ASME PTC 13 Wire-to-Air Performance Test Code for Blower Systems Part 3

Mark Addison, Artesian Water Company
John Conover, Air Clean USA
Fred Constantino, ASME
Keynote Speakers

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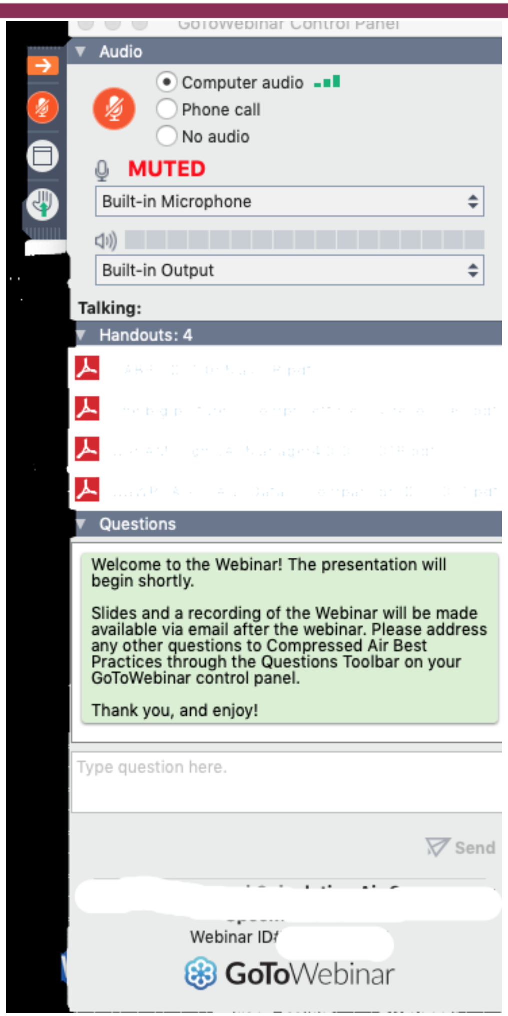

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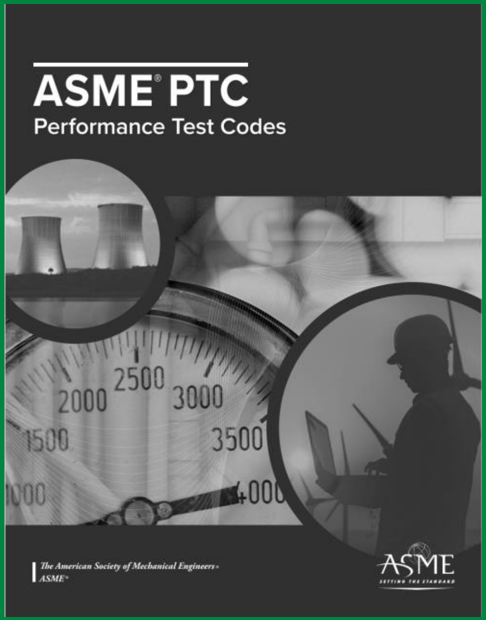
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ASME PTC 13 Wire-to-Air Performance Code for Blower Systems Part 3

Introduction

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About the Speakers

Mark Addison
Senior Engineer
Artesian Water Company
Keynote Speaker

John Conover
Business Development Manager
Air Clean USA
Keynote Speaker

Fred Constantino
S&C Project Engineering Advisor
ASME
Keynote Speaker

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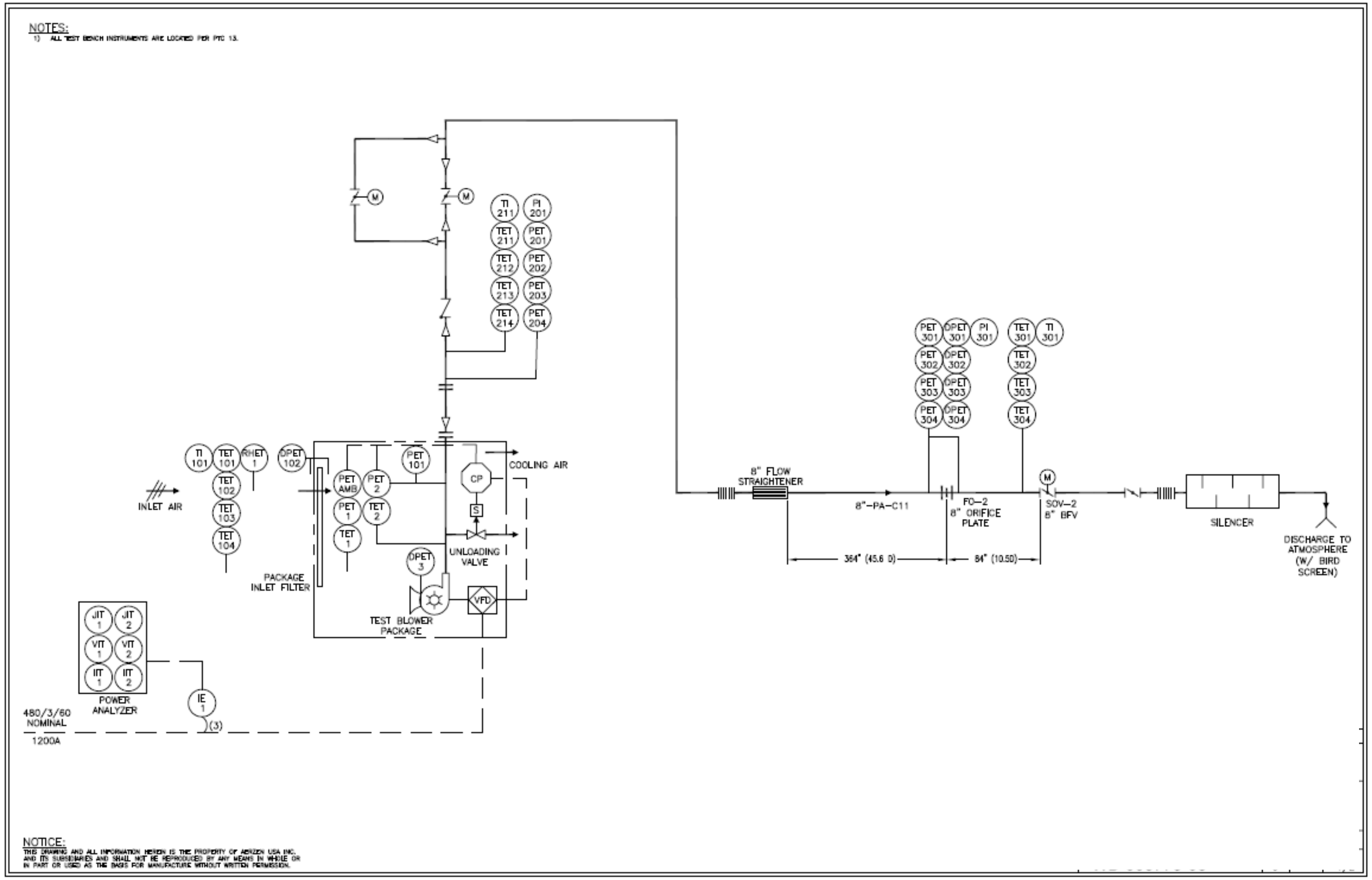
Test Bench Overview

Image courtesy of APG-Neuros

Measuring Stations

- Inlet Temperature
- Barometric Pressure
- Relative Humidity
- Filter Delta P
- Discharge Temperature
- Discharge Pressure
- Pressure upstream of Orifice Plate
- Pressure downstream of Orifice Plate
- Temperature downstream of Orifice Plate
- Real Power (kW)
- Voltage
- Amperage

