Compressed Air as a Quality/Safety Manufacturing Process Variable

Tom Taranto
Data Power Services
Keynote Speaker

The recording and slides of this webinar will be made available to attendees via email later today.

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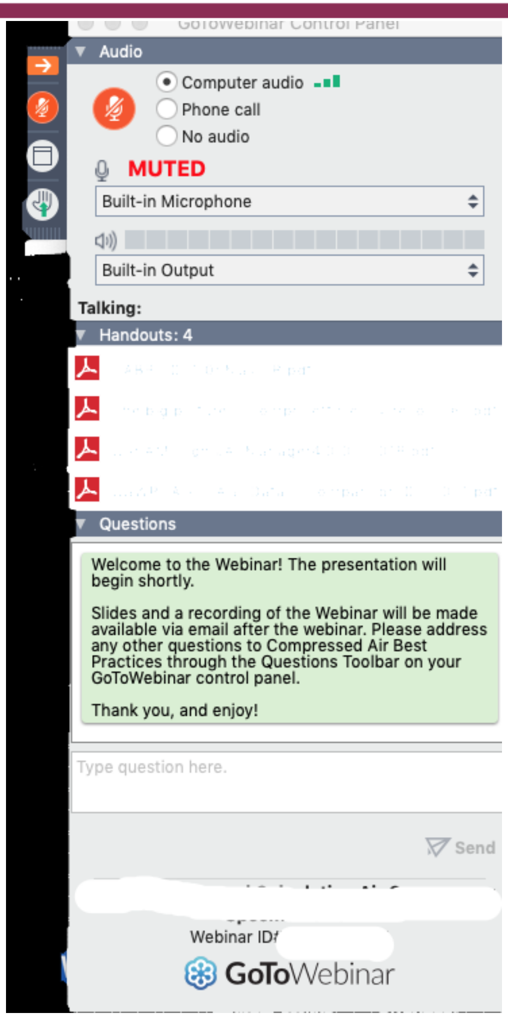
Q&A Format



- Panelists will answer your questions during the Q&A session at the end of the Webinar.

- Please post your questions in the Questions Window in your GoToWebinar interface.

- Direct all questions to Compressed Air Best Practices® Magazine

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BestPractices Technical Case Study

June 2001

OFFICE OF INDUSTRIAL TECHNOLOGIES

ENERGY EFFICIENCY AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY

Benefits
- Saves $226,000 annually
- Reduces energy use
- 40% reduction in compressed air energy costs per unit of production
- Increases reliability
- Reduces CO_2 emissions

Applications

Compressed air systems are found throughout industry and consume a significant portion of the electricity used at manufacturing plants. Specifying correct pressure levels for end-use equipment and making the appropriate changes to the supply system can improve the performance of almost any compressed air system.

Compressed Air System Redesign Results in Increased Production at a Fuel System Plant

Summary

In 1999, Caterpillar Fuel Systems performed a compressed air system improvement project at its fuel injector plant in Pontiac, Illinois. The project's implementation greatly improved the compressed air system's reliability and efficiency. As a result, the plant achieved important energy savings through reduced energy consumption, was able to increase production by 18% without purchasing additional compressors, and solved an air supply problem to a critical production area. Had the plant not increased its production, it would have been able to take some of its compressors offline. The plant's compressed air energy savings total $226,000 (5,280,000 kWh) per year and represent over 6% of annual energy costs. Since the project's cost was approximately $1,000,000, the simple payback is 4.4 years. In addition, the project resulted in a 40% reduction in compressed air energy costs per unit of production.

Caterpillar's Pontiac Plant

Disclaimer

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Compressed Air as a Quality/Safety Manufacturing Process Variable

Introduction by

Compressed Air Best Practices® Magazine

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About the Speaker

Tom Taranto
Data Power Services

- Owner, Data Power Services

- Over 45 years of experience in the compressed air industry

- U.S. DOE Energy Expert, Compressed Air Challenge technical committee member, Compressed Air Challenge qualified instructor and instructor for Qualified AIRMaster+ Specialist Training

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Compressed Air as a Quality/Safety Manufacturing Process Variable

April 27, 2023

Tom Taranto, Principal Engineer
Data Power Services, LLC

About the Speaker – Tom Taranto

- Tom Taranto is an independent fluid power professional with 45 years' experience providing services to industrial clients, utilities, and energy agencies. He is managing Principal of Data Power Services, LLC.
  - He has extensive experience in design and application of fluid power systems both hydraulic and pneumatic.
  - Tom is Chairperson for ASME Standard EA-4-2010 "Energy Assessment for Compressed Air Systems".
- He is an instructor for;
  - Compressed Air Challenge fundamentals and advanced training.
  - AIRMaster+ Specialists qualification training for the US DOE AIRMaster+ software tool.
  - United Nations Industrial Development Organization (UNIDO) Industrial Motor Systems Efficiency program
    - Co-author and International Instructor for UNIDO's compressed air system assessment training.
- Mr. Taranto is a graduate of Clarkson University, with a Bachelor's Degree in Mechanical Engineering. He is a member of ASME, AFE, and IFPS.
  - Past President of the Fluid Power Society, Chapter 21 Syracuse, NY.

Compressed Air as a Utility – or – Process Variable

Utility

- As a Utility Compressed Air supports but does not directly impact the product or production process.

Process Variable

- As a Process variable Compressed Air can impact product quality, product safety, & productivity.

Compressed Air as a Utility – or – Process Variable

Compressed Air as a Utility

- Powering Maintenance Tools
  - Impact tool – Air wrench – Air ratchet
  - Chippers
  - Grinders
- Construction Equipment
  - Nailers
  - Sprayers
  - Pavement breakers – Hammers

Compressed Air as a Process Variable

- Powering Manufacturing Equipment
  - Automated assembly
  - Material handling / transport
  - Cleaning & drying
- Manufacturing Process Applications
  - Fermentation
  - Oxidizer
  - Aeration

Compressed Air ~~as a Utility~~ – or – Process Variable

- Compressed Air – Process Variable changes how we control, monitor, & record / document performance.

- For any given process there are many variables.
  - Parameters that have significant impact to product safety, quality, scrap, rework, through put, productivity, etc. are referred to in various ways.
    - KPIs – Critical Process Parameters – PMF Process Major Factors – CTQ (critical to quality) parameters – CCP Critical Control Point

- ASME EA-4 –2010 Energy Assessment for Compressed Air Systems

6.6 Critical Air Demands

Critical air demands are those end uses of compressed air that have the potential to impact product quality, production rate, scrap rate, rework cost, customer satisfaction, etc. As such, improving performance of critical air demand is most relevant in terms of nonenergy benefits to production operations. However, there are often energy-related benefits associated with improving performance of critical air demands.

Food Industry – Statutory Requirement – Pharmaceutical Industry

- Federal Food, Drug, and Cosmetic (FD&C) Act
  - Title 21 of the CFR rules of the Food and Drug Administration – FD&C Act Chapter IV: Food
- Food Safety Modernization Act (FSMA)
- ISO 22000:2005 Food safety management systems
- Food & Beverage Grade Compressed Air Best Practice Guideline BPG 102-1 (BCAS)
- Global Food Safety Initiative (GFSI)
- International Featured Standards (IFS)
  - IFS are GFSI (Global Food Safety Initiative) recognized standards for auditing food manufacturers.
  - IFS PACsecure food packaging standard
    - The IFS PACsecure Standard is for assessing packaging material manufacturing and converting processes.

IFS International Featured Standards

IFS Standards are uniform food, product and service standards.

- They ensure that IFS-certified companies produce a product or provide a service that complies with customer specifications, while continually working on process improvements.

NSF

Food Safety, Quality and Risk Management

- founded in 1948 as the National Sanitation Foundation
- Current Good Manufacturing Practices (cGMPs) for Food Safety

- Federal Food, Drug, and Cosmetic (FD&C) Act
  - Title 21 of the CFR rules of the Food and Drug Administration - FD&C Act Chapter V: Drugs and Devices
  - cGMP standards and quality systems WHO World Health Organization
  - Current Good Manufacturing Practice (CGMP) Regulations
    - CGMP regulations for drugs contain minimum requirements for the methods, facilities, and controls used in manufacturing, processing, and packing of a drug product.
  - 21 CFR Part 210. Current Good Manufacturing Practice in Manufacturing Processing, packing, or Holding of Drugs
  - 21 CFR Part 211. Current Good Manufacturing Practice for Finished Pharmaceuticals.

