CONTAMINATION CONTROL ASSESSMENT OF THE WORLD'S LARGEST SPACE ENVIRONMENTAL SIMULATION CHAMBER

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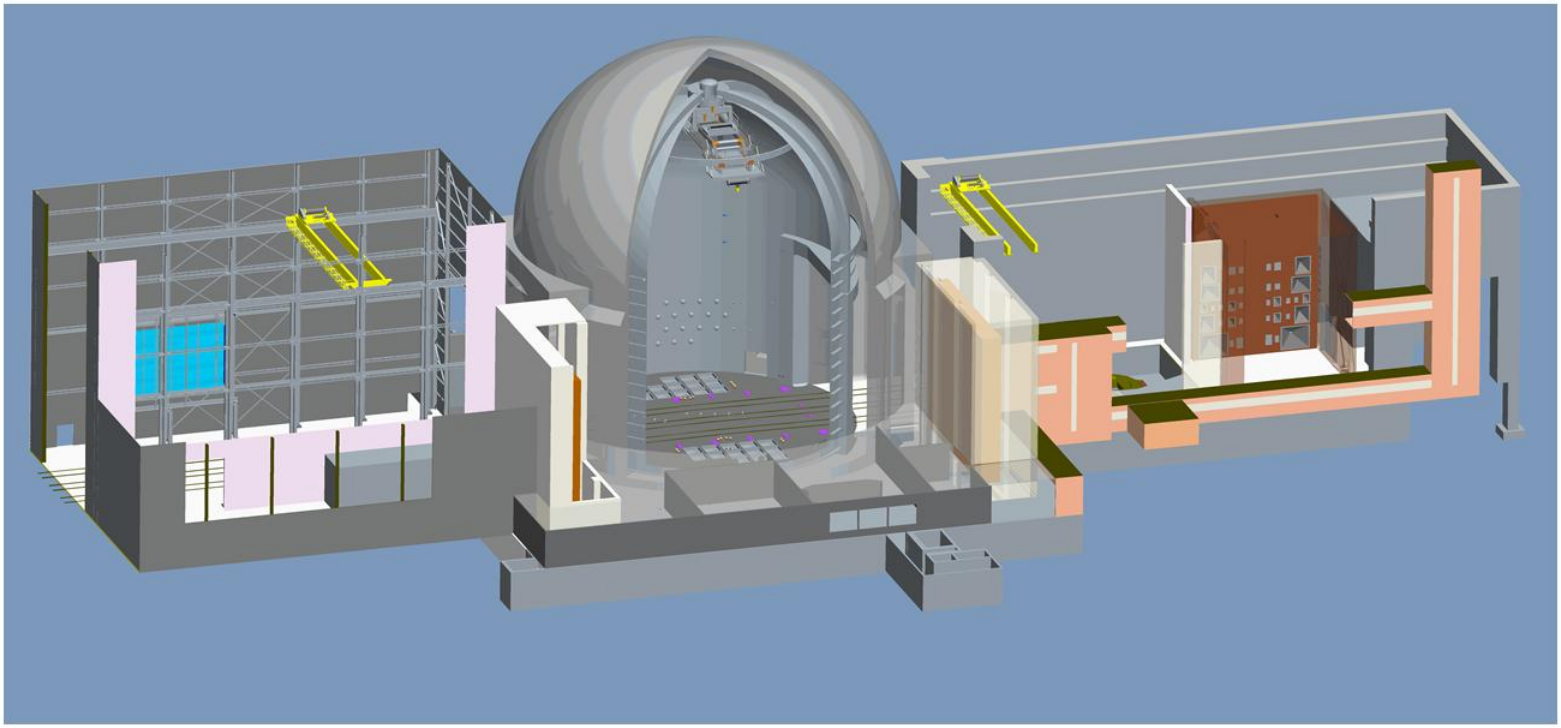
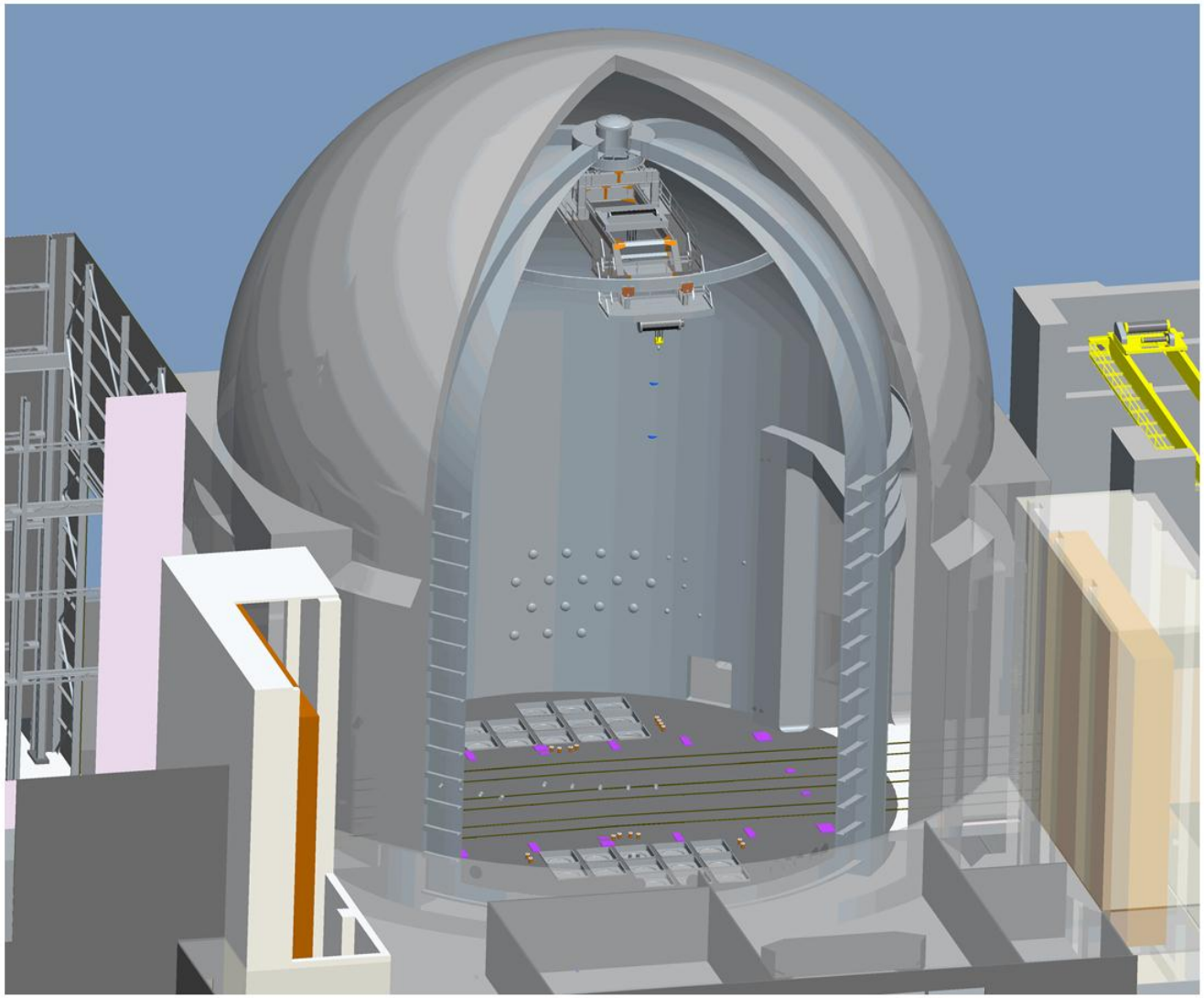
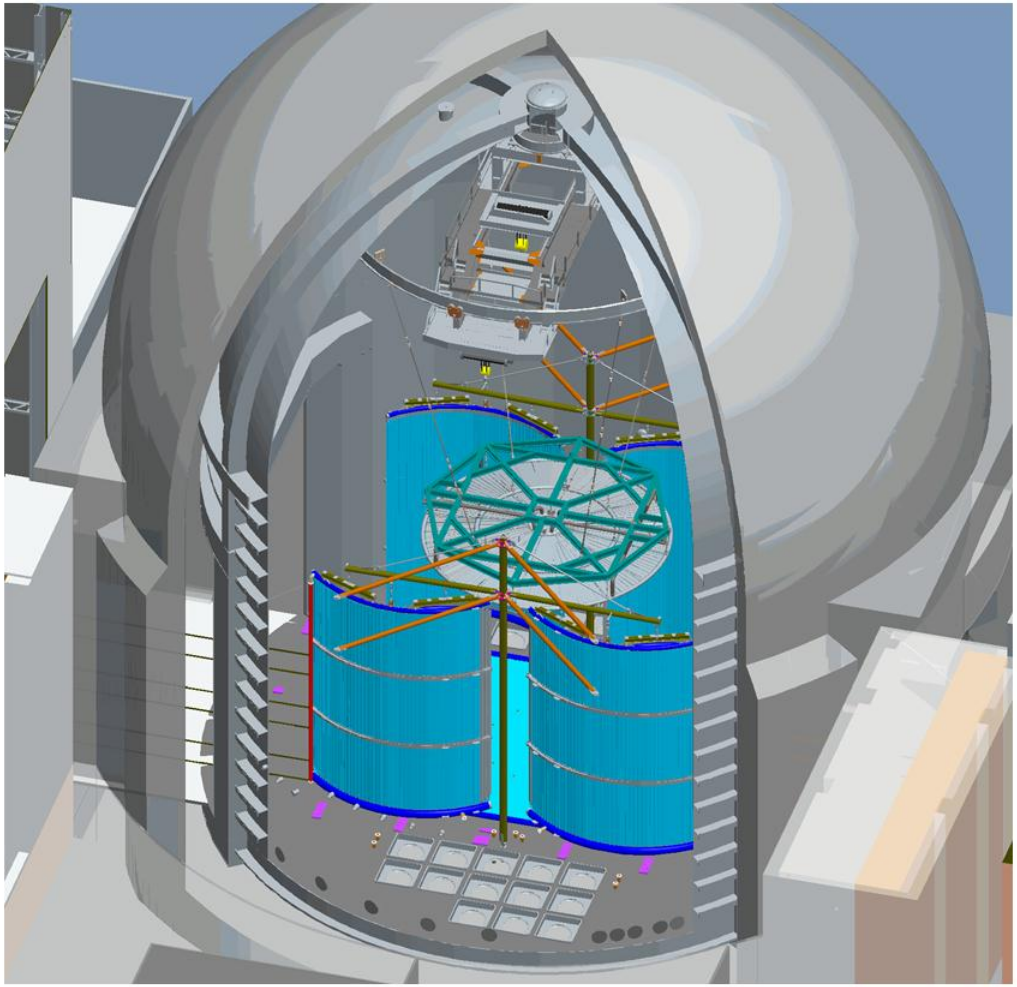