Ref Section 4 in PTC 13 for
instrumentation details



Drawing courtesy of Aerzen USA

Measuring Stations

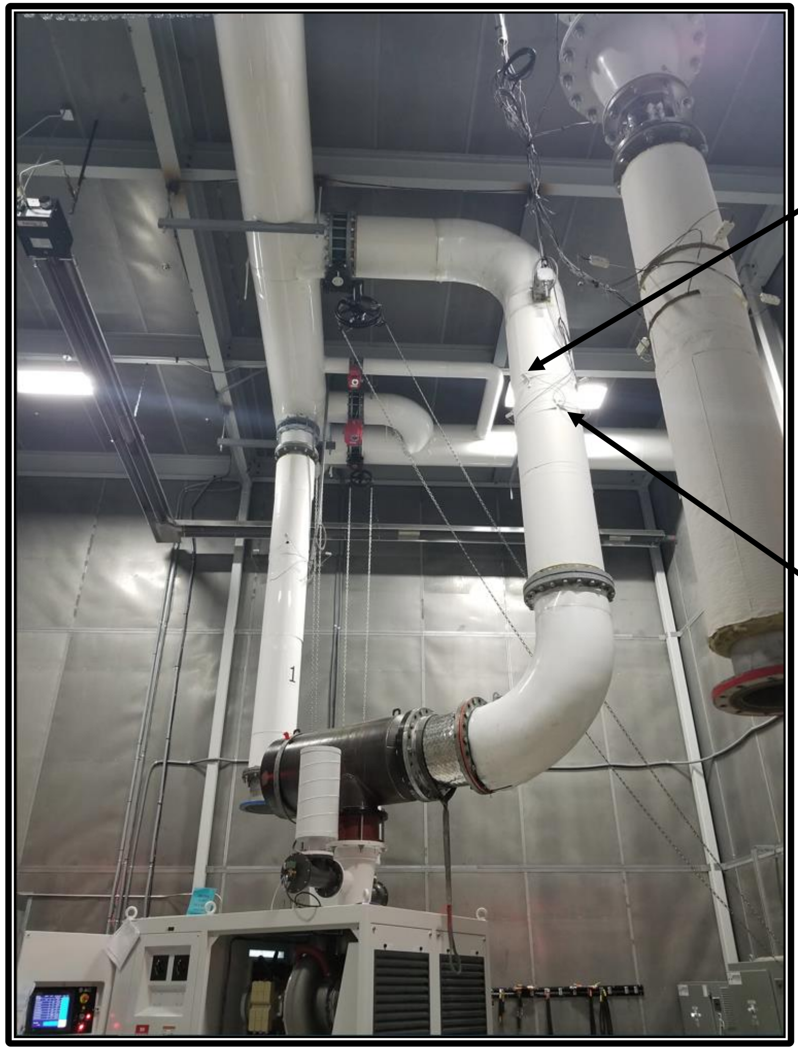
(Ref Sections 4-3 & 4-4 in PTC 13)

Typical Discharge Piping Arrangement

Images courtesy of APG-Neuros

Measuring Stations

(Ref Sections 4-3 & 4-4 in PTC 13)



Discharge Temperature
(4 places)

Discharge Pressure
(4 places)

