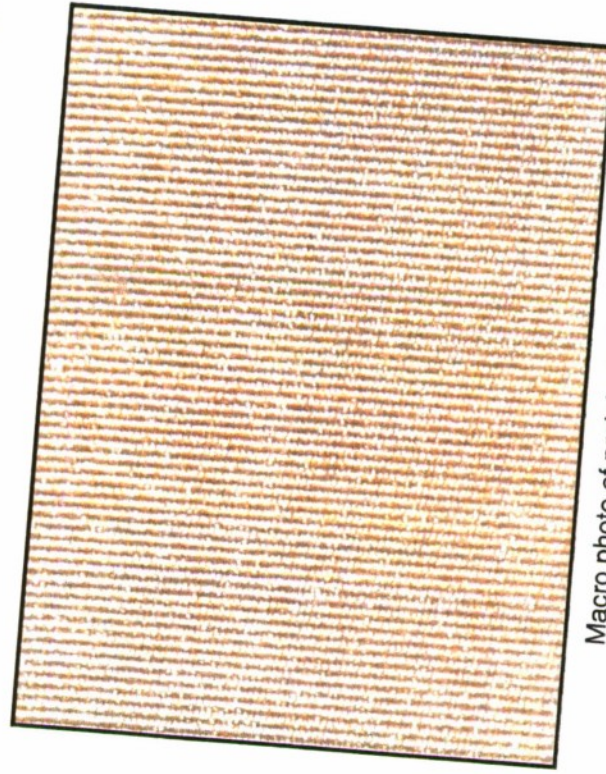
* Molecular conductance measured for a Clausing beam profile, not for an omnidirectional pressure distribution. These experiments can be thought of as measuring the mass throughput attenuation of the ascent particle filter.



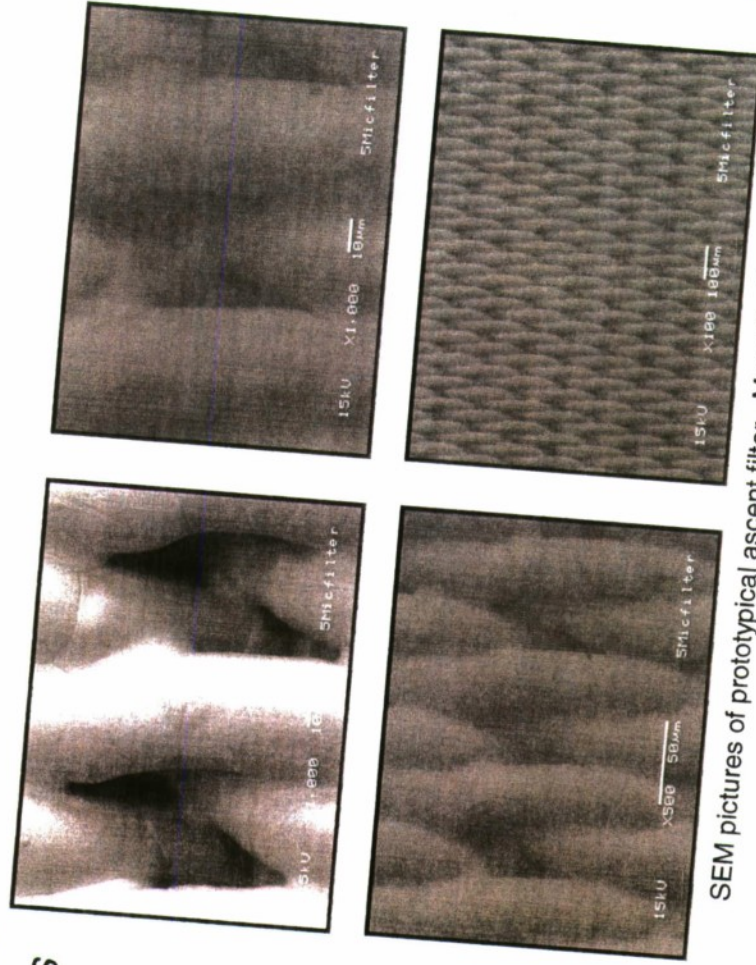
Ascent Particle Filter Molecular Conductance Study

Prototypical Ascent Filter

- Rigimesh 5 μm Filter from Pall Aeropower Corporation
 - Wire Thickness: 0.0014 inches
 - Filter Thickness: 0.006 inches



Macro photo of prototypical ascent filter.



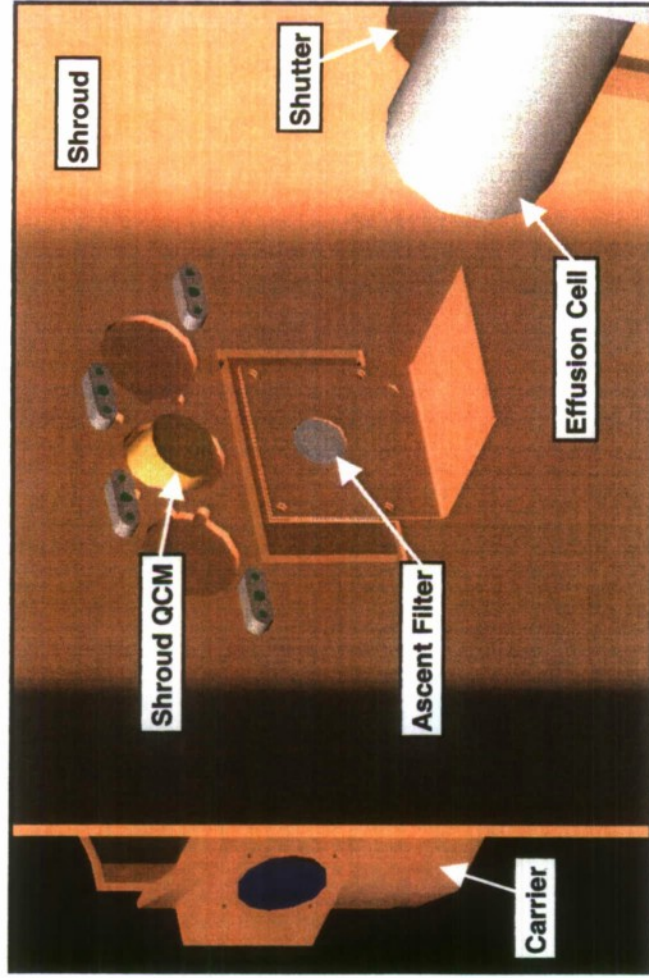
SEM pictures of prototypical ascent filter. Magnification specified.

Prototypical sintered stainless steel wire mesh filter

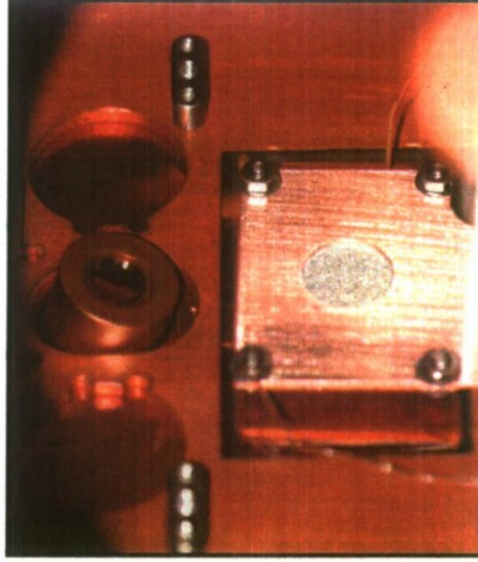
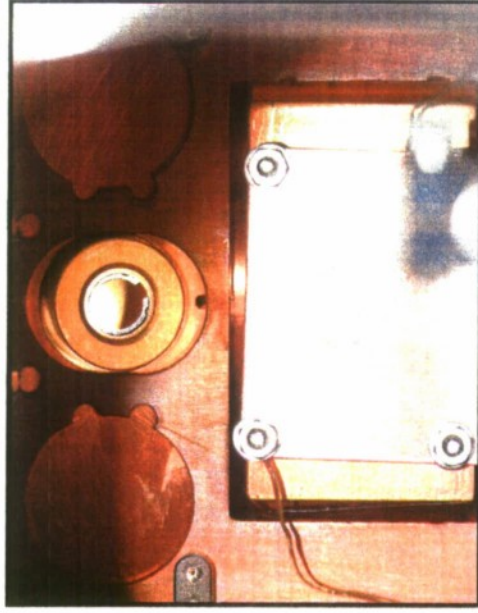


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Chamber Configuration



The Carrier QCM, which is mounted on the Carrier, is identical to the Shroud QCM. For this study, it was located directly behind the Ascent Filter, with a gap of approximately 0.2 inches. Both QCMs were held at -75°C to collect all impinging flux, but not condense water.



Ascent particle filter mounted in chamber for testing



Ascent Particle Filter Molecular Conductance Study

Experiment Overview

- QCM Calibration
 - Calibrate the unobstructed Carrier QCM to the Shroud QCM to understand mass accumulation rate differences
- Install the filter approximately 0.2 in directly in front of the Carrier QCM
- 21 °C Single Filter Tests
 - Measure mass accumulation on the Carrier QCM & Shroud QCM with the single filter held at 21 °C (+2 °C, -1 °C) for each molecular flux of interest
- 5 °C Single Filter Tests
 - Measure mass accumulation on the Carrier QCM & Shroud QCM with the single filter held at 5 °C (+2 °C, -1 °C) for each molecular flux of interest

Filter testing performed at two filter temperatures and multiple molecular flux levels



Ascent Particle Filter Molecular Conductance Study

Single Filter Test Accumulation Rate* Summary

4/21/2008 QCM Calibration		4/29/2008 21°C Single Filter		5/14/2008 21°C Single Filter		5/28/2008 21°C Single Filter		5/28/2008 5°C Single Filter		5/29/2008 5°C Single Filter	
Background†	Carrier QCM	0.038 †	0.488	0.709	0.469	0.452	1.358				
	Shroud QCM	0.115 †	0.087	0.445	1.240	0.668	0.704				
Effusion Cell 30°C	Carrier QCM	1.060	0.091	0.212	16.8% §						
	Shroud QCM	1.409	0.894	1.260							
Effusion Cell 50°C	Carrier QCM	10.70	0.370	0.434	4.4% §						
	Shroud QCM	10.91	9.512	9.874							
Effusion Cell 60°C	Carrier QCM					1.155	3.6% §	0.692	1.2% §	0.291	3.1% §
	Shroud QCM					31.65		31.70		9.517	
Effusion Cell 70°C	Carrier QCM	97.32	3.975			2.962	3.0% §	1.922	2.2% §	0.784	2.5% §
	Shroud QCM	100.4	100.3			100.0		97.99		31.79	
Effusion Cell 80°C	Carrier QCM					9.770	3.3% §	3.983	2.0% §	1.680	1.7% §
	Shroud QCM					292.5		283.6	1.4% §	4.163	1.5% §

* All Rates in Angstroms per hour (Å/hr)

† Background rates measured with the effusion cell at 10°C and the shutter closed before all depositions each day (0Å deposited on each QCM)

‡ Measured after calibrations at 30°C, 50°C, and 70°C (Approximately 240Å deposited on each QCM)

§ Carrier QCM Rate as a percentage of the Shroud QCM Rate during the same deposition



Ascent Particle Filter Molecular Conductance Study

Summary

- To what extent does a typical ascent particle filter limit the conductance of molecular contamination?