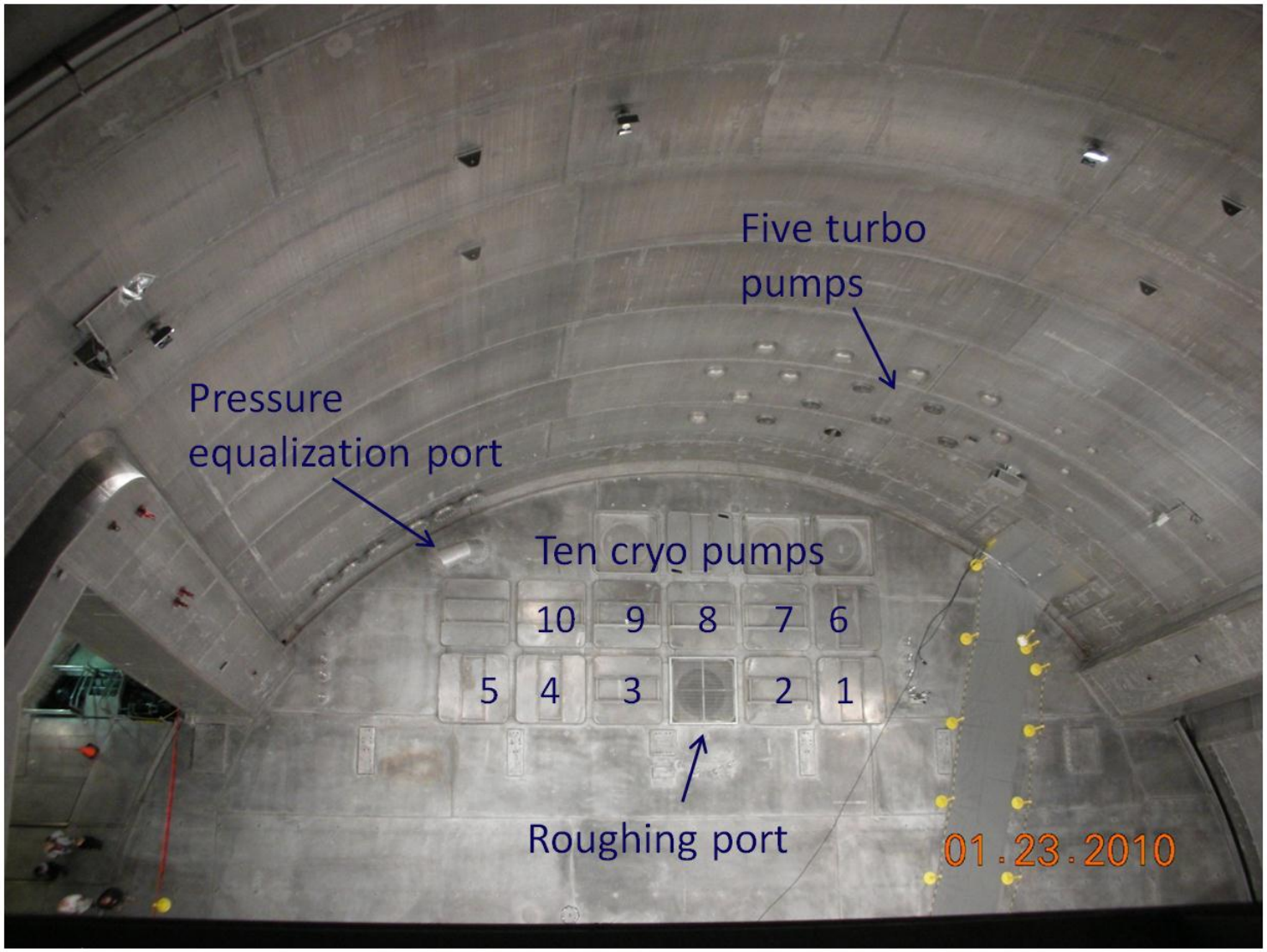
Thermal-Vacuum Test Chamber within Concrete Dome



Cryo-Shroud in Open Configuration



View of Test Chamber from Polar Crane Bridge



Test Chamber and Annulus Roughing Piping

Inlet chamber piping

Chamber piping

Chamber piping isolation valve

Chamber and annulus piping

Roughing piping to blowers

Chamber piping

Chamber and annulus piping

Piping at stage-1 blowers

Stage-2, stage-3, and stage-4 blowers


Torr Master
CVT

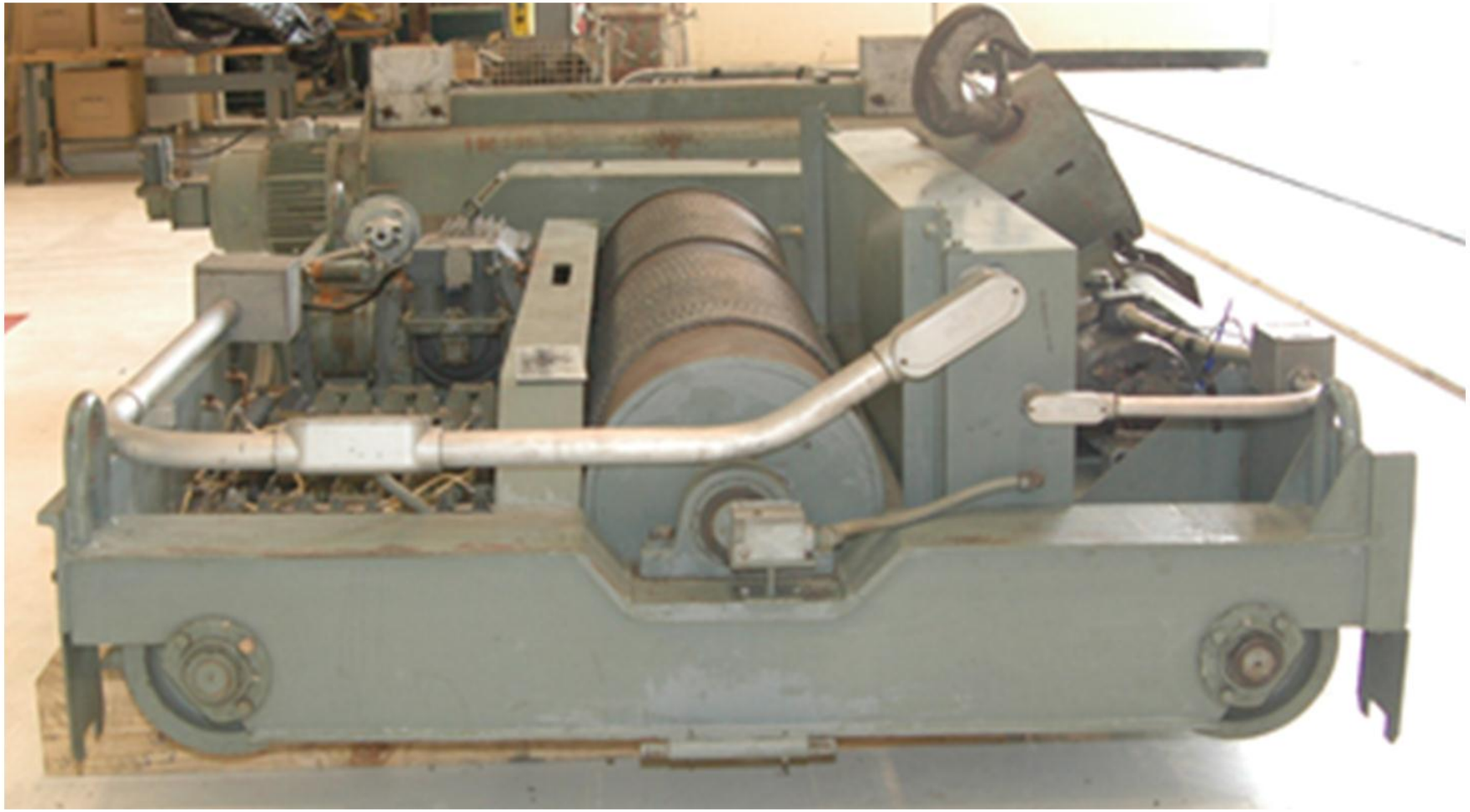
Stripped Polar Crane Bridge at Top of Test Chamber