Discharge Pressure & Temperature Measuring Station

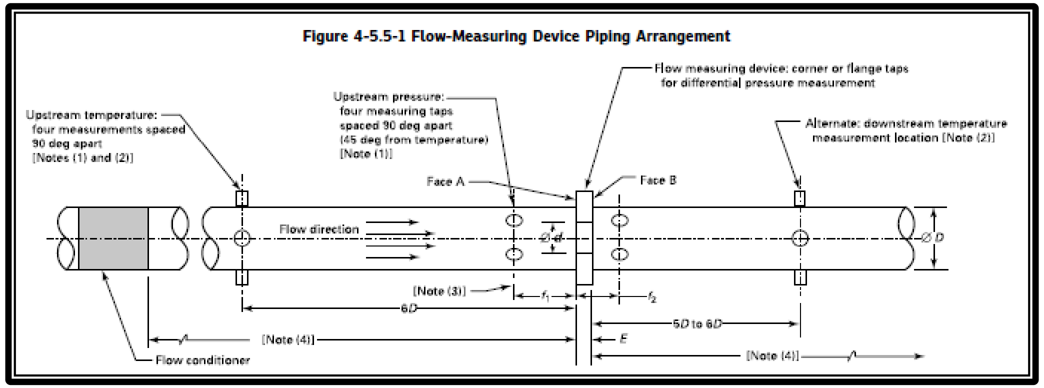
Image courtesy of APG-Neuros

Measuring Stations

Orifice Plate

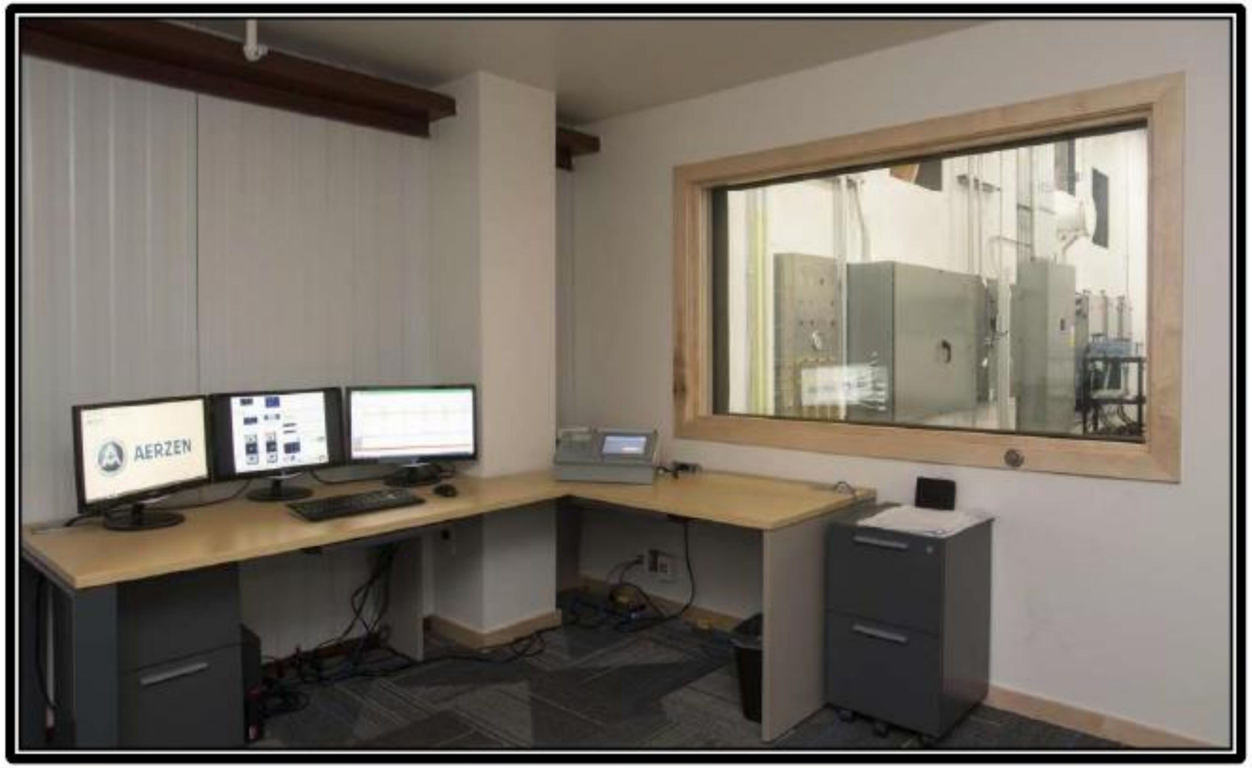
Discharge Flow Measuring Station

Image courtesy of APG-Neuros

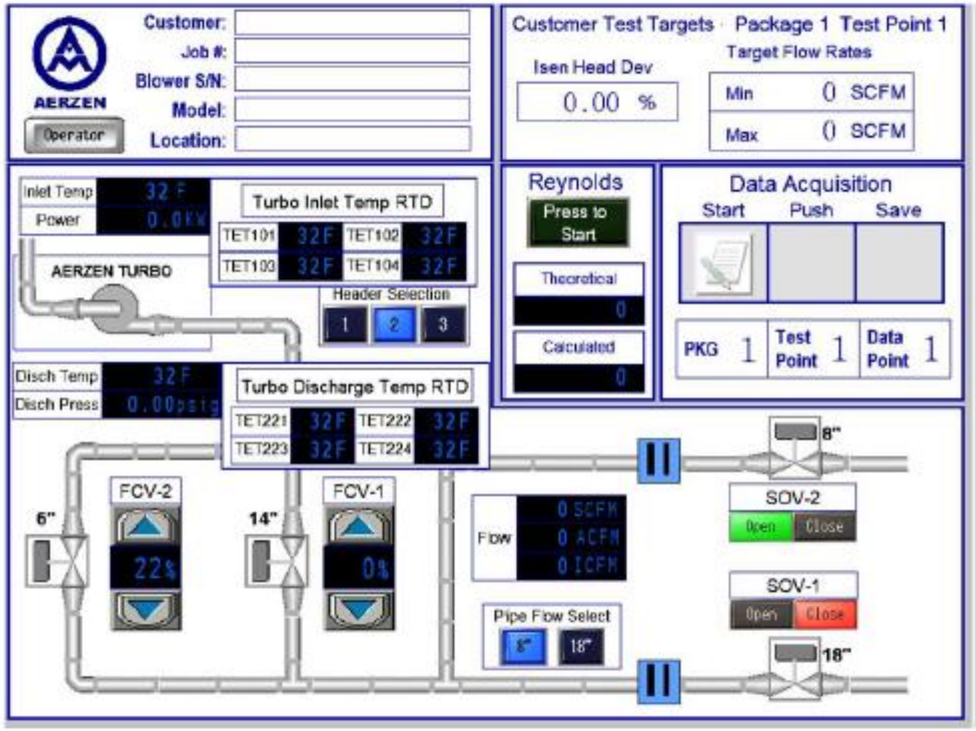


(Ref Section 4-5 in PTC 13)

Observation



Test Bench Control Room



Typical Test Station HMI Screen

Images courtesy of Aerzen USA

Non-Mandatory Test Bench Features

Manufacturer's test benches may include some of the following features:

- A separate control room
- A data acquisition system
- An enclosed test bench
- Modularized test stations

Images courtesy of Atlas Copco

Planning the Test

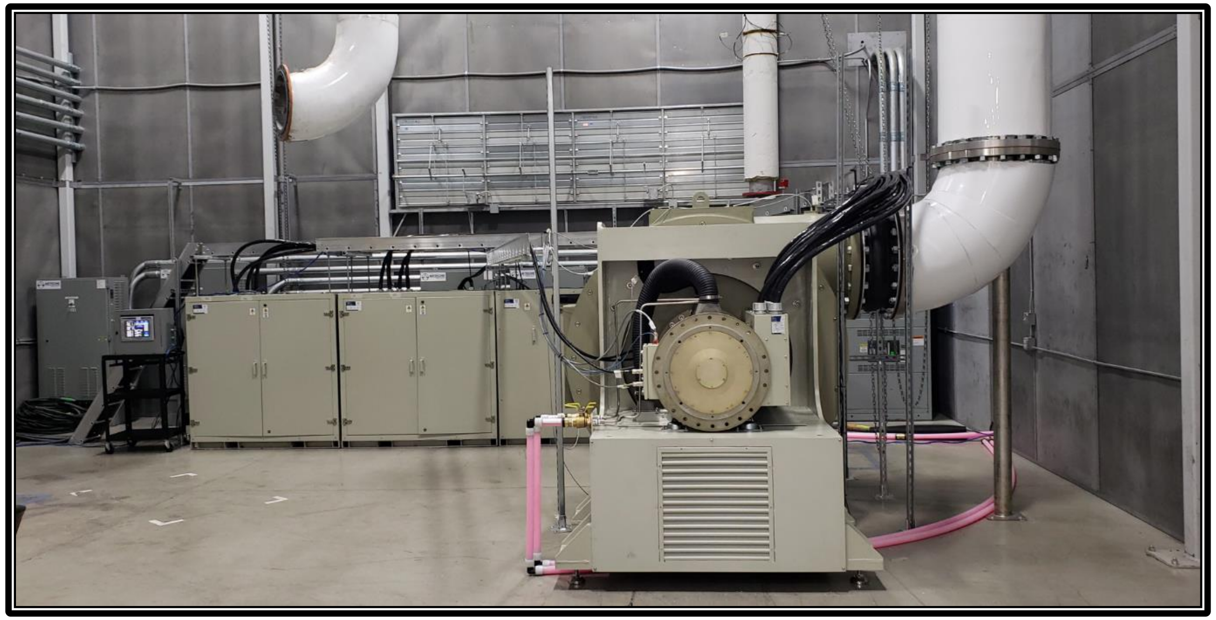


Image courtesy of APG-Neuros

- Machine Type: Dynamic or positive displacement
  - (Ref Section 5 & Appendices B & C in PTC 13)
- Project Specification Requirements
  - No. of machines to be tested
  - No. of performance points to be tested
  - Functional Testing
  - Witnessed (in-person or virtual) and non-witnessed testing.
  - Requirements for witnessed calibration of instruments, inspection of measuring stations, etc.
- Manufacturer’s Test Plan

Expectations during Testing

- Safety Briefing: Awareness, PPE, “Don’t touch that button!, etc.

- Functional Testing may include
  - Alarm Functions
  - Sound Measurements
  - Vibration Measurements
  - Rise to Surge

- Performance Testing
  - Ref Section 3 of PTC 13 for guiding principles
  - Idle time
    - Waiting for conditions to stabilize
      - Ref Table 3-5.5-1 of PTC 13
      - Time to reach stable readings, Time to test a machine
        Performing calculations & analyzing data
    - Swapping out machines

Table 3-5.5-1 Permissible Fluctuations of Test Readings

Measurement, Symbol, Units	Fluctuation (%) [Note (1)]
Inlet pressure, p_i, psia	2
Inlet temperature, T_i, °R	0.5
Discharge pressure, p_d, psia	2
Differential pressure of flow-measuring device, Δp, psi	1
Flow device temperature, T, °R	0.5
Relative humidity, RH, %	2
Wire power, P, kW	1
Line voltage, V, volts	2
Speed, N, rpm	1

GENERAL NOTE: The fluctuations follow Tables 3-5.4-1 and 3-5.4-2.

NOTE: (1) A fluctuation is the percent difference between the minimum and maximum test reading divided by the average of all sets readings for one test point.

What to expect?