NSF

NSF International, Pharmaceutical Services

- founded in 1948 as the National Sanitation Foundation
- Pharmaceutical and cGMP Education Programs

Action Items: Hazard Analysis and Critical Control Point (HACCP)

- HACCP: A systematic approach to the identification, evaluation, and control of food safety hazards.
- Hazard Identification: Can be regarded as a brain storming session creating a list of potential hazards.
- Hazard Analysis: The process of collecting and evaluating information on hazards associated with the food under consideration to decide which are significant and must be addressed in the HACCP plan.
- CCP Decision Tree: A sequence of questions to assist in determining whether a control point is a Critical Control Point.

- HACCP Principals
  - Principle 1: Conduct a hazard analysis.
  - Principle 2: Determine the critical control points (CCPs).
  - Principle 3: Establish critical limits.
  - Principle 4: Establish monitoring procedures.
  - Principle 5: Establish corrective actions.
  - Principle 6: Establish verification procedures.
  - Principle 7: Establish record-keeping and documentation procedures.

Action Items: Hazard Analysis and Critical Control Point (HACCP)

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- Compressed Air System Approach
  - ASME EA-4 – 2010 Identify Critical Air Demands
  - Compressed Air Quality; particulate, water and oil
  - Other; microbes, bacterial, virus, sterile compressed air.
  - Dynamic Air Flow Rate; average flow, peak flow
  - Air Pressure; minimum, maximum, stability
  - Treatment; air dryer, filters, monitoring, alarms
  - Flow Restrictions; pipe, and component sizing
  - Air storage, pressure monitoring & control, alarms verification

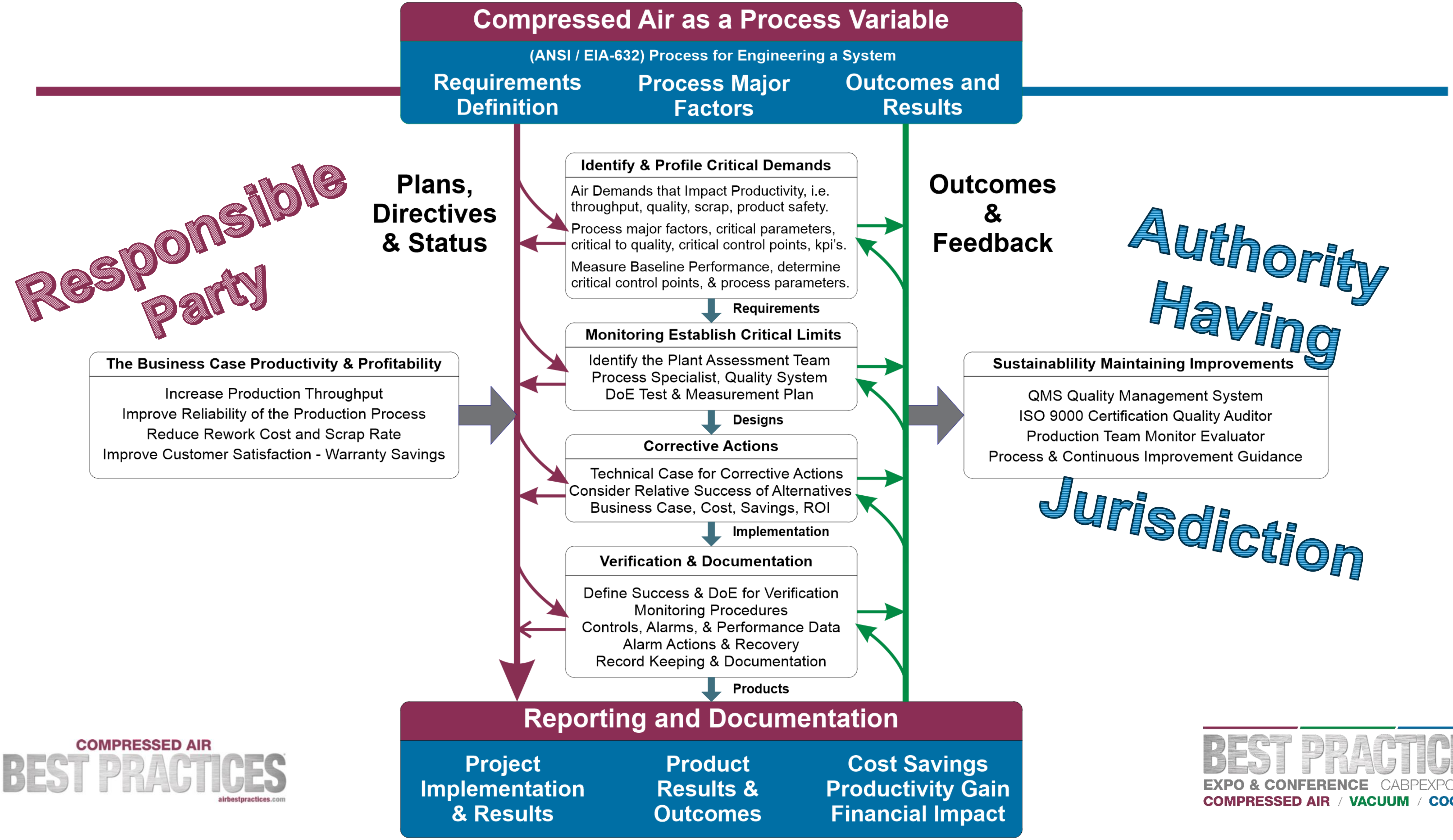
The business case – Compressed Air as a Process Variable

- Food and Pharmaceuticals have Statutory / Regulatory requirements for HACCP.

- Responsible Party – Corporate Requirement
  - Senior Management
  - Corporate Leadership Team
  - Plant Leadership Team

- What is the business case for other manufacturers?
  - Increased productivity and profitability
    - Increased throughput of the manufacturing process.
    - Improved reliability of the production process.
    - Reduced warranty cost / improved customer satisfaction.
    - Reduced rework cost
    - Reduced scrap cost

- Authority having jurisdiction?
  - ISO9000 Certification
  - QMS Quality Management System
  - Production Management
  - Process Engineering