Preparing to Lower the Polar Crane

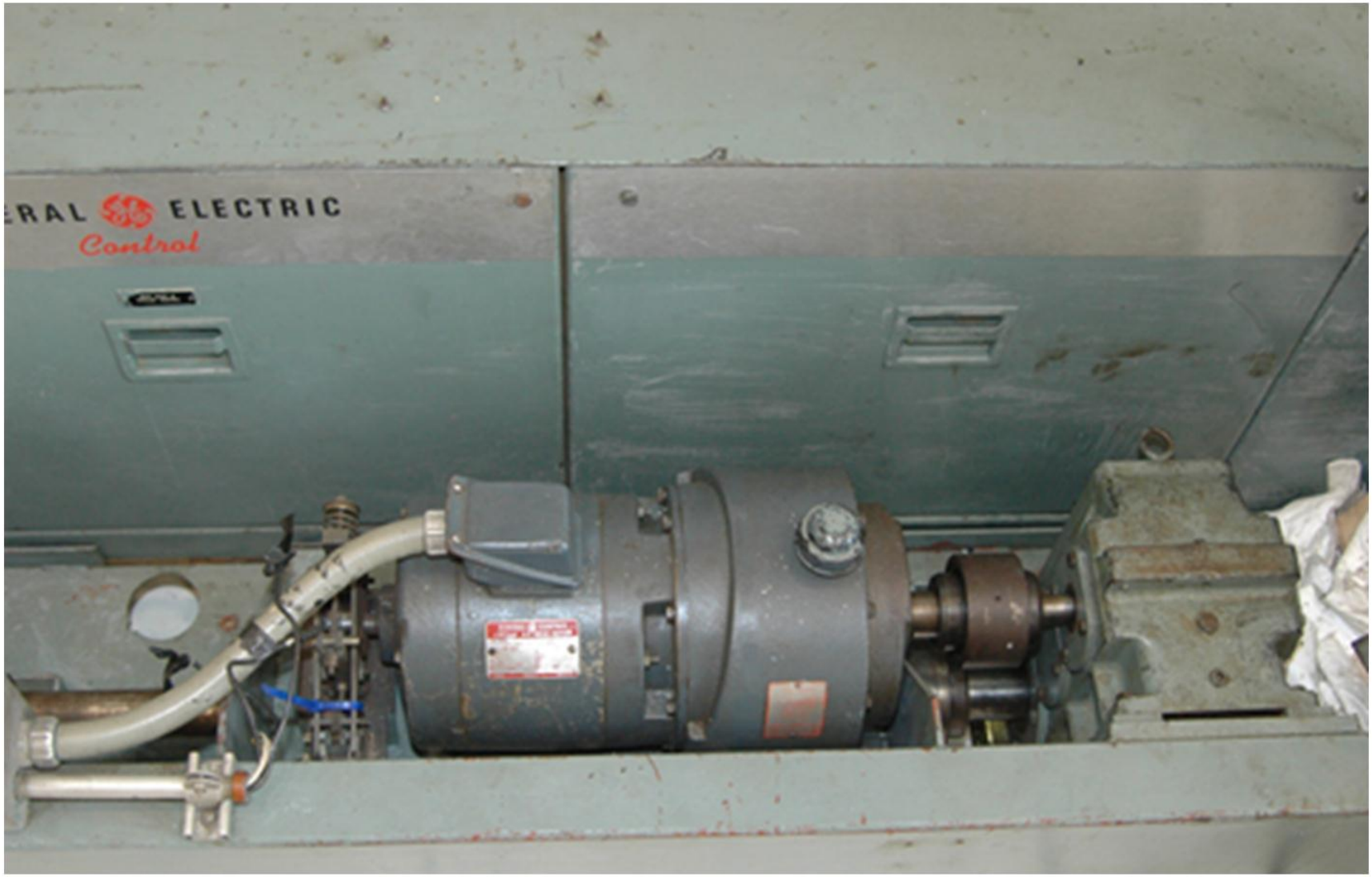
Polar Crane Bridge Being Lowered

Final Stage of Lowering Polar Crane Bridge

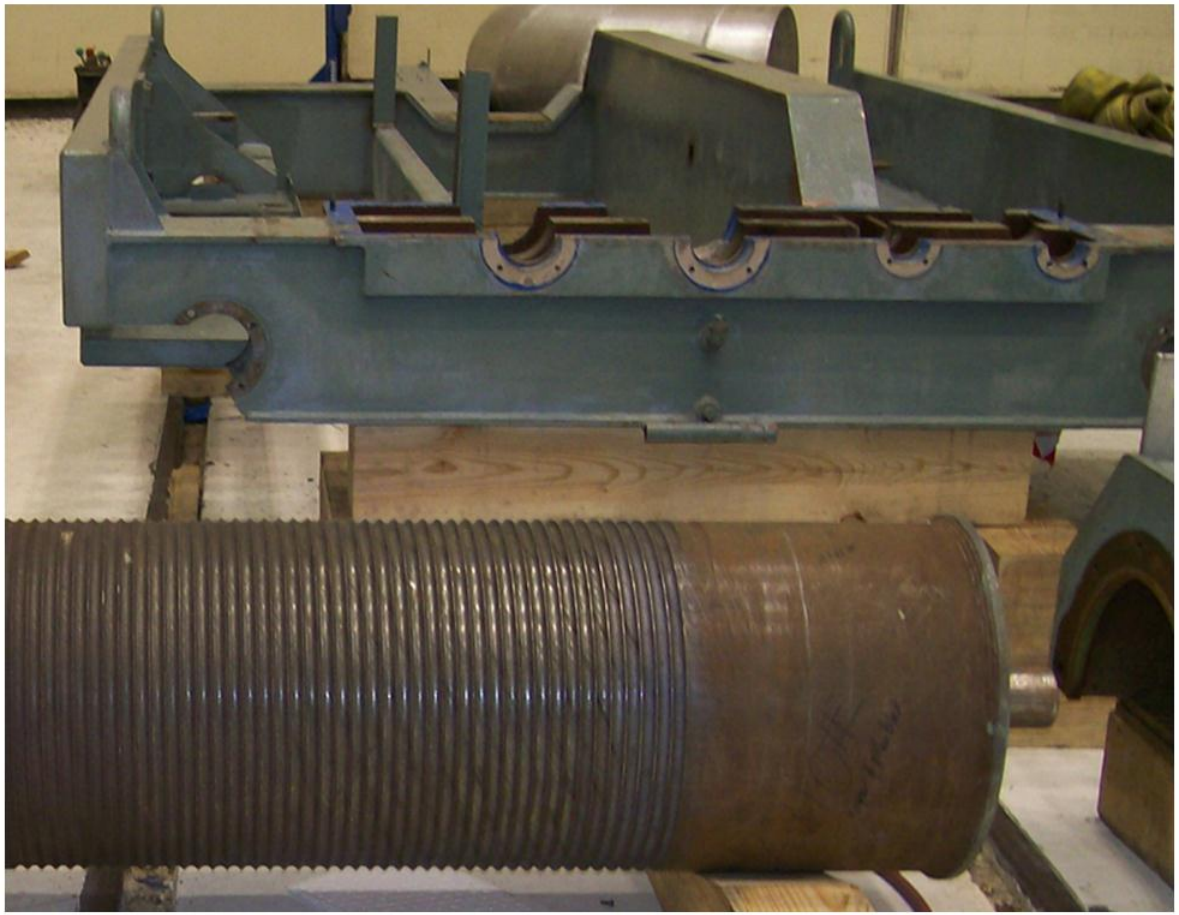
Polar Crane Trolley before Refurbishment



