
Understanding and Calculating Air Compressor Specific Power

Loran Circle, Compressed Air
Systems Training
Keynote Speaker

The recording and slides of this webinar will be made available to attendees via email within 2 days.

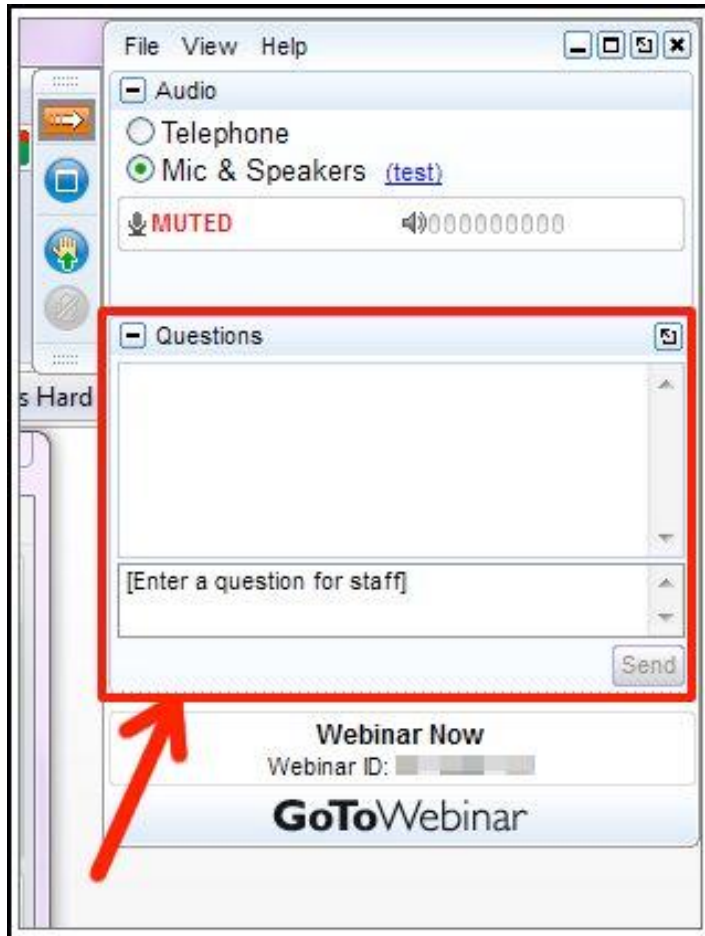
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Q&A Format




- 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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Handouts




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Compressed Air System Management

Sigma Air Manager 4.0
Key technology for Industry 4.0

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100
1919 - 2019
MAKING AIR EFFICIENT




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CAGI Data Sheets

An apples to apples performance comparison

Werner Rausch, Compressors Product Manager
Kaeser Compressors, Inc.



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Additional resources

Looking for more information on compressed air topics? Check out the following resources below:

- ✓ www.kaesertalksshop.com
- ✓ us.kaeser.com/cagi
- ✓ us.kaeser.com/resources - compressed air resources including white papers, e-books, archived webinars, the [Kaeser Toolbox](#), and more

Reliable, Safe and Energy/Water-Efficient Systems Powering Automation

COMPRESSED AIR BEST PRACTICES

airbestpractices.com



Food Packaging

Food & Beverage Processing & Packaging Machinery Feature

14 Schoenck Containers Leaves No Stone Unturned with Compressed Air

20 Achieving "Technically Oil-Free" Compressed Air

30 Microbiological Testing for Compressed Air in Food Plants

38 Reciprocating Air Compressor Maintenance

May 2021

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Understanding and Calculating Air Compressor Specific Power

Introduction

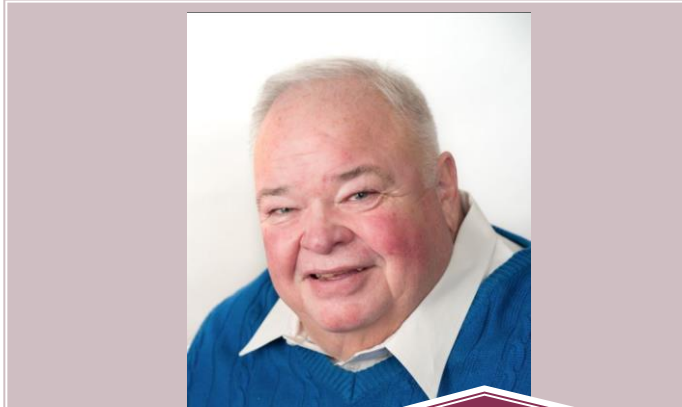
Compressed Air Best Practices® Magazine

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About the Speaker



Loran Circle

Compressed Air Systems Training

- Compressed Air Systems Sales Training
- Design and Consulting of Compressed Air Systems
- Certified DOE AirMaster+

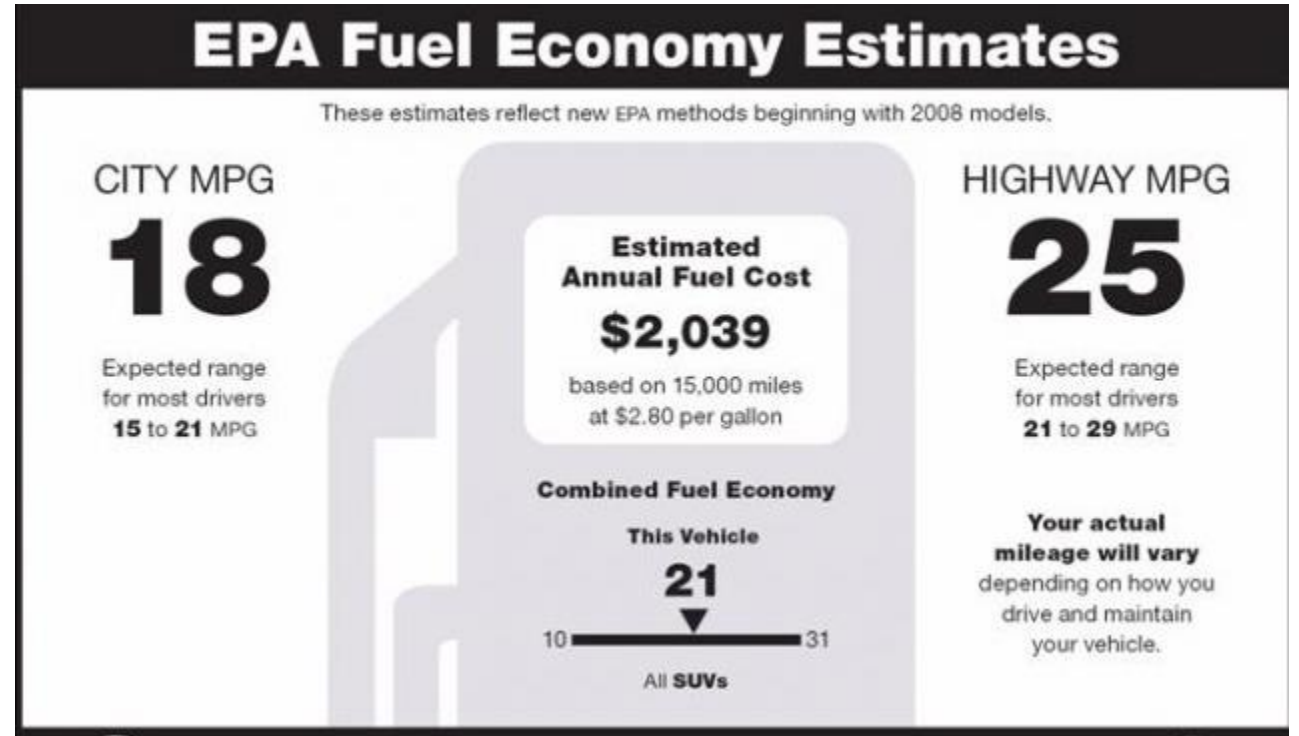
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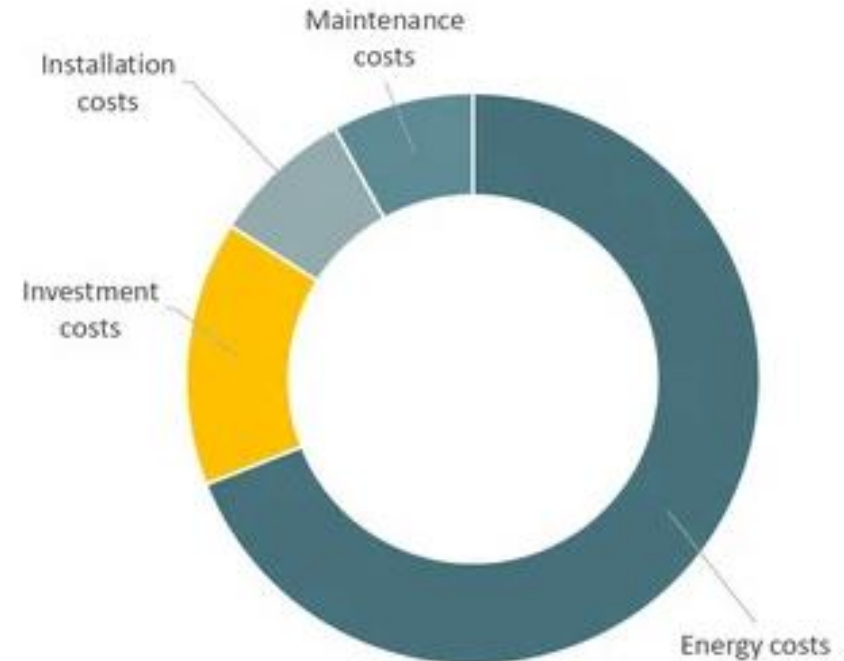
What is Specific Power?