Package 1								Inlet: Type CR				Blower S/N:									
Description:		TEST POINT 1				TEST POINT 2				TEST POINT 3				TEST POINT 4				MINIMUM FLOW TEST POINT			
Test Date:		12/15/2020				12/15/2020				12/15/2020				12/15/2020				12/15/2020			
Time:	Hour	15	15	15	Average	15	15	15	Average	14	14	14	Average	13	13	13	Average	16	16	16	Average
	Minute	29	35	42		0	5	10		18	24	30		44	50	55		6	6	6	
Data Points:		1	2	3		1	2	3		1	2	3		1	2	3		1	2	3	
TEST DAY CONDITIONS:		TEST DAY CONDITIONS:				TEST DAY CONDITIONS:				TEST DAY CONDITIONS:				TEST DAY CONDITIONS:				TEST DAY CONDITIONS:			
Total Input Power(kW)		168.79	168.38	168.69	168.62	150.42	150.74	150.63	150.60	119.34	119.44	119.34	119.38	115.77	115.88	115.88	115.84	74.08	73.98	73.98	74.01
Pressure (ambient, psia)		14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.50	14.50	14.50	14.50	14.51	14.51	14.51	14.51
Relative Humidity (%)		8.50	8.50	8.50	8.50	7.87	7.87	7.93	7.89	9.25	9.25	9.18	9.23	10.93	11.00	10.93	10.95	12.68	12.68	12.68	12.68
Filter Pressure Loss (meassured, psig)		0.058	0.058	0.058	0.058	0.051	0.051	0.050	0.051	0.035	0.035	0.035	0.035	0.033	0.033	0.033	0.033	0.012	0.012	0.012	0.012
Discharge Pressure (measured, psig)	PET 201	11.55	11.55	11.53	11.57	11.52	11.51	11.50	11.54	11.60	11.64	11.62	11.65	11.70	11.69	11.71	11.71	12.00	11.95	12.01	12.01
	PET 202	11.59	11.60	11.59		11.56	11.56	11.55		11.66	11.69	11.68		11.73	11.71	11.75		12.03	12.01	12.05	
	PET 203	11.57	11.59	11.55		11.55	11.55	11.52		11.62	11.65	11.64		11.72	11.67	11.73		12.01	12.03	12.00	
	PET 204	11.57	11.58	11.56		11.55	11.55	11.53		11.64	11.67	11.65		11.71	11.71	11.74		12.02	12.04	12.02	
Pressure upstream of Orifice (psia)	PET 301	15.61	15.61	15.61	15.61	15.43	15.45	15.43	15.44	15.11	15.11	15.11	15.12	15.05	15.05	15.05	15.06	14.66	14.66	14.64	14.66
	PET 302	15.63	15.63	15.63		15.45	15.46	15.45		15.13	15.13	15.13		15.09	15.07	15.07		14.68	14.68	14.66	
	PET 303	15.59	15.58	15.58		15.41	15.41	15.41		15.11	15.09	15.09		15.05	15.05	15.05		14.64	14.64	14.62	
	PET 304	15.63	15.63	15.63		15.46	15.45	15.46		15.13	15.13	15.13		15.09	15.07	15.07		14.68	14.68	14.66	
ΔP across Orifice (psig)	DPET 301	1.78	1.78	1.79	1.82	1.55	1.54	1.55	1.58	1.03	1.03	1.02	1.06	0.96	0.96	0.97	0.99	0.29	0.29	0.29	0.32
	DPET 302	1.77	1.77	1.79		1.54	1.54	1.54		1.03	1.03	1.03		0.94	0.95	0.96		0.28	0.29	0.29	
	DPET 303	1.89	1.86	1.85		1.64	1.61	1.62		1.10	1.10	1.09		1.03	1.02	1.03		0.35	0.35	0.36	
	DPET 304	1.86	1.86	1.85		1.63	1.63	1.62		1.09	1.11	1.10		1.02	1.00	1.03		0.35	0.35	0.35	
Discharge Flow, SCFM (measured at orifice)		3426	3423	3422	3424	3186	3186	3193	3188	2636	2638	2637	2637	2560	2559	2564	2561	1454	1455	1453	1454
Temperature (ambient, °F)		94	94	94	94	99	99	99	99	96	96	96	96	93	93	93	93	83	83	83	83
Inlet Temperature (measured @ filter plane, °F)	TET 101	96	96	96	94	101	101	101	99	97	97	96	96	94	93	93	93	84	84	84	84
	TET 102	93	93	93		98	98	98		95	95	95		92	91	92		83	83	83	
	TET 103	91	91	91		97	97	97		96	96	96		93	93	93		83	83	83	
	TET 104	97	97	97		101	101	101		98	98	98		95	95	95		85	85	85	
Discharge Temperature (measured, °F)	TET 201	239	239	239	239	237	237	237	237	228	228	228	228	224	223	224	223	235	235	235	235
	TET 202	239	239	239		238	238	238		228	228	228		224	224	224		235	235	235	
	TET 203	238	238	238		237	236	237		227	227	227		223	222	223		234	234	234	
	TET 204	239	239	239		237	237	237		228	227	227		223	223	223		235	235	235	
Temp. Downstream of Orifice (°F)	TET 301	232	232	232	232	230	230	230	230	220	220	220	220	213	213	213	213	228	228	228	228
	TET 302	231	231	231		230	230	230		220	220	220		213	213	213		228	228	228	
	TET 303	231	232	231		230	230	230		220	220	220		213	213	213		228	228	228	
	TET 304	232	232	232		230	230	230		220	220	220		213	213	213		228	228	228	
PKG HMI INPUT:		PKG HMI INPUT:				PKG HMI INPUT:				PKG HMI INPUT:				PKG HMI INPUT:				PKG HMI INPUT:			
Inlet Temperature T1 [°F]		100				104				98				96				91			
Filter Pressure Loss [psi]		0.057				0.049				0.033				0.032				0.009			
Discharge Pressure P2 [psi]		11.40				11.40				11.50				11.50				11.90			
Discharge Temperature T2 [°F]		233				230				224				220				233			
Bell Mouth Delta P [Pa]		15120				12740				8100				7760				2000			
Flow Rate (at bell mouth) [icfm]		3890				3640				2990				2910				1535			
Blower Speed [rpm]		35710				34530				32940				32680				32100			
Total Input Power [KW]		167.7				149.9				119.4				115.4				74.1			
Set Value % of Max. PWM Duty		100 / 3900				92 / 3900				76 / 3900				74 / 3900				48 / 3900			
Normalized Actual Value [PWM]		3900				3588				2964				2886				1872			
D.C-Link Voltage [VDC]		645.9				644.3				653.2				645.5				652.7			
Actual Load [%]		87.7				74.2				50.6				48.0				20.2			
Power Stack Temperature [°F]		157.2				147.3				125.2				120.7				101.4			
Motor Core Temperature [°F]		226.7				220.1				198.1				192.3				174.3			
Inverter Output Current [A]		290.4				267.0				220.6				214.5				139.4			
Inverter Output Voltage [VAC]		336.6				325.9				309.6				307.4				300.6			