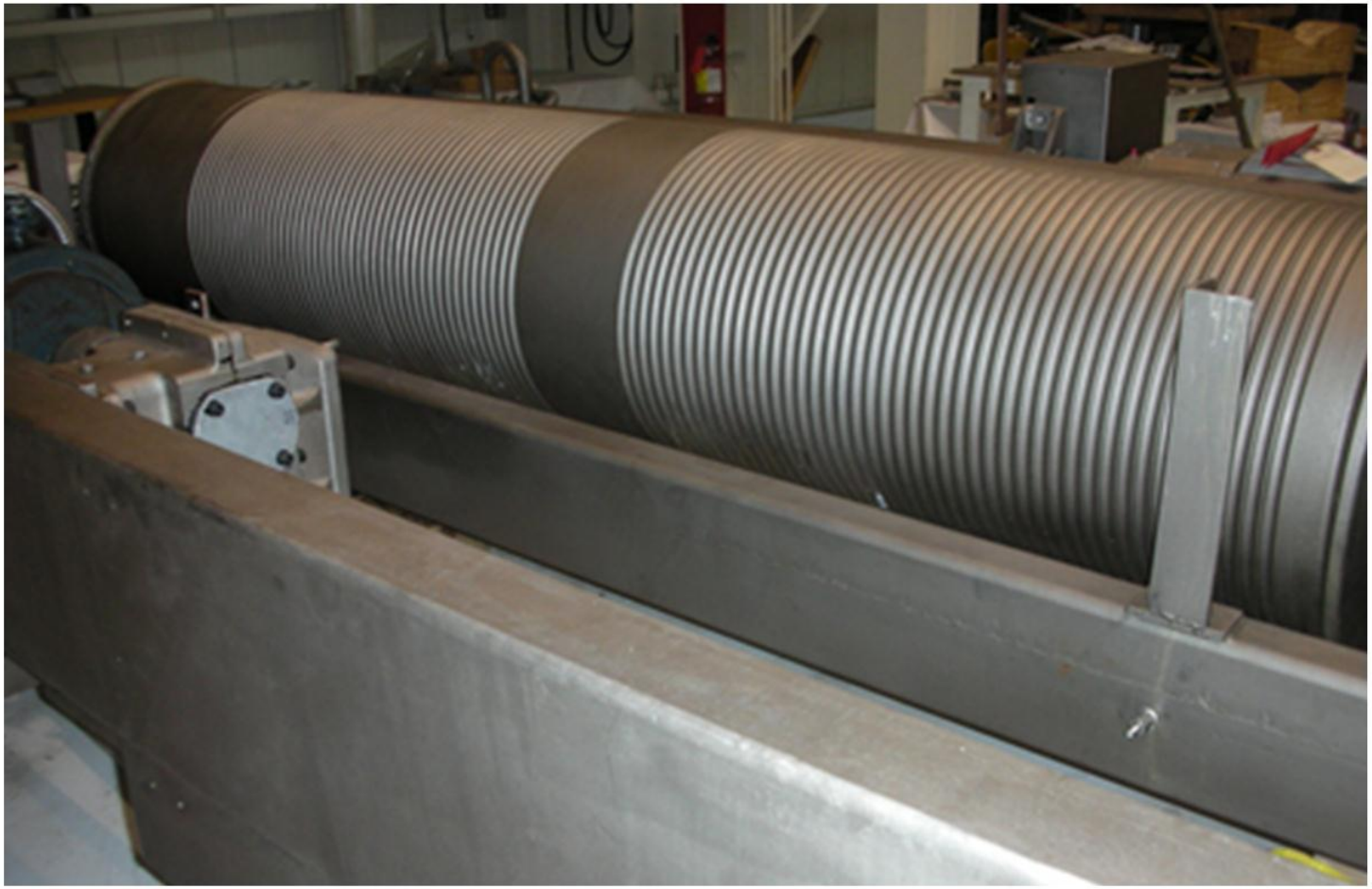
Trolley Control Cabinet and Drive Motor before Refurbishment



Polar Crane Trolley and Auxiliary Drum before Refurbishment



Electroless Ni-Plating of Trolley and Main Hoist Drum



Electroless Ni-Plated Trolley Components

Lubrication of Wire Rope with Specialty Oil

Cleaning of Polar Crane Bridge

Locations of Silicon Wafer Pairs

Polar Crane Bridge – Set 1

Chamber Floor – Set 2

Scavenger Plates – Set 3

IST Results: Organic NVR Levels, ng/cm^2

	IST-2010			IST-2011		
Boiler Range	Set 1	Set 2	Set 3	Set 1	Set 2	Set 3
Low C7-C10	0.9	0.7	0.7	0.7	1.8	1.3
Medium C11-C20	7.6	7.2	9.2	3.1	3.5	4.3
High >C20	13.7	26.2	41.9	11.5	16.7	13.9
Sum >C6	22.2	34.1	51.8	15.3	22.0	19.5

Set 1: Polar Crane; Set 2: Chamber Floor, Set 3: Scavenger Plates

IST-2011: Total NVR

Location	Weight, mg	Surface Density, ng/cm^2
Set 1 - Polar Crane Bridge	0.034	108
Set 2 - Center Chamber Floor	0.039	124
Set 3 - Scavenger Plate Wells	0.036	115

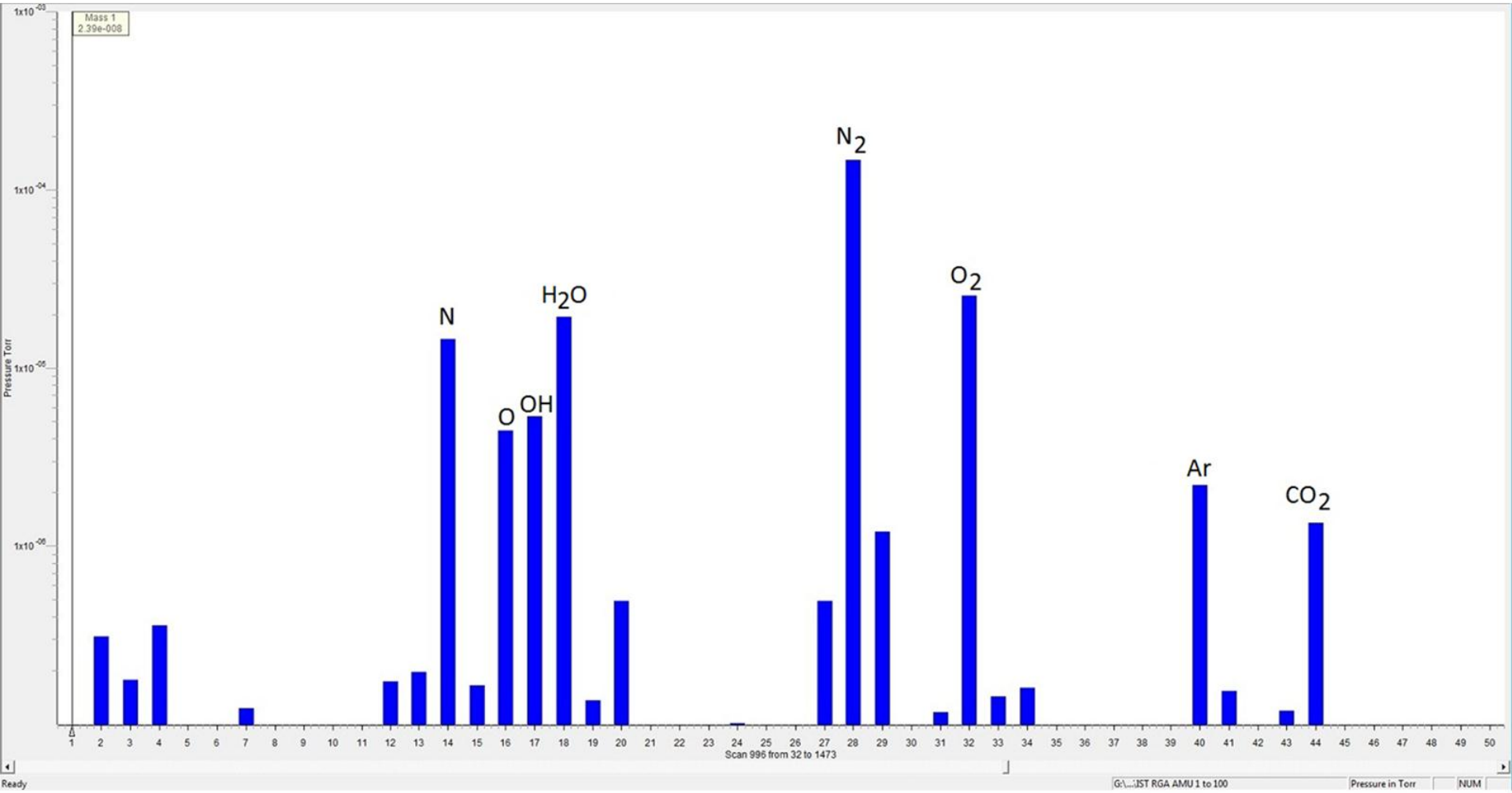
These levels (A/5 of FED-STD 209) of NVR typically meet: *high* spacecraft sensitivity requirements for quantitative levels for *non-optics allowable* and *high* spacecraft sensitivity requirements for quantitative levels for *optics allowable*.