21 °C Single Filter Tests

- The filter reduced the mass accumulation on the Carrier QCM to between 3.0% and 4.4% of the accumulation on the unobstructed Shroud QCM

5 °C Single Filter Tests

- The filter reduced the mass accumulation on the Carrier QCM to between 1.2% and 3.1% of the accumulation on the unobstructed Shroud QCM

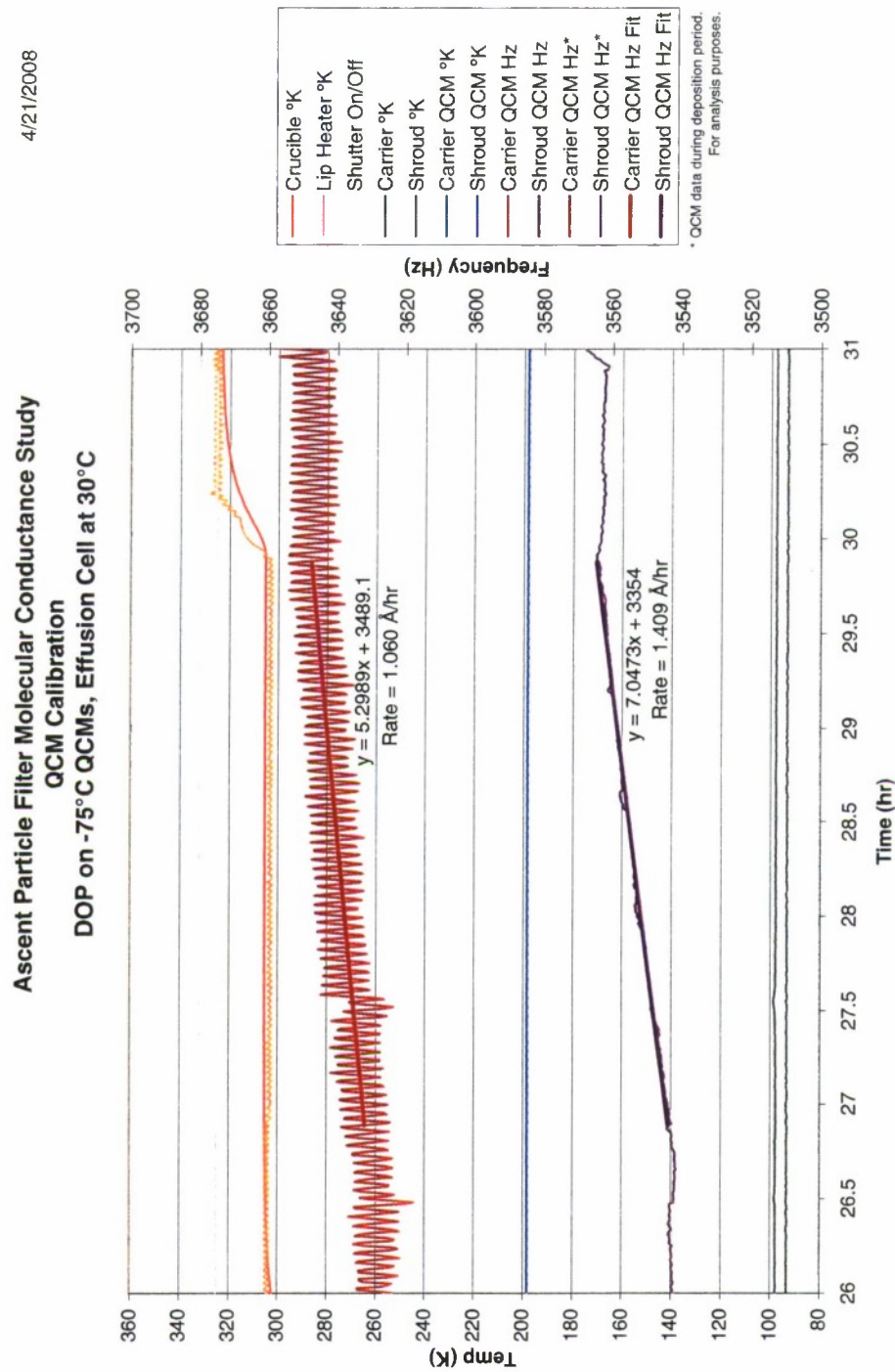
Note: Data recorded with the effusion cell at 30 °C is difficult to interpret because the deposition rates were very low.



Appendix: Data Archive

Ascent Particle Filter Molecular Conductance Study

Appendix: Data Archive

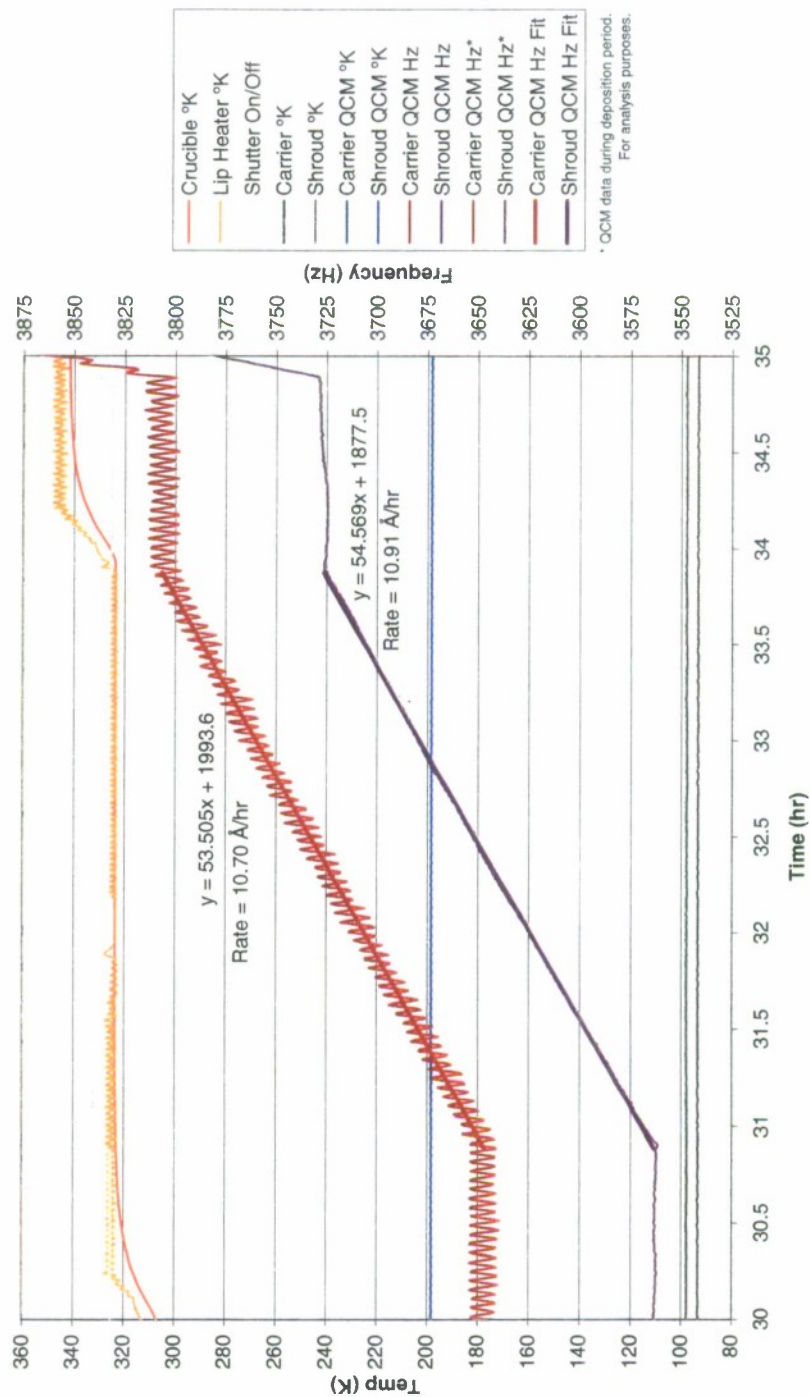


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Ascent Particle Filter Molecular Conductance Study
QCM Calibration
DOP on -75°C QCMs, Effusion Cell at 50°C

4/21/2008



* QCM data during deposition period.
For analysis purposes.

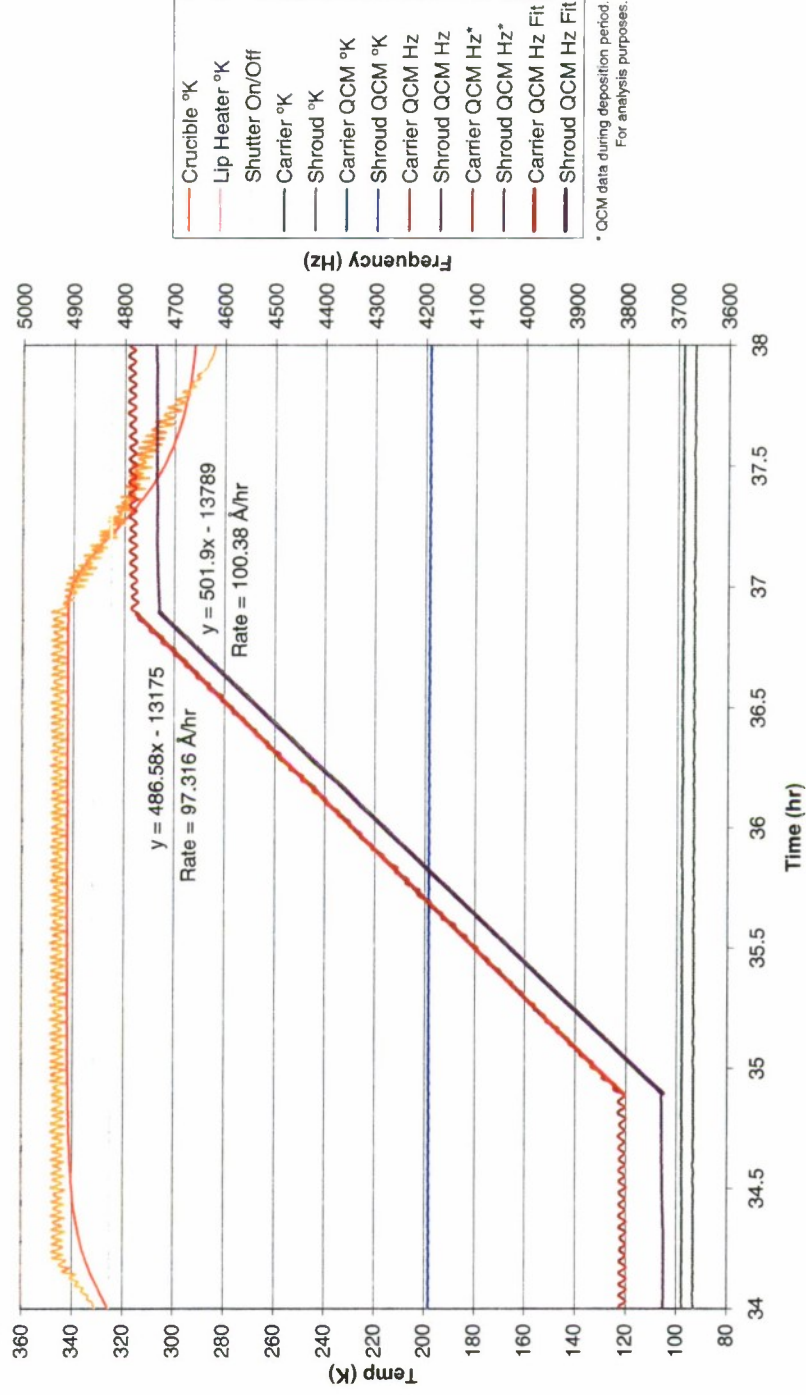


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QCM Calibration
DOP on -75°C QCMs, Effusion Cell at 70°C

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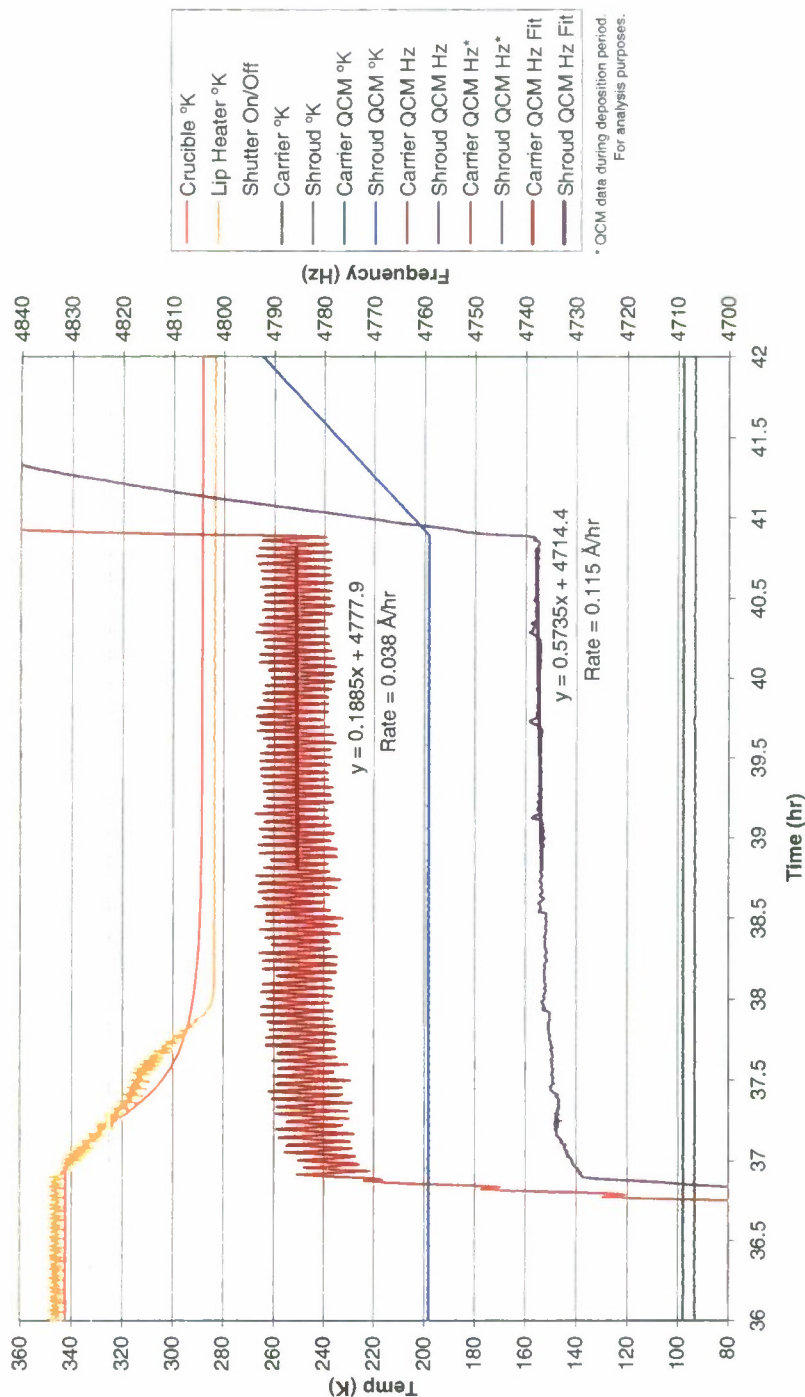