- Specific power is like a gas mileage rating on vehicles. Air Compressors specific power tech data sheets shows the ratio of the total package power input kW of a complete compressor package, including cooling fans, pumps, and other electrical loads for every 100 cfm of output.



Why It Matters?

- Energy costs are the highest costs of ownership of an air compressor
- An air compressor is an **Energy Conversion Machine**
- Electricity is used to generate HP then the HP is converted to compressed air where then you use that energy to drive your equipment.
- The idea is not to put in \$100 worth of electricity and only get \$50 worth of productivity.



Example

- 50 HP compressor average price \$16,000
- HP + Service factor $50 \times 1.1 = 55$ HP
- $55 \times .746 / \text{Motor Efficiency rating } (.94) = 43.65$ kWh
- Cost per kWh = \$.10/ kWh
- 8000 hours $\times 43.65$ kWh \times \$.10 = **\$34,920.00 in energy costs for one year!**
- Fixed speed 50 HP compressors energy cost will **EXCEED** the cost of the compressor in the first 6 months running triple shift.

How YOU Can Measure and Use Performance In Your Compressor Decisions

- Use the CAGI data sheets for information for specific power comparisons.
- It is available at www.cagi.org under performance verification.
- Data Sheets - Performance Verification/Data Sheets/Manufacturers/Model

COMPRESSOR DATA SHEET
In Accordance with Federal Uniform Test Method for Certain Lubricated Air Compressors
Rotary Compressor: Fixed Speed

MODEL DATA - FOR COMPRESSED AIR

1	Manufacturer: ABC Compressor		
2	Model Number: 12A 22B 40 - 125 psig / 460V/3ph/60Hz	Date: 8/12/2019	
	<input checked="" type="checkbox"/> Air-cooled <input type="checkbox"/> Water-cooled	Type: Screw	
		# of Stages: 1	
3*	Rated Capacity at Full Load Operating Pressure ^{a, e}	175.0	acfm^{a, e}
4*	Full Load Operating Pressure ^b	125	psig^b
5	Maximum Full Flow Operating Pressure ^c	125	psig^c
6	Drive Motor Nominal Rating	40	hp
7	Drive Motor Nominal Efficiency	93.6	percent
8	Fan Motor Nominal Rating (if applicable)	1.3	hp
9	Fan Motor Nominal Efficiency	80	percent
10*	Total Package Input Power at Zero Flow ^e	9.1	kW^e
11	Total Package Input Power at Rated Capacity and Full Load Operating Pressure ^d	36.12	kW^d
12*	Package Specific Power at Rated Capacity and Full Load Operating Pressure ^e	18.69	kW/100 cfm^e
13	Isentropic Efficiency	72.77	Percent

*For models that are tested in the CAGI Performance Verification Program, these items are verified by the third party administrator. Consult CAGI website for a list of participants in the third party verification program: www.cagi.org

NOTES:

- Measured at the discharge terminal point of the compressor package in accordance with ISO 1217, Annex C; ACFM is actual cubic feet per minute at inlet conditions.
- The operating pressure at which the Capacity (Item 3) and Electrical Consumption (Item 11) were measured for this data sheet.
- Maximum pressure attainable at full flow, usually the unload pressure setting for load/no load control or the maximum pressure attainable before capacity control begins. May require additional power.
- Total package input power at other than reported operating points will vary with control strategy.
- Tolerance is specified in ISO 1217, Annex C, as shown in table below:

NOTE: The terms "power" and "energy" are synonymous for purposes of this document.

Volume Flow Rate at specified conditions		Volume Flow Rate	Specific Energy Consumption	No Load / Zero Flow Power
m ³ / min	ft ³ / min	%	%	%
Below 0.5	Below 17.6	+/- 7	+/- 8	
0.5 to 1.5	17.6 to 53	+/- 6	+/- 7	
1.5 to 15	53 to 529.7	+/- 5	+/- 6	+/- 10%
Above 15	Above 529.7	+/- 4	+/- 5	

12/19 Rev 3 This form was developed by the Compressed Air and Gas Institute for the use of its members participating in the PVP. CAGI has not independently verified the reported data.

What Are The Steps?

- Start with determining your demand and pressure requirements by performing an “air audit”.
- Most distributors do audits of your plant air system
- There are also independents who can perform audits
- Determine a baseline for your system to show actual savings.
- Don’t fix anything before an audit.
- An audit of plant issues along with the specific power (CAGI data Sheets) Determine problem areas of your plant i.e. pressure losses, leaks etc.
- Identify your exact needs and match to data sheets.
- Once you have identified your demand and pressure requirement, along with correcting problem areas, now you are ready to execute a plan for your compressed air system.
- My BEST advice, Do not look at upfront Price!!! No matter what your budget, the difference in machine prices WILL be paid back in weeks with proper sizing and Specific Power Analysis.
- Price vs. Cost. You pay the PRICE once you pay the Cost over the lifetime of the machine.

Comparing Data Sheets

COMPRESSOR DATA SHEET
In Accordance with Federal Uniform Test Method for Certain Lubricated Air Compressors
Rotary Compressor: Fixed Speed

MODEL DATA - FOR COMPRESSED AIR

1	Manufacturer: [REDACTED]		
2	Model Number: 25hp-125psi	Date: 1/4/2021	
	<input checked="" type="checkbox"/> Air-cooled <input type="checkbox"/> Water-cooled	Type: Screw	
		# of Stages: 1	
3*	Rated Capacity at Full Load Operating Pressure ^{a, e}	574.2	acfm ^{a, e}
4*	Full Load Operating Pressure ^b	125	psig ^b
5	Maximum Full Flow Operating Pressure ^c	130	psig ^c
6	Drive Motor Nominal Rating	125	hp
7	Drive Motor Nominal Efficiency	95	percent
8	Fan Motor Nominal Rating (if applicable)	3.5	hp
9	Fan Motor Nominal Efficiency	89.5	percent
10*	Total Package Input Power at Zero Flow ^e	30.1	kW ^e
11	Total Package Input Power at Rated Capacity and Full Load Operating Pressure ^d	108.43	kW ^d
12*	Package Specific Power at Rated Capacity and Full Load Operating Pressure ^e	18.88	kW/100 cfm ^e
13	Isentropic Efficiency	79.54	Percent

*For models that are tested in the CAGI Performance Verification Program, these items are verified by the third party administrator.
Consult CAGI website for a list of participants in the third party verification program: www.cagi.org

NOTES:

- Measured at the discharge terminal point of the compressor package in accordance with ISO 1217, Annex C; ACFM is actual cubic feet per minute at inlet conditions.
- The operating pressure at which the Capacity (Item 3) and Electrical Consumption (Item 11) were measured for this data sheet.
- Maximum pressure attainable at full flow, usually the unload pressure setting for load/no load control or the maximum pressure attainable before capacity control begins. May require additional power.
- Total package input power at other than reported operating points will vary with control strategy.
- Tolerance is specified in ISO 1217, Annex C, as shown in table below:

NOTE: The terms "power" and "energy" are synonymous for purposes of this document.

Volume Flow Rate at specified conditions		Volume Flow Rate	Specific Energy Consumption	No Load / Zero Flow Power
m ³ / min	ft ³ / min	%	%	%
Below 0.5	Below 17.6	+/- 7	+/- 8	
0.5 to 1.5	17.6 to 53	+/- 6	+/- 7	
1.5 to 15	53 to 529.7	+/- 5	+/- 6	+/- 10%
Above 15	Above 529.7	+/- 4	+/- 5	

ROT 030.1

12/19 Rev 3 This form was developed by the Compressed Air and Gas Institute for the use of its members participating in the PVP. CAGI has not independently verified the reported data.

COMPRESSOR DATA SHEET
In Accordance with Federal Uniform Test Method for Certain Lubricated Air Compressors
Rotary Compressor: Fixed Speed

MODEL DATA - FOR COMPRESSED AIR

1	Manufacturer: [REDACTED]		
2	Model Number: 460V/3ph/60Hz	Date: 7/1/2020	
	<input checked="" type="checkbox"/> Air-cooled <input type="checkbox"/> Water-cooled	Type: Screw	
		# of Stages: 1	
3*	Rated Capacity at Full Load Operating Pressure ^{a, e}	595	acfm ^{a, e}
4*	Full Load Operating Pressure ^b	115	psig ^b
5	Maximum Full Flow Operating Pressure ^c	125	psig ^c
6	Drive Motor Nominal Rating	125	hp
7	Drive Motor Nominal Efficiency	96.2	percent
8	Fan Motor Nominal Rating (if applicable)	3 / 1	hp
9	Fan Motor Nominal Efficiency	89.5 / 82.5	percent
10*	Total Package Input Power at Zero Flow ^e	21.6	kW ^e
11	Total Package Input Power at Rated Capacity and Full Load Operating Pressure ^d	98.8	kW ^d
12*	Package Specific Power at Rated Capacity and Full Load Operating Pressure ^e	16.60	kW/100 cfm ^e
13	Isentropic Efficiency	86.47	Percent

*For models that are tested in the CAGI Performance Verification Program, these items are verified by the third party administrator.
Consult CAGI website for a list of participants in the third party verification program: www.cagi.org

NOTES:

- Measured at the discharge terminal point of the compressor package in accordance with ISO 1217, Annex C; ACFM is actual cubic feet per minute at inlet conditions.
- The operating pressure at which the Capacity (Item 3) and Electrical Consumption (Item 11) were measured for this data sheet.
- Maximum pressure attainable at full flow, usually the unload pressure setting for load/no load control or the maximum pressure attainable before capacity control begins. May require additional power.
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1.5 to 15	53 to 529.7	+/- 5	+/- 6	+/- 10%
Above 15	Above 529.7	+/- 4	+/- 5	

ROT 030.1

12/19 Rev 3 This form was developed by the Compressed Air and Gas Institute for the use of its members participating in the PVP. CAGI has not independently verified the reported data.