Identified Organic Levels for Wafer Pairs, ng/cm^2

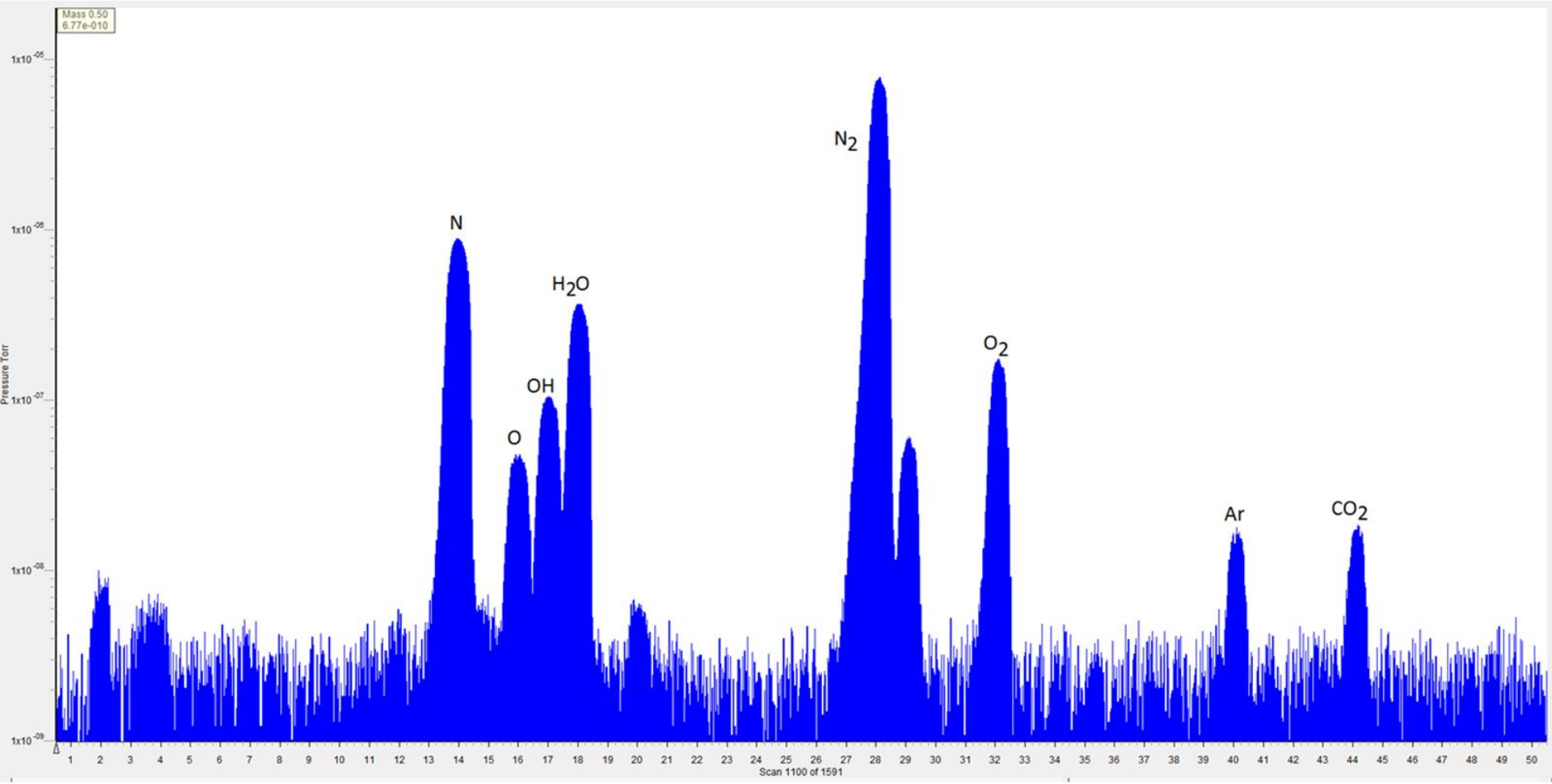
Phthalates 72% of NVR

Semi-Quantitative Levels of Identified Organic Compounds	IST 2010			IST 2011		
	Set 1	Set 2	Set 3	Set 1	Set 2	Set 3
Diisononyl phthalate (DINP)	5.8	18.2	16.7	5.8	15.4	10
Dioctyl phthalate (DEHP, DOP)	0.7	0.8	2.9	0.9	0.4	1.4
Dinonyl phthalate	0.9	1	2.4			
2-(2-Butoxyethoxy)-ethanol	1.7	0.6	0.4	0.3	0.6	0.3
C20-C24 hydrocarbons	0.8	0.6	1.7			
C6-C10 Hydrocarbons				0.2	1.8	0.9
Siloxane	0.2		1.3	0.2	0.2	0.7
Unknown(m/z: 45, 57, 73, 89, 103, 119, 161, 175, 191)	1.5	1				
Tetradecanoic acid amide		0.5	1.7			
Phthalic anhydride		0.2	0.2	0.1	0.6	0.3
Dibutyl phthalate	0.2	0.2	0.3	0.2	0.1	0.2
1ST Peak in FRYOL PCF	0.5	0.4	0.2			
Unknown(m/z: 43, 57, 70, 99, 114, 127, 141, 171)				1		
Dioctyl adipate	0.3	0.2	0.4			
Octadecanenitrile		0.3	0.2		0.2	0.2
Unknown(m/z: 43, 57, 71, 99, 137, 149)		0.4	0.4			
Dodecyl dihydrofuranone	0.3	0.2	0.3			
Alkyl amide		0.7				
Unknown(m/z: 43, 77, 91, 121, 163)		0.2	0.4			
Methyldiphenyl(methyldiphenylsilyl)oxy-silane			0.6			
Butyl benzyl phthalate	0.1	0.1	0.3			
C10-C15 hydrocarbons	0.5					
Alkyl ketone		0.1	0.4			
Caprolactam		0.2	0.2			
Butyl benezenesulfonimide	0.1	0.1	0.2			
Unknown(m/z: 41, 45, 57, 71, 77, 85, 99, 117, 125,139, 157, 175)			0.4			
Hexadecannenitrile		0.1	0.2			
Unknown(m/z: 41, 45,57,71, 85, 89,149, 163)			0.3			
Methyldiphenyloxy-silane plus Dinonyl phthlate	0.3					
Dimethyl indanone	0.1		0.1			
Diethyl toluamide			0.2			
Unknown(m/z: 44, 55, 72, 86, 100, 212, 220)		0.2				
Unknown(m/z: 44, 55, 72, 86, 100, 212, 226, 429)			0.2			
C18-C23 Hydrocarbons						0.2
Dioctyl adipate + Alkylamide					0.2	
Diisopropenyl benzene	0.1					
Unknown(m/z: 43, 59, 91, 119, 161, 179, 194)			0.1			
Dodcecanamide			0.1			
Tributylcitrate acetate			0.1			
Unknown(m/z: 45, 57, 73, 89, 103, 119, 145, 161, 175)				0.1		
Tetradecanoic acid amide + C24						0.1
Hexadecanamide						0.1