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Ascent Particle Filter Molecular Conductance Study
QCM Calibration
DOP on -75°C QCMs, Background with Effusion Cell at 10°C

4/21/2008

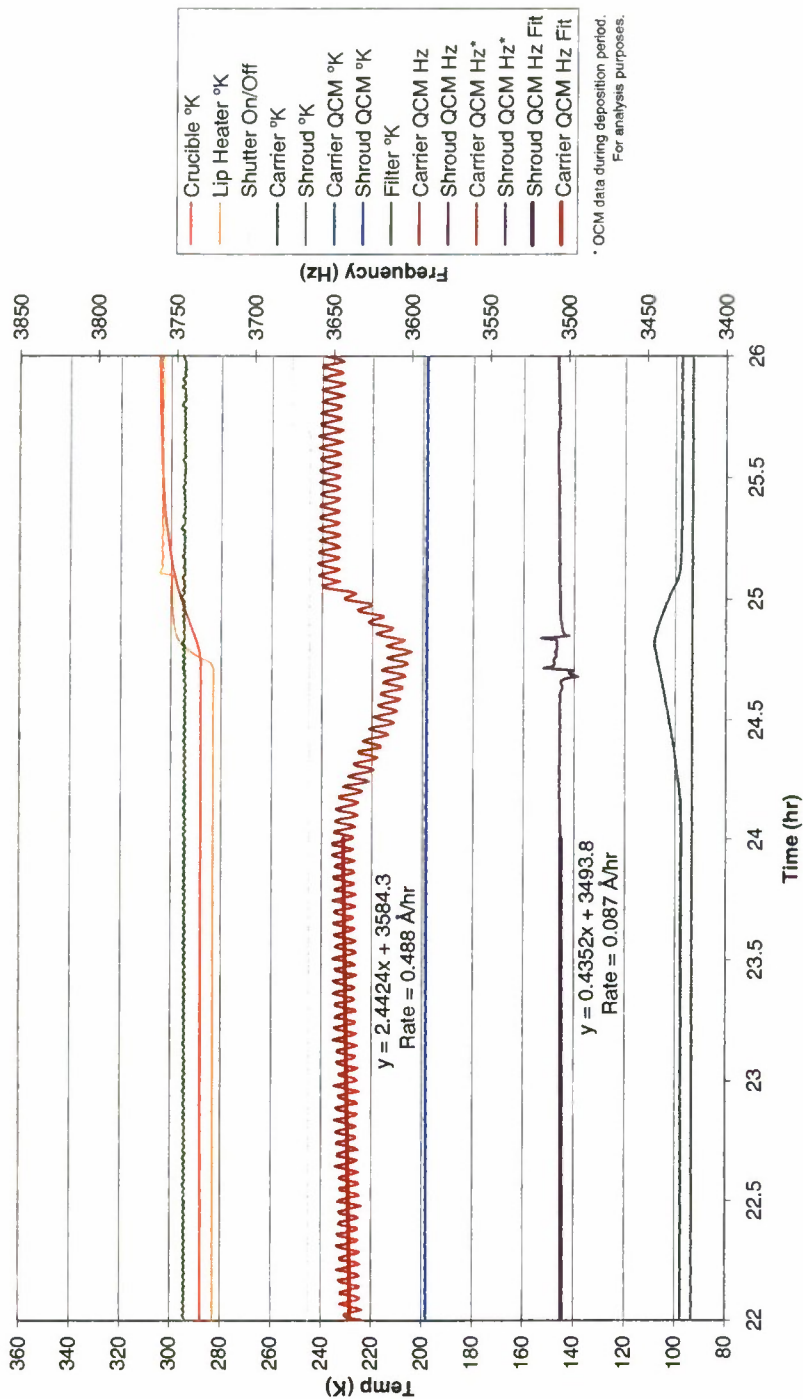


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Ascent Particle Filter Molecular Conductance Study
21°C Single Filter Test, Filter Shielding Carrier QCM
DOP on -75°C QCMS, Background with Effusion Cell at 10°C

4/29/2008

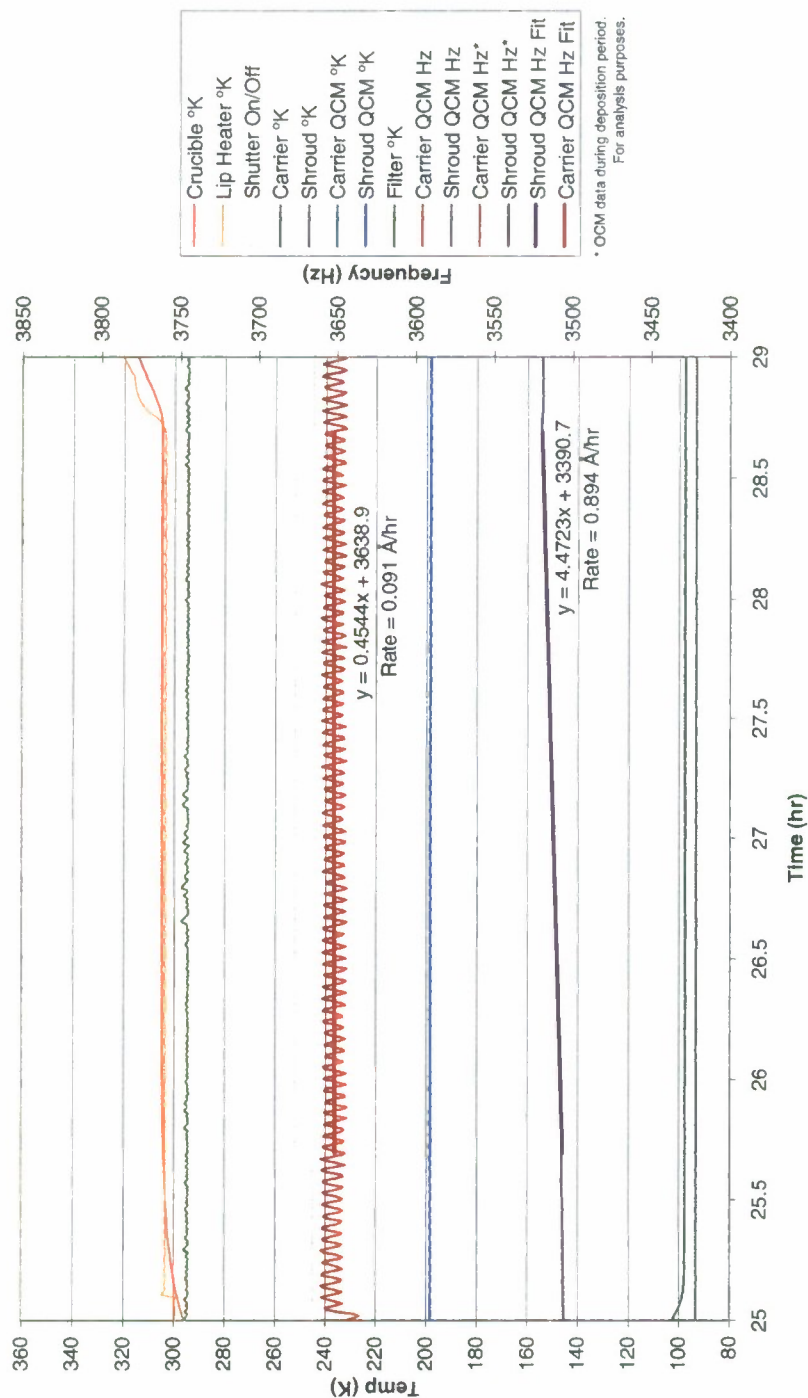


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Ascent Particle Filter Molecular Conductance Study
21 °C Single Filter Test, Filter Shielding Carrier QCM
DOP on -75 °C QCMS, Effusion Cell at 30 °C

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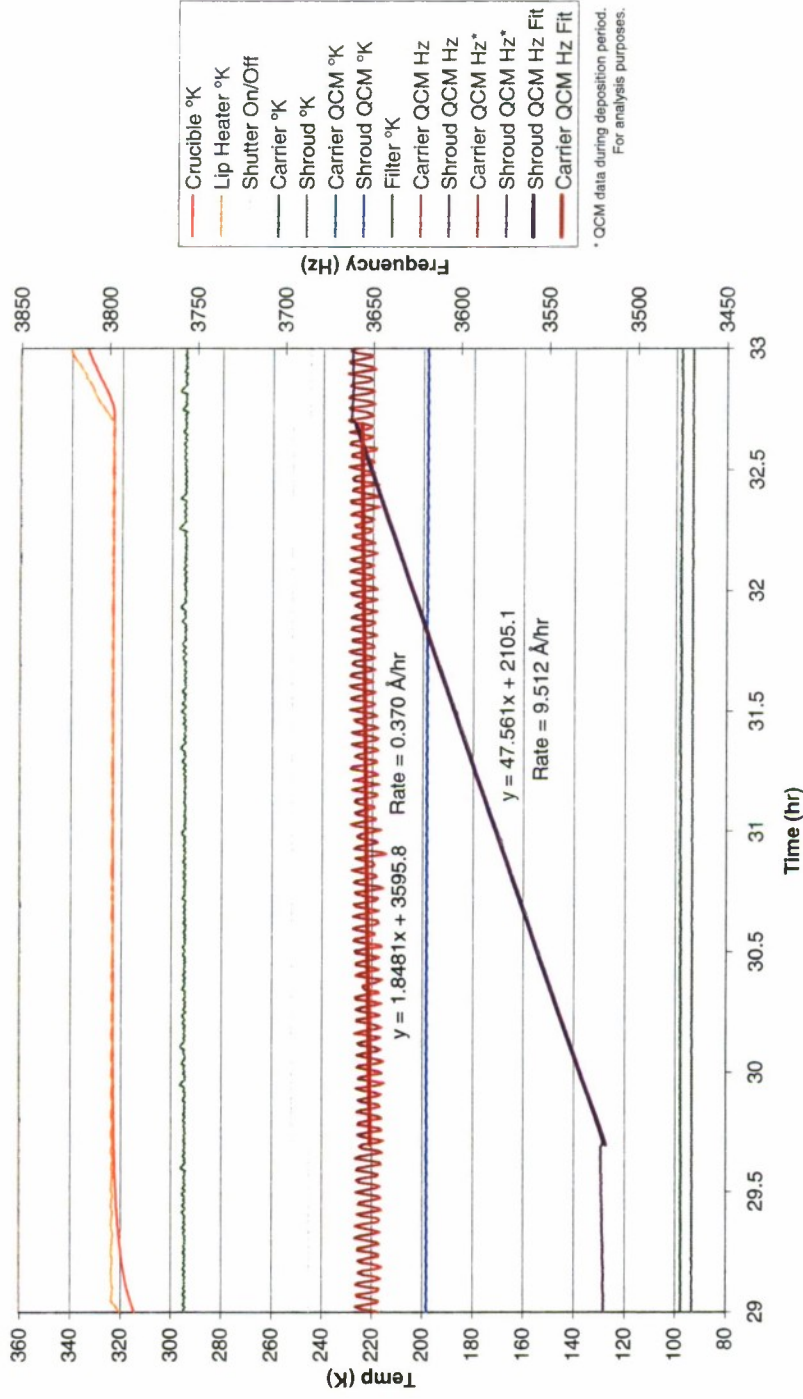


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Ascent Particle Filter Molecular Conductance Study
21°C Single Filter Test, Filter Shielding Carrier QCM
DOP on -75°C QCMS, Effusion Cell at 50°C

