Planning for Redundancy and Reliability in Critical Air Applications

Tim Dugan, P.E.
Compression Engineering Corporation
Keynote Speaker

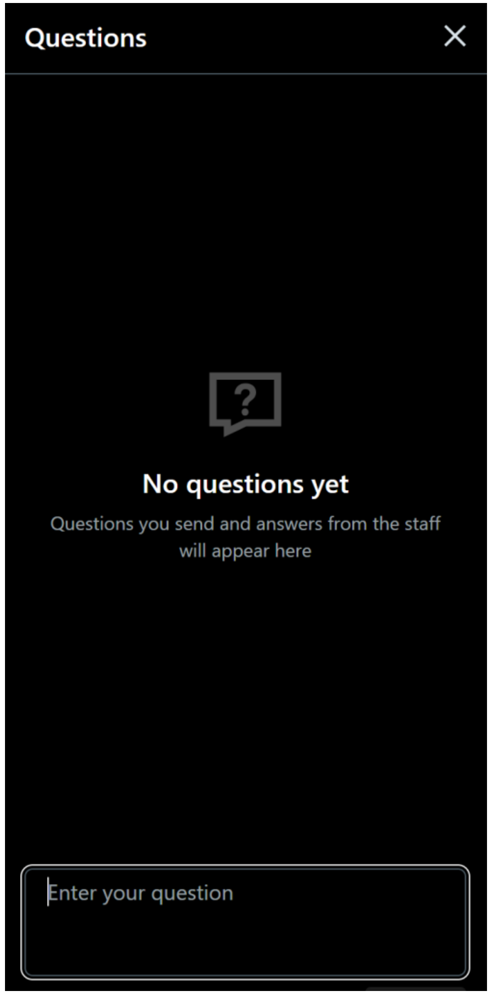
Sponsored by

KAISHAN

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

Q&A Format



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

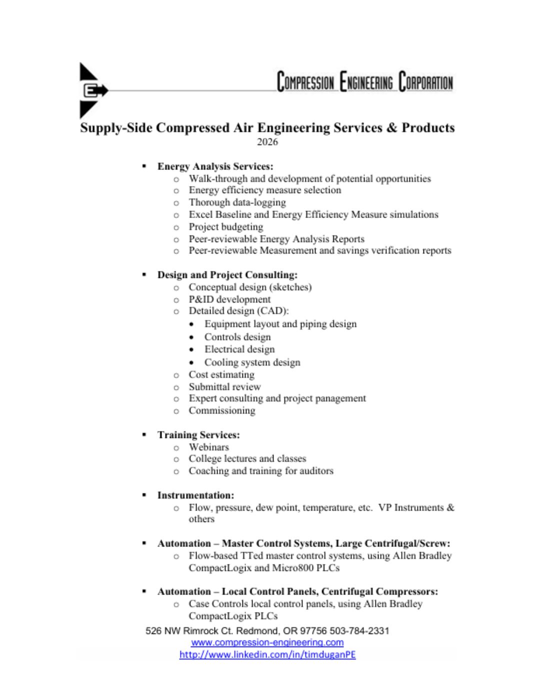
- Please post your questions in the Questions Window in your GoToWebinar interface.

- Direct all questions to Best Practices® Magazine

Sponsored by

KAISHAN

Handouts



Compression Engineering Corporation

Supply-Side Compressed Air Engineering Services & Products
2026

- **Energy Analysis Services:**
  - Walk-through and development of potential opportunities
  - Energy efficiency measure selection
  - Thorough data-logging
  - Excel Baseline and Energy Efficiency Measure simulations
  - Project budgeting
  - Peer-reviewable Energy Analysis Reports
  - Peer-reviewable Measurement and savings verification reports
- **Design and Project Consulting:**
  - Conceptual design (sketches)
  - P&ID development
  - Detailed design (CAD):
    - Equipment layout and piping design
    - Controls design
    - Electrical design
    - Cooling system design
  - Cost estimating
  - Submittal review
  - Expert consulting and project panagement
  - Commissioning
- **Training Services:**
  - Webinars
  - College lectures and classes
  - Coaching and training for auditors
- **Instrumentation:**
  - Flow, pressure, dew point, temperature, etc. VP Instruments & others
- **Automation – Master Control Systems, Large Centrifugal/Screw:**
  - Flow-based TTed master control systems, using Allen Bradley CompactLogix and Micro800 PLCs
- **Automation – Local Control Panels, Centrifugal Compressors:**
  - Case Controls local control panels, using Allen Bradley CompactLogix PLCs

526 NW Rimrock Ct. Redmond, OR 97756 503-784-2331
www.compression-engineering.com
http://www.linkedin.com/in/timduganPE

Disclaimer

All materials presented are educational. Each system is unique and must be evaluated on its own merits.

REGISTRATION NOW OPEN!