Data, and lots of it

P_{vp}	Sat. Vapor Pressure (specified)	1.06995	psia			1.06995	psia		
	Sat. Vapor Pressure (@ Inlet Temp measured)	0.76685	psia			0.59766	psia		
CALCULATIONS:									
R	Specific Gas Constant (specified)	54.573				54.573			
	Specific Gas Constant (test)	53.468				53.471			
	Specific Gas Constant (std conditions)	53.511				53.511			
MW	Mole Fraction of water vapor (specified)	0.0596				0.0596			
	Mole Fraction of water vapor (test)	0.0062				0.0064			
	Molecular Weight of air mixture (specified)	28.317	lb/lb_{mole}			28.317	lb/lb_{mole}		
	Molecular Weight of air mixture (test)	28.902	lb/lb_{mole}			28.900	lb/lb_{mole}		
ρ	Density (specified@ inlet conditions)	0.0672	lb/ft3			0.0672	lb/ft3		
	Density (specified@ discharge conditions)	0.0971				0.0969			
	Density (test@inlet conditions)	0.0705	lb/ft3			0.0714	lb/ft3		
	Density (test@discharge conditions)	0.1031	lb/ft3			0.1050	lb/ft3		
	Density (std conditions)	0.0749	lb/ft3			0.0749	lb/ft3		
c_p	Specific Heat Capacity, dry air (@ specified inlet conditions)	0.2400	BTU/lb-R			0.2400	BTU/lb-R		
	Specific Heat Capacity, water vapor (@ specified inlet conditions)	0.4461	BTU/lb-R			0.4461	BTU/lb-R		
	Heat Capacity of air mixture (@ specified inlet conditions)	0.2478	BTU/lb-R			0.2478	BTU/lb-R		
	Specific Heat Capacity, dry air (@ test inlet conditions)	0.2399	BTU/lb-R			0.2399	BTU/lb-R		
	Specific Heat Capacity, water vapor (@ test inlet conditions)	0.4456	BTU/lb-R			0.4453	BTU/lb-R		
	Heat Capacity of air mixture (@ test inlet conditions)	0.2407	BTU/lb-R			0.2407	BTU/lb-R		
k_{mix}	ratio of specific heats (specified)	1.3947				1.3947			
	ratio of specific heats (test)	1.3994				1.3995			
Q	Volume Flow (specified)(test_target)	2800.29	CFM	1.079227		2710.37	CFM	1.079227	
	Target Flow in SCFM	2637.85	SCFM			2587.45	SCFM		
	Volume Flow (actual test inlet)	2799.76	CFM	1.014209		2699.75	CFM	1.015304	
SPECIFIED DATA:	Pressure Ratio r_p (specified)	1.77				1.77			
	Isentropic Head W_i (specified)	18981	ft-lb/lb			18981	ft-lb/lb		
	Specific Volume Ratio (specified)	1.44				1.44			
TEST DATA:	Pressure Ratio r_p (test)	1.81	filter loss included			1.83	filter loss included		
	Isentropic Head W_i (test)	19028	ft-lb/lb			19134	ft-lb/lb		
	Specific Volume Ratio (test)	1.46				1.47			
TARGET DATA:	Pressure Ratio r_p (test_target-isentropic)	1.80		1.183514		1.82		1.186197	
	Discharge Pressure (test_target-isentropic)	11.58	psig			11.78	psig		
	Discharge Pressure (test_target-specific volume)	11.10	psig			11.09	psig		
TEST POWER	Mass Flow (test)	197.28	lb/min			192.81	lb/min		
	Isentropic Power (test)	113.75	HP	84.82	KW	111.79	HP	83.36	KW
	Total Input Power (measured_test))			118.46	KW			117.10	KW
	Wire To Air Efficiency (calculated_test)			71.60%				71.19%	
SPECIFIED POWER	Mass Flow (specified)	188.24	lb/min			182.20	lb/min		
	Isentropic Power (specified)	80.74	KW			78.15	KW		
	Total Input Power (calculated_specified)			112.77	KW			109.78	KW
	Power Deviation			-5.95%				-4.96%	
	Total Input Power Guaranteed			119.90	KW			115.50	KW
TEST DATA CONVERTED TO SPECIFIED CONDITIONS	Discharge Pressure (calculated_specified)	11.03	psig			11.11	psig		
	Test Inlet Volume Flow (converted to specified conditions)	2800	CFM			2700	CFM		
	Test Inlet Volume Flow in SCFM delivered at specified conditions	2509	SCFM			2420	SCFM		

Calculations, and lots of it

Typical Report Contents

(Ref Section 6 in PTC 13)

- Executive Summary
  - Brief Description of the test and machines, including dates, attendees, etc.
  - Typically includes tables of results, ie. Flow, Power, Pass/Fail for multiple machines and test points
- Detailed Report
  - Typically includes tables showing all data collected and results of all calculations for all machines and all test points.
- Appendices and Illustrations
  - Typically includes a schematic of the test bench, showing instrumentation and piping including straight runs upstream and downstream of flow measurement
  - Instrumentation Lists, Calibration Certificates, etc.

Management of Expectations

- “Unspoken expectations are premeditated resentments” -Neil Strauss
- Communication is important, before during and after the test.
  - Scheduling & timing
  - Final assembly
  - Logistics-Setting up and testing multiple machines
  - Unexpected Events-failure to meet test requirements, equipment failure, test bench issues, etc.

Relationship Transition

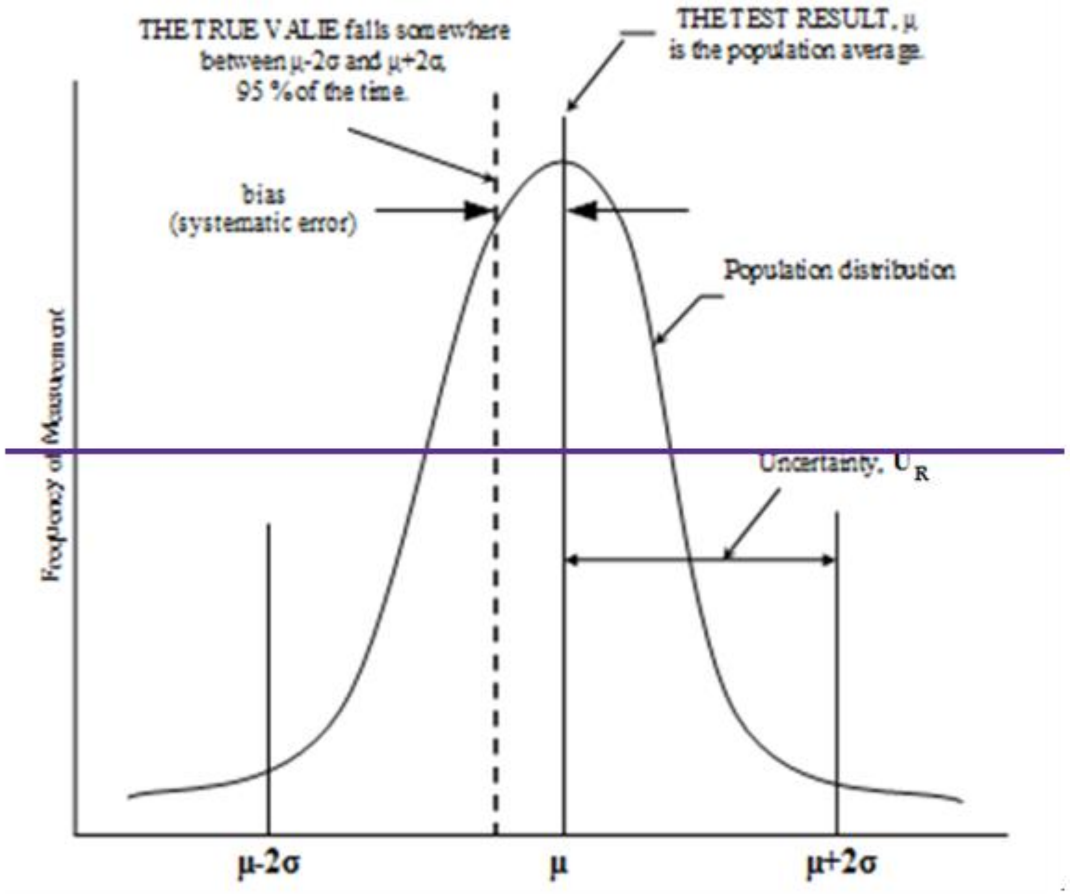
- Witness Testing is an opportunity to:
  - Expand understanding of the machines you have purchased
    - Training on the machines (operation, service, etc.)
  - Build Relationships
  - Learn more about the manufacturer
    - Other technologies and products
    - Start the after sale relationship
    - Facility tour
    - Meet Senior Management, Project Management, Engineering and Service Personnel

Uncertainty Analysis: What is it and why do I care?

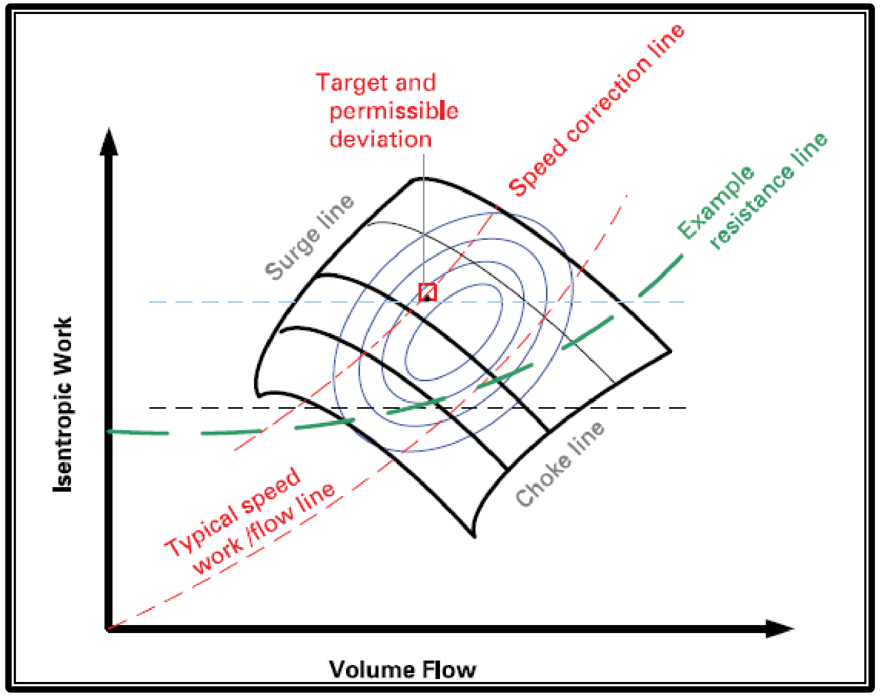
- Uncertainty Analysis: A procedure for quantifying the quality of the test.
  - Assurance of accuracy
  - Identify areas for improvement
  - Can be an exhaustive, time-consuming process
- This code references existing code
  - “Test Uncertainty PTC 19.1 – 2018”
- Types of Uncertainty
  - Elemental Error Sources
  - Systematic Uncertainty
  - Random Uncertainty
  - Combined Uncertainty

Uncertainty Analysis: What is it and why do I care?