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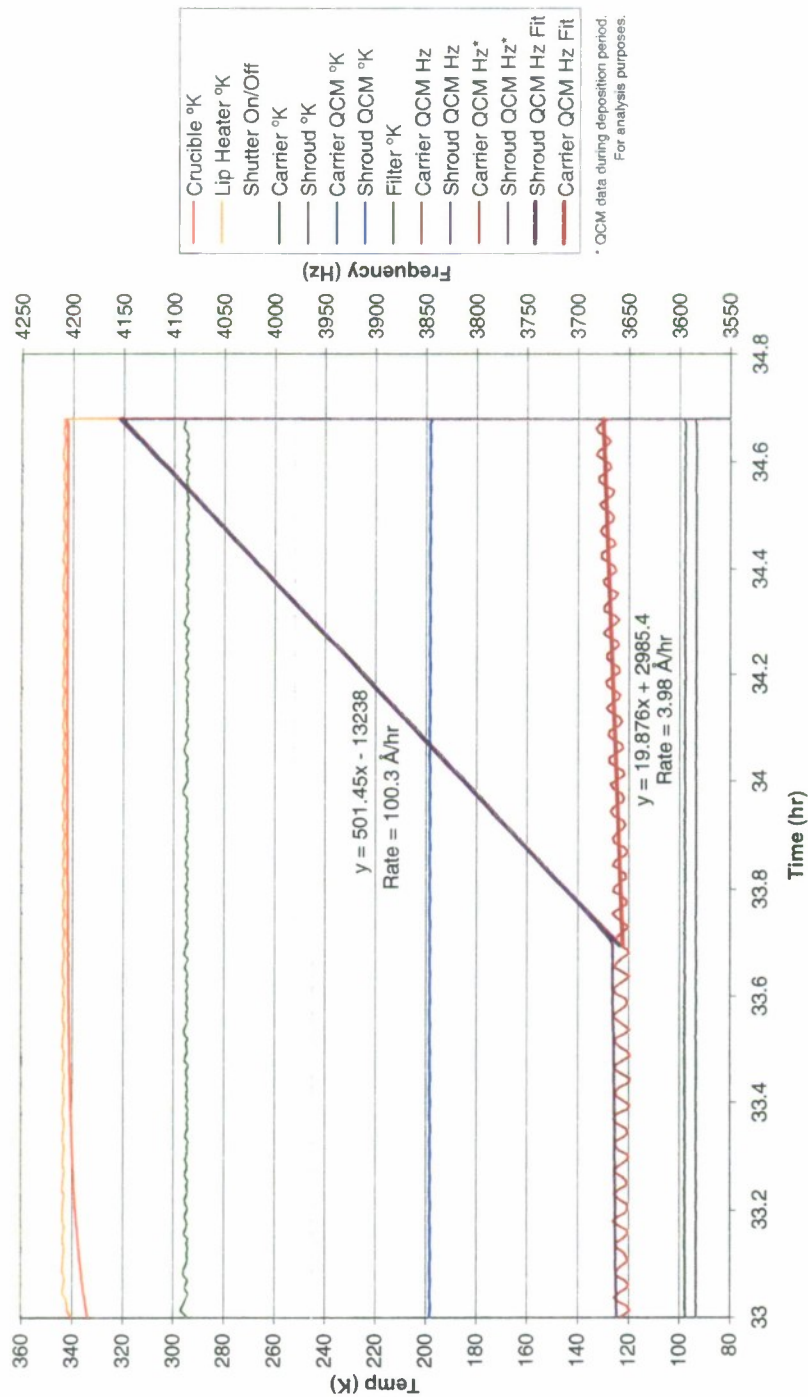


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Ascent Particle Filter Molecular Conductance Study
21°C Single Filter Test, Filter Shielding Carrier QCM
DOP on -75°C QCMS, Effusion Cell at 70°C

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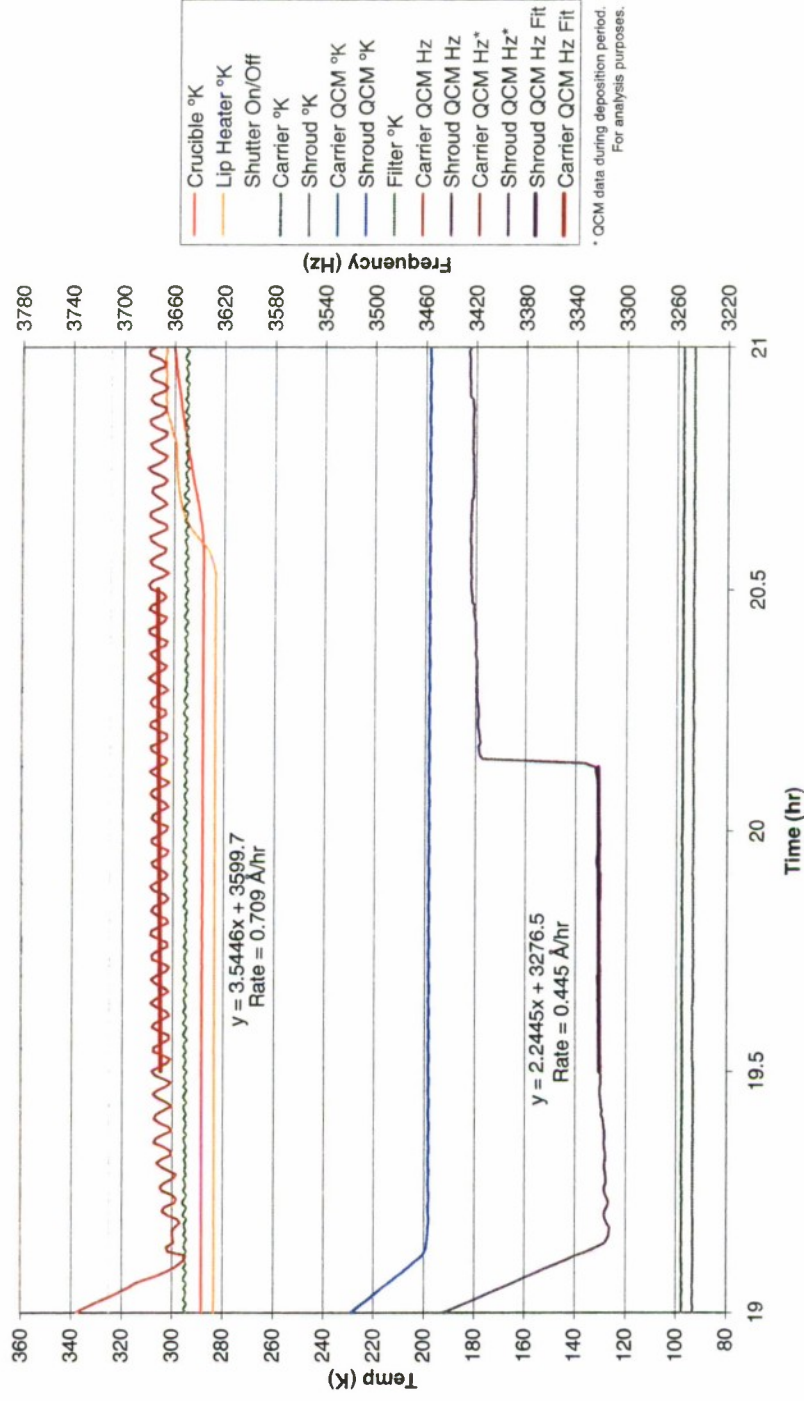


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Ascent Particle Filter Molecular Conductance Study
21°C Single Filter Test, Filter Shielding Carrier QCM
DOP on -75°C QCMS, Background with Effusion Cell at 10°C

5/14/2008

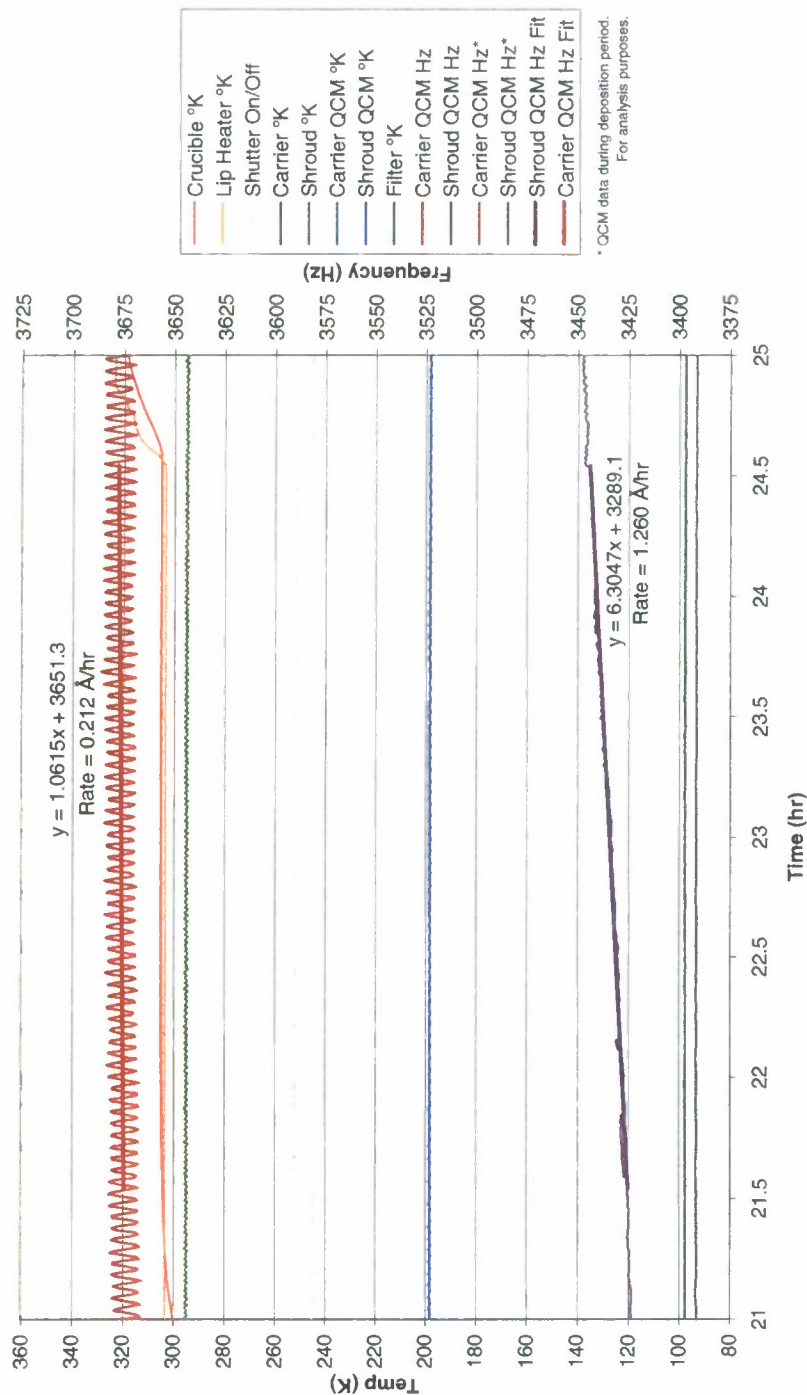


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Ascent Particle Filter Molecular Conductance Study
21°C Single Filter Test, Filter Shielding Carrier QCM
DOP on -75°C QCMS, Effusion Cell at 30°C

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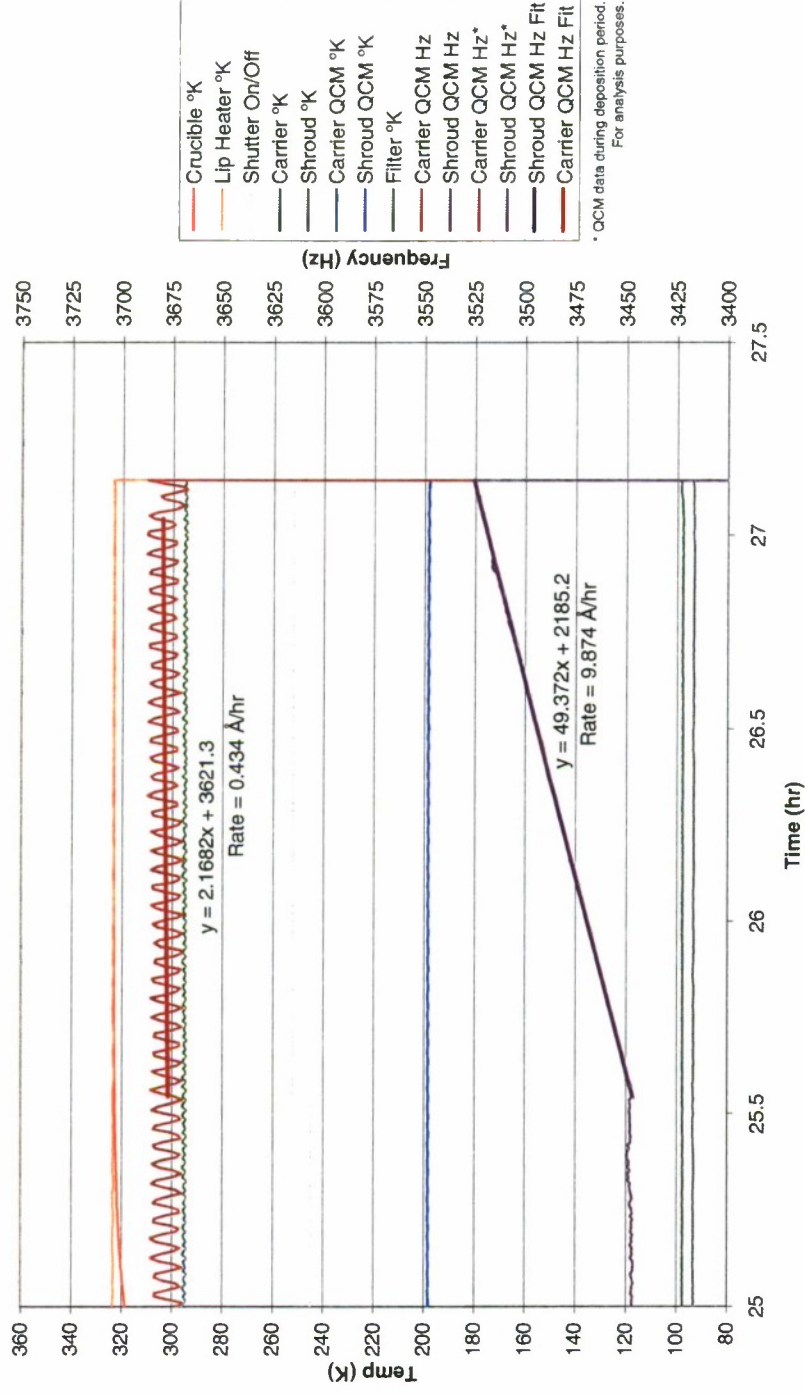