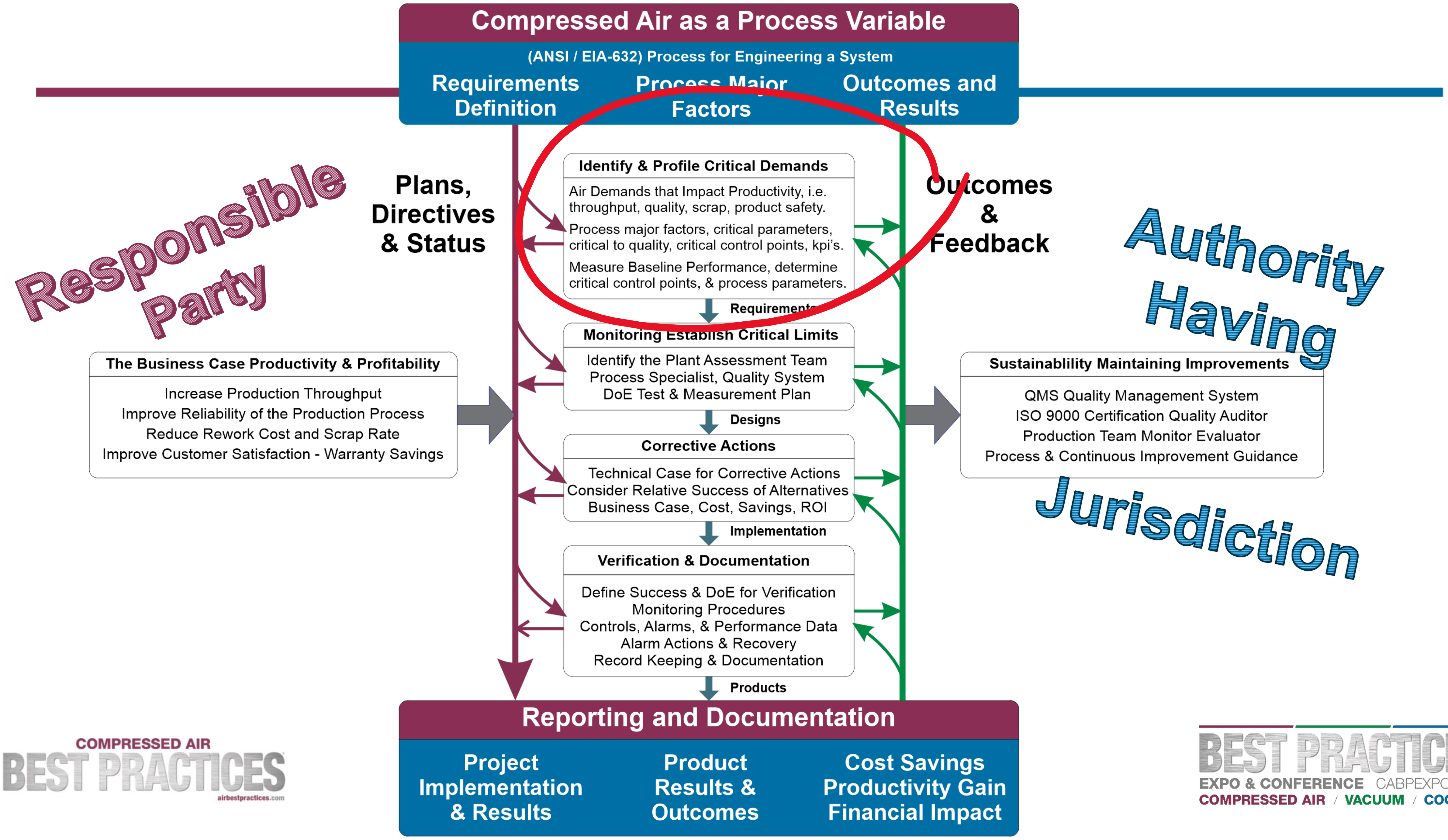
Compressed Air as a Process Variable
(ANSI / EIA-632) Process for Engineering a System
Requirements Definition
Process Major Factors
Outcomes and Results
Responsible Party
Plans, Directives & Status
Outcomes & Feedback
Authority Having Jurisdiction
Identify & Profile Critical Demands
Air Demands that Impact Productivity, i.e. throughput, quality, scrap, product safety.
Process major factors, critical parameters, critical to quality, critical control points, kpi's.
Measure Baseline Performance, determine critical control points, & process parameters.
Requirements
Monitoring Establish Critical Limits
Identify the Plant Assessment Team
Process Specialist, Quality System
DoE Test & Measurement Plan
Designs
Corrective Actions
Technical Case for Corrective Actions
Consider Relative Success of Alternatives
Business Case, Cost, Savings, ROI
Implementation
Verification & Documentation
Define Success & DoE for Verification
Monitoring Procedures
Controls, Alarms, & Performance Data
Alarm Actions & Recovery
Record Keeping & Documentation
Products
The Business Case Productivity & Profitability
Increase Production Throughput
Improve Reliability of the Production Process
Reduce Rework Cost and Scrap Rate
Improve Customer Satisfaction - Warranty Savings
Sustainablility Maintaining Improvements
QMS Quality Management System
ISO 9000 Certification Quality Auditor
Production Team Monitor Evaluator
Process & Continuous Improvement Guidance
Reporting and Documentation
Project Implementation & Results
Product Results & Outcomes
Cost Savings Productivity Gain Financial Impact

HACCP Principals - Identify & Profile Critical Air Demands

- Identify possible critical air demands
  - Impact on production rate, scrap rate, rework cost, customer satisfaction

- Analyze potentially critical air demands – Measure Baseline Performance
  - Impact to production, Process Major Factors, Critical to Quality, Critical Control Points.

- Identify Critical Air Demands and Critical Control Points.
  - Air flow rate – average flow, peak flow
  - Air pressure – target pressure minimum & maximum limits
  - Air pressure variation – critical limit +/- ??
  - Contamination Class ISO 8573; particle size – pressure dew point – oil content
  - Other contamination; microbes, oil vapor & organic solvent, gaseous contaminate