ULTRA EARLY BIRD RATES – ONLY 2 WEEKS LEFT!
Rates valid through January 31, 2026

Best Practices 2026 Expo & Conference

Indiana Convention Center - Indianapolis, Indiana

October 13–15, 2026

ULTRA EARLY BIRD PRICING

- EXPO Hall Pass: $35
- Full Conference Pass: $375

Register today at:
https://cabpexpo.com/

COMPRESSED AIR
BEST PRACTICES
airbestpractices.com

BEST PRACTICES
EXPO & CONFERENCE CABPEXPO.COM
COMPRESSED AIR / VACUUM / COOLING

Planning for Redundancy and Reliability in Critical Air Applications

Introduction by

Compressed Air Best Practices® Magazine

Sponsored by

KAISHAN

COMPRESSED AIR BEST PRACTICES airbestpractices.com

BEST PRACTICES EXPO & CONFERENCE CABPEXPO.COM
COMPRESSED AIR / VACUUM / COOLING

About the Speaker

Tim Dugan, P.E.
Compression Engineering Corporation

- President and Principal Engineer, Compression Engineering Corporation
- Over 38 years of experience in the industry
- 25 years of independent consulting experience

Sponsored by

KAISHAN

Outline

- Work Backwards from Critical Processes to Compressor Room:
  - Minimum Required Pressure & Quality, at Peak Flow
  - Regenerative Dryer Failures
  - VFD, Oil Free, and 2-stage Lubricated Compressor Failures
  - The Main Enemies
  - Neglected Root Causes of Failure
- Energy Efficiency Controls:
  - Which Reduce Redundancy and Reliability
  - Which Improve Redundancy and Reliability
- Best Practices System Designs for Reliability:
  - Best Practices, Controls
  - Best Practices, Mechanical

Work Backwards from Processes

- Minimum Required Pressure & Quality, at Peak Flow?
- Design for One System that meets the “Maximum of the Minimums”
- Avoid Separate Systems & Subsystems
- Minimize Points of Failure and Standardize Air Delivery
- Avoid Complex, Proprietary Pressure-flow Controllers
- When You do Pressure Control, Use High Grade Valve Like a Fisher, w-Properly Sized CV And Sufficient Delta P
- Use High Quality, Quick Acting Fail Open Valves for On-off
- Minimize Sensors, and Use Robust Ones
- Oversize Contactors
- Minimize Valves, Controllers, and POU Dryers

Regenerative Dryer Failures

- Regenerative Air Dryers Have More Points of Failure Than Compressors
- Valves Stick Open or Closed
- Valves Are Sluggish to Open
- Solenoids Fail (Esp Those That Are Always Energized Closed or Open)
- Sensors Fail, Esp Dew point
- Heaters and Contactors Fail
- Controllers and I-O Boards Fail
- Pressure Differentials Are High, and Highly Variable
- Rental Regenerative Dryers Are Harder to Find Than Compressors
- Technicians Who Understand Them Are Rare
- Why Then Are There So Many Systems with One Regenerative Dryer?
- Because Auditors and Sales Engineers Have Been Specifying Them!

VFD, Oil Free & 2-stage Lubricated Compressors Failures

- VFD Compressors Have More Points of Failure Than Fixed-speed Compressors
- Heat Loads Are Highly Variable – Thermal Cycling
- Oil Flows Are Highly Variable (lubricated compressors)
- Packaged VFDs and Controllers Overheat Easily
- Cabinet Fans Become Plugged on Packaged VFDs in Dirty Areas
- VFDs Are Undersized
- 2 Stage Lubricated Compressors Have 2X the Number of Bearings as 1-Stage
- Oil Free Compressors Have > 2X the Number of Bearings as Lubricated
- Why Then Are There So Many Systems with VFD, Oil Free and 2-Stage Lubricated Compressors?
- Because Auditors and Sales Engineers Have Been Specifying Them!

Root Causes of Most Dryer and Compressor Failure

- High Electrical/Electronic System Temperature: Fatigue & Cracking, Contact Corrosion Acceleration
- High Oil Temperature: Reduced Oil Life, Bearing Life
- Plugged Filters
- Vibration: Accelerates Cracking, Mechanical and Electrical Contact Failure, Loosens Fittings
- Controls Problems: Too Many Start/Stops, Too Rapid Load-unload Cycling

Poor Energy Efficiency Controls That Reduce Reliability

- Sequencers Are Typically Last In, First Out (LIFO)
- Sequencers Start, Stop, Load and Unload Compressors Based on Demand
- Sequencers Are Typically Not Type & Size Smart
- They Really Can Save Lots of Energy Over Constant Local Run – When Programmed and Tuned Properly
- However, They Can Reduce Reliability:
- No Feedback for Compressor % Load, Running Multiple Part-loaded
- Excessive Pressure Band, esp. to Bring in More Compressors at High Peak
- Excessive Starts & Stops Due to Pressure Rate of Change Logic
- Excessive Load-unload Cycling Caused by Pressure Flow Controllers (PFCs)
- Excessive Pressure From PFCs
- All of These Problems Cause Excessive Run Time From Potentially Redundant Compressor(s) and Increased Wear and Tear

Case Study of Unreliable Efficiency Controls

- No Master Plan
- Complex Piping From Several Consultant’s Ideas Over Time
- Fluid Cooling System Neglected by Compressor Vendor(s) and Consultant(s)
- Random Mix of Compressors From Several Vendor’s/Consultant’s Favorite Technologies
- Very Crowded Compressor Rooms
- Partial Automation From Firm That Wants to Replace All Local Controllers
- New Tech Compressors Failing
- Very Conservatively Set Automation, with “Old Reliable” Compressors Running Higher Priority Than New Tech