Final Steps

- Match up your demand and pressure requirements to a specific size of compressor.
- Use Specific Power to determine which compressor will have the lowest operating costs based on your audit findings.
- Now you can genuinely perform an analysis that includes hard number estimates for actual cost of operation.
- Order your choice compressor. Don't focus on PRICE focus on COST.
- Correct the issues found in your plant air audit.
- Install the machine.
- Do an after audit to determine ROI and cost/payback analysis.

Thanks For Attending

Understanding And Estimating Air Compressor Specific Power

Loran Circle
Compressed Air System Design and Consulting
Certified DOE AirMaster+

Contact information can be made through Compressed Air Best Practices

This and many other educational presentations are available online at
www.airbestpractices.com

Educational articles can be found for all your compressed air questions.
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About the Speaker



Werner Rauer
Kaeser Compressors

- Rotary Screw Compressors Product Manager, Kaeser Compressors
- Over 35 years of industry experience
- Active leader in CAGI, developing the widely used CAGI compressor performance datasheets
- Chairs CAGI's Engineering Committee for rotary/positive displacement compressors
- CAGI Certified Compressed Air System Specialist and has completed the DOE Compressed Air Challenge I and II

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The big picture in compressed air energy efficiency



Specific performance of the whole system

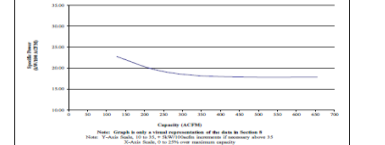
Limits of CAGI data sheets

- Based on fictional load profile
- Spec Perf changes with pressure
- Need to consider part load operations

COMPRESSOR DATA SHEET

In Accordance With Federal Uniform Test Method for Certain Lubricated Air Compressors
Rotary Compressor: Variable Frequency Drive
MODEL DATA - FOR COMPRESSED AIR

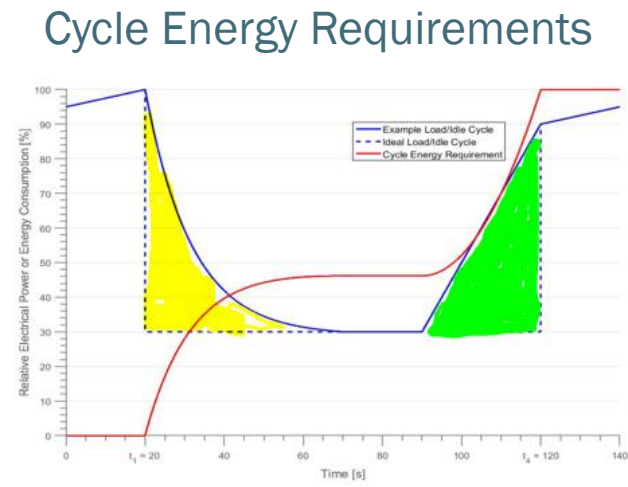
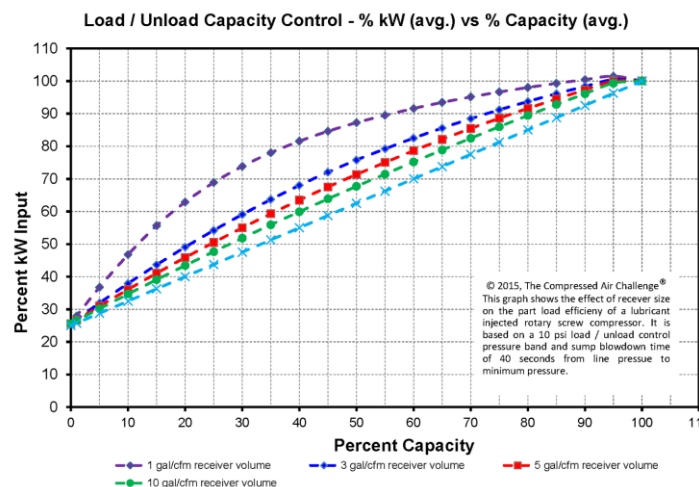
1	Manufacturer:	Kaeser Compressors, Inc.	
2	Model Number:	87C-90 - 128 psig / 400V/3ph/60Hz	Date: 07/01/20
	<input checked="" type="checkbox"/> Air-cooled <input type="checkbox"/> Water-cooled	Type:	Screen
3*	Full Load Operating Pressure:	128	psig
4	Drive Motor Nominal Rating:	128	hp
5	Drive Motor Nominal Efficiency:	96.2	percent
6	Fan Motor Nominal Rating (if applicable):	3 / 1	hp
7	Fan Motor Nominal Efficiency:	89.8 / 82.8	percent
	Input Power (kW)	Capacity (cfm) ¹	Specific Power (kW/100 cfm) ²
	117.0	17.56	6.65
	87.4	490	17.84
	61.4	337	18.22
	44.7	238	19.63
	32.9	137	22.76
9*	Total Package Input Power at Zero Flow ³ :	0.0	kW
10	Isentropic Efficiency:	82.88	%



COMPRESSOR DATA SHEET

Uniform Test Method for Certain Lubricated Air Compressors
Rotary Compressor: Fixed Speed
MODEL DATA - FOR COMPRESSED AIR

1	Manufacturer:	Kaeser Compressors, Inc.	
2	Model Number:	87C-90 - 128 psig / 400V/3ph/60Hz	Date: 7/1/2020
	<input checked="" type="checkbox"/> Air-cooled <input type="checkbox"/> Water-cooled	Type:	Screen
3*	Full Load Operating Pressure:	128	psig
4	Drive Motor Nominal Rating:	128	hp
5	Drive Motor Nominal Efficiency:	96.2	percent
6	Fan Motor Nominal Rating (if applicable):	3 / 1	hp
7	Fan Motor Nominal Efficiency:	89.8 / 82.8	percent
	Input Power (kW)	Capacity (cfm) ¹	Specific Power (kW/100 cfm) ²
	117.0	17.56	6.65
	87.4	490	17.84
	61.4	337	18.22
	44.7	238	19.63
	32.9	137	22.76
9*	Total Package Input Power at Zero Flow ³ :	0.0	kW
10	Isentropic Efficiency:	82.88	%



What affects system efficiency?

Proper sizing Control buffers Leaks

Filters Storage Drain type Piping

Flow range Inappropriate uses Dryer type

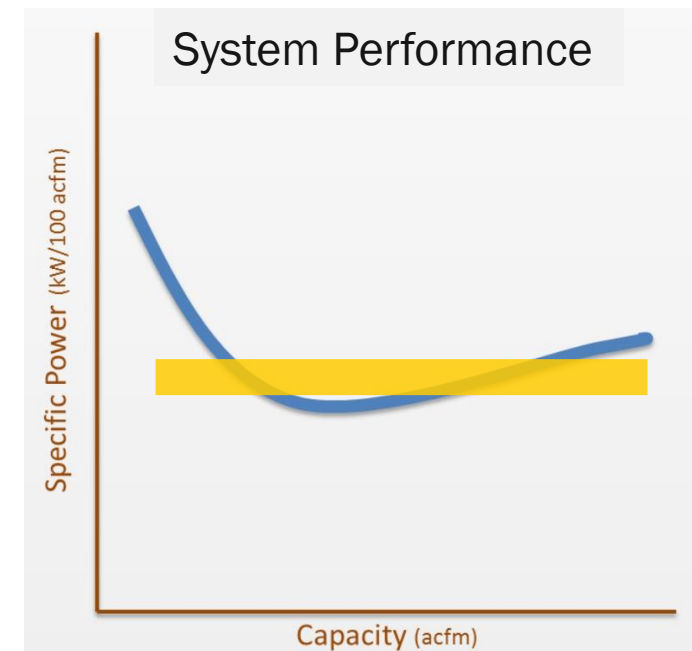
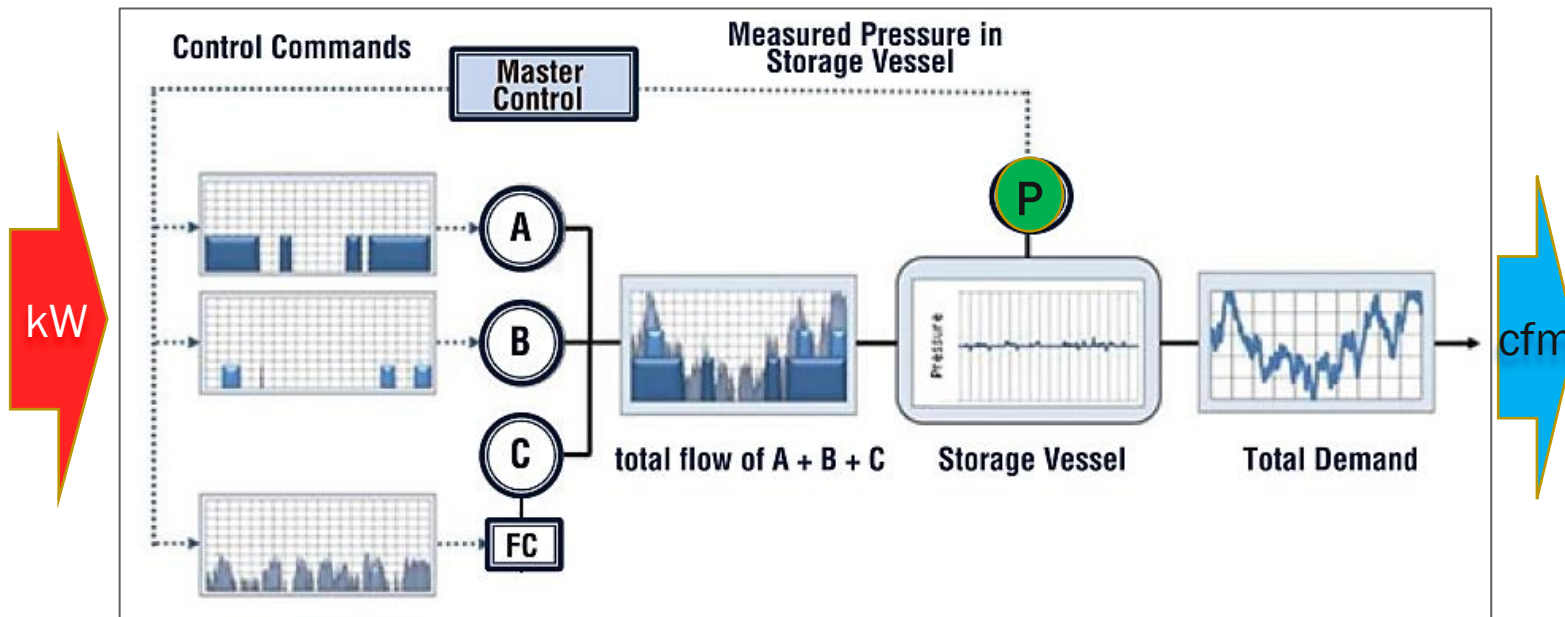
Efficiency of components System operation Pressure