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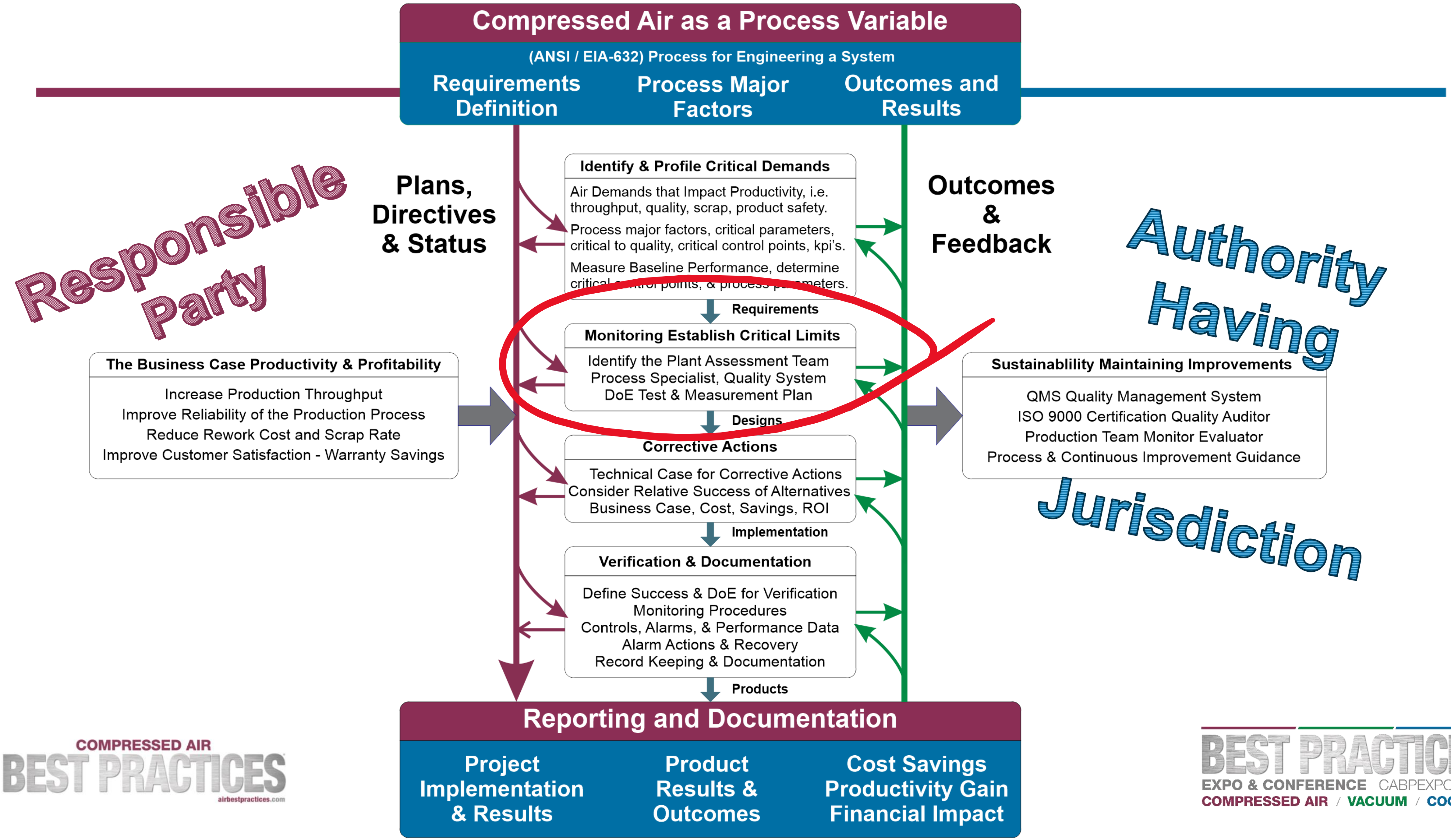
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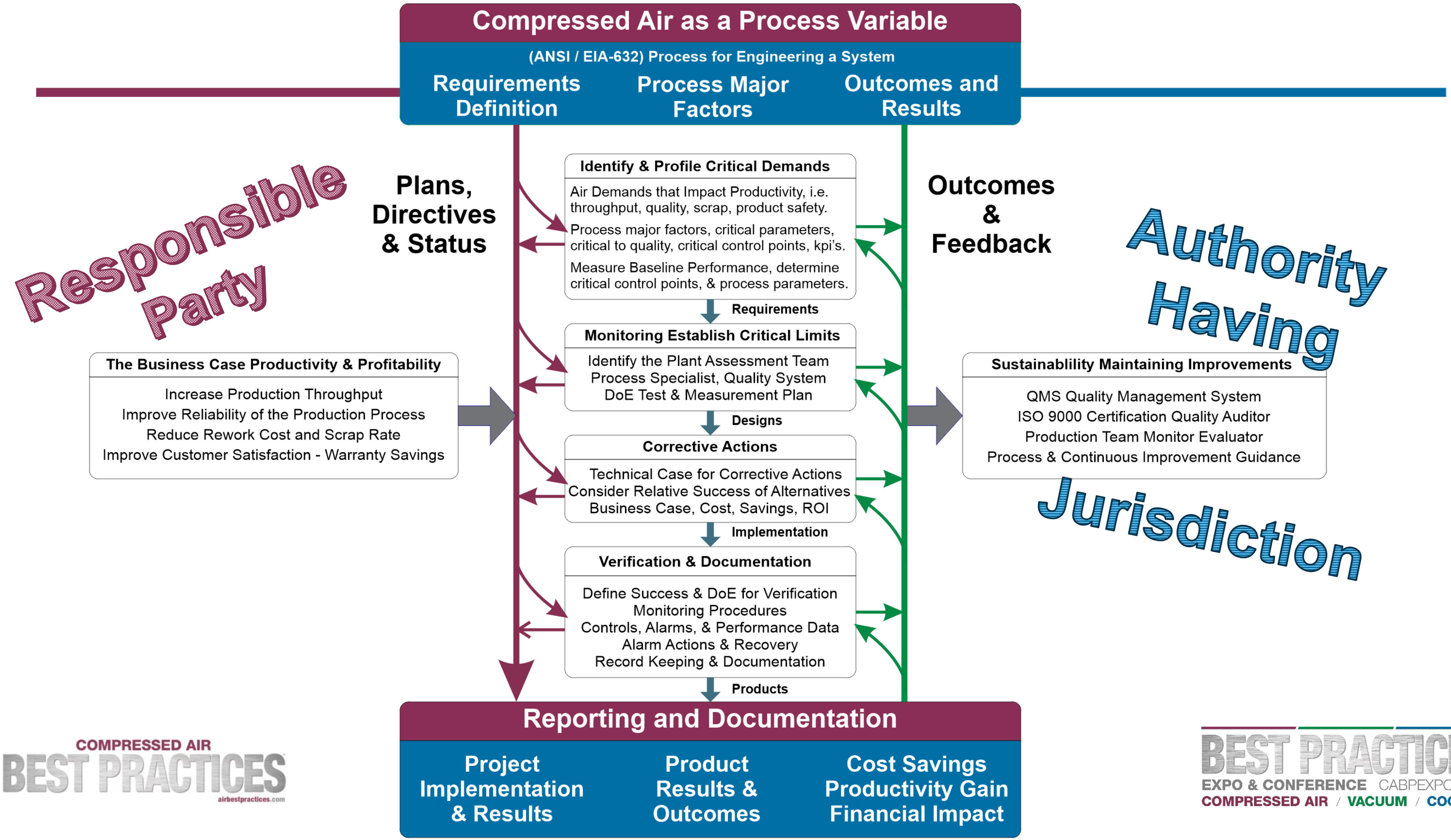
HACCP Principals – Monitoring Establish Critical Limits

- Identify Plant Assessment Team Members
  - Engage team members with specialized knowledge about the product, production machinery, manufacturing process. This may include people with knowledge related to the Quality Management System (QMS), Maintenance personnel, Production personnel, Operators, and others.
- Establish Critical Limits
  - Consider measuring KPIs, Critical Process Parameters, Major Factors, CTQ (critical to quality) parameters and evaluate existing control performance for identified CCPs Critical Control Points.
  - Design of Experiments (DoE) to characterize performance while changing critical input parameters revealing their response and effect on KPIs and established quality parameters.
- Establish Monitoring Procedures
  - Combine information related to critical limits and measurement experience to establish monitoring procedures to determine when the process is with-in control limits.
  - Identify if the process is outside control limits, what actions are needed to bring the process back under control.

HACCP Principals – Corrective Actions

- Establish Potential Corrective Actions
  - Evaluate the technical case for possible corrective actions and consider the relative success of various alternatives.
  - Evaluate the business case for possible corrective actions including total cost, savings resulting from anticipated productivity gains, project life, ROI and other financial, and corporate business objectives.
- Establish Verification Procedures
  - Define test methods for post implementation process measurements and criteria to determine operation is with-in critical limits.
  - Define product quality characteristics with-in the existing QMS or measures that should be incorporated in the QMS structure to verify the intended results have been achieved.
- Establish record-keeping and documentation procedures.
  - Starting with existing record-keeping and documentation procedures integrate post implementation results.
  - Consider any modifications or additions to existing record keeping methods that are needed to support new critical parameters that must be documented and retained.