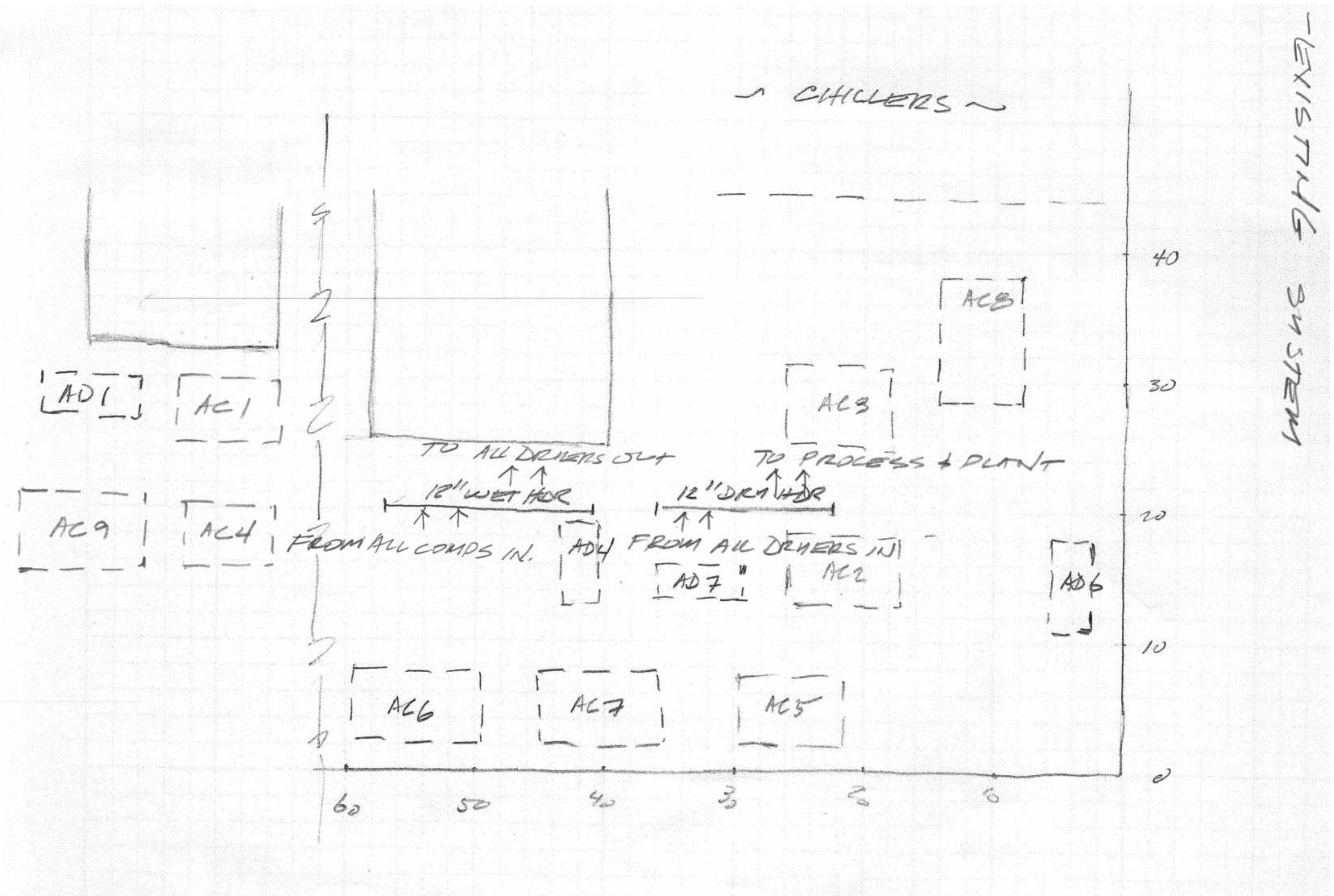
Case Study of Unreliable Efficiency Controls

COMP/ DRYER NO	DESCRIPTION	TYPE	MODEL	FULL LOAD CAPACITY, ACFM	MOTOR NAMEPLATE, HP	VOLTAGE	PRESSURE RATING	CONTROL MODE	CONTROL PANEL	DATE OF MFG	COMMENTS
AC1	Ingersoll Rand Centac	2-stage centrifugal, water-cooled	1CV12M2	1200	300	460	125	Inlet modulating with blow-off	Case AirLogix	1989	
AC2	Gardner Denver (Compair) Quantima	2-stage centrifugal, VFD, water-cooled	Q52-8.0W	1752	400	460	116	VFD, Inlet modulating with blow-off	OEM	2010	Blowing off
AC3	Ingersoll Rand Nirvana	2-stage oil-free rotary screw, water-cooled	IRN200H-OF	1050 (appx)	200	460	150	VFD	OEM	<10yrs old	Fails on second stage inlet temp, when temp is not high
AC4	AtlasCopco ZR	2-stage centrifugal, water-cooled	ZR110	660	150	460	110	load-unload	Case AirStar		
AC5	Gardner Denver (Compair) Quantima	2-stage centrifugal, VFD, water-cooled	Q52-8.0W	1807	400	460	116	VFD, Inlet modulating with blow-off	OEM	2015	
AC6	Ingersoll Rand Centac	2-stage centrifugal, water-cooled	1BCV14M2	1501	300	460	105	Inlet modulating with blow-off	Case AirLogix	2005	Surges at 105 psig
AC7	Ingersoll Rand Centac	2-stage centrifugal, water-cooled	1CV12M2	1235	7.5	460	100	Inlet modulating with blow-off	Case AirLogix	1997	
AC8	Gardner Denver	2-stage oil-free rotary screw, water-cooled	ENVTVS200	1200 (appx)	268	460	123	Load-unload	OEM	2018	
AC9	Ingersoll Rand TA-2000	3-stage centrifugal, water-cooled	TA2000	1500	350	460	125	Inlet modulating with blow-off	OEM (Maestro)		
AD1	Zeks	Cycling refrigerated	2400HSF	2400	11	460	100	Heat synch, cycling			
AD4	Zeks	Cycling refrigerated	2400HSF	2400	11	460	100	Heat synch, cycling			
AD7	Zeks	Cycling refrigerated	2400HSF	2400	11	460	100	Heat synch, cycling			
AD6	Zeks	Cycling refrigerated	2400HSF	2400	11	460	100	Heat synch, cycling			
TOTAL COMPRESSSORS				**11905**	**2376**						
TOTAL DRYERS				**9600**	**42**						