- Uncertainty Basics:
  - Random Error
    - Same measurements are taken repeatedly, but numbers don't exactly match from each reading.
  - Systematic Error
    - A calibrated instrument may drift during a test.
    - A instrument may have a fixed offset



Uncertainty Analysis: How the code applies



- How the code deals with Uncertainty
  - Steady State
  - Very accurate instruments in redundancy
  - Multiple measurements
    - At least 30 measurements for each sample.
  - Readings before and after test are confirmed in agreement.

Uncertainty Analysis: Summary

- Code Requirements for Uncertainty Analysis
  - ASME PTC 19.1 is the primary reference for calculation methods of uncertainty.
  - Within PTC-13, allowable uncertainty is not defined.
    - Rigorous recommendations are provided.
    - Uncertainty is a non-mandatory requirement
  - Based upon agreement between parties
    - Scope of Analysis, parameters to analyze
    - Define Objectives and expected outcomes

Uncertainty Analysis: Takeaways

- Key Takeaways:
  - Vendors include uncertainty in their guarantees
    - Measurement uncertainty is never used to add tolerances or adjust power numbers after the fact.
  - If the test stand complies with the code requirements regarding instrument selection, design of measuring stations & recording practices, an unreasonable level of uncertainty will not arise.

PTC 13 Summary

- PTC13 Key Takeaways:
- It isn’t a compromise solution.
- It is a thoughtful approach to providing a uniform way of testing different types of compression in a fair and balanced way.
- Co-developed by Engineering community and manufacturers
- It can be trusted with confidence.
- Use it with confidence.

BENEFITS of PTC 13

- Provides tools for accurate prediction of the overall electric (wire-to-air) power required by a blower at specified airflow rate, discharge pressure, and inlet conditions.

- Describes procedures for measurements of blower package air capacity (as defined in terms of inlet volumetric flow rate), isentropic work with speed matching or blower pressure (PD blowers), and electric input active power (input wire).

- Ensures the blower test results in accurate prediction of power at specified site conditions.

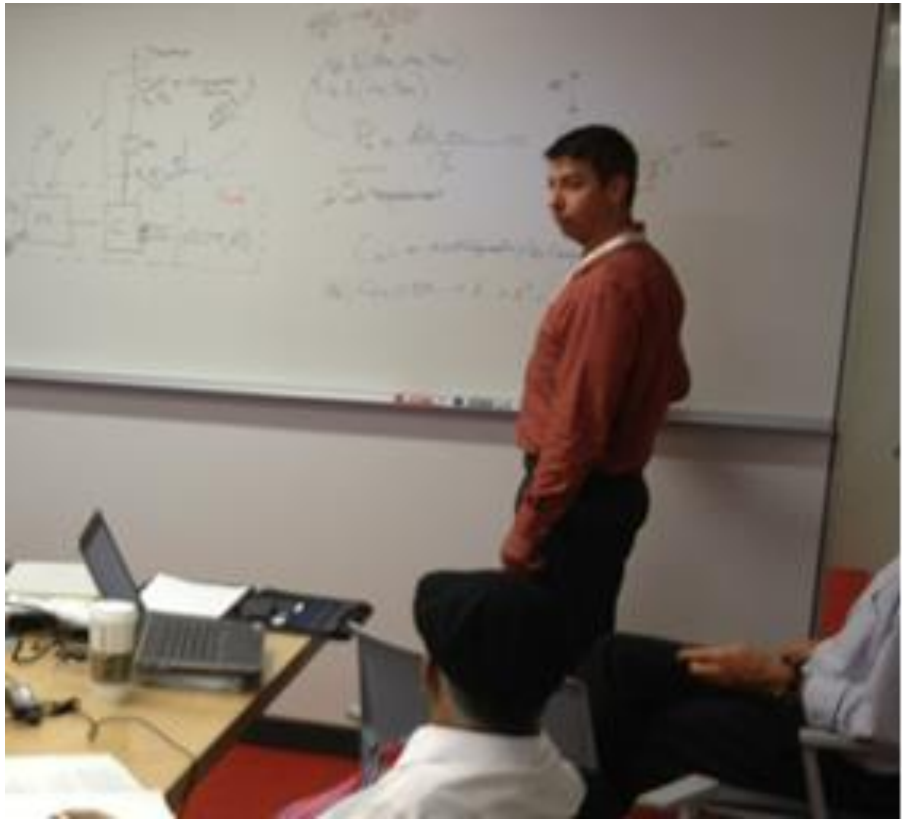
- Determination of total power required for all energy consuming devices in both integrated blower packages or simple blower/motor systems.

- The first code that is applicable to both dynamic and displacement blower packages without knowledge of internal construction details.

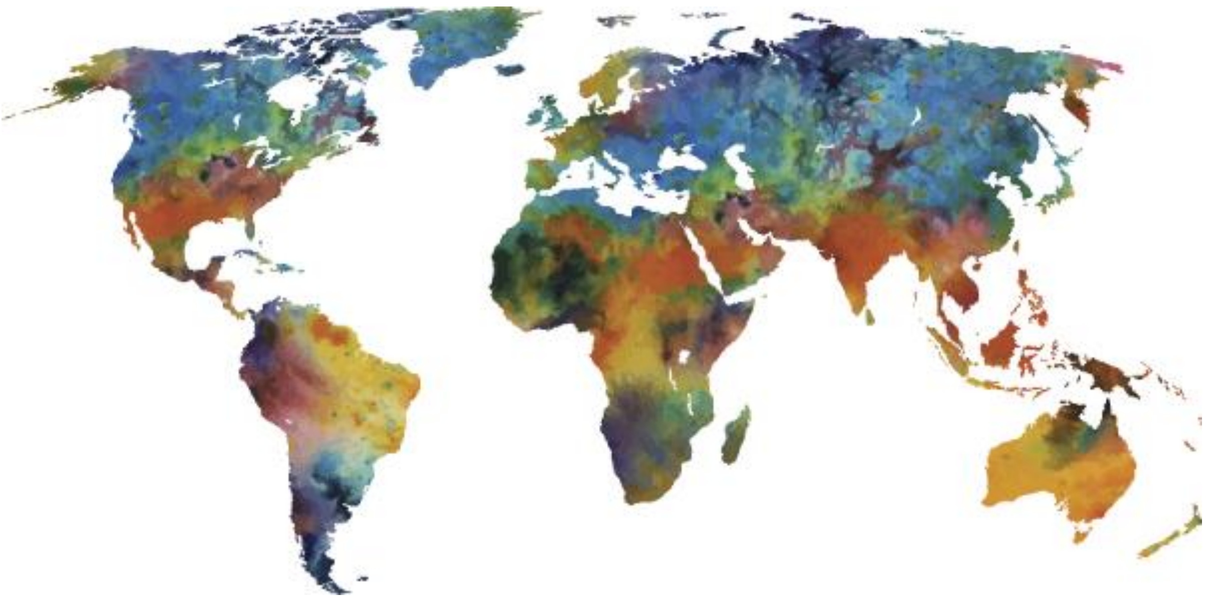
- Testing and reporting procedures that are easily applied by specifiers and purchasers of blowers with simplified thermodynamic calculation methods.