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Ascent Particle Filter Molecular Conductance Study
21°C Single Filter Test, Filter Shielding Carrier QCM
DOP on -75°C QCMS, Effusion Cell at 50°C

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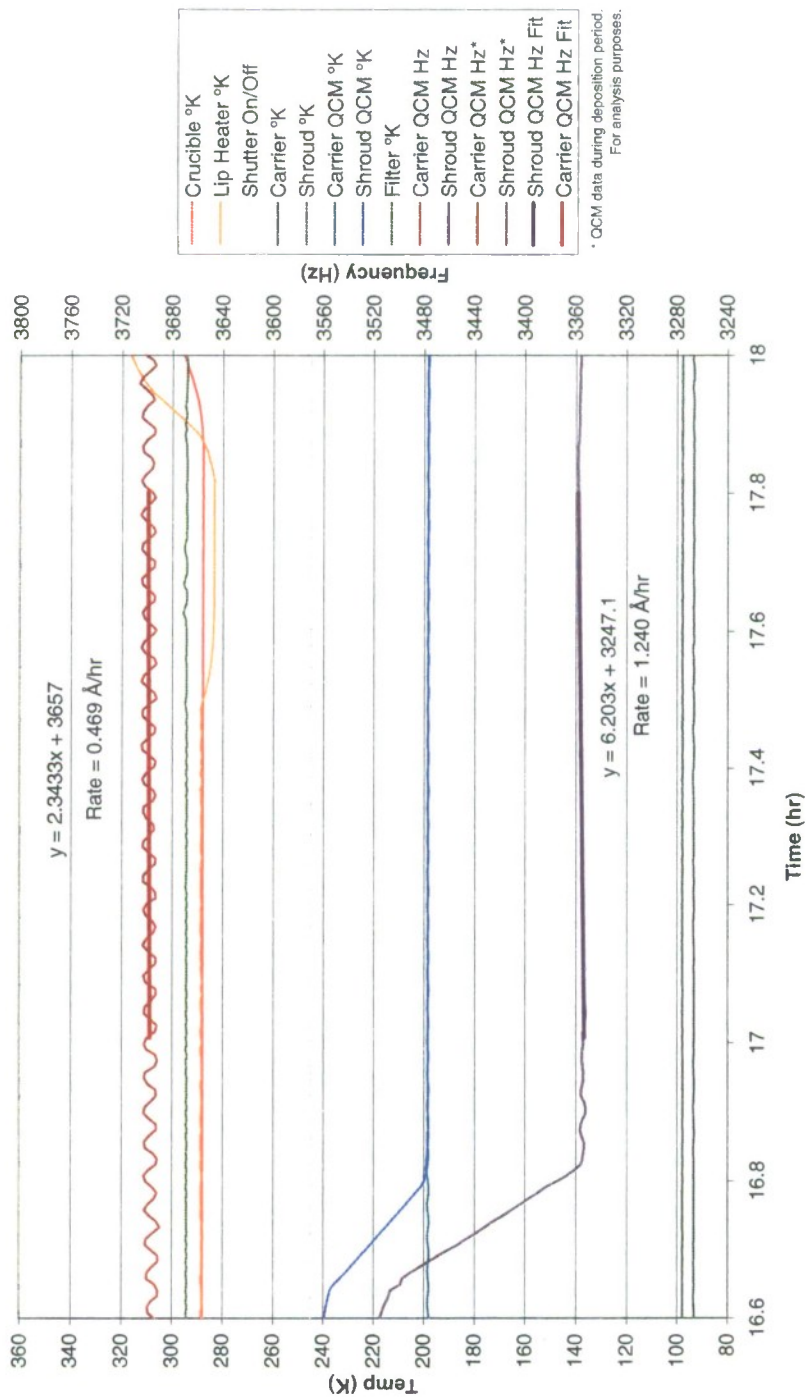


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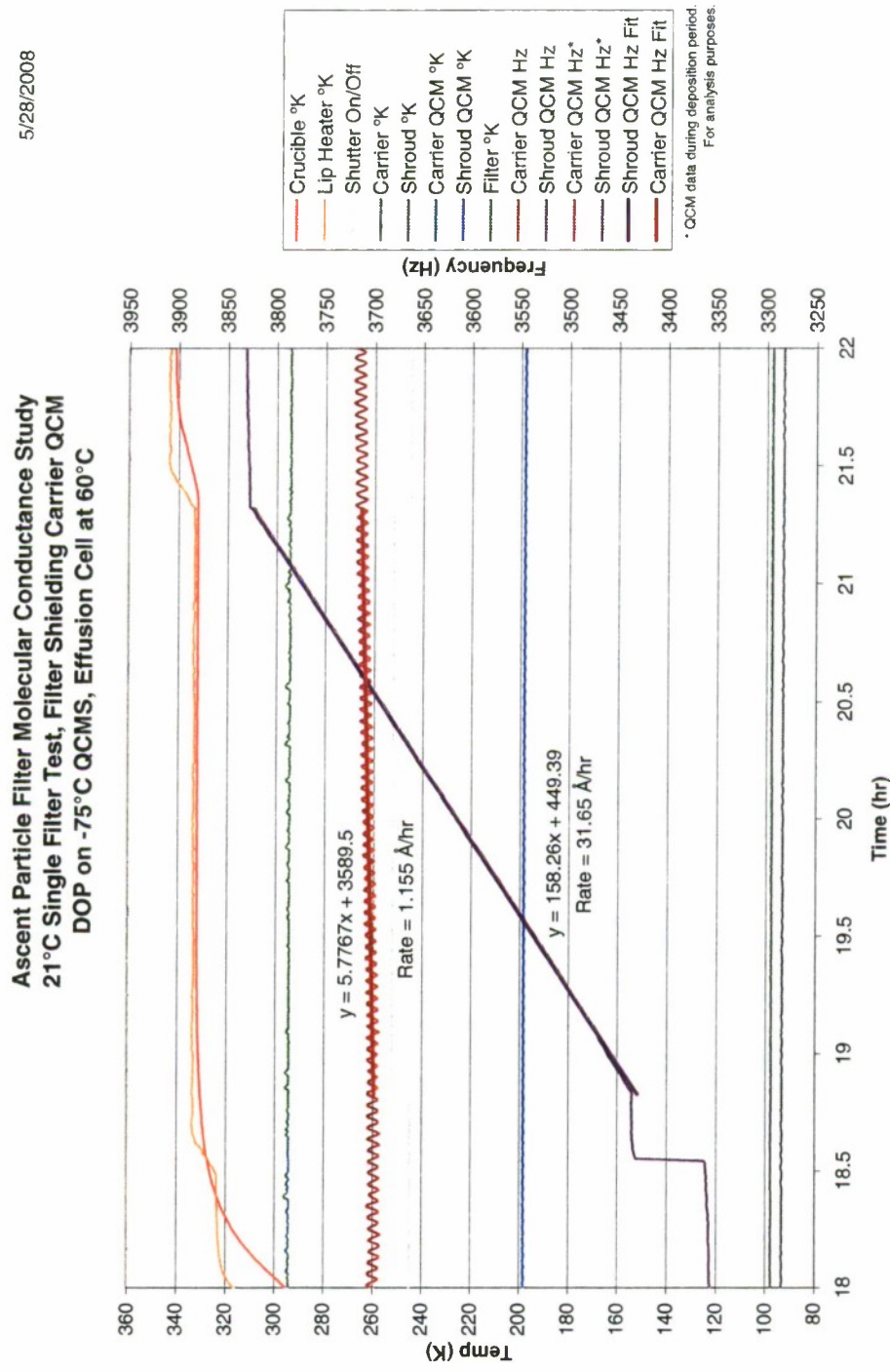
Ascent Particle Filter Molecular Conductance Study
21°C Single Filter Test, Filter Shielding Carrier QCM
DOP on -75°C QCMS, Background with Effusion Cell at 10°C

5/28/2008



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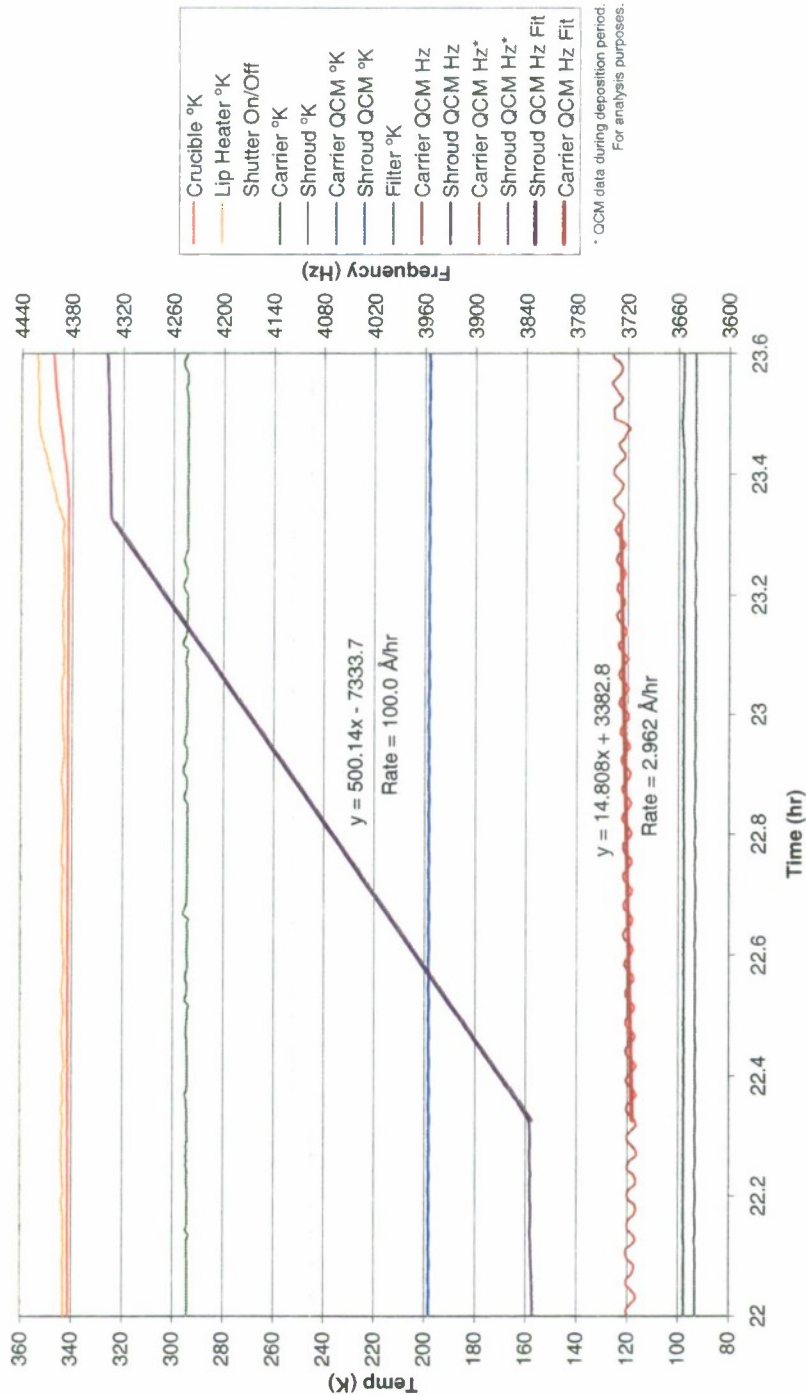