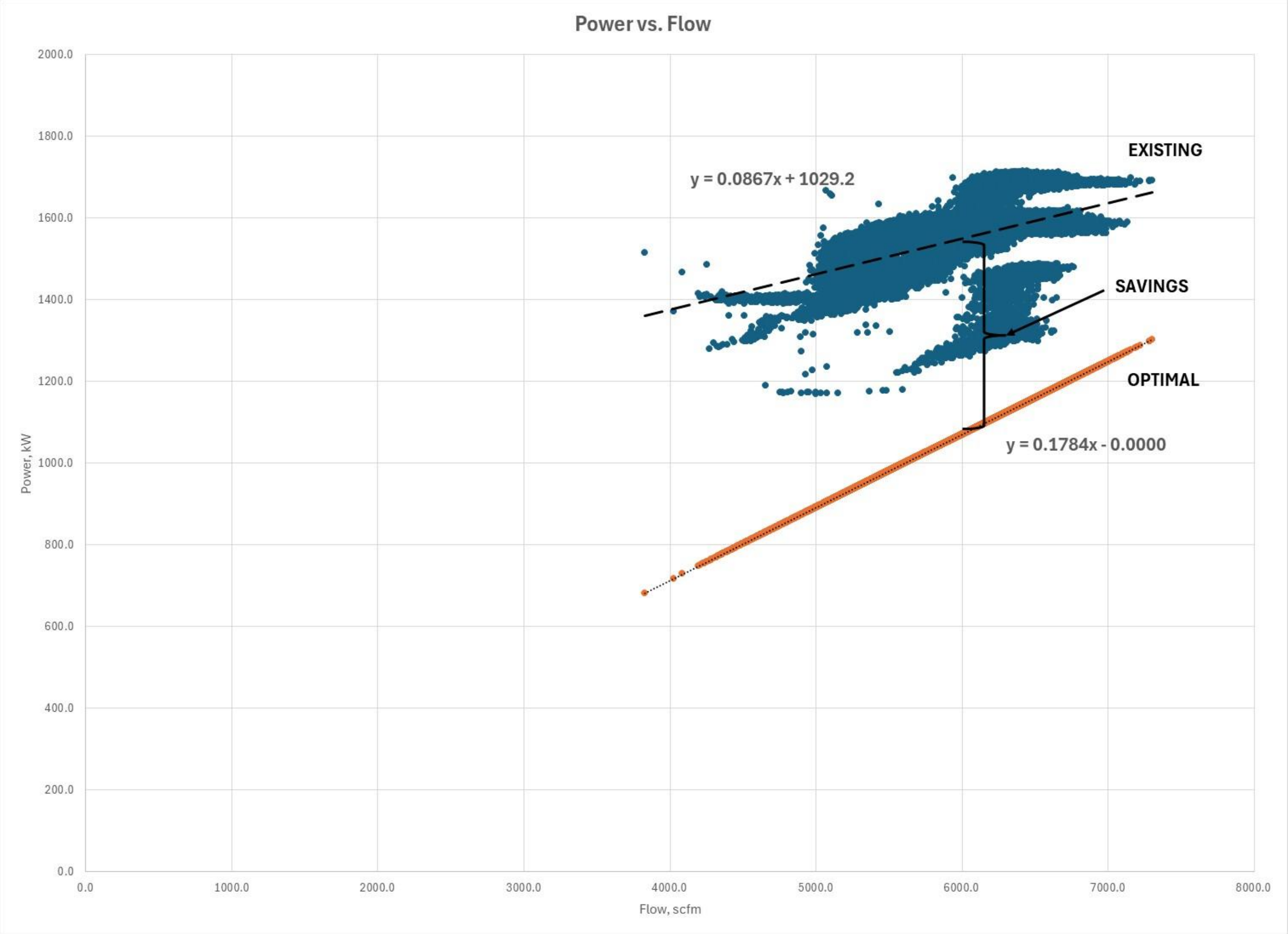
Case Study of Unreliable Efficiency Controls