Presentation Dedicated to Jacque Shultz, Previous PTC 13 Chair, Howden Americas Compressors

- Jacque Schultz – July 3, 1974 - March 21, 2022
- Jacque was the PTC 13 chair for many years and a key person in the development of the performance test code.
- He provided many of the technical calculations for centrifugal blowers and in testing procedures.
- His work lives on and we will think of him every time ‘similitude’ is mentioned.



What is ASME?



- Standards
- Certification
- Conformity Assessment
- Courses
- Conferences
- Publications
- ASME.org
- Education
- Membership

ASME helps the global engineering community develop solutions to real-world challenges

ASME Mission & Vision

MISSION STATEMENTS

"To serve **diverse global communities** by advancing, disseminating and applying **engineering knowledge for improving the quality of life** — and communicating **the excitement of engineering**."

VISION STATEMENTS

"**To be the essential resource** for mechanical engineers and other technical professionals throughout the world for **solutions that benefit humankind**."

We Welcome You to Join ASME!

- **Complete the ASME Participation Acknowledgement Form (PAF) and the Personnel Form (PF-1) to begin.**

  - **Then you will:**
    - be eligible for **membership on Committees**;
    - be granted **access to Committee documents**;
    - be able **to participate in Committee ballots**.

Join an ASME Standards & Certification Committee

Questions?

Thank you for your kind attention!

Fredric Constantino	Mark Addison	John Conover
ASME	Artesian Water Co.	AirCleanUSA, LLC
Phone: (212) 591-8684	Email:	Email:
E-mail: ConstantinoF@asme.org	maddison@artesianwater.com	john.conover@aircleanusa.com

About the Speaker

Omar Hammoud
APG-Neuros

- President and CEO, APG-Neuros
- Founded APG-Neuros in 2005
- Spent 25 years in the aerospace and defense industries
- Passionate about the environment and sustainability

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APG Neuros

Our Background

2005

APG, Inc. established in Montreal, QC

2006

First turbo blower installed in Saint-Pie, QC outdoors

2010

APG-Neuros, Inc. opens the Plattsburgh, NY production facility & new Head Office in Blainville, QC