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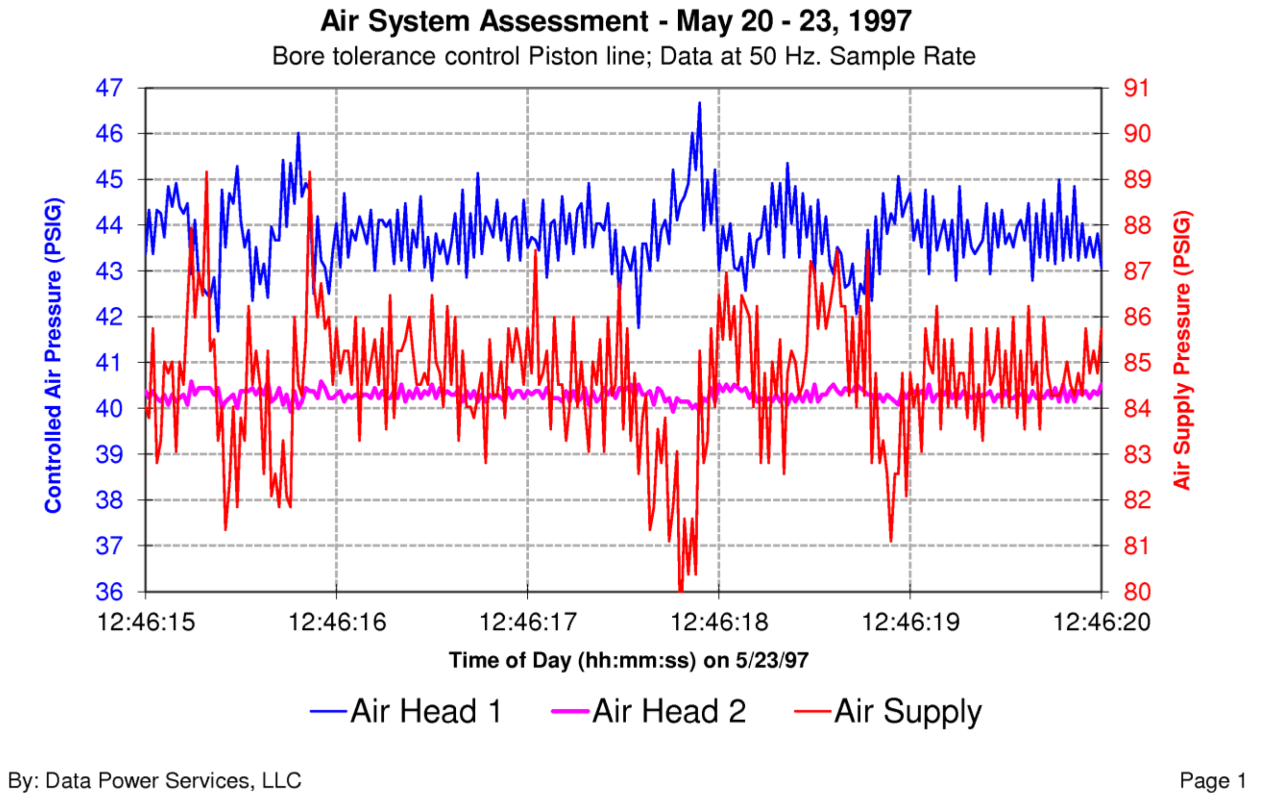
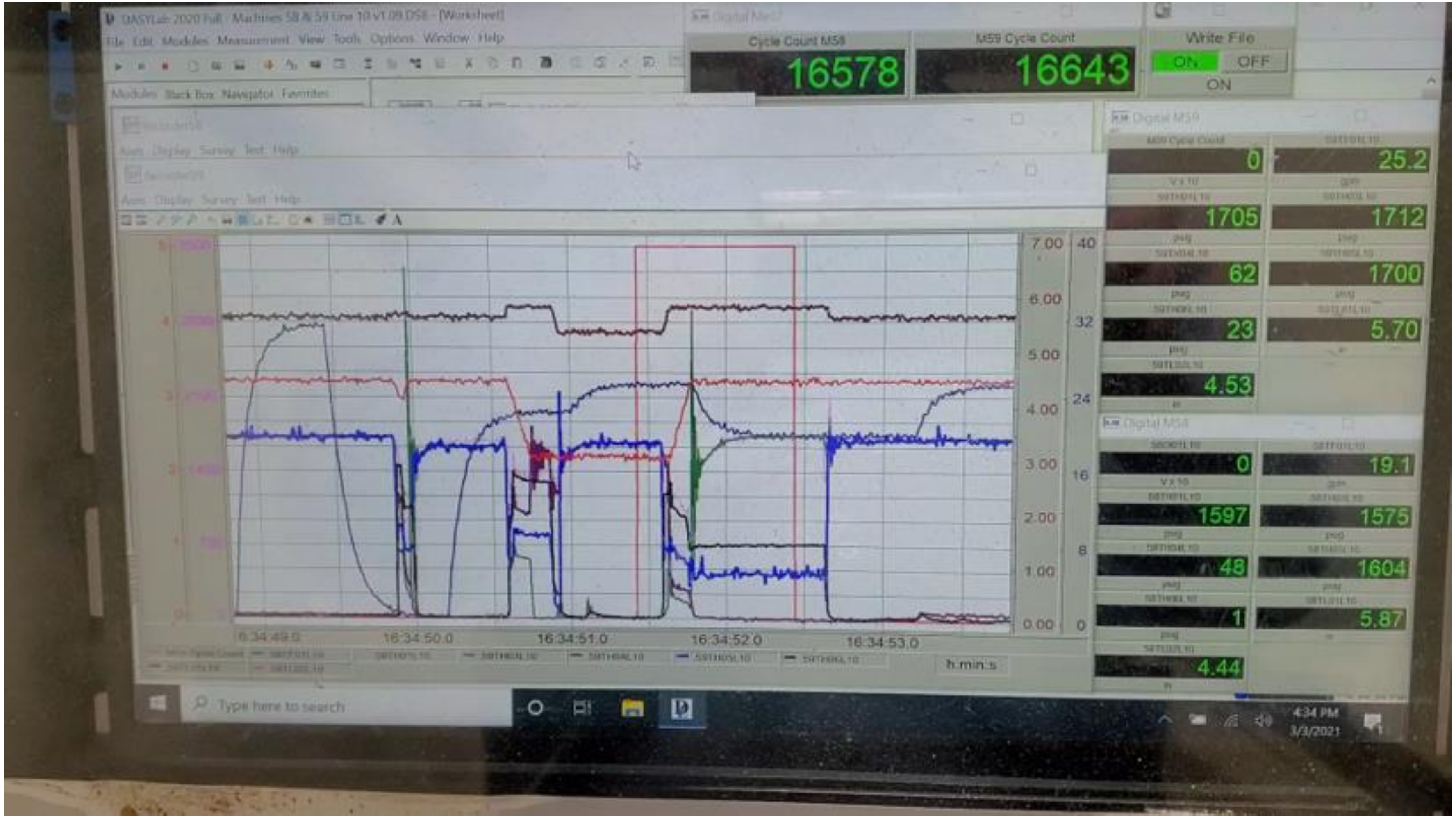
Automotive Engine Manufacturer had 5% scrap rate, piston wrist pin bore tolerance defect

- Potential Productivity Improvement
  - 5% scrap rate wrist pin bore tolerance
- Critical Control Point
  - Honing tool 1:4 air / oil booster
- Critical Limit Controlled Air Pres. Stability
  - Controlled pressure +/- 0.5 psi
- Monitoring Practice
  - High Speed Pressure 50 samples / second
- Corrective Action
  - Rebuild control & stabilize supply pressure
- Verification
  - 5 short runs 100% test ~ 100 pcs normal defects
- Record Keeping & Documentation
  - Resume previous statistical process control



Monitoring Practice – Edge Computing System 16 Parameters 10 ms Data Interval



Improve Product Quality & Safety, with Energy Reduction too

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BestPractices Technical Case Study

OFFICE OF INDUSTRIAL TECHNOLOGIES
ENERGY EFFICIENCY AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY

June 2001

COMPRESSED AIR SYSTEM REDESIGN RESULTS IN INCREASED PRODUCTION AT A FUEL SYSTEM PLANT

Summary

In 1999, Caterpillar Fuel Systems performed a compressed air system improvement project at its fuel injector plant in Pontiac, Illinois. The project's implementation greatly improved the compressed air system's reliability and efficiency. As a result, the plant achieved important energy savings through reduced energy consumption, was able to increase production by 18% without purchasing additional compressors, and solved an air supply problem to a critical production area. Had the plant not increased its production, it would have been able to take some of its compressors offline. The plant's compressed air energy savings total $226,000 (5,280,000 kWh) per year and represent over 6% of annual energy costs. Since the project's cost was approximately $1,000,000, the simple payback is 4.4 years. In addition, the project resulted in a 40% reduction in compressed air energy costs per unit of production.

BENEFITS

- Saves $226,000 annually
- Reduces energy use
- 40% reduction in compressed air energy costs per unit of production
- Increases reliability
- Reduces CO_2 emissions

APPLICATIONS

Compressed air systems are found throughout industry and consume a significant portion of the electricity used at manufacturing plants. Specifying correct pressure levels for end-use equipment and making the appropriate changes to the supply system can improve the performance of almost any compressed air system.

- Automated assembly line not making rated production output.
- Direct energy savings $226,000 per year (5,280,000 kWh).
- Increased production and reduced energy combine to decrease energy intensity by 40% / fuel injector.
- $1 million dollar project with 4.4 year payback

References – ASME EA-4 – 2010 Assessment for Compressed Air Systems

- 1.3.1. Document issues and concerns with compressed air use, critical production functions
- 1.3.3.a) understand compressed air point of use as it supports critical plant production functions
- 6.6 Critical Air Demands – defined
- 6.6.1 Effect on Productivity & Energy
- 6.6.2 Critical End Use Characteristics
- 6.6.3 Analyze Process Limits
- 6.6.3 Remedial Measures and Quantify Savings

- Appendix I-4 Inventory Key End Use Demands f.1) Poorly performing applications
- Appendix II-5 Pressure Profile a.2) Critical end use applications
- Appendix II-8a. present pressure performance
- Appendix II-8b. flow static critical end use
- Appendix II-8c. flow dynamic critical end use
- Appendix II-8d. Determine the need for process control style monitoring and control

References – ASME EA-4G – 2010 Guidance for ASME

EA-4, Energy Assessment for Compressed Air Systems

- **2.1 Elements and Characteristics of Industrial Compressed Air Systems**

- **2.1.3.5 Instrumentation.** In some critical applications compressed air system performance has a direct impact on production rate, product quality, scrap rate, and rework cost. Compressed air is a processes variable that should be controlled, monitored, and recorded in a manner consistent with other process controls.