BASELINE, 1WK OF DATA												
COMP NO	COMPRESSOR / DRYER DESCRIPTION	LOCATION	FULL LOAD CAPACITY, ACFM	AVERAGE COMP FLOW, SCFM	PEAK COMP FLOW FLOW, SCFM	AVERAGE DISCHARGE PRESSURE, PSIG	AVERAGE SYSTEM PRESSURE, PSIG	AVERAGE POWER, KW	PEAK POWER, KW	SPECIFIC EFFICIENCY, SCFM/KW	ENERGY CONSUMPTION, KWH/YR
AC1	IR Centac 2S Centrif 300hp	SE BOILER ROOM	1200	953	1466	107	101	245	253	3.89	2,146,879
AC2	Quantima 2S Centrif 400hp	NE BOILER ROOM	1752	737	824	107	101	236	285	3.13	2,065,925
AC3	IR VFD Screw 200hp	NE BOILER ROOM	1050	0	6539	107	101	0	0	#DIV/0!	-
AC4	Atlas ZR Screw 150hp	SE BOILER ROOM	660	261	624	107	101	52	126	5.05	451,680
AC5	Quantima 2S Centrif 400hp	NE BOILER ROOM	1717	1488	1670	107	101	267	295	5.57	2,341,525
AC6	IR Centac 2S Centrif 300hp	E CENTER BOILER ROOM	1501	353	696	107	101	215	262	1.65	1,879,471
AC7	IR Centac 2S Centrif 300hp	E CENTER BOILER ROOM	1235	1156	1241	107	101	238	247	4.85	2,086,636
AC8	GD Screw 200hp	SS P500 - FS Elliott	1200	0	0	107	101	0	0	#DIV/0!	-
AC9	IR TA2000 3S Centrif 350hp	SE BOILER ROOM	1482	1359	1621	107	101	266	287	5.11	2,329,554
AD1, 4, 6 & 7	(4) Zeks 2400 HSF Cycling Refrigerated Dryers	ALL OVER	9600					30	37		
	ESTIMATED COMP ROOM DRAINS/LEAKS	ALL OVER		-200	-200						
TOTAL COMPRESSOR ROOM OUTLET FLOW			**11797**	**6107**	**7076**	**107**	**101**	**1548**	**1715**	**3.94**	**13,301,671**
	Plant Flow Meter 1			1300	1853						
	Plant Flow Meter 2			1322	1545						
	Plant Flow Meter 3			2048	2439						
	Process Flow Meter 1			1260	1728						
	Process Flow Meter 2			55	98						
TOTAL FLOW METER FLOW				**5984**	**7301**						

Case Study of Unreliable Efficiency Controls



Case Study of Unreliable Efficiency Controls



Energy Efficiency Controls That Improve Reliability

- Piping and Storage Designed for Common Pressure Control Points w-o Dynamic Pressure Drops Between Compressors and Master Pressure
- Regenerative Dryers Tuned to Reduce/eliminate False Signals/Peaks
- Smart Master Controllers with Pre-Programmed Sets of Compressors for Each Rotation Scenario
- Staging Sets Based on Flow
- Flow Feedback from Compressors to Know They Are Efficiently Sharing the Load
- Real Time Pressure Control in Each Staging Set, Logically Based on Base & Trim
- Rotating Like-for-Like, Base and Trim
- Avoiding Base Compressor / Trim Compressor Rapid Shifts ("Control Gap")
- Load Up Sets of Compressors in Their "Sweet Spot", Avoiding Very Light Load

Energy Efficiency Controls That Improve Reliability

- Common Compressor Types/Brands (Base and Trim Sets)
- Common Local Control Panels (LCPs)
- Master Controller System (MCS) with Pre-Programmed Sets of Compressors for Each Flow Range & Failure Scenario
- LCPs Pre-Tuned to Accept Remote Commands From MCP And Respond Reliably
- Full HMI Integration to LCPs
- MCS Knows Which Are "Base", and Controls Their Set Points to Either "Load-Share" or be "100%"
- MCP Knows Which Are "Trim", and Controls Their Set Points/Start/Load as a Set in a "Target"
- Understands Trim Capacity & Demand in Real Time
- Same Pressure Band for All Sets
- MCS Makes System "Land on its Feet" When Any Compressor Fails
- Full Commissioning

VFD Controls That Improve Reliability

- Load-sharing Multiple VFDs Can Keep Heat Load More Stable, High Enough but Not Too High
- Smart Base-load Control Can Keep VFDs from Going Too High or Too Low in Pressure
- Piping VFDs to a Common Tank Before Dryer(s) Allows Much More Stable Control
- ASHRAE 90.1 Rule:
- “Must Have One or More VSD Trim Compressor(s) w- Combined Capacity of > 1.25 x Largest Net Capacity Increment of Base Compressors”

Centrifugal Compressor Controls That Improve Reliability

- Centrifugals Have the Longest Life of All Compressors, But Are Large
- For Higher Loads (>3,000 scfm), Consider one or more 3-stage Centrifugal Compressors
- Can Run a System with Only One or Two, But Blow-off is Likely
- A "Hybrid" System w- Centrifugal(s) and Screw Compressor(s) and Smart Master Controls Can Reduce or Eliminate Blow-off