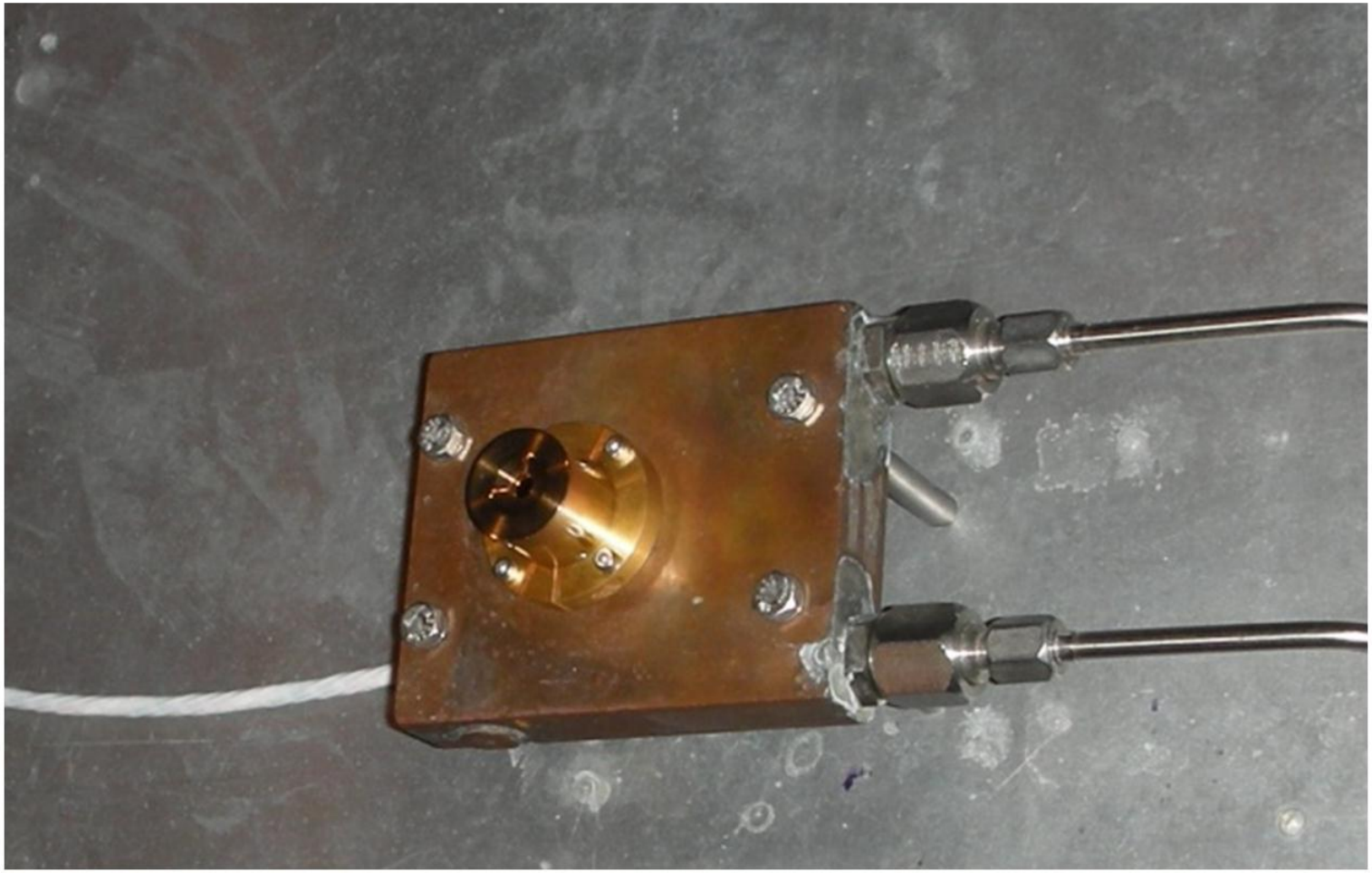
IST-2010 RGA Histogram Spectrum



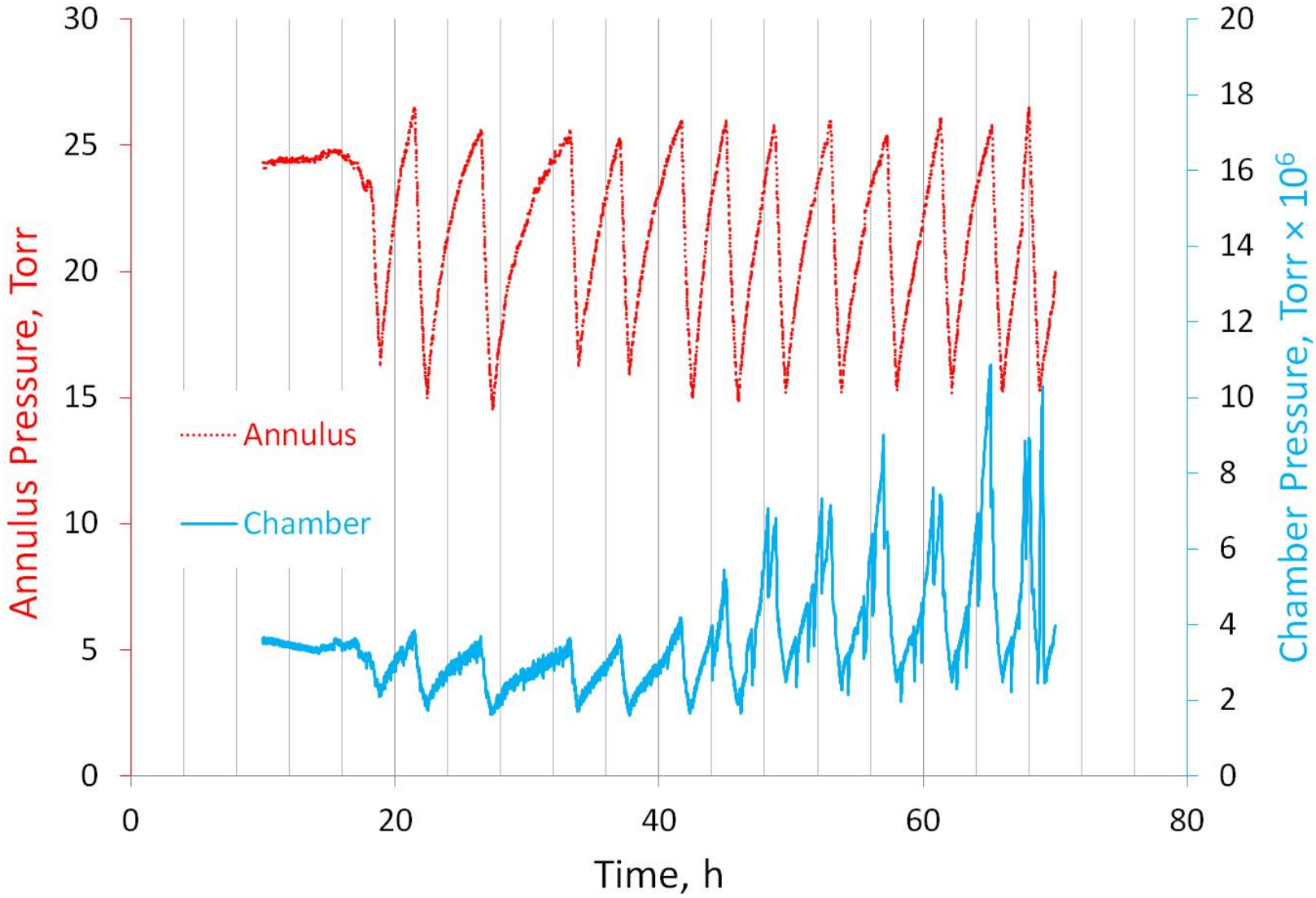
IST-2011 RGA Spectrum



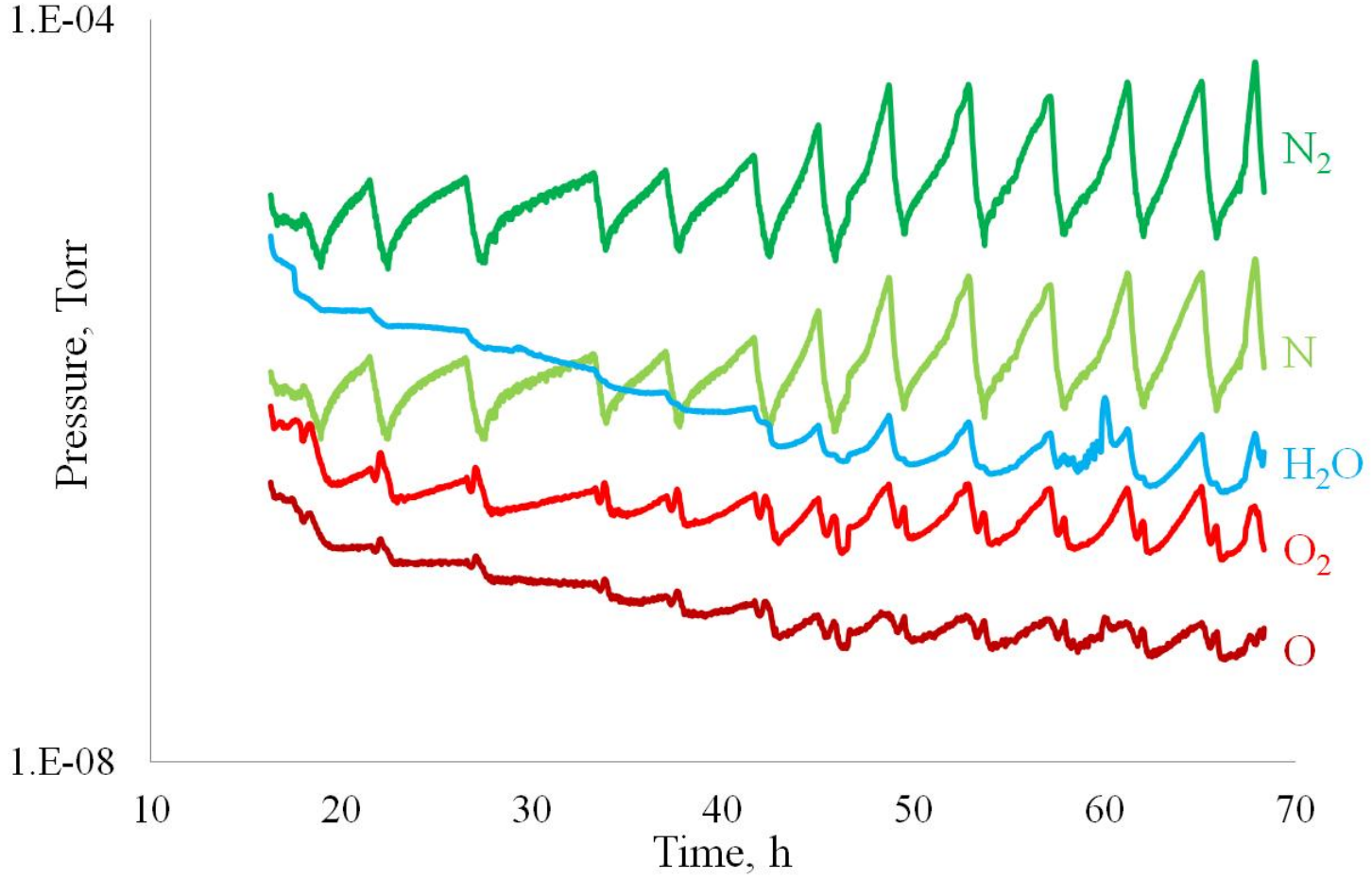