Pressure drop Control types ISO 50001 process

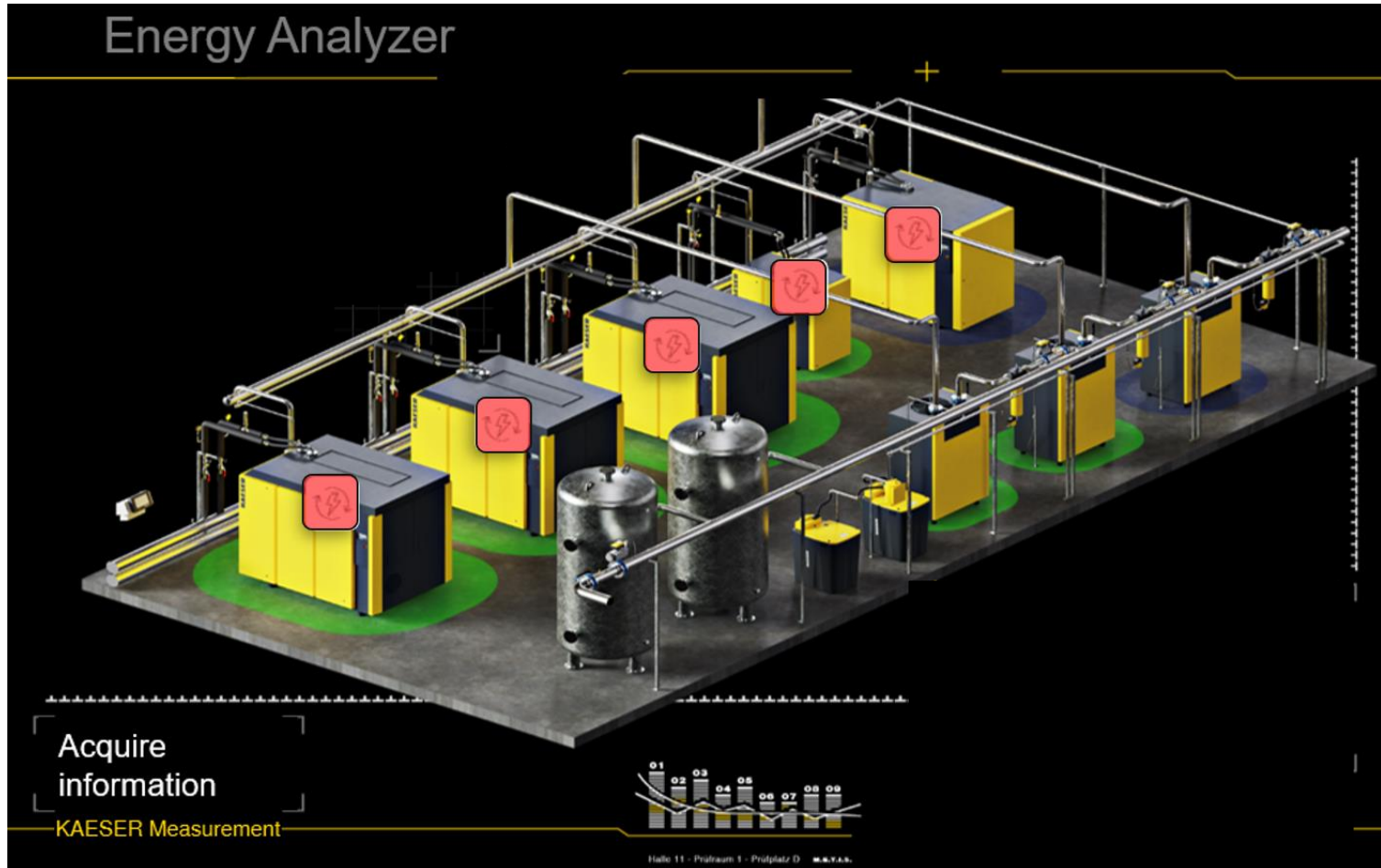
Artificial demand Cooling water Master controller

Specific power

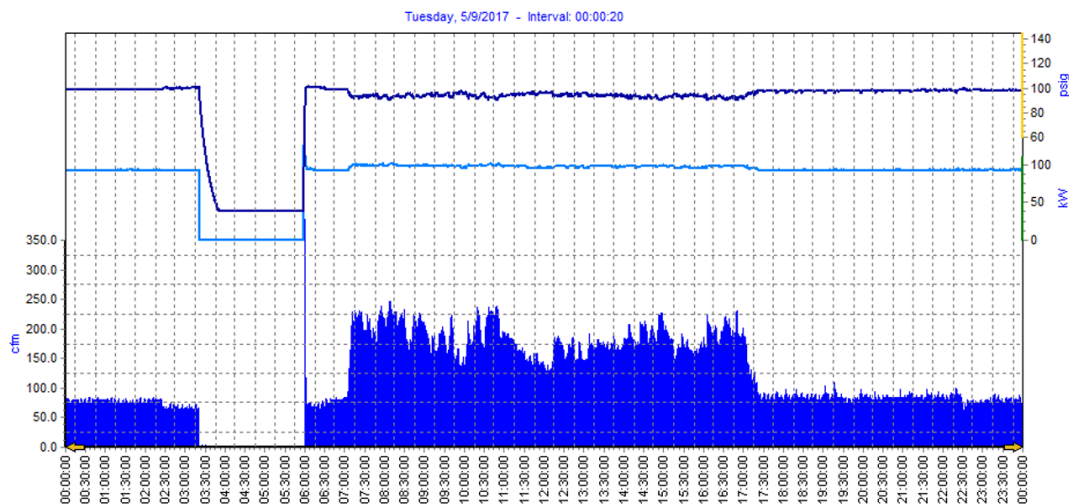
The ratio of **input power** to **compressed air flow rate** at a given **pressure** typically stated in units of **kW/100 cfm**. The lower the **specific power** the more efficient the **compressed air system** is at a given **compressed air load**.