Best Practices Design - Controls

- Smart Controls on Compressors with a Common Wet Header
- Know Failure Modes and Risks, And Design Accordingly, Based on Each Compressor and Dryer’s Location-Specific Issues:
- Dirtier, Hotter, Poorer Power Quality, Poorer Coolant Pressure Locations
- Flow-based Master Controls for Different Sizes of Compressors
- Program Logical Sets of Compressors for Base & Trim, in Each Scenario and Flow Range, not Just LIFO
- Load-share Sets of Compressors, Increasing Efficient Turndown with Fewer Start-stops
- Pre-tune Proportional (VFD, Spiral Valve & Centrifugal) Compressors for Known Pressure Range & Dynamics
- Select Locally-supported, Generously-sized VFDs
- Install VFDs in Filtered and Cool MCC

Best Practices Design - Mechanical

- Ensure Fluid Coolers Are Sized Correctly, Have Enough Coolant Pressure Differential, and Are Balanced
- Ensure Coolers Are Cleaned
- Duct Air-cooled Coolers Properly to Avoid Recirculation
- Maximize Aftercooling and Minimize Dryer Moisture Load With Cooler Air, Chilled Water, Higher Flow, and/or Low Approach Temp Aftercooler
- Install Adequate Wet Side Storage (Enough for Starting Base Compressor and Turning Back Trim in Small Pressure Band)
- Install At Least Two Parallel (Same Size and Type) Dryers, Max Flow of 75%/ea., Minimizing Pressure Drop
- Use High Quality Valves, Fail-Safe

About the Speaker

Manhar Grewal
Kaishan

- Product Manager at Kaishan Compressor USA
- 11 years experience in the compressed air industry
- Holds a degree in Nuclear Engineering from Purdue University

Sponsored by

KAISHAN

KAISHAN

ENGINEERING THE FUTURE

COMPRESSED AIR BEST PRACTICES

PLANNING FOR REDUNDANCY AND RELIABILITY IN CRITICAL AIR APPLICATIONS

JANUARY 15, 2026

TABLE OF CONTENTS

SECTION 1 — PRE-PLANNING
Before the purchase

SECTION 2 — AIR COMPRESSOR TYPES
A brief overview

SECTION 3 — OPTIMIZATION
Setting up redundancy

SECTION 4 — RAPID CYCLING
And what to do about it

SECTION 5 — CONTROL STRATEGIES
For redundant systems

PRE-PLANNING

PRE-PLANNING

PREP WORK BEFORE BUYING REDUNDANT EQUIPMENT

- When was the last time you performed a compressed air audit?
  - Was leak detection part of the audit?
- What is your controls strategy?
  - OEM controllers to block / sequence?
  - Master controller?
  - Building management system (BMS)? If so, how?
- What does redundancy mean to your company?
  - Just compressed air (compressors)?
  - Is dew point critical (dryers)?
- Talk to an expert—simply buying equipment is not always the right solution!
  - Oversized compressors do more harm than benefit