TQCM Mounted to Heat Sink



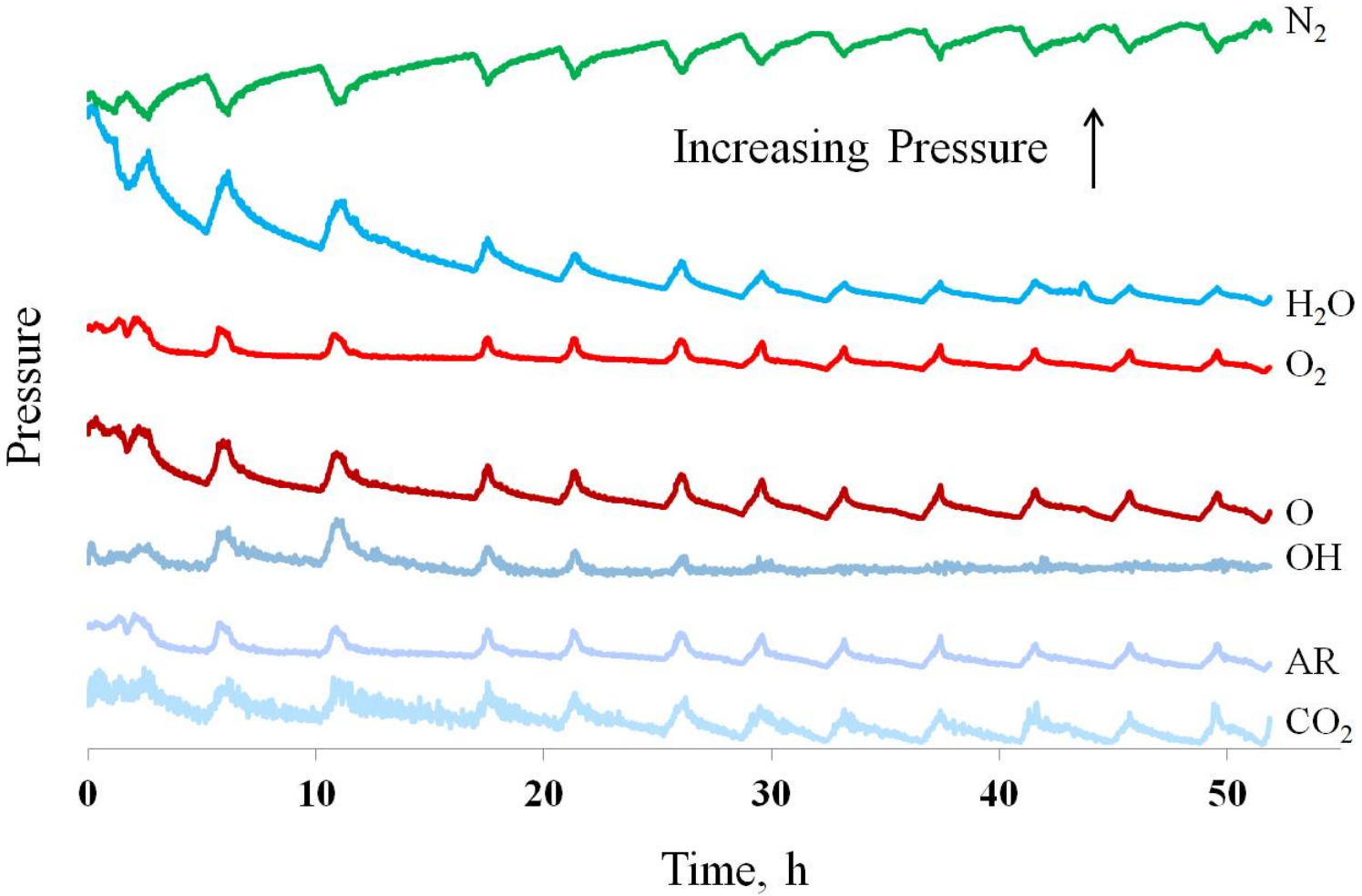
IST-2011: Annulus and Chamber Pressure



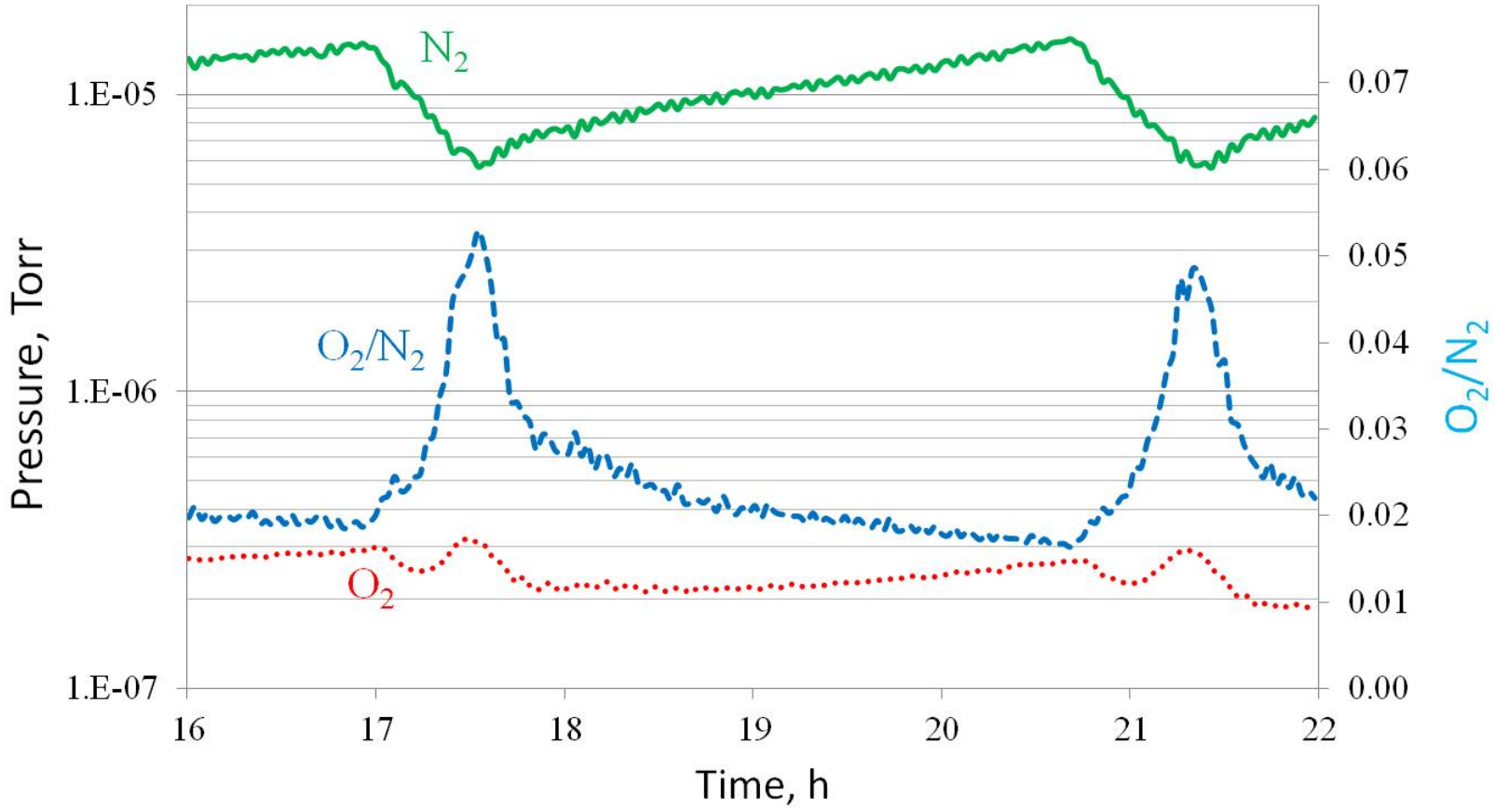
IST-2011: AMU Pressure Trends Versus Time