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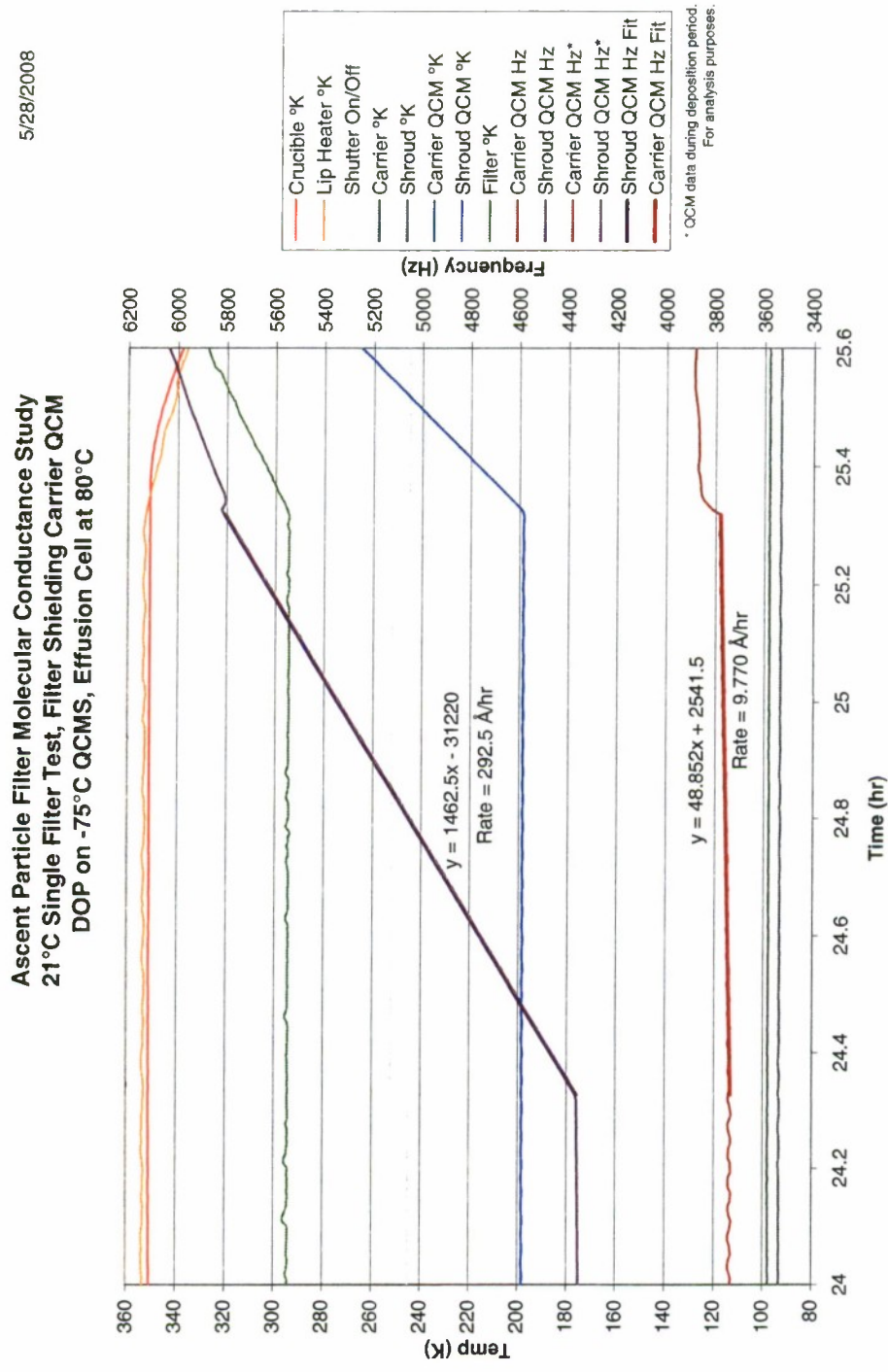
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21°C Single Filter Test, Filter Shielding Carrier QCM
DOP on -75°C QCMS, Effusion Cell at 70°C

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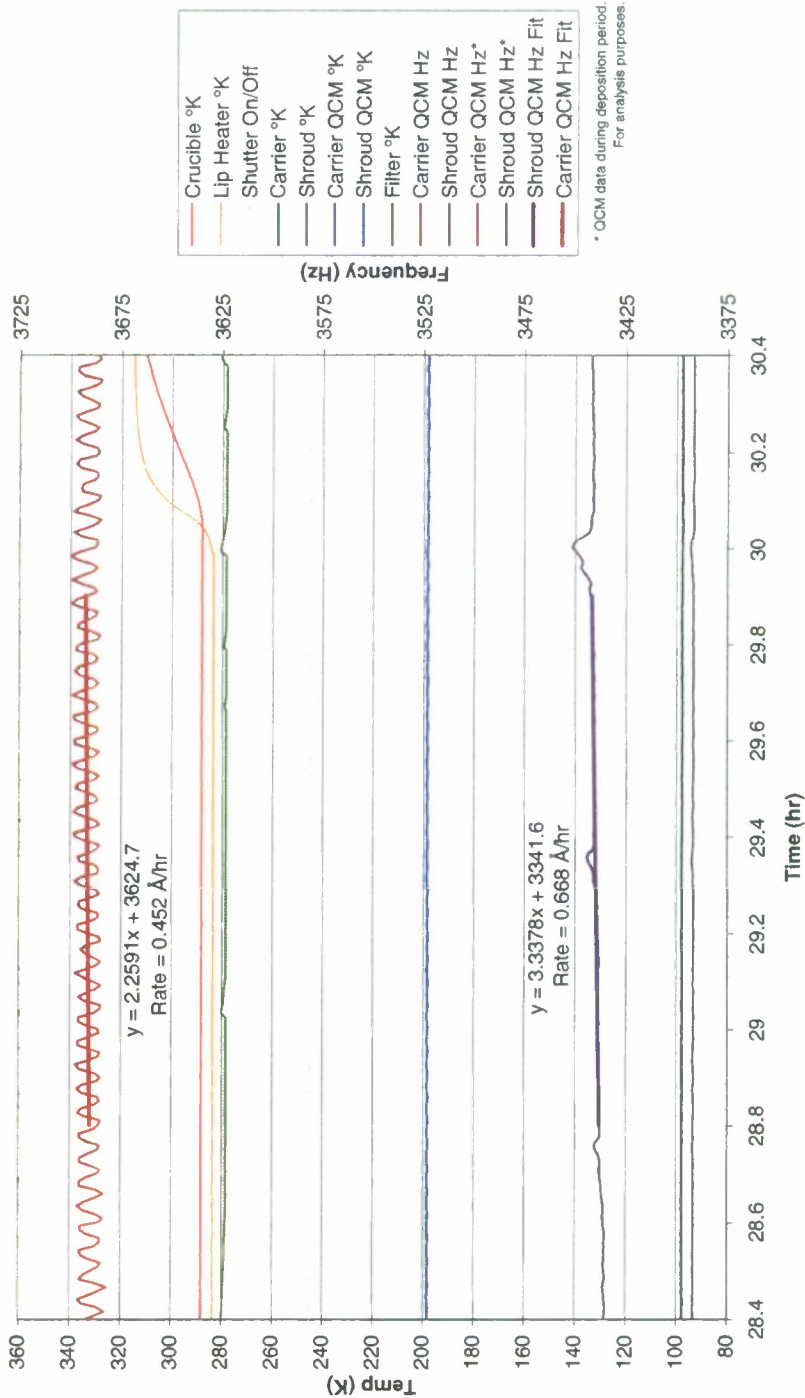


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Ascent Particle Filter Molecular Conductance Study
5°C Single Filter Test, Filter Shielding Carrier QCM
DOP on -75°C QCMS, Background with Effusion Cell at 10°C

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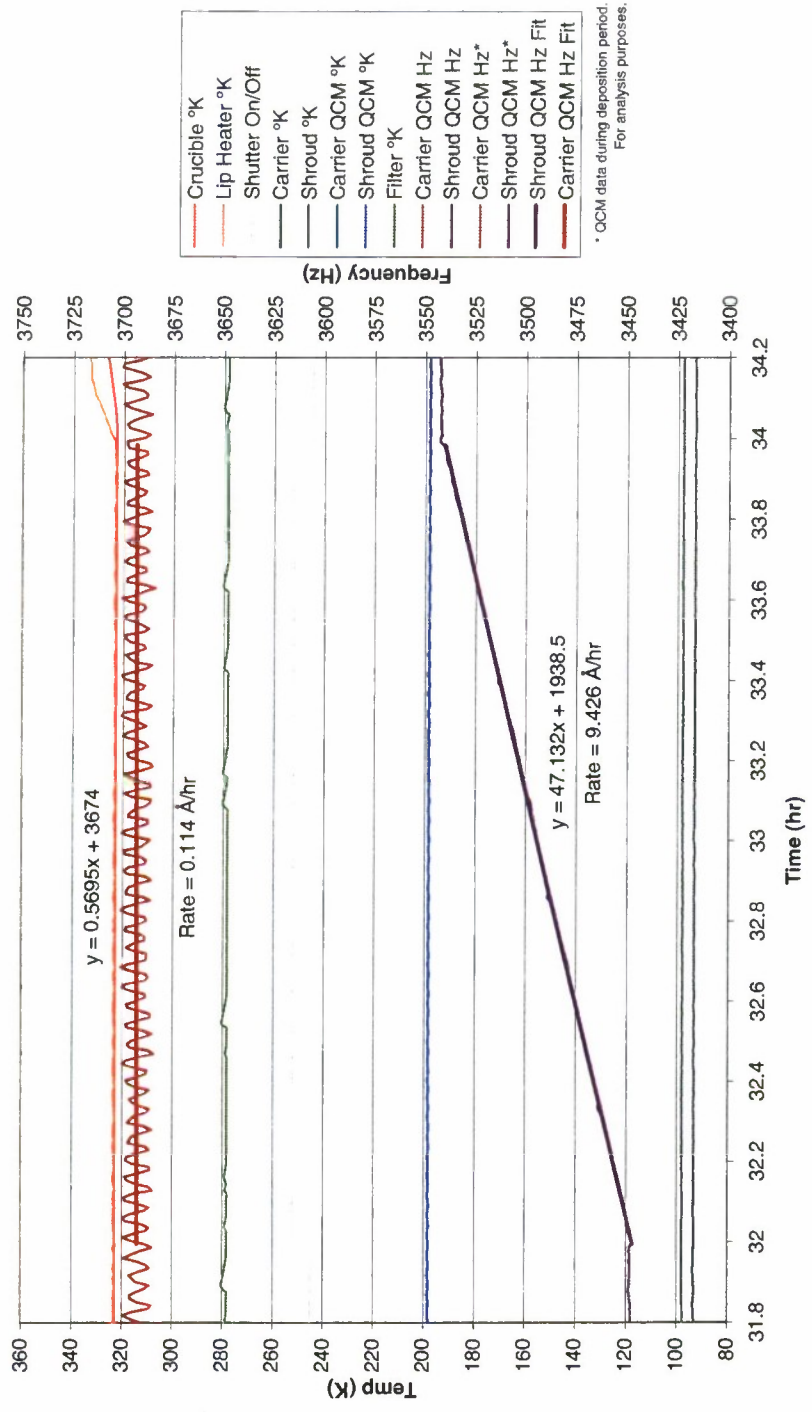


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Ascent Particle Filter Molecular Conductance Study
5°C Single Filter Test, Filter Shielding Carrier QCM
DOP on -75°C QCMS, Effusion Cell at 50°C

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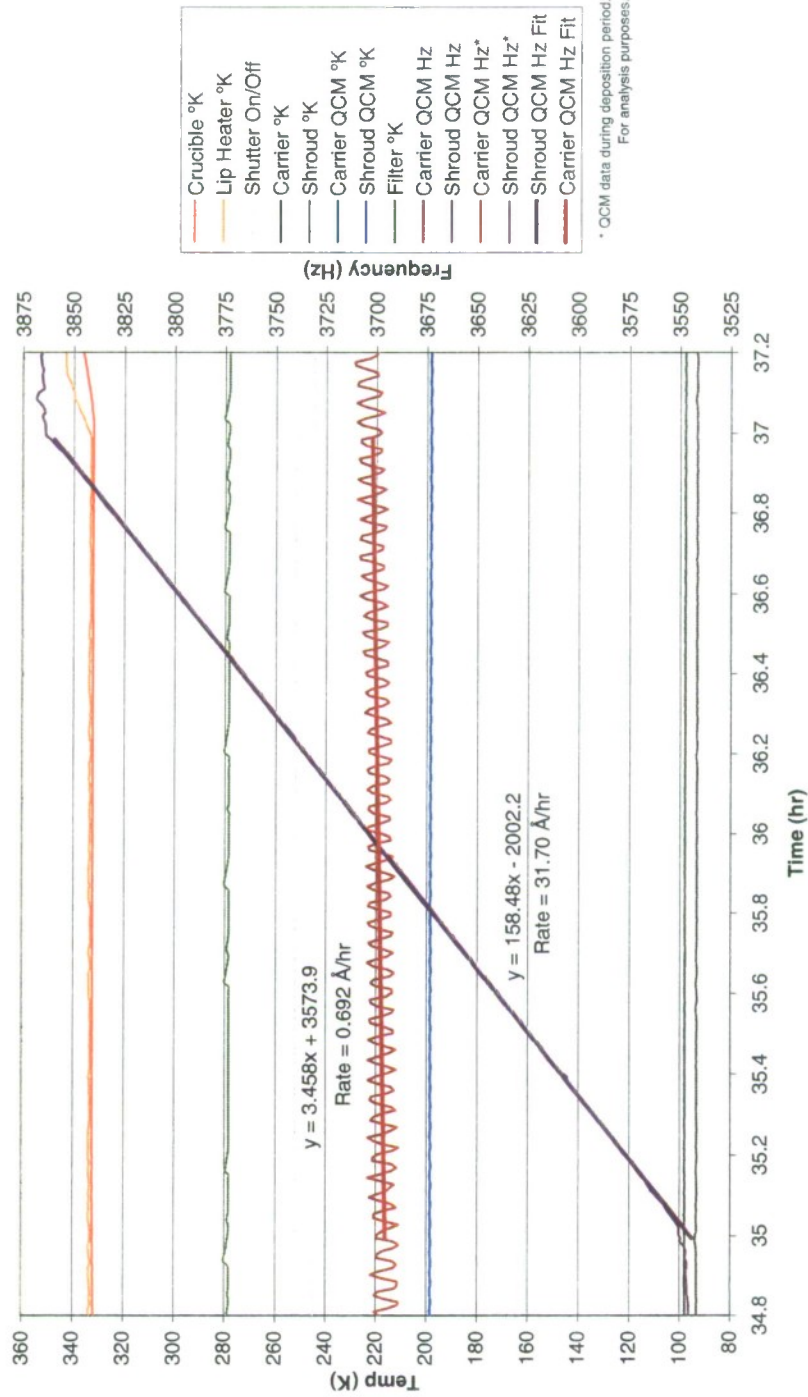