- **6.6 Critical Air Demands**

- **6.6.1 Effect on Productivity and Energy.** The team should consider that this analysis of critical air demands may benefit from narrowing the measurement boundary.

- **6.6.2 Critical End Use Characteristics.** When evaluating critical end-use requirements, it is helpful to classify the end use as "Flow Static" or "Flow Dynamic."

Thank you!

Thank You !

Data Power Services, LLC

- Tom Taranto

- tom@datapowerservices.com
- o. (315) 635 – 1895
- c. (315) 447 – 2723

About the Speaker

Dave George
Kaishan

- President, Kaishan
- Certified DOE AirMaster+
- 37 years of experience in the air compressor industry

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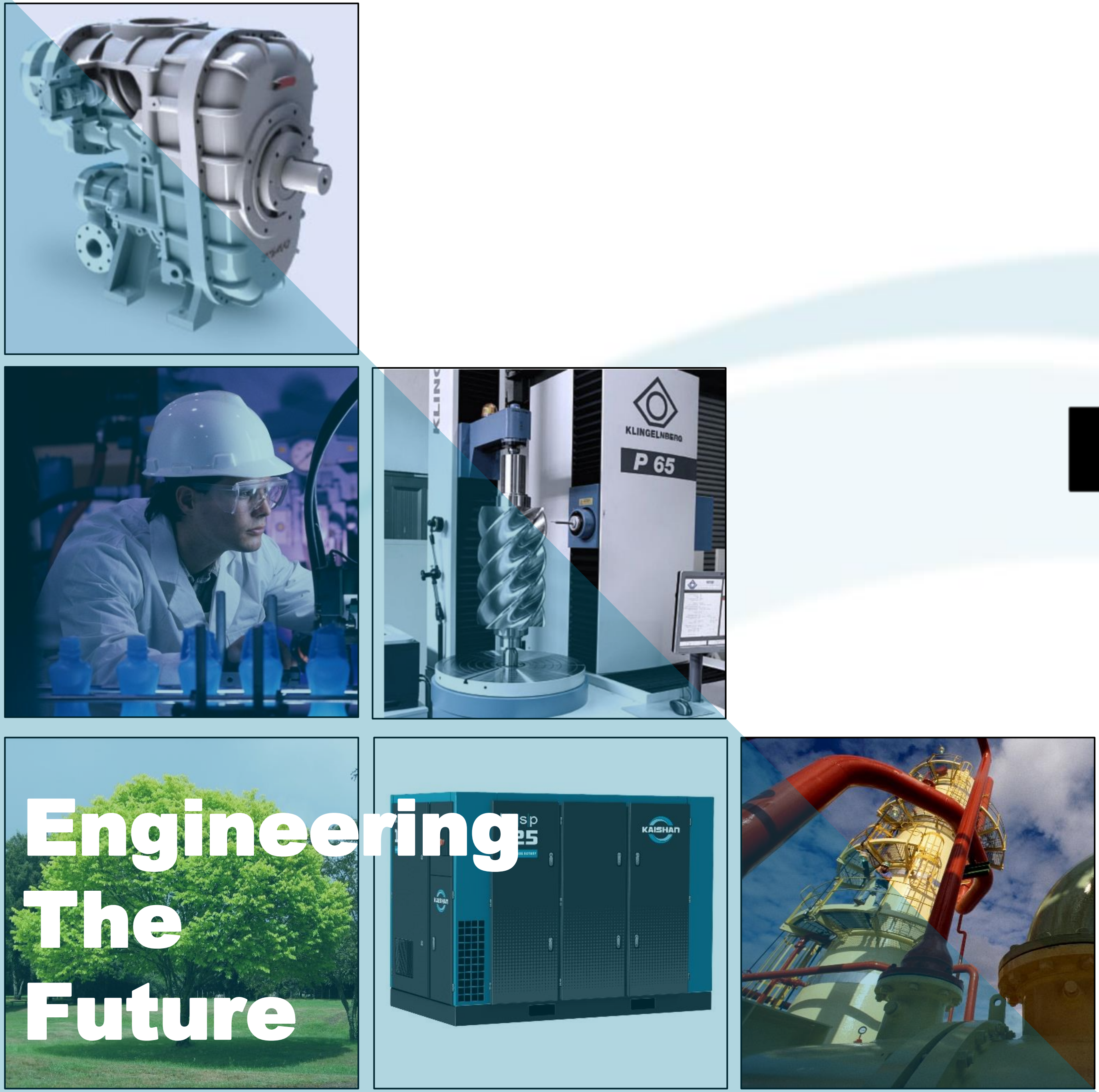

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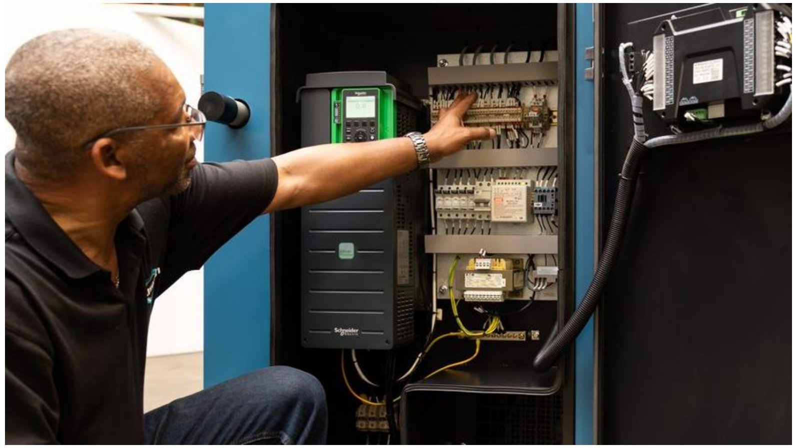
Safety and Maintenance on a Rotary Screw Air Compressor

April 2023

Safety Features of a Typical Rotary Screw Air Compressor System

- Typical Safety threats:
  - Electrical Power
  - Compressed Air Pressure
  - Temperature – Hot Surfaces
  - Mechanical Movement

Energy from Electricity



- Properly sized breaker/fused disconnect

- Control Panel with overload control.
  - Main Motor
  - Fan Motor(s)

- Neat and bundled wiring, terminal lugs and strips for connections

CHECK ELECTRICAL CONNECTIONS ANNUALLY!