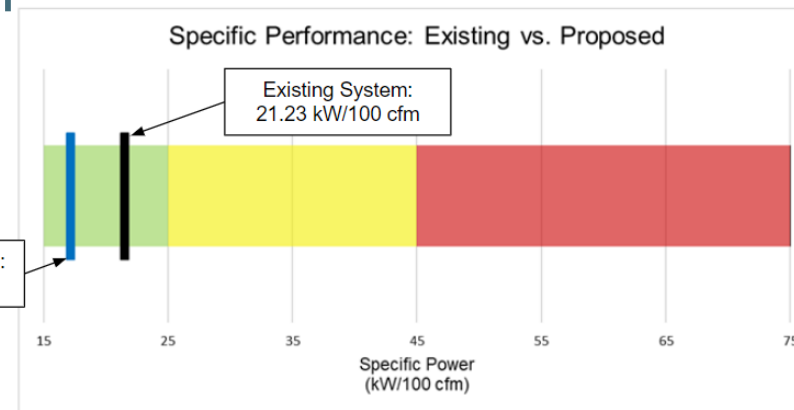
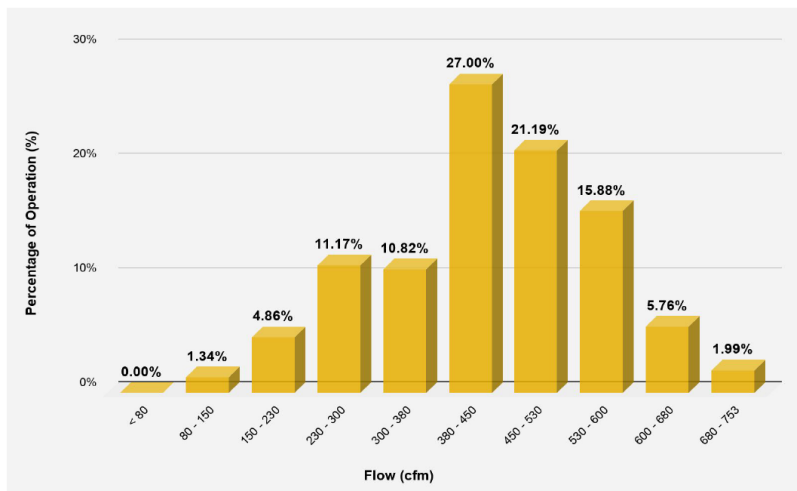
Audits



The power of measuring

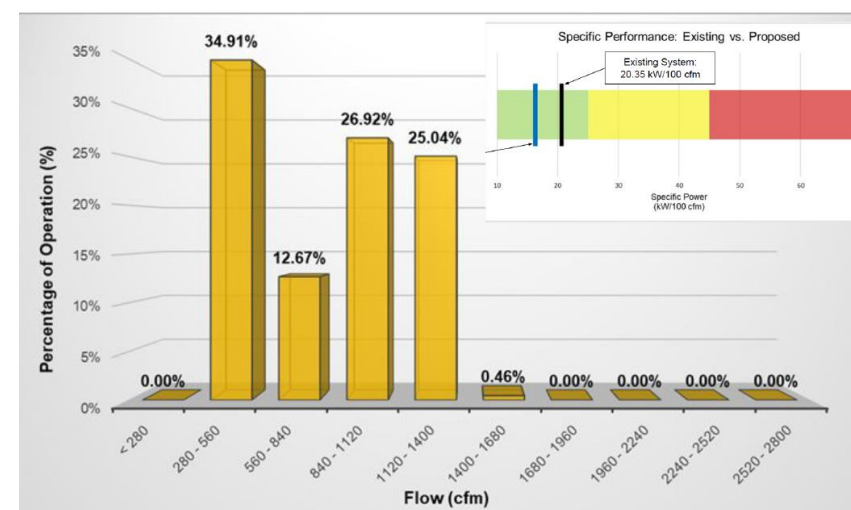
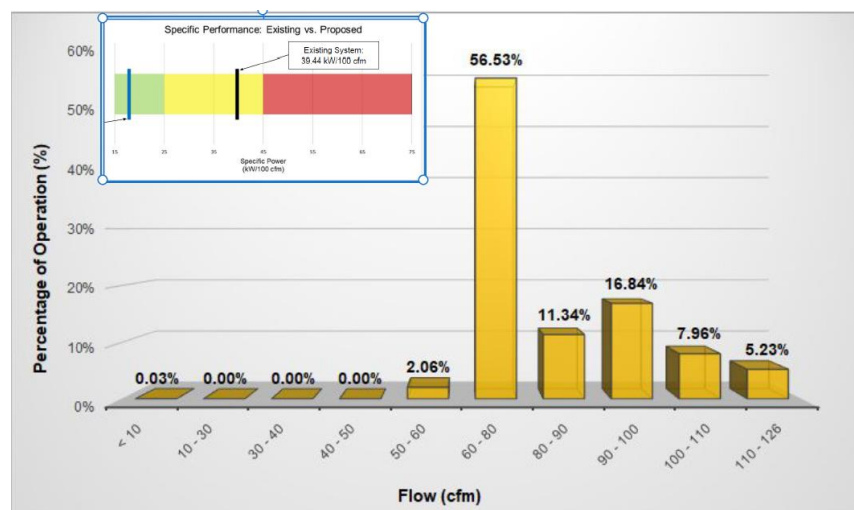
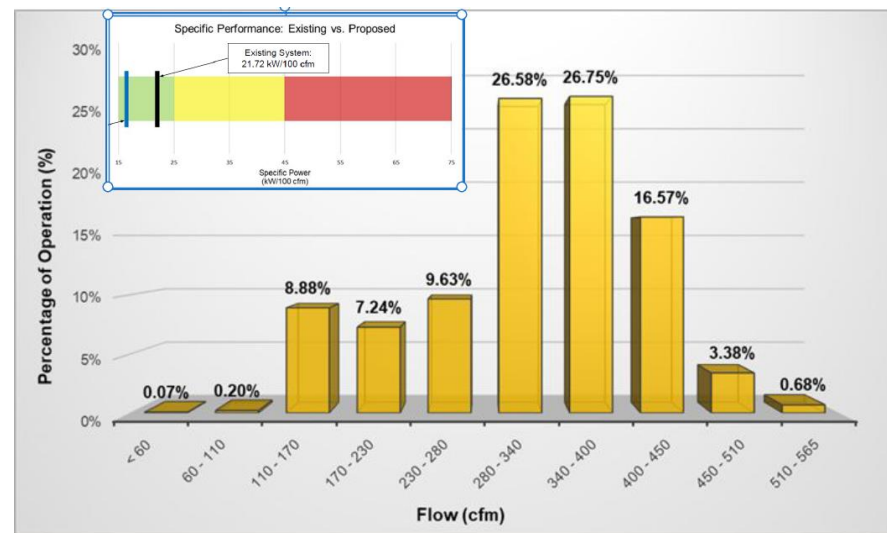
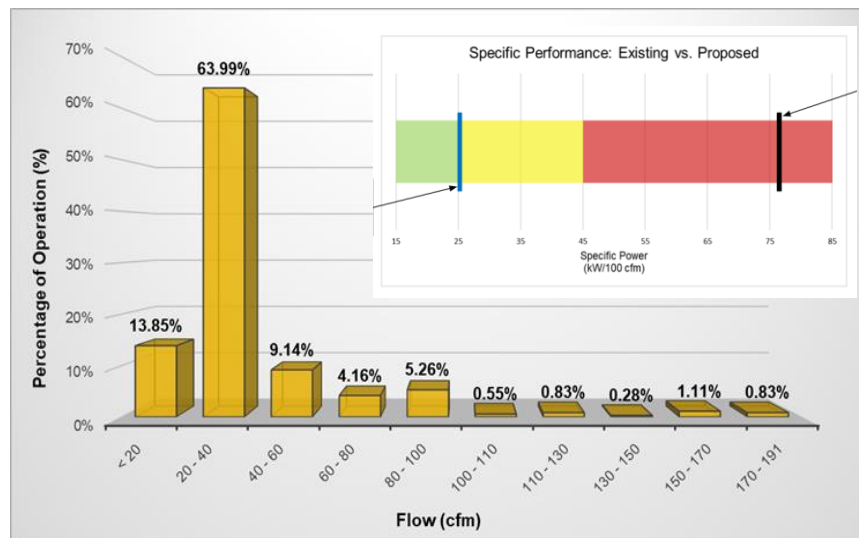


- An audit is the first thing you want to do to see the real specific power of the system
- Measure kW, flow, and pressure