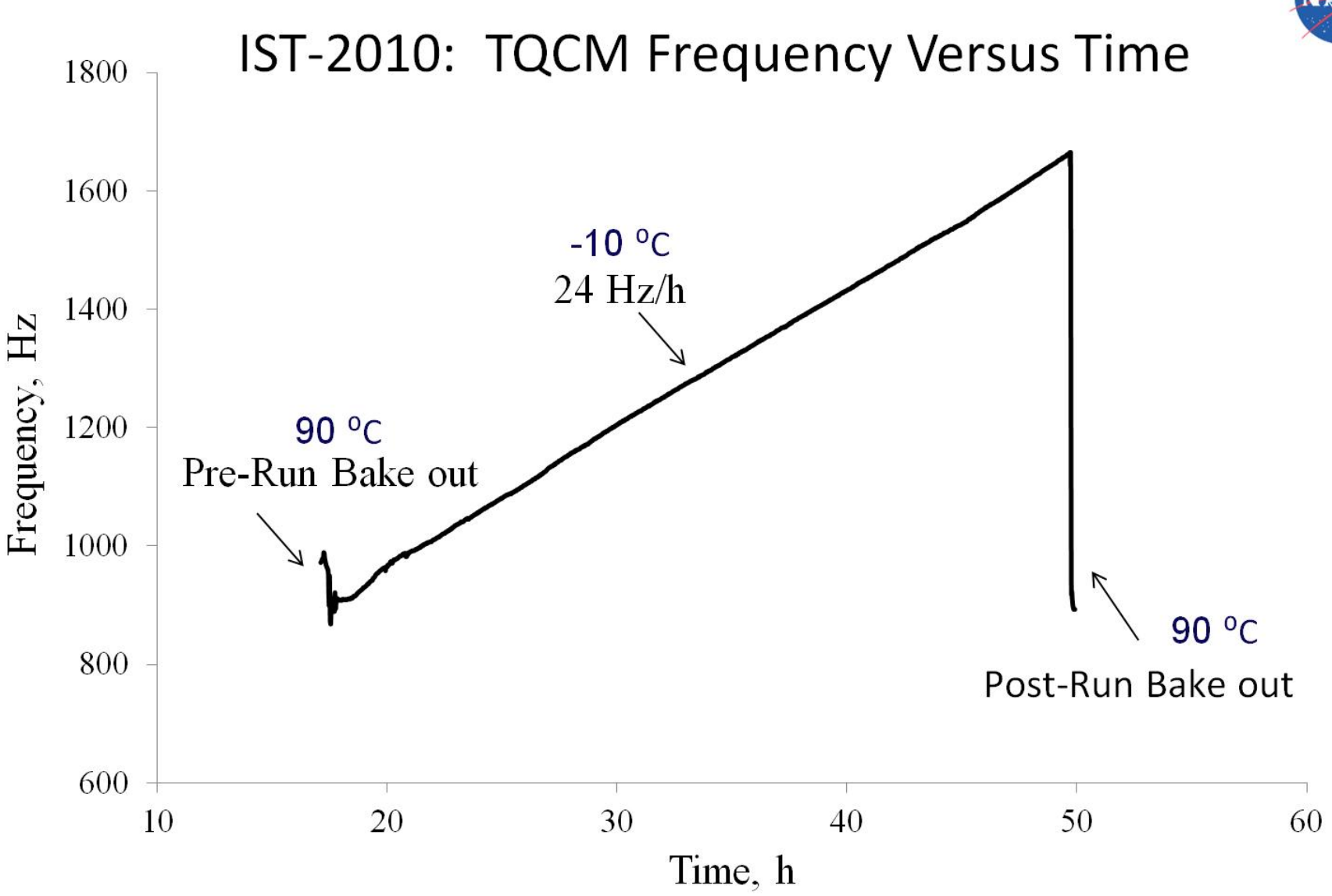


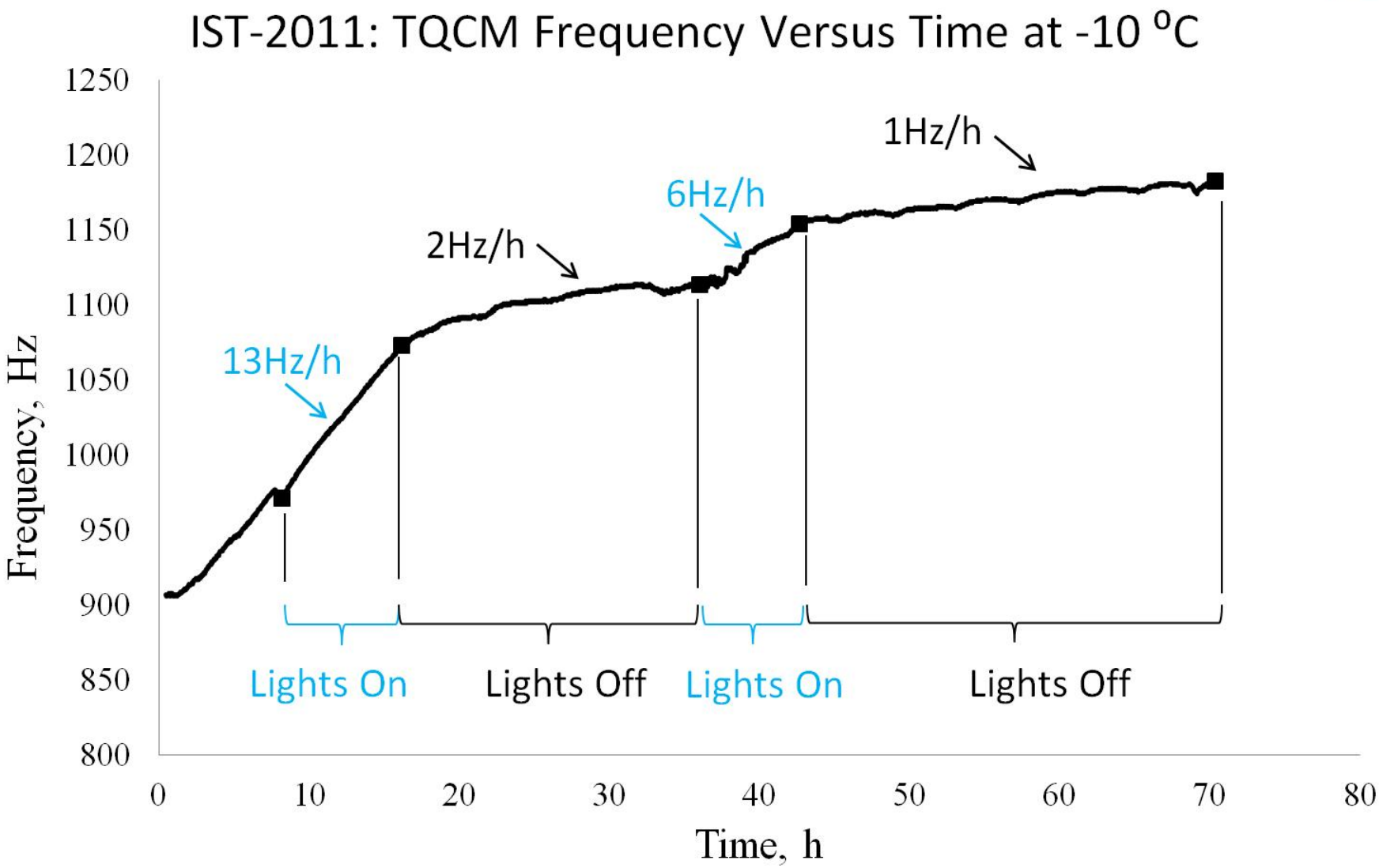
IST-2011: Correspondence of Various AMU



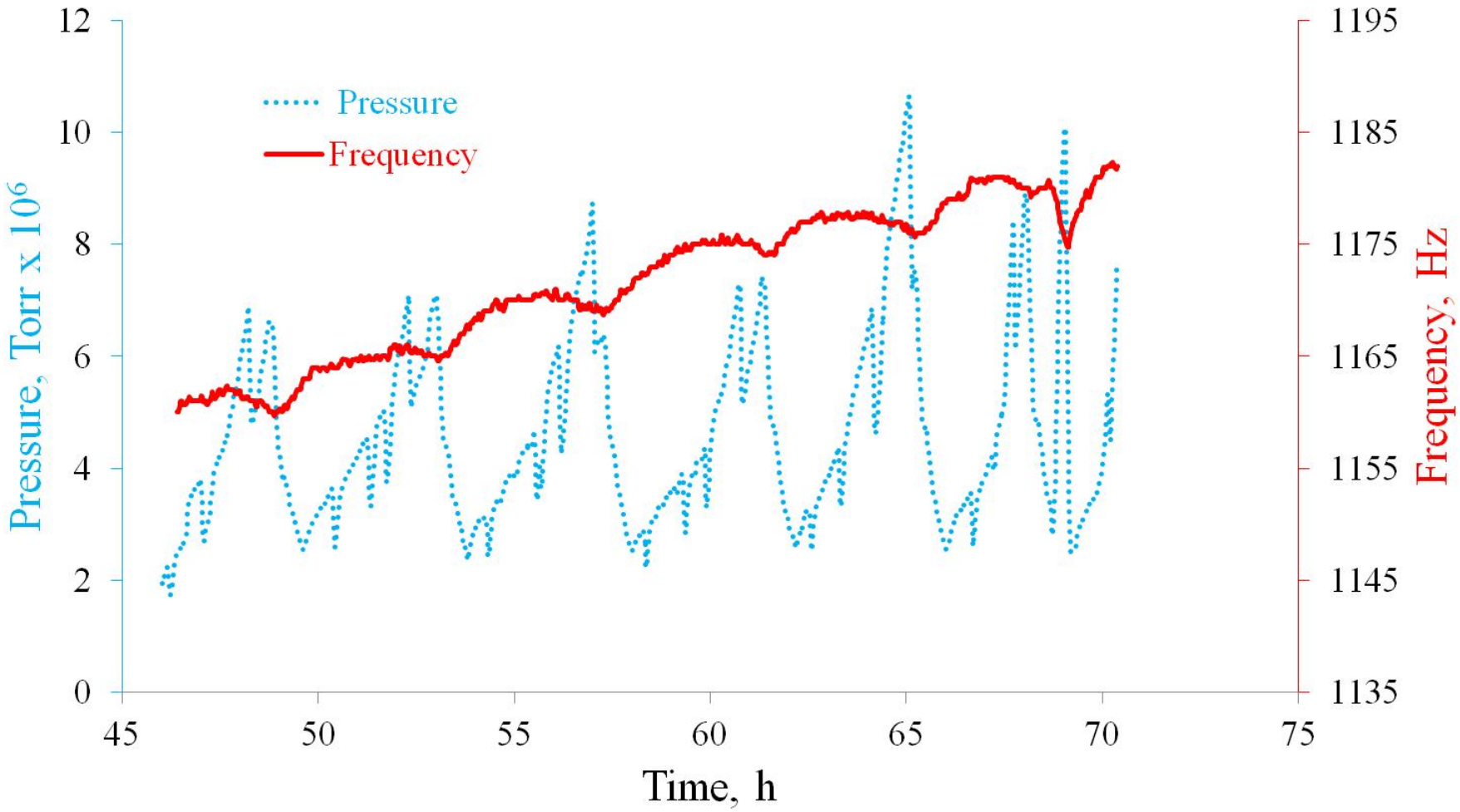
IST-2011: N_2 and O_2 and O_2/N_2 Versus Time




IST-2010: TQCM Frequency Versus Time
Frequency, Hz
1800
1600
1400
1200
1000
800
600
10
20
30
40
50
60
Time, h
-10 °C
24 Hz/h
90 °C
Pre-Run Bake out
90 °C
Post-Run Bake out


IST-2011: TQCM Frequency Versus Time at -10 °C
Frequency, Hz
1250
1200
1150
1100
1050
1000
950
900
850
800
0
10
20
30
40
50
60
70
80
Time, h
13Hz/h
2Hz/h
6Hz/h
1Hz/h
Lights On
Lights Off
Lights On
Lights Off

IST-2011: Chamber Pressure and TQCM Frequency Versus Time



Concluding Remarks

- Two high-vacuum ISTs were conducted in SPF's large 100 ft diameter by 122 ft high thermal-vacuum chamber.
- Organic analysis of witness wafers revealed low NVR levels and identified individual compounds with phthalate groups being the major contributors.
- Inorganic and organic total NVR meets quantitative level "A/5" of *FED-STD 209* – this quantitative level exceeds some *high* spacecraft sensitivity requirements for both non-optics allowable and for optics allowable.
- RGA spectra did not indicate any particular contaminant was present.
- RGA spectrum revealed a large N_2 leak was present during IST-2011
- For IST-2011 contamination rates were higher during periods when chamber lights were operated.
- TQCM rates for the last 24 hours: IST-2010 24 Hz/h and IST-2011 1 Hz/h.
- Analysis of RGA and TQCM results revealed contaminations rates were reduced with increasing N_2 concentrations, which may explain the reduced TQCM rates from IST-2010 to IST-2011.
- Flooding GN_2 into "bagged" annulus leak zones may reduce contamination.