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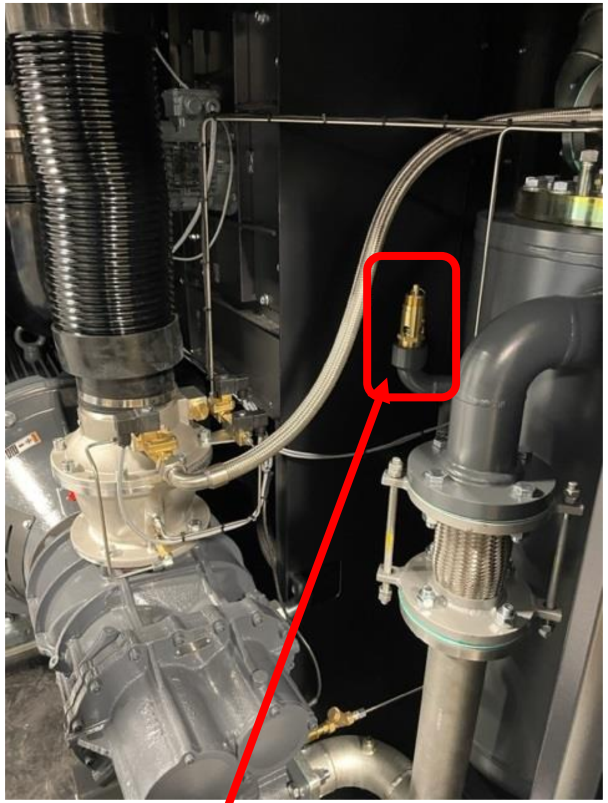
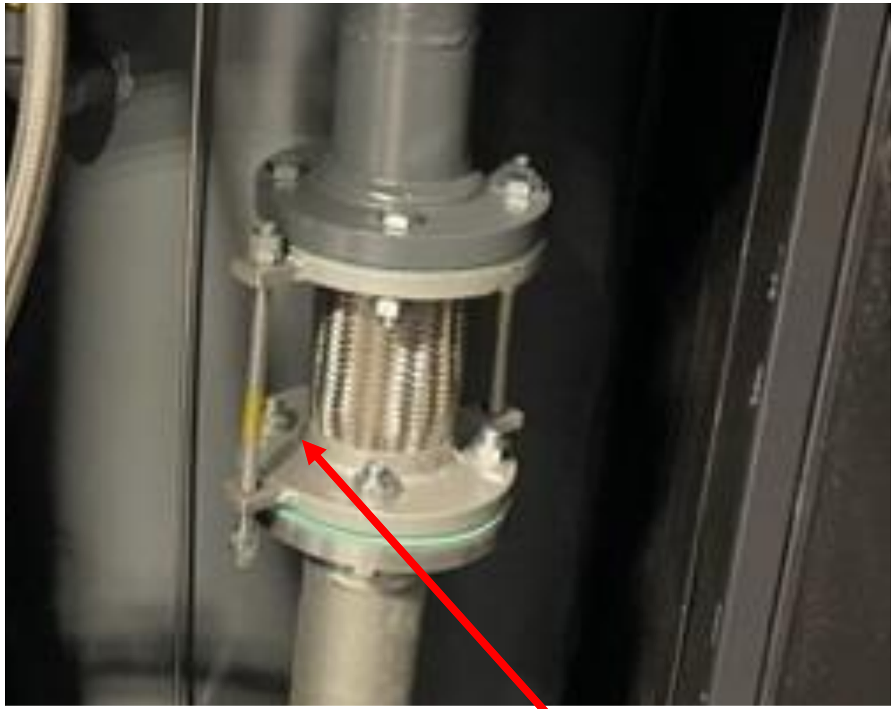
Energy from Pressure



❖ Tank Safety Relief Valve

❖ Oil fill port with pressure weep hole



❖ Flexible discharge pipe with safety rods

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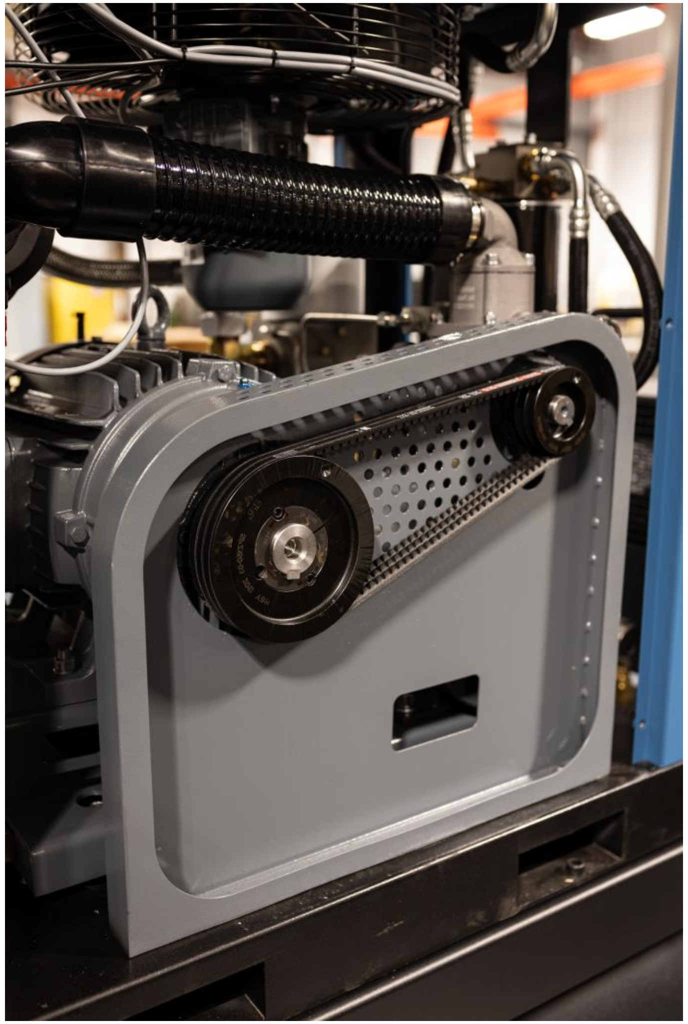
Thermal Energy

Blower Purge

Grounding Tabs

- Use proper safety gloves when working on hot equipment!
- Extremely hot surfaces should have insulation
- Thermal energy = 

Mechanical Energy



- Mechanical guards
  - Coupling guards
  - Fan guards
  - Belt guards

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How are Safety and Maintenance related?

- A well-maintained system is generally a safe system
- What does good routine maintenance entail?
- Who is qualified to perform maintenance?
- Key maintenance points and frequency.

Good Routine Maintenance

- Rotary Screw Compressor
  - Oil/fluid maintenance is critical
    - ✓ *Routine oil sampling is like checking your blood pressure*
    - ✓ *TAN (total acid number) critical*
    - ✓ *Particle contamination*
    - ✓ *Water contamination*
    - ✓ *Chemical contamination*

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Lubricant Analysis Report

North America: +1-251-202-0577

0	1	2	3	4
NORMAL		ABNORMAL		CRITICAL

Viscosity & Acid Number

Particles and Water Content

Comments	Check for source of water contamination (SEALS, BREATHERS, FILL PORTS). Water is at a SEVERE LEVEL. Particle count is at a MINOR LEVEL. Barium is an additive in many transmission, gear and compressor oils; Please provide COMPONENT MODEL number to compare data to the correct standards for this component. Lubricant and filter change acknowledged.

Sample Approver Comments	16-Mar-2023	no changes

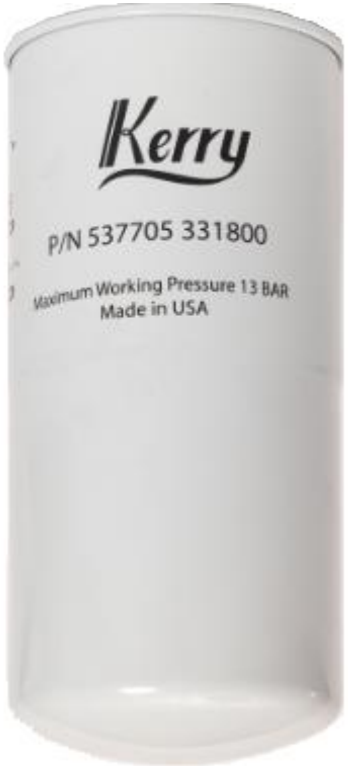
	Wear Metals (ppm)										Contaminant Metals (ppm)			Multi-Source Metals (ppm)						Additive Metals (ppm)				
Sample #	Iron	Chromium	Nickel	Aluminum	Copper	Lead	Tin	Cadmium	Silver	Vanadium	Silicon	Sodium	Potassium	Titanium	Molybdenum	Antimony	Manganese	Lithium	Boron	Magnesium	Calcium	Barium	Phosphorus	Zinc
BL	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	20	0
1	1	0	0	1	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0	6	25	34	7