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Ascent Particle Filter Molecular Conductance Study
5°C Single Filter Test, Filter Shielding Carrier QCM
DOP on -75°C QCMS, Effusion Cell at 60°C

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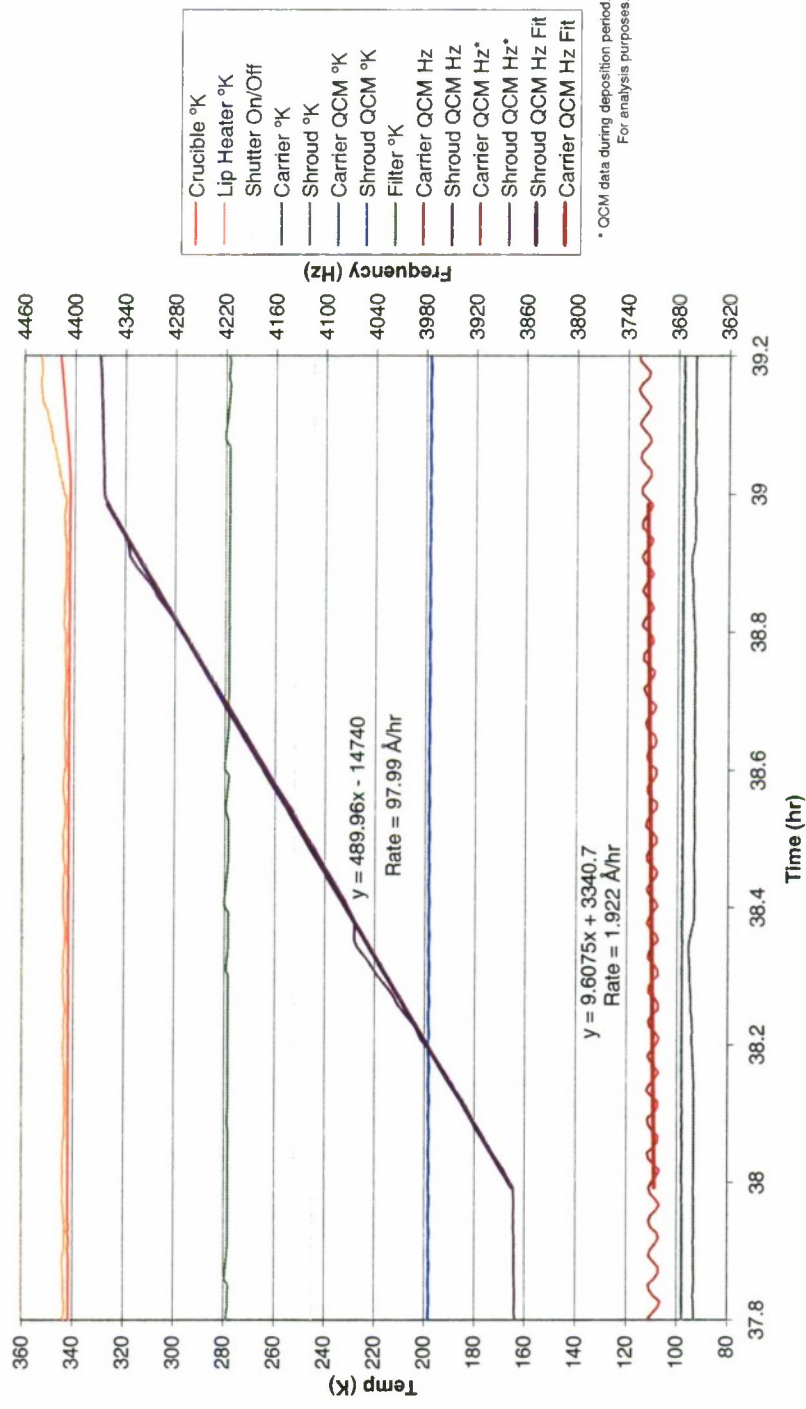


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5°C Single Filter Test, Filter Shielding Carrier QCM
DOP on -75°C QCMS, Effusion Cell at 70°C

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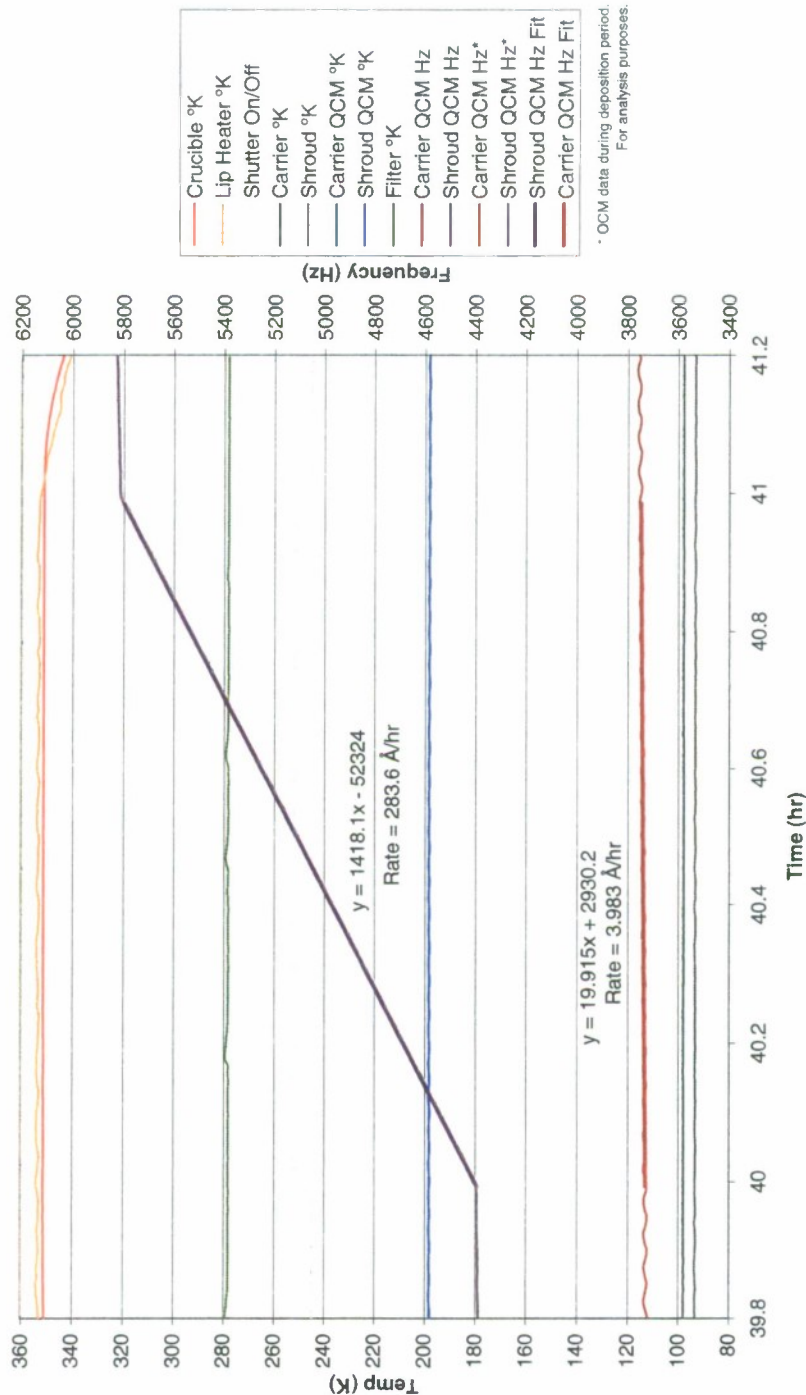


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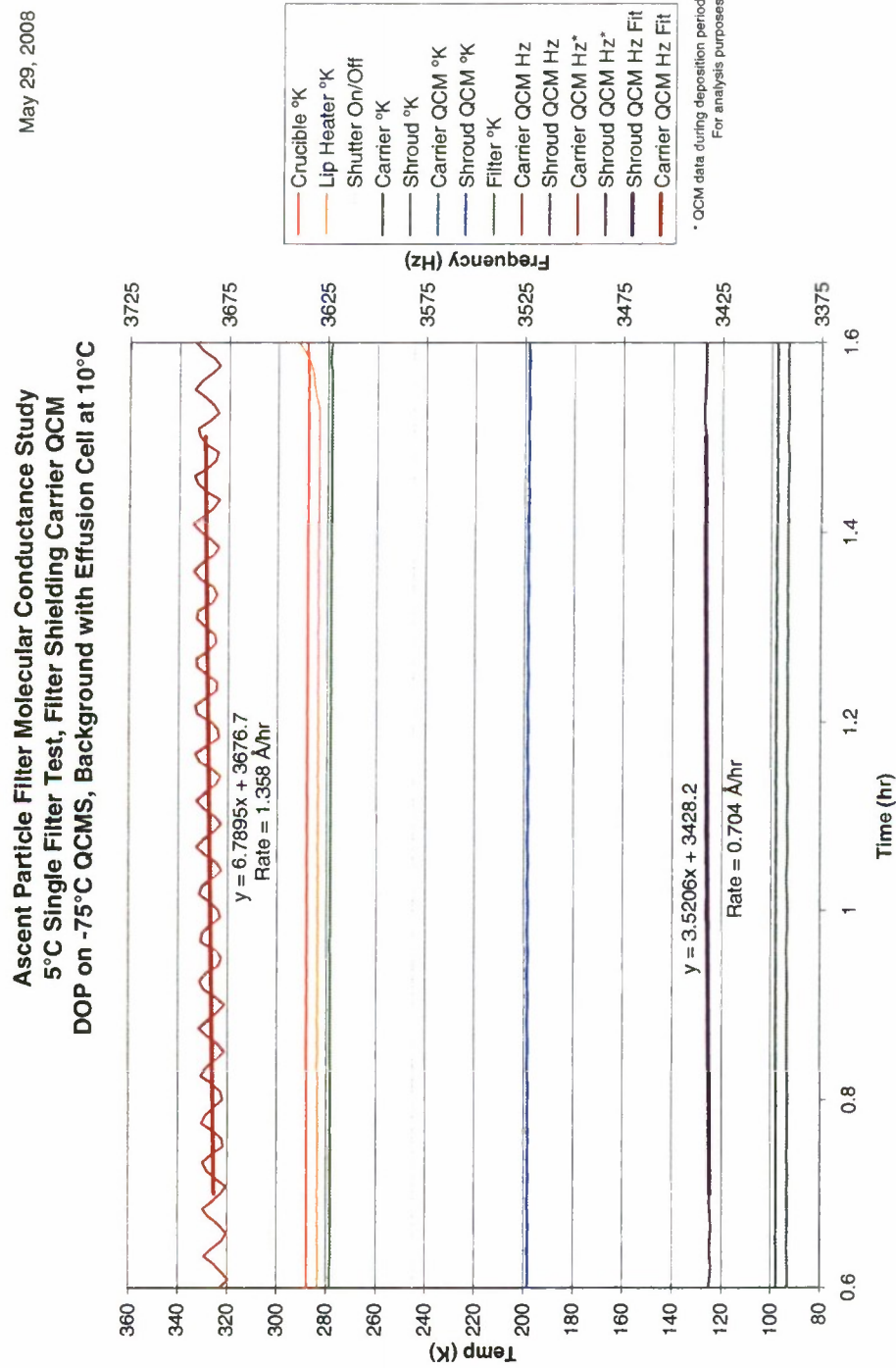
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5°C Single Filter Test, Filter Shielding Carrier QCM
DOP on -75°C QCMS, Effusion Cell at 80°C