2021

Over 1600 Turbo Blowers Installed across North America, Europe & the Middle East

Our Customers

Over 1,700 units in North America

More than 600 installations

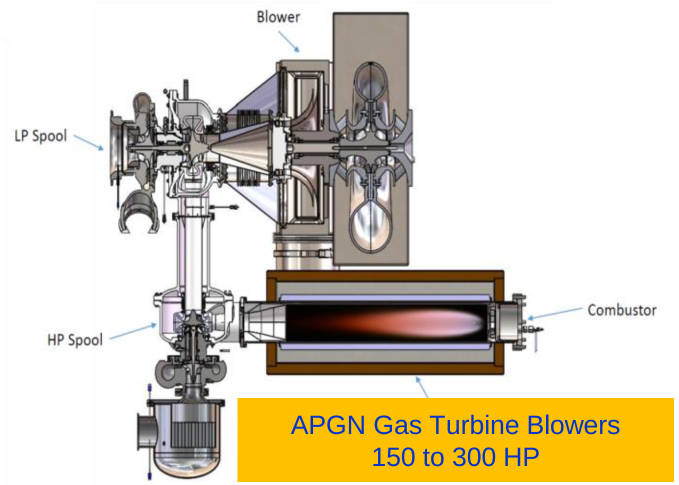
More than 30% repeated customer

Our Products

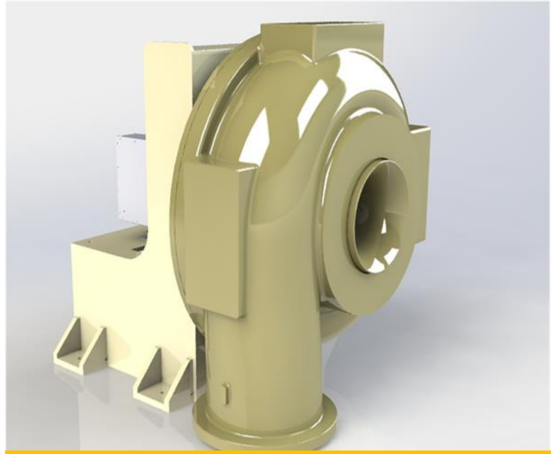
NX series Turbo Blowers
30 to 1000 HP

APGN series Turbo Blowers
500 to 1000 HP

NXM Magnetic Bearing :200Hp to 500HP



APGN Gas Turbine Blowers
150 to 300 HP



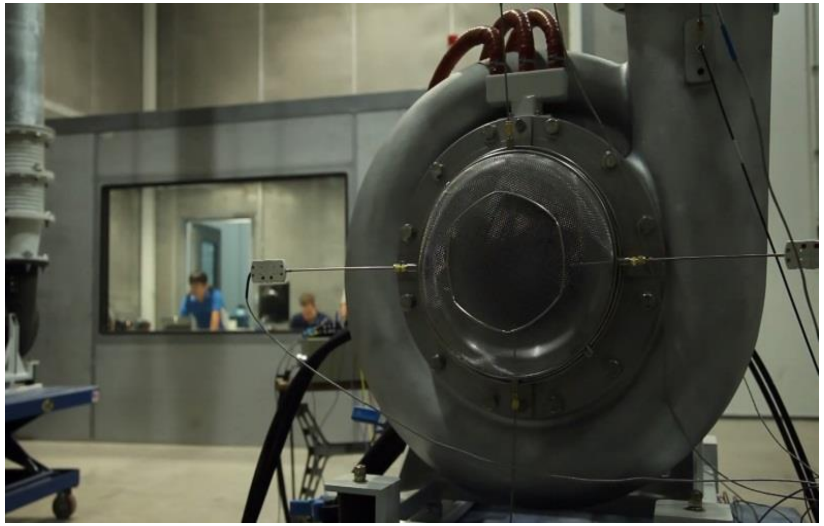
APGN Turbo Blowers 1500 to 3000 HP

Headquarters – Blainville, QC

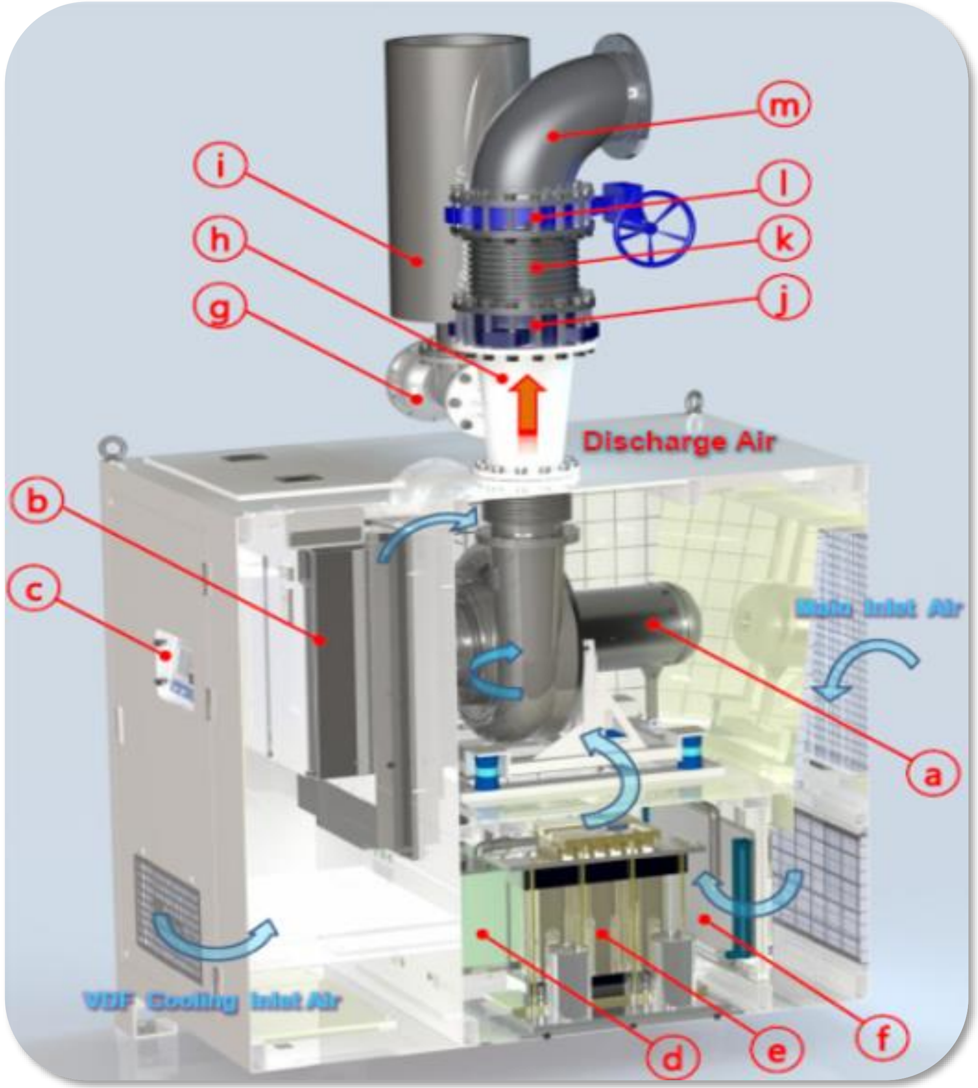
- 32,000 square feet
- Corporate headquarters
- Executive, finance & administration
- Engineering and support
- R & D
- Automation Department

PTC13 Test Facility - Plattsburgh, NY

- 60,000 square feet in Plattsburgh, NY
- 30 Production and Support employees
- 15 Factory based service test technicians
- Production- Assembly & Test
- Customer Support Staff
- Over $10.4 million in parts inventory



By Agreement - Blower PACKAGE counted in PTC13 Testing



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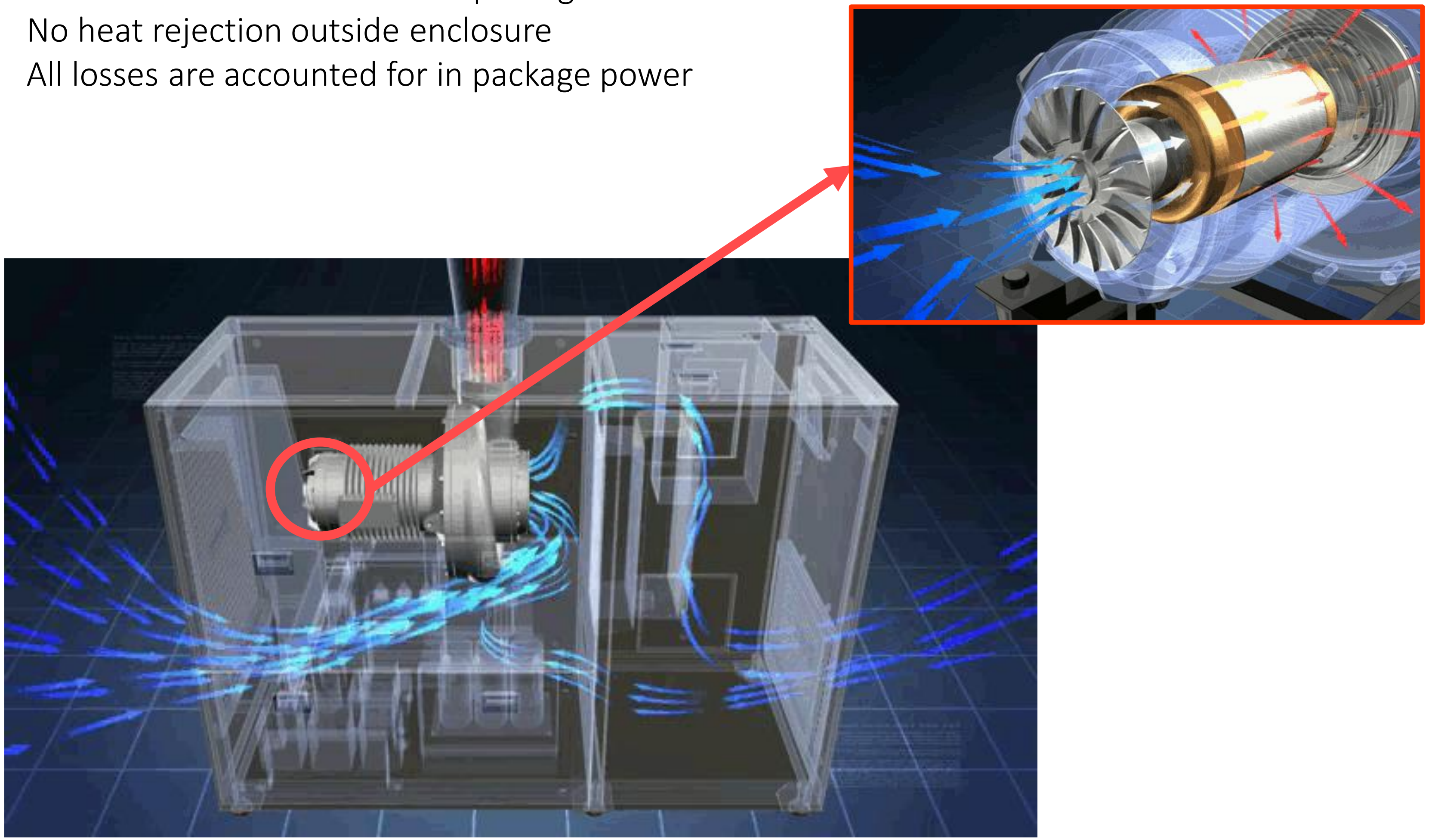
A. Blower Core
B. Variable Frequency Drive (VFD)
C. Control Panel
D. Coolant System (200HP and up)
E. Sine Wave Filter
F. Radiator (200HP and up)
G. Blow-off Valve (BOV)
H. Discharge Cone
I. Blow-off Silencer
J. Check Valve
K. Flexible Joint
L. Isolation Valve
M. Elbow (Process Air Discharge)

Packaged Turbo Blower – PTC13

- Air Flow measured on discharge from Blower Package
- Power is measured on inlet to package
- No heat rejection outside enclosure
- All losses are accounted for in package power



Advance Preparations of PTC13 Testing

- Review Specification and agree on & Test Requirements
- Review agreement on Test Procedure and Test Apparatus
- Establish written agreement on any deviations
- Carryout preliminary testing in advance of witnessing
- Share preliminary test results with customer (optional)

Preparations & Conduct during actual PTC13 Testing

- Welcome and greet witnessing team
- Walk through test facilities, test procedure and test equipment
- Agree on plan of testing; time schedule, no of units to be tested
- Review calibrations of instruments and answer questions
- Review the list of components to be included
- Agree on deviations to be accepted
- Start testing and record raw data in presence of witnesses
- Wrap up testing with discussions and observations
- Follow up by sending Factory Acceptance Test Report
- Review FAT with customer, answer open questions
- Reach approval on FAT report

ASME PTC 13 Wire-to-Air Performance Code for Blower Systems Part 3

Q&A

Please submit any questions through the Question Window on your GoToWebinar interface, directing them to Blower & Vacuum Best Practices Magazine. Our panelists will do their best to address your questions and will follow up with you on anything that goes unanswered during this session.

Thank you for attending!

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PDH Certificates will be e-mailed to Attendees by within 2 days

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Tie Duan
E.W. Klein & Co
Keynote Speaker

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