Find a Kaishan distributor

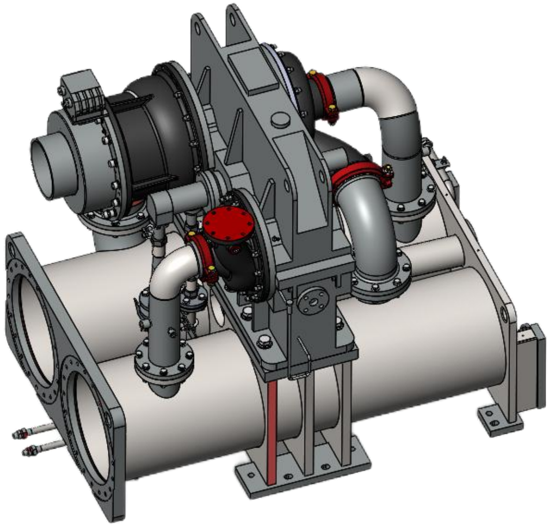
KAISHAN

AIR COMPRESSOR TYPES

KAISHAN

AIR COMPRESSOR TYPES

CENTRIFUGAL AIR COMPRESSORS

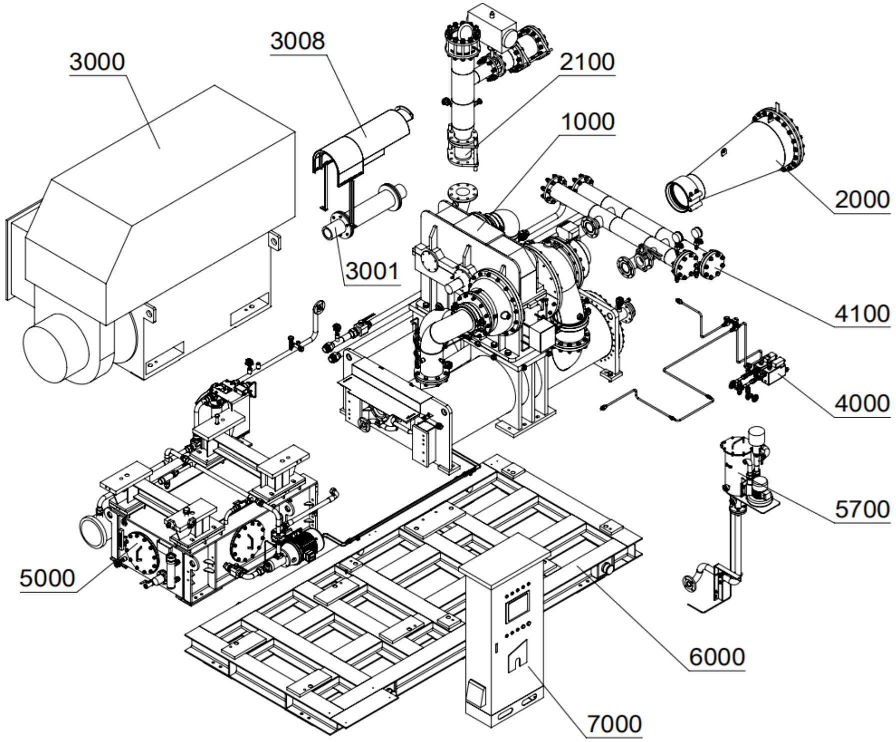


- Oil-free
- Commonly two-, three- or four-stage compression
- Oil used only for internal gearing and bearings
  - Safely sealed (extremely unlikely to enter compression chambers)
- Oil contaminants depend on atmospheric conditions
- Commonly used at:
  - 300+ HP
  - 1,200+ CFM
  - 55-325 PSIG

KAISHAN

AIR COMPRESSOR TYPES

CENTRIFUGAL AIR COMPRESSORS



Parts :