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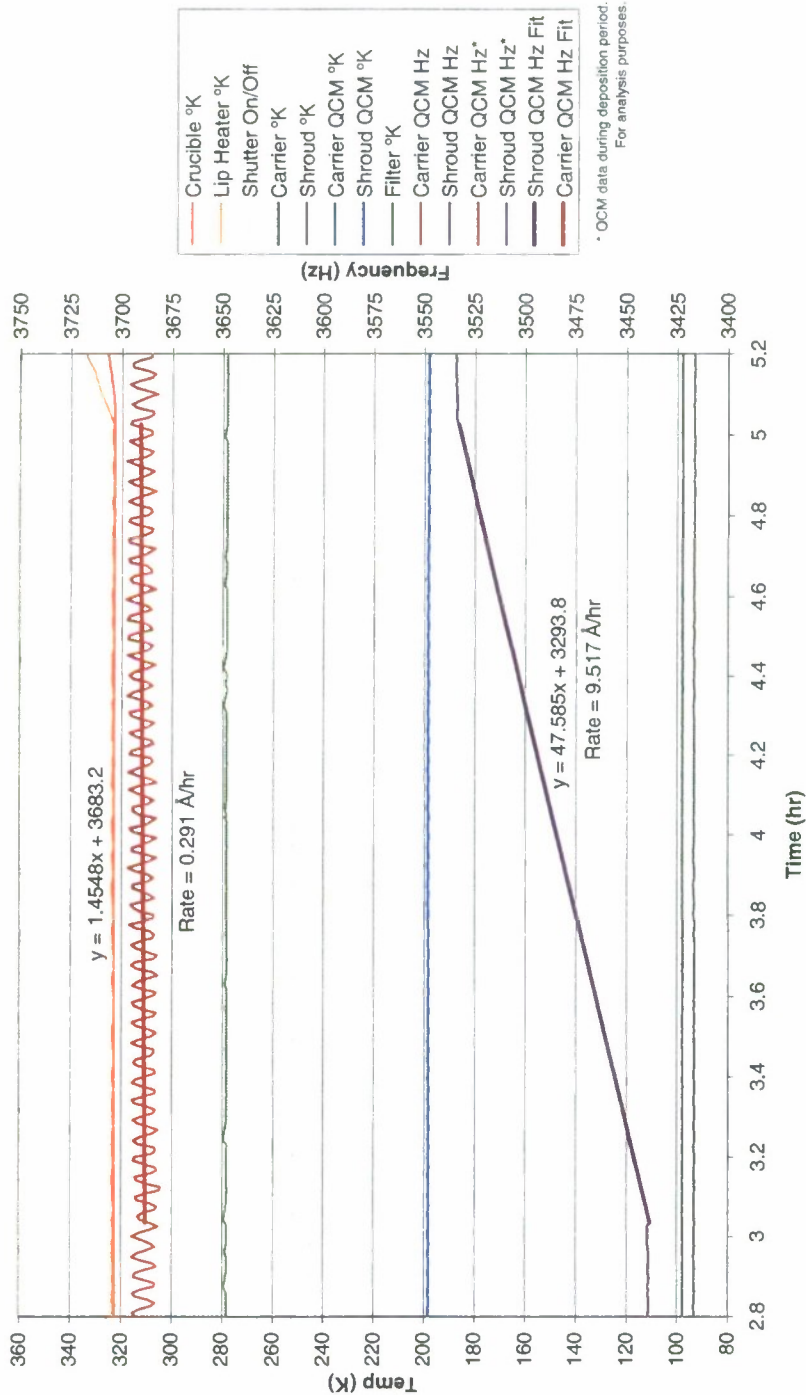


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5°C Single Filter Test, Filter Shielding Carrier QCM
DOP on -75°C QCMS, Effusion Cell at 50°C

May 29, 2008

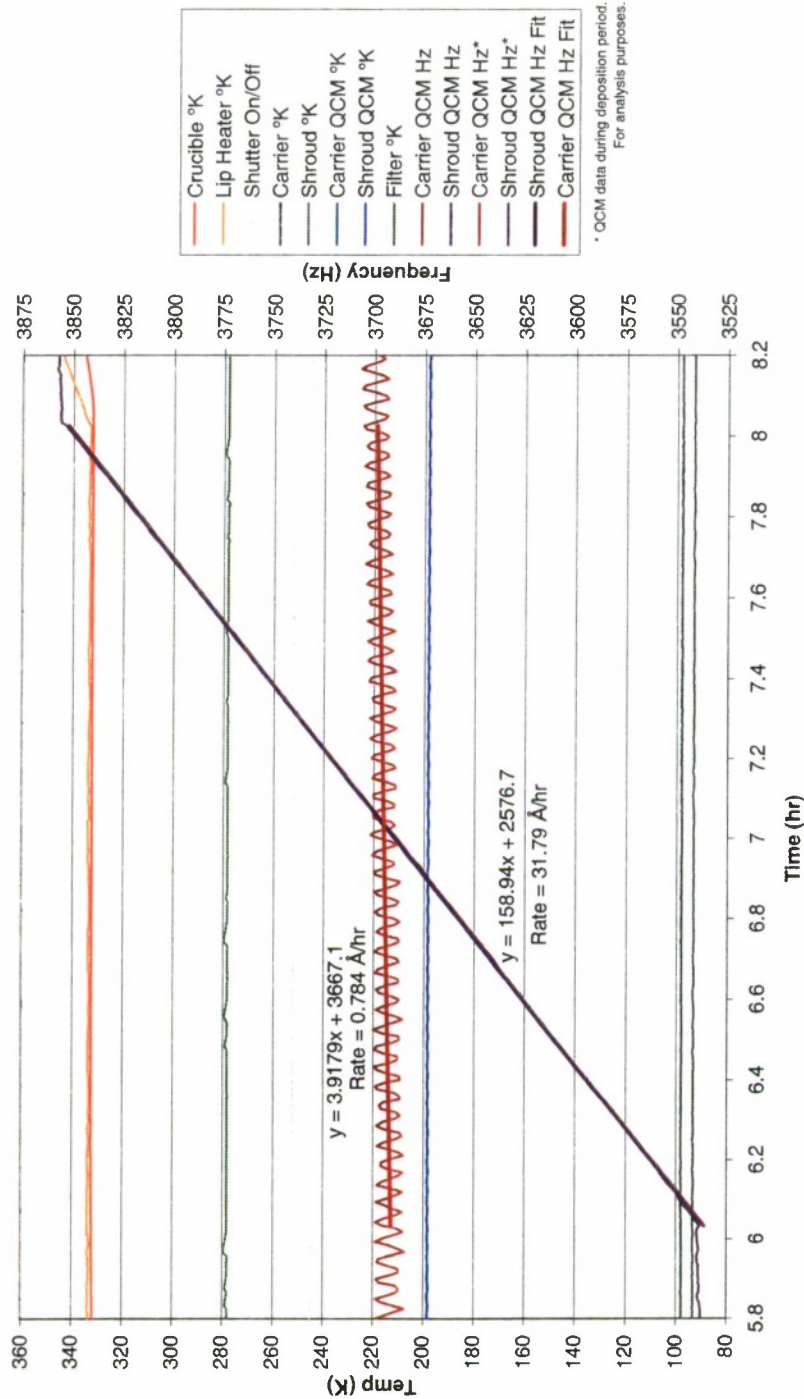


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5°C Single Filter Test, Filter Shielding Carrier QCM
DOP on -75°C QCMS, Effusion Cell at 60°C

May 29, 2008

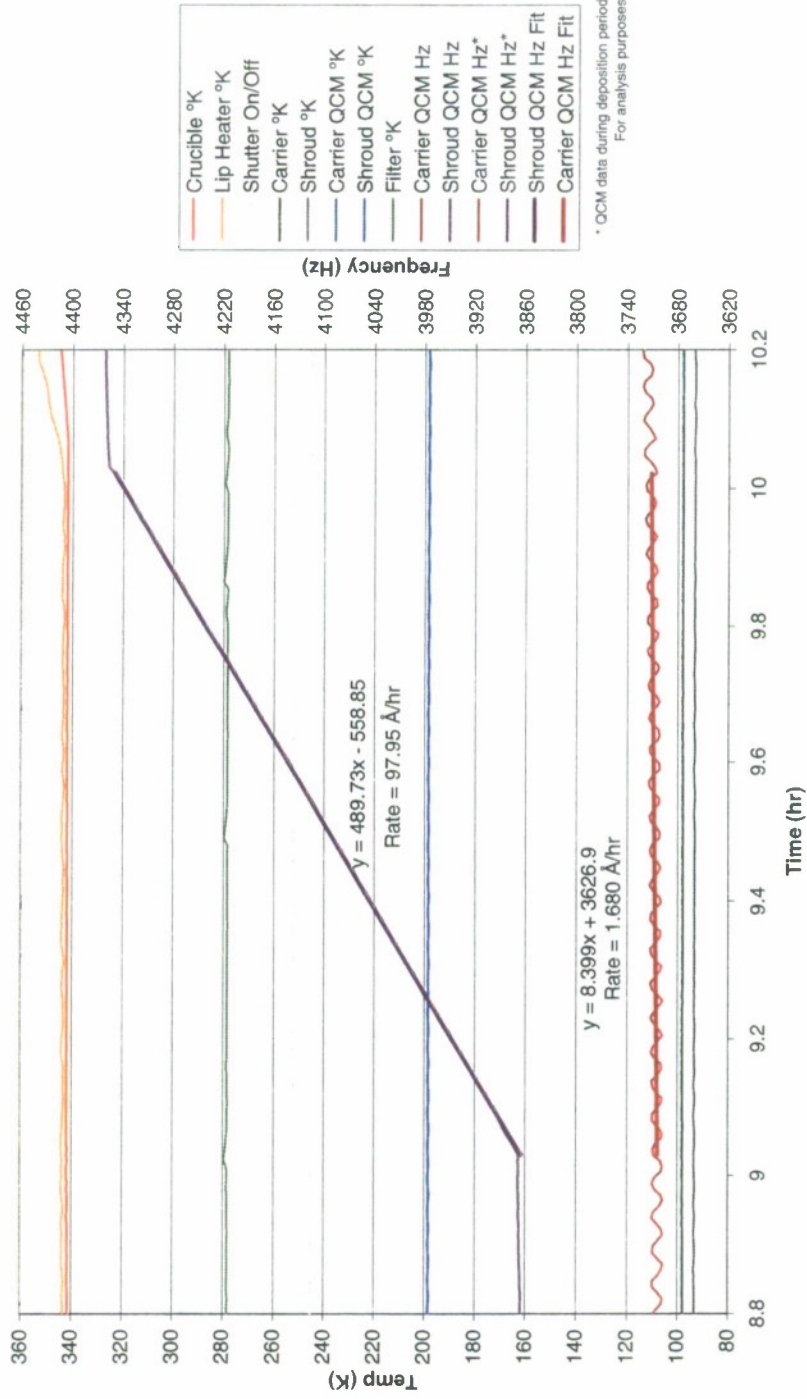


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Ascent Particle Filter Molecular Conductance Study
5°C Single Filter Test, Filter Shielding Carrier QCM
DOP on -75°C QCMS, Effusion Cell at 70°C

May 29, 2008

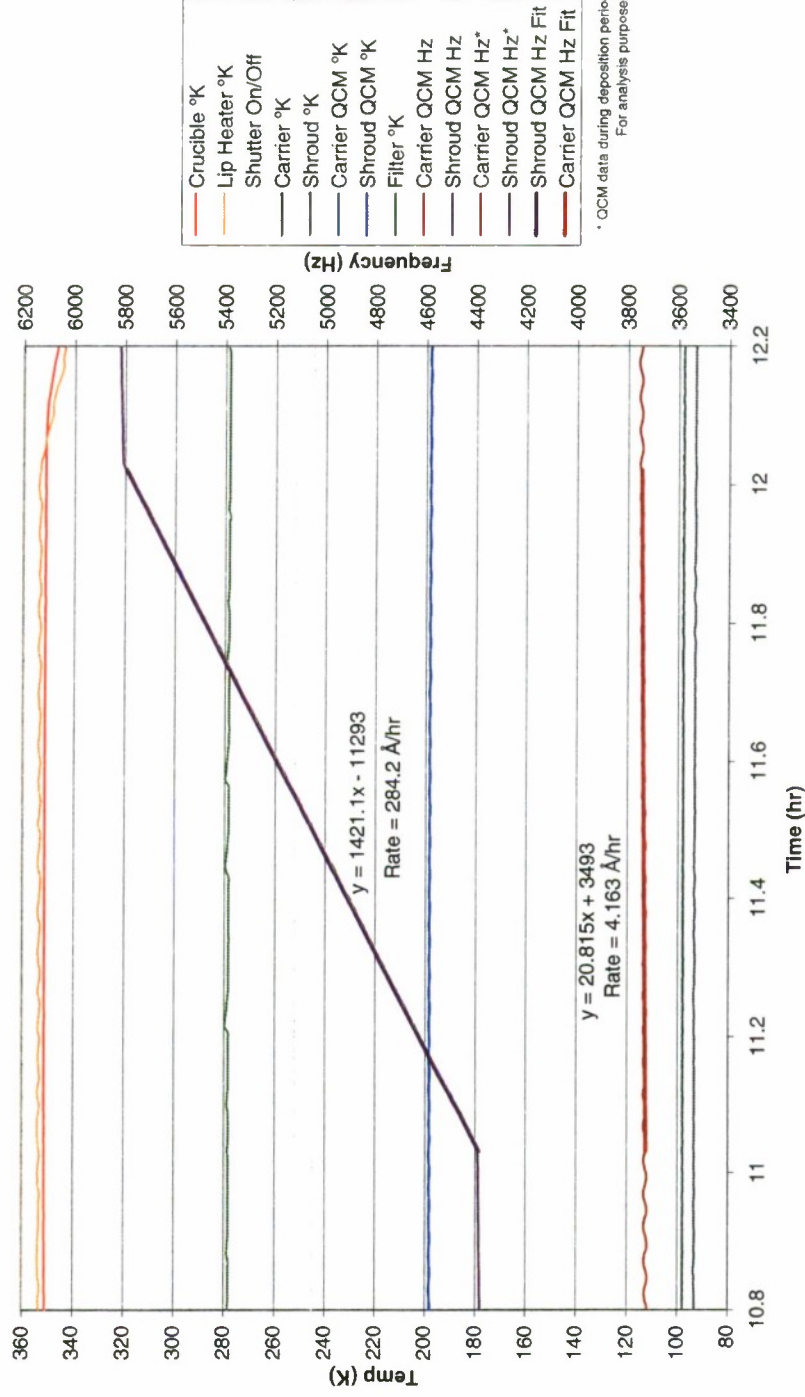


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Ascent Particle Filter Molecular Conductance Study
5°C Single Filter Test, Filter Shielding Carrier QCM
DOP on -75°C QCMS, Effusion Cell at 80°C

May 29, 2008



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