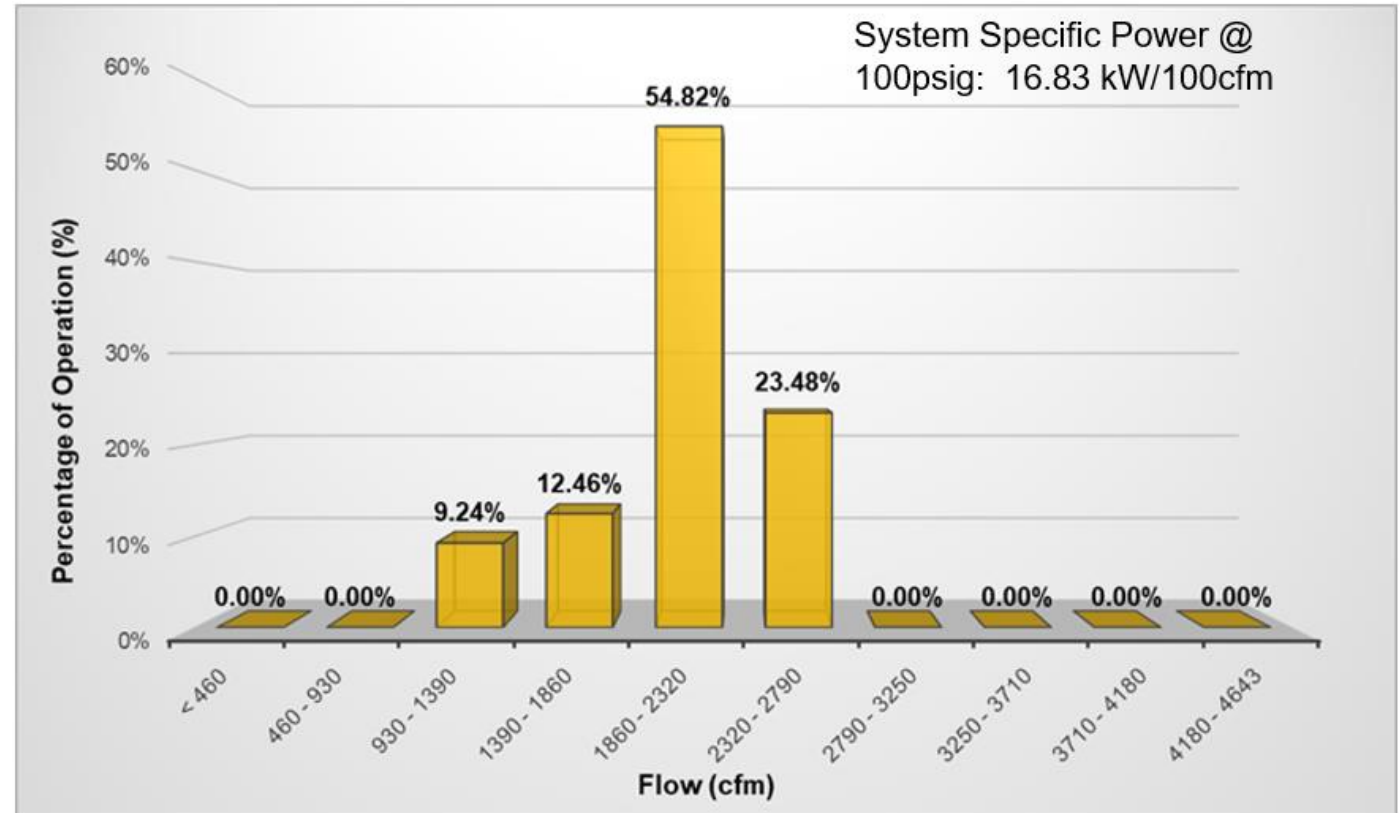
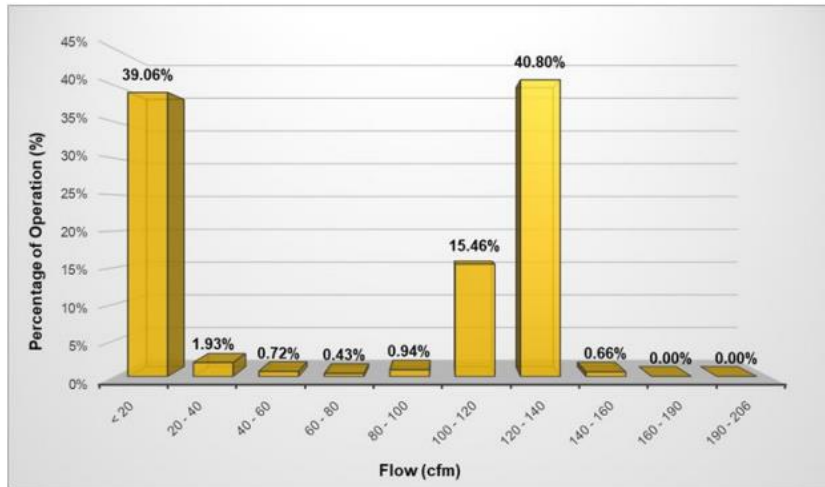
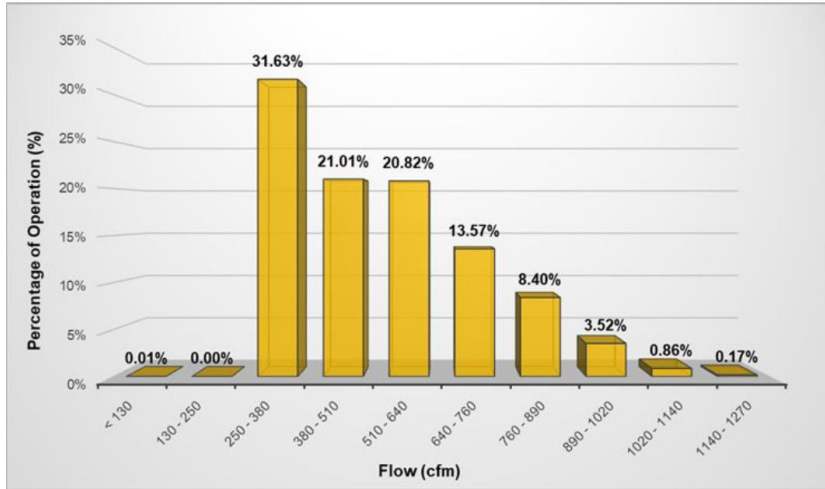


Specific Power Reduction: 19.1%
Energy Savings: \$33,522 per year

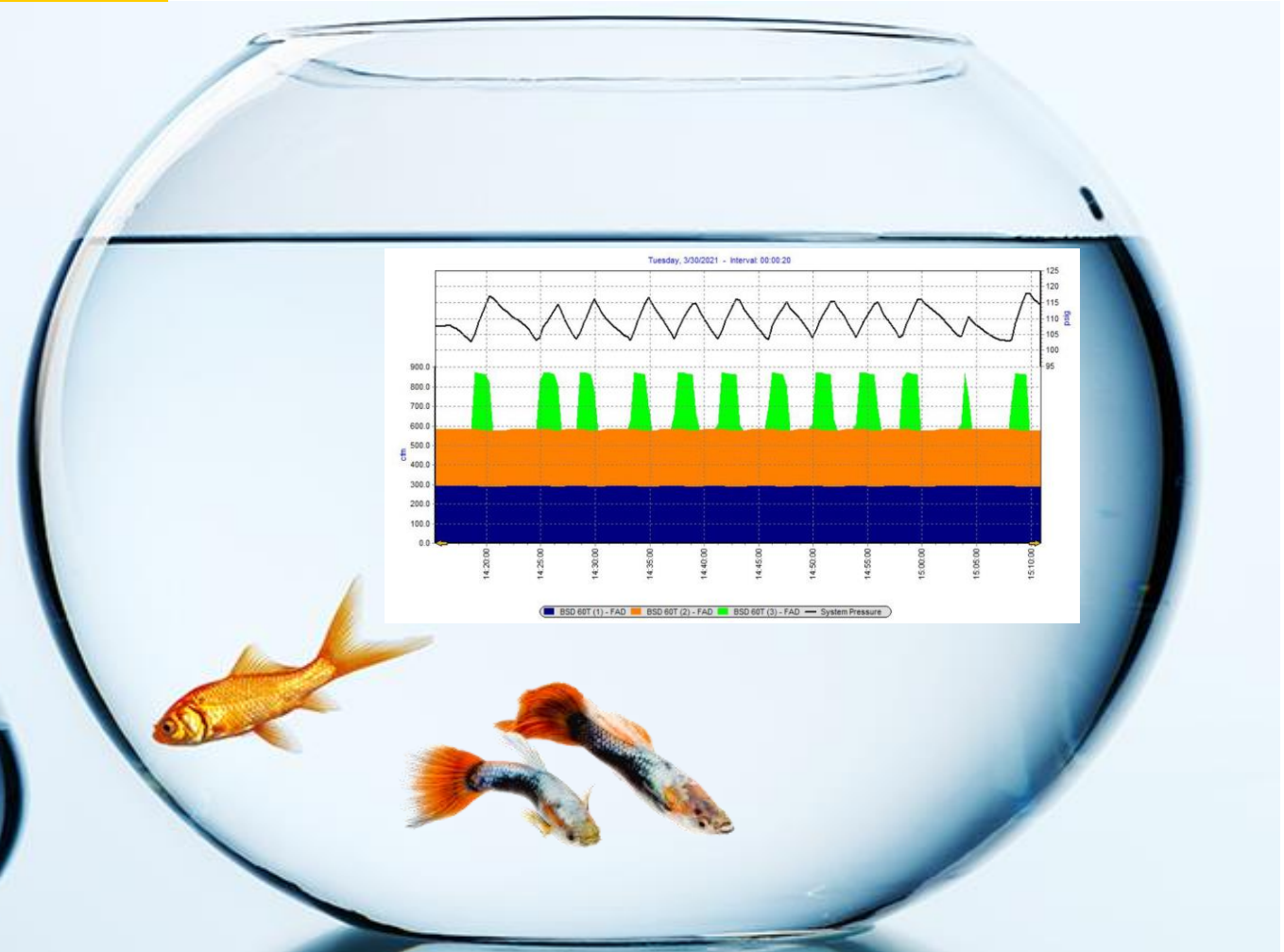
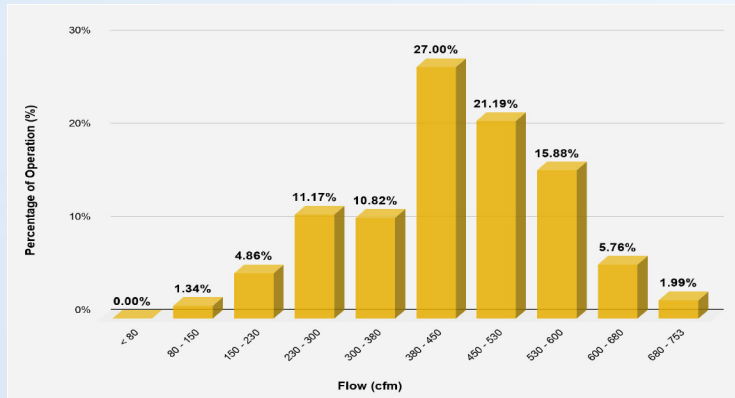
The power of measuring



The power of measuring



➔ Proper sizing



➔ Proper sizing


Development of a splitting concept

For minimizing idling time

System splitting
depending on air demand:

Shift 1	500 cfm
Shift 2	300 cfm
Shift 3	150 cfm

560 cfm +
560 cfm standby



Full load
portion:

~40%

2 x 280 cfm +
280 cfm standby



~60%

2 x 160 cfm + 280 cfm +
280 cfm standby



~95%

56 – 224 cfm + 140 cfm + 200 cfm +
200 cfm standby



~95%

Control types

System controls versus individual compressor controls

■ Individual Controls






- Safe, efficient internal unit supervision
- Maintenance-related information
- Various control types (e.g. Start/Stop; Load/Unload; Variable Modulation)

■ System Controls

- Monitors station
- Learns and adapts behavior
- Keep records and statistics
- Determines when, if, and which compressors to start, load, unload/trim, stop

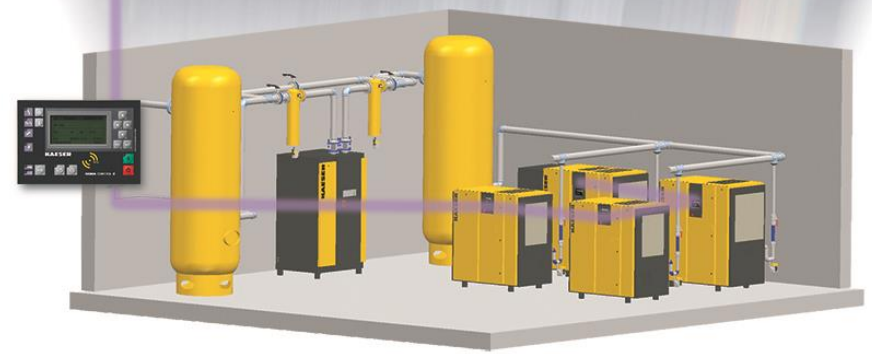
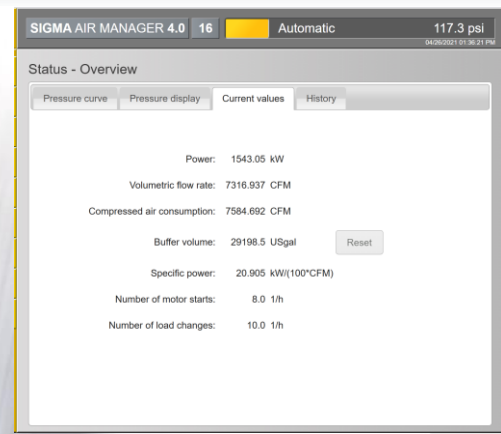
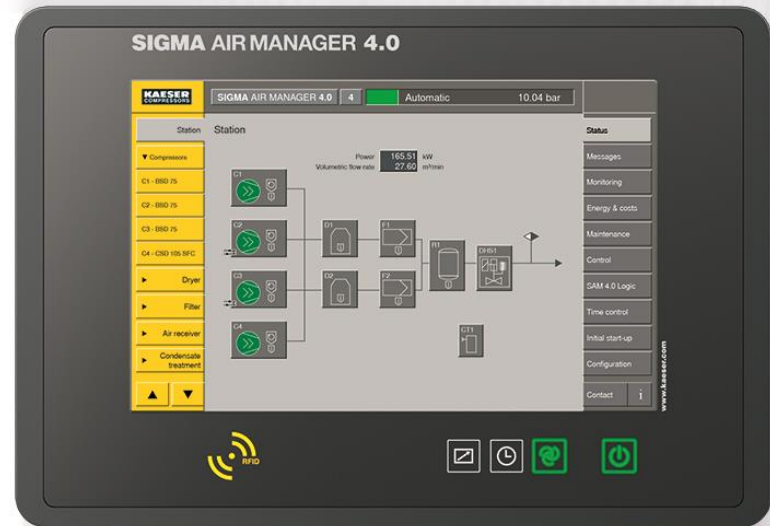


➔ **Master controller**

-  Tracking and logging
-  Analyze and learn
-  Unlimited options
-  Simulate and evaluate
-  Optimize the system



➔ **Master controller**



➔ Master controller

KAESER COMPRESSORS SIGMA AIR MANAGER 4.0 4 Automatic 101.8 psi 18.02.2019 12:17:47 Observation ACCESS MODE

Compressors

- C1 - BSD 60
- C2 - BSD 60
- C3 - CSD 100
- C4 - CSD 100

Start: 17.02.2019 12:16:00 End: 18.02.2019 12:16:00 Refresh

	Power consumption / kWh			Energy costs / \$		
	On load	Idle	Total	On load	Idle	Total
C1	441.99	7.89	449.88	22.10	0.39	22.49
C2	629.68	49.95	679.63	31.48	2.50	33.98
C3	907.46	9.08	916.54	45.37	0.45	45.82
C4	1117.94	6.86	1124.80	55.90	0.34	56.24
Compressed air generators	3097.07	73.78	3170.85	154.85	3.68	158.53
Total	3097.07	73.78	3170.85	154.85	3.68	158.53

Volume: 1048054 cu.ft

Specific power: 18.14 kW/(100*CFM)

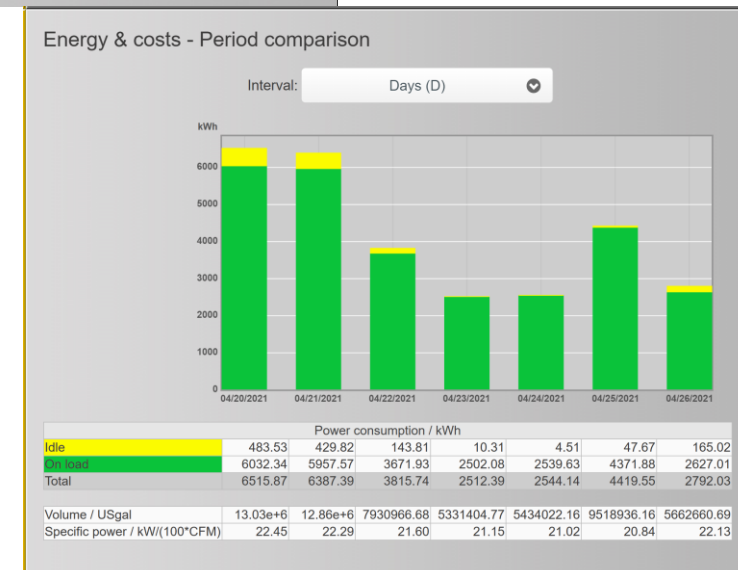
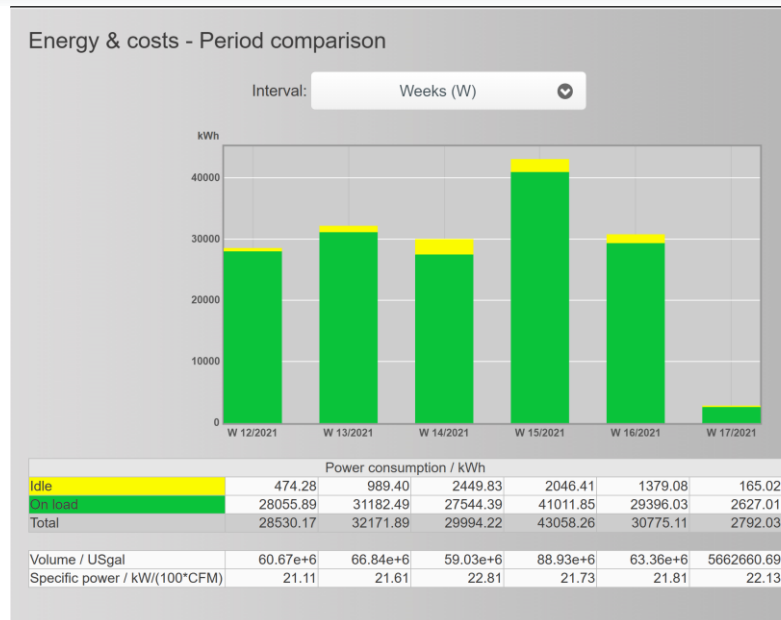
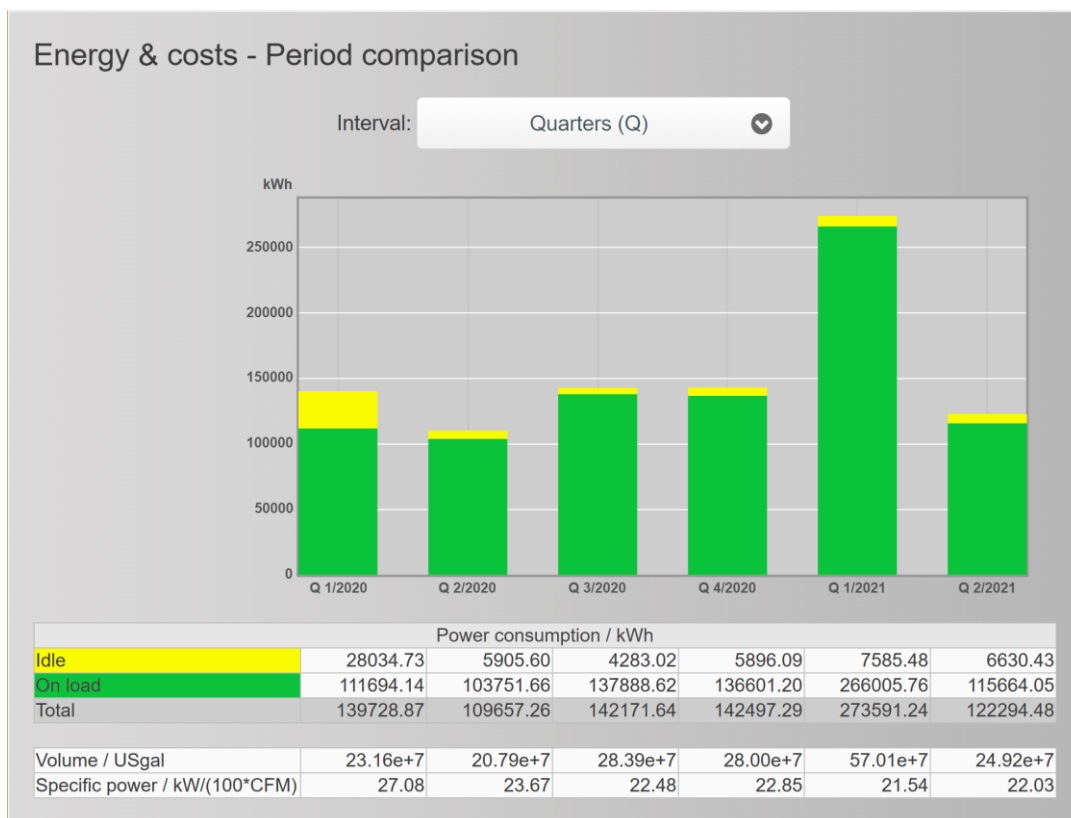
Compressed air index: 0.15 \$/1000cu.ft