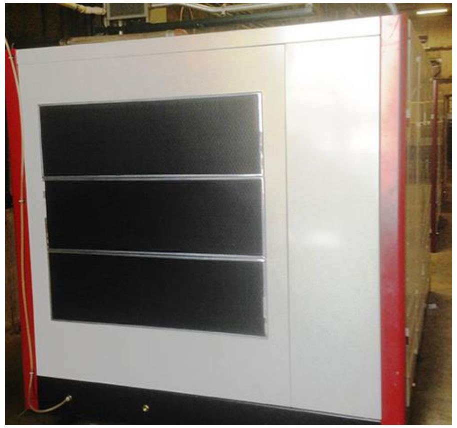
	Sample Information							Contaminants			Fluid Properties					
Sample #	Date Sampled	Date Received	Lube Time h	Unit Time h	Lube Change	Lube Added gal	Filter Change	Fuel Dilution %	Soot %	Water %	Viscosity 40°C cSt	Viscosity 100 °C cSt	Acid Number mg KOH / g	Base No. D4739 mg KOH / g	Oxidation abs / cm	Nitration abs / 0.1mm
BL	N/A	15-Jan-2021	0	0	Unk	0	Unk				46.9	8.3	0.02			
1	08-Mar-2023	15-Mar-2023	504	11869	Yes	0	Yes				47.7		0.45			

	Particle Count (particles/mL)										Additional Testing
Sample #	ISO Code Based On 4/6/14	> 4 particles / mL	> 6 particles / mL	> 10 particles / mL	> 14 particles / mL	> 21 particles / mL	> 38 particles / mL	> 70 particles / mL	> 100 particles / mL	Test Method	Water by Karl Fischer - mod. 6304C ppm
BL	19 / 16 / 11	2948	496	62	18	4	1	0	0	ASTM D7647	53
1	23 / 21 / 17	53202	16803	3641	1135	215	8	0	0	ASTM D7647	797

Good Routine Maintenance

- Rotary Screw Compressor
  - Filters that support long oil life
    - ✓ *Oil filter*
    - ✓ *Inlet air filter*
    - ✓ *Package air filtration*
    - ✓ *Air/oil separator element*
    - ✓ *Airborne contaminants (Installation)*

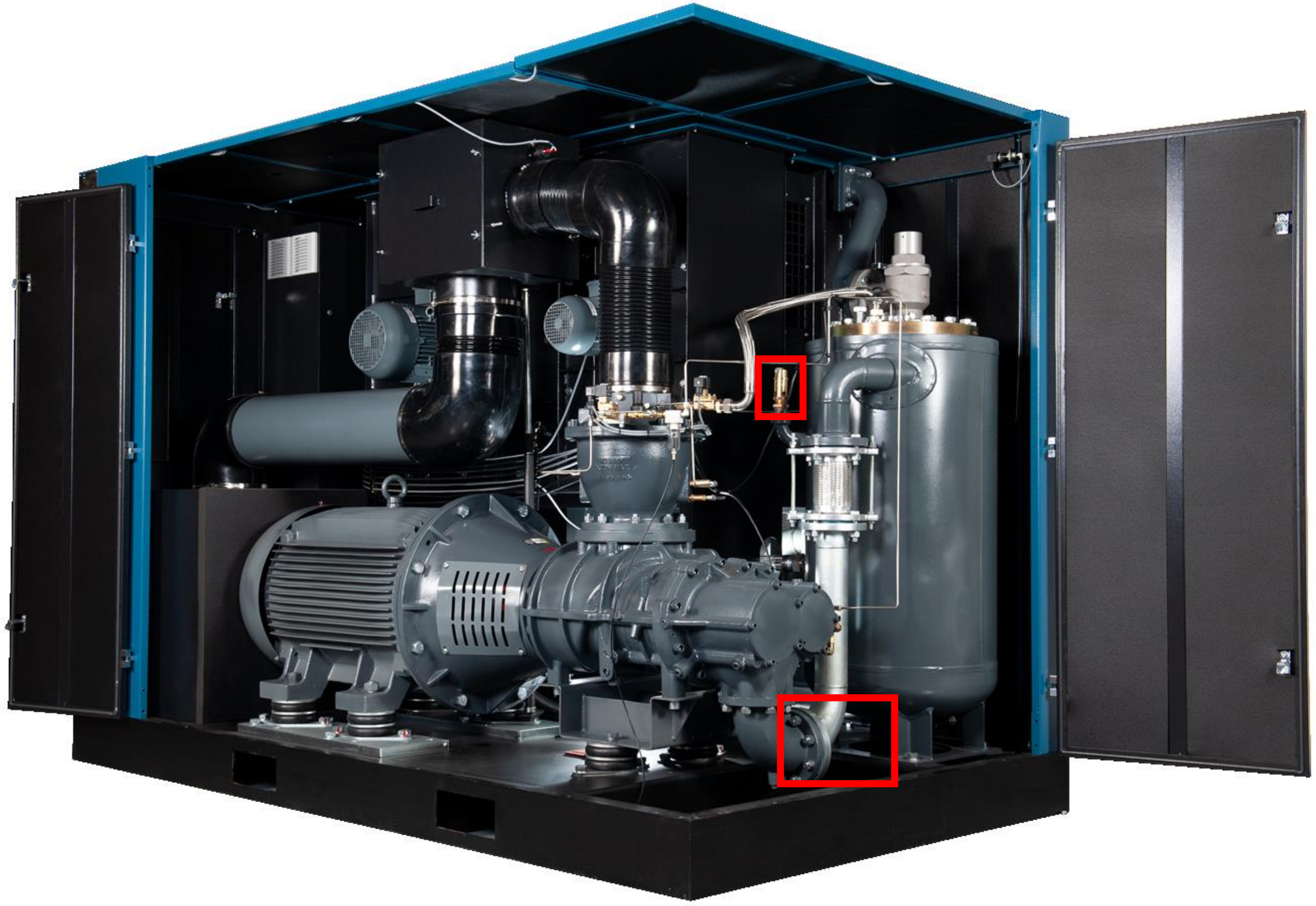




Good Routine Maintenance

- Rotary Screw Compressor
  - Safety device checks
    - ✓ *High discharge temperature shutdown*
    - ✓ *Pressure relief devices*
    - ✓ *Electrical connections*
    - ✓ *Chemical contamination*

Flir thermal image phone accessory



Discharge Temp probe

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Good Routine Maintenance

- Dryers & Contaminant Removal System
  - Compressed air filters to protect dryer
  - Final air filters for air quality to system
  - Condensate drains on dryers, tanks, filters
  - Pressure relief valves on tanks – test regularly!

Who is qualified to perform maintenance?

- Trained technicians – Distributor or Factory
- Trained in house maintenance
- PM contracts
- Extended warranties
- Use OEM filters, separators and fluids!

Frequency of Maintenance

- Daily checks
  - Visual inspection
    - ✓ *Leaks*
    - ✓ *Dirt*
    - ✓ *Drains*
    - ✓ *Airflow*
    - ✓ *Temperatures*
    - ✓ *Sounds*
    - ✓ *Amps*

- Quarterly Checks
  - Oil sample
  - Oil filter
  - Air filter
  - Package filter
  - Electrical inspection
  - Thermal imaging
  - CRS filter DP
  - Drains all working properly

- Annual Checks
- Quarterly plus:
  - Oil change
  - Separator change
  - HATS check
  - PRV checks
  - CRS filter changes

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Conclusions:

- Safety is #1 priority
- Every system is different
- Know your safety weak points
- Work with an expert vendor or local distributor trained in compressed air systems.
- I'll be glad to help you with your analysis – contact me.

Thank You

Dave George – Kaishan USA
239-213-8797
dgeorge@kaishanusa.com
www.kaishanusa.com

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Best Practices EXPO Contest

Play for a chance to win a **FREE Full Conference Pass** to the Best Practices 2023 EXPO & Conference!! This is a $675 value! This contest is open to factory personnel, compressed air distributors, utility incentive programs and engineering firms. Exhibiting and sponsor companies are not qualified. Winners will be randomly selected from those who submitted a correct answer and notified tomorrow via email.

Please submit your answer in the upcoming poll

What is impacted by Compressed Air as a Process Variable?

A
- Product Quality

B
- Product Safety

C
- Productivity

*By entering you are giving permission to announce your name if you are a winner

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Compressed Air as a Quality/Safety Manufacturing Process Variable

Q&A

Please submit any questions through the Question Window on your GoToWebinar interface, directing them to Compressed Air 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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Thank you for attending!

The recording and slides of this webinar will be made available to attendees via email later today.

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

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Andy Smiltneek
Growth Solutions Consultants
Keynote Speaker

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