Observation
 Status
 Messages
 Monitoring
 Energy & costs
 Control
 Time control
 Initial Start-up
 Configuration



Master controller

Specific power



Monitoring - Measurement data

Diagram

Setting analogue

Setting digital

8 hours / 40 secs.

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04/30/2021

06:56:40 PM

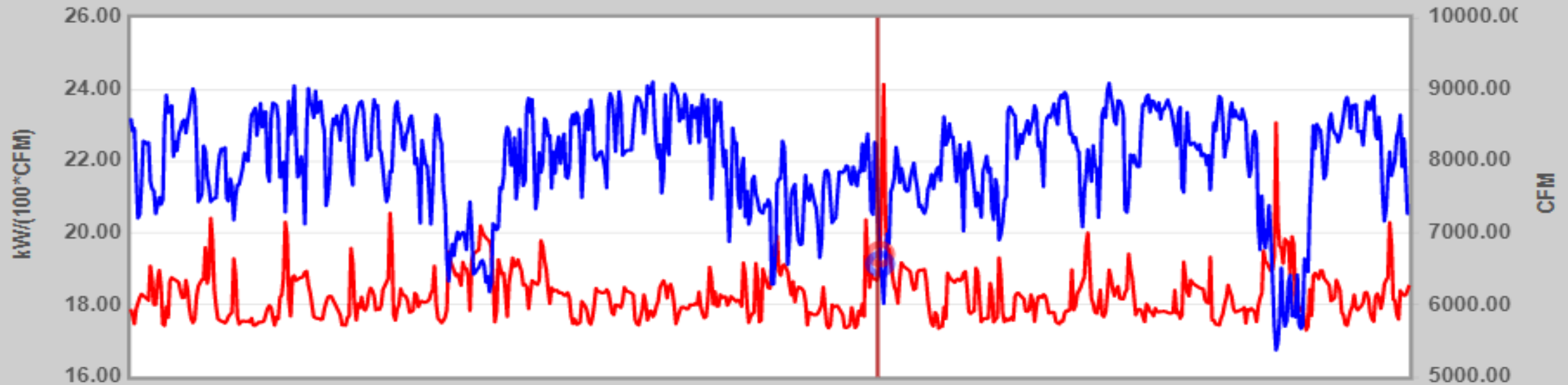
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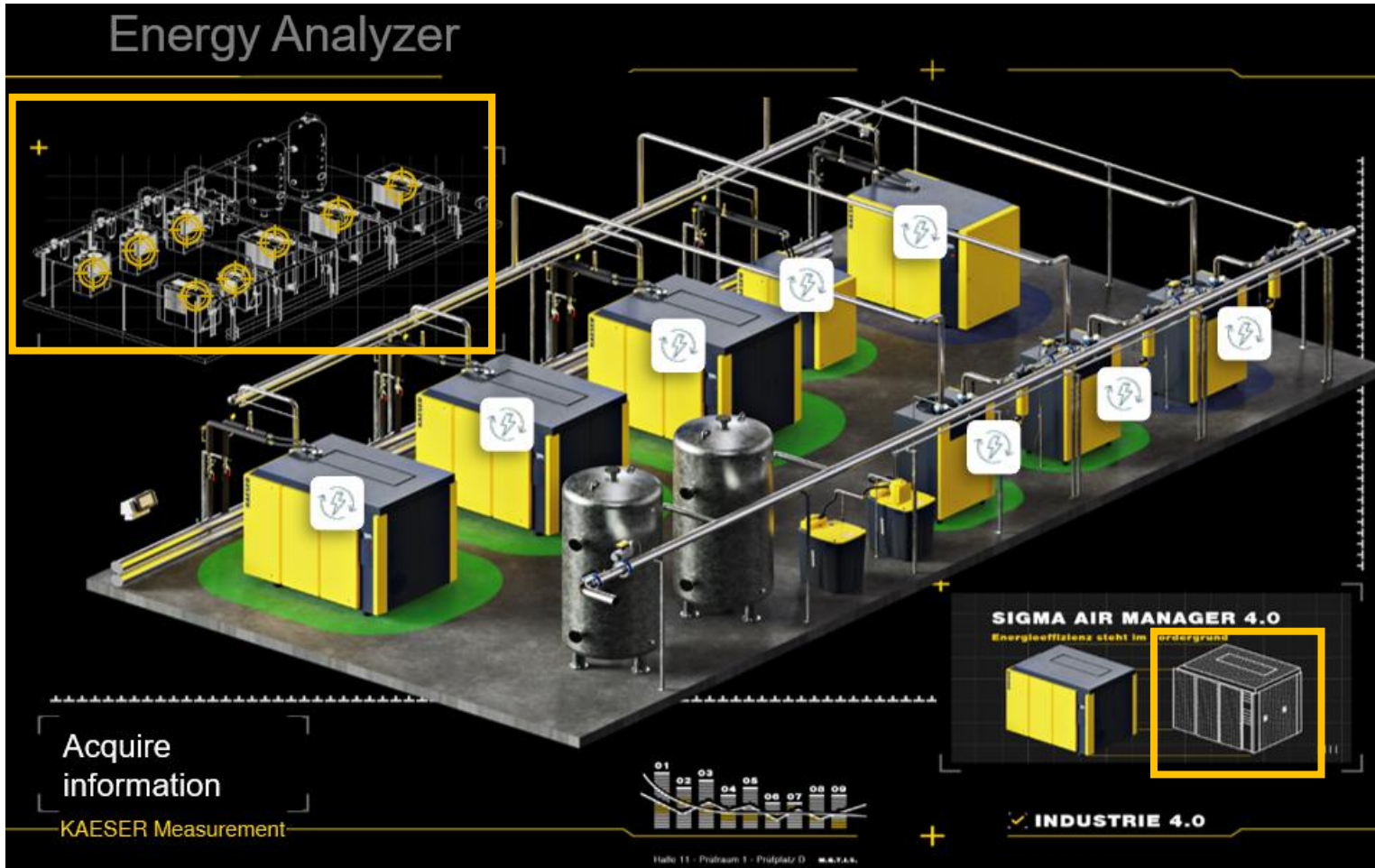
Page 1

CO1-SAM 4.0/Specific power
18.79 kW/(100*CFM)

CO1-SAM 4.0/Compressed air
consumption
7072.41 CFM



Ongoing measurement analysis



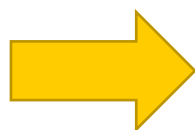
Compressed air production/generating efficiency

Audit

- Analyze
- Select types... Sizes. ...Control types --> be flexible
- Select master controller and algorithm
- Ongoing monitoring of the KPIs

Repeat:

- Analyze
- Optimize



Flexible systems lend well to low specific power, anytime (i.e., economic downturn or peak production)

Additional resources



Looking for more information on compressed air topics?
Check out the following resources below:

- ✓ www.kaesertalksshop.com
- ✓ us.kaeser.com/cagi
- ✓ us.kaeser.com/resources - compressed air resources including white papers, e-books, archived webinars, the Kaeser Toolbox, and more

Understanding and Calculating Air Compressor Specific Power

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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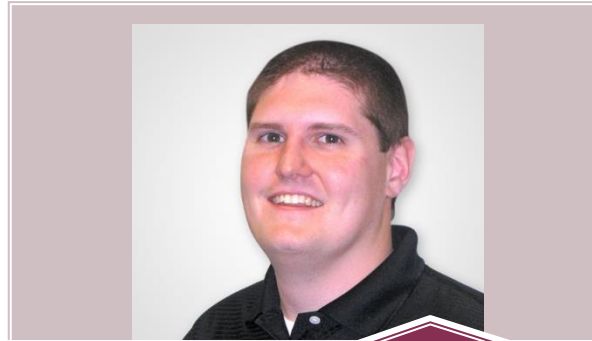
Thank you for attending!

The recording and slides of this webinar will be made available to attendees via email within 2 days.

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

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