1000 - Mainframe

2000 - Inlet component

2100 - Exhaust component

3000 - Main motor

3001 - Coupling

3008 - Coupling shroud

4000 - Condensate removal system

4100 - Cooling water system

5000 - Lubrication system

5700 - Oil mist removal system

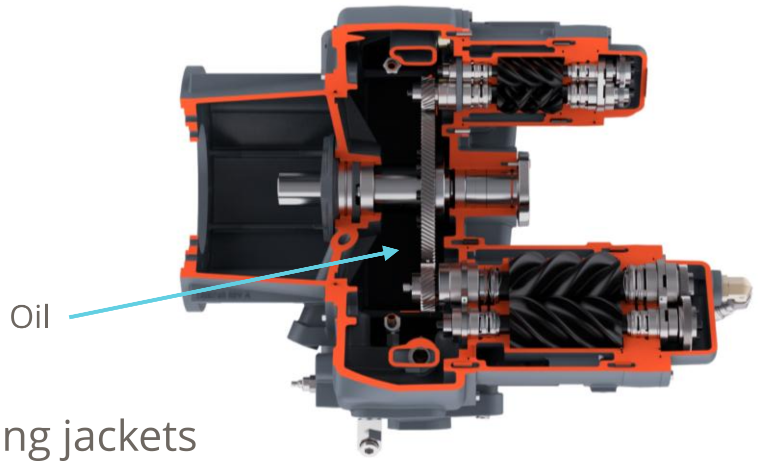
6000 - Common bed

7000 - PLC control system

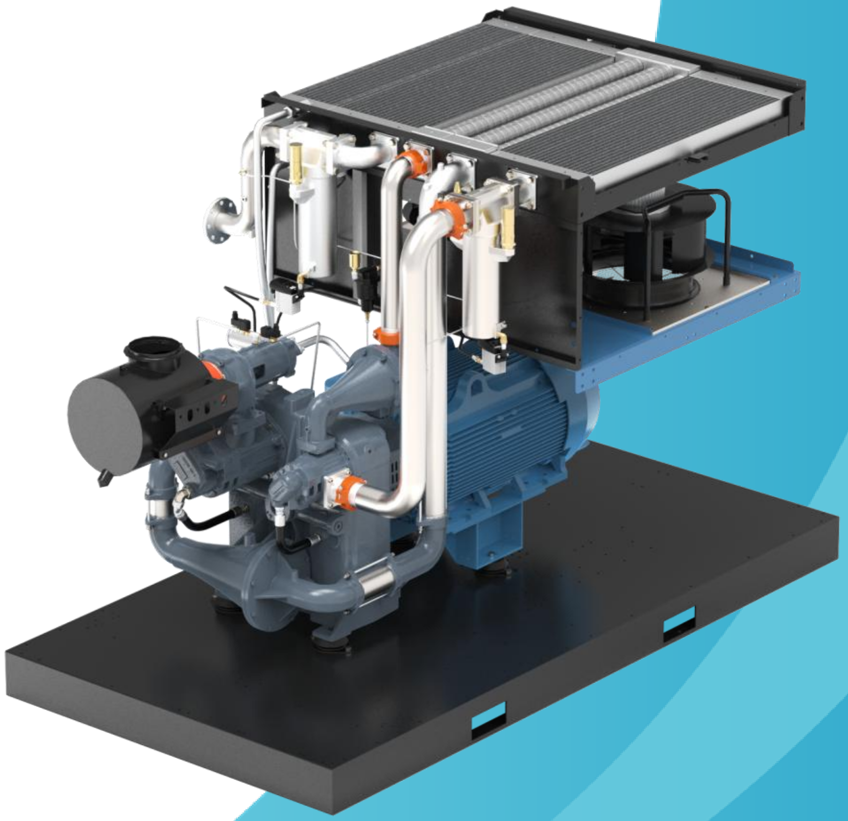
KAISHAN

AIR COMPRESSOR TYPES

ROTARY SCREW AIR COMPRESSORS



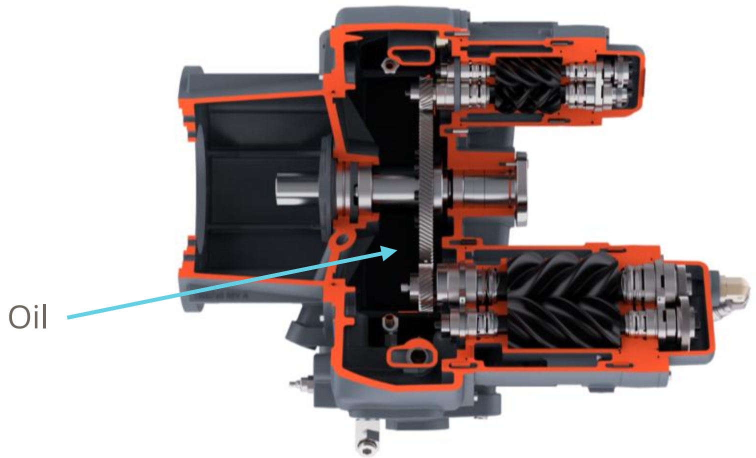
- Oil-free rotary screw
  - Two-stage compression
  - Oil used only for gears, bearing and cooling jackets
  - Oil contaminants depend on atmospheric conditions
    - Typically less than 0.5 PPM in atmospheric air
    - Discharge from compressor less than 0.05 PPM
  - Commonly used at:
    - 50-400 HP
    - 200-2,000 CFM
    - 100-150 PSIG



KAISHAN

AIR COMPRESSOR TYPES

ROTARY SCREW AIR COMPRESSORS



- Oil-injected rotary screw
  - Also called oil-flooded, oil-lubricated or contact cooled
  - Commonly single- or two-stage
  - Oil used to cool, lubricate and seal (typical oil carryover at 3-5 PPM)
  - More flow per HP due to lower temperature in the compression chamber
  - Commonly used at:
    - 5-600 HP
    - 15-3,000 CFM
    - 100-200 PSIG

KAISHAN

COMPRESSOR DATA SHEET

Federal Uniform Test Method for Certain Air Compressors Not Applicable

Rotary Compressor: Fixed Speed

MODEL DATA - FOR COMPRESSED AIR

1	Manufacturer: **Kaishan Compressor USA**		
2	Model Number: **KRSP2-250-125**	Date:	**7/12/2021**
	[X] Air-cooled [ ] Water-cooled	Type:	**Screw**
	[X] Oil-injected [ ] Oil-free	# of Stages:	**2**
3*	Rated Capacity at Full Load Operating Pressure [a, e]	**1271.0**	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	**250**	hp
7	Drive Motor Nominal Efficiency	**96.2**	percent
8	Fan Motor Nominal Rating (if applicable)	**7.5 & 2.0**	hp
9	Fan Motor Nominal Efficiency	**91.0 & 87.5**	percent
10*	Total Package Input Power at Zero Flow [e]	**39.4**	kW [e]
11	Total Package Input Power at Rated Capacity and Full Load Operating Pressure [d]	**216.40**	kW [d]
12*	Specific Package Input Power at Rated Capacity and Full Load Operating Pressure [e]	**17.03**	kW/100 cfm [e]
13	Isentropic Efficiency	**88.22**	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:

a. 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.
b. The operating pressure at which the Capacity (Item 3) and Electrical Consumption (Item 11) were measured for this data sheet.
c. 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.
d. Total package input power at other than reported operating points will vary with control strategy.
e. 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.

Member

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	+/- 10%
0.5 to 1.5	17.6 to 53	+/- 6	+/- 7	
1.5 to 15	53 to 529.7	+/- 5	+/- 6	
Above 15	Above 529.7	+/- 4	+/- 5	

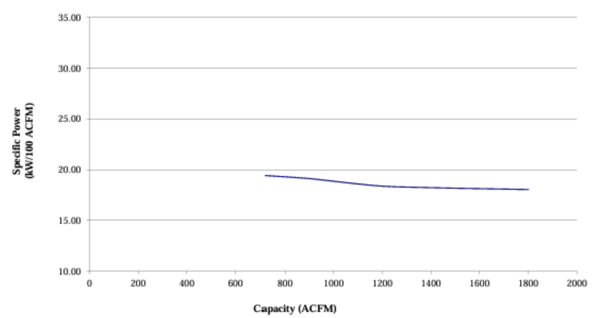
ROT 030.2

COMPRESSOR DATA SHEET

Federal Uniform Test Method for Certain Air Compressors Not Applicable

Rotary Compressor: Variable Frequency Drive

MODEL DATA - FOR COMPRESSED AIR

1	Manufacturer: **Kaishan Compressor USA**			
2	Model Number: **KRSP2-350-125 VSD**		Date:	**07/12/21**
	[X] Air-cooled [ ] Water-cooled		Type:	**Screw**
	[X] Lubricated [ ] Oil Free		# of Stages:	**2**
3*	Full Load Operating Pressure [b]		**125**	psig [b]
4	Drive Motor Nominal Rating		**350**	hp
5	Drive Motor Nominal Efficiency		**96.2**	percent
6	Fan Motor Nominal Rating (if applicable)		**15&4**	hp
7	Fan Motor Nominal Efficiency		**91.7&89.1**	percent
8*	Input Power (kW)		Capacity (acfm) [a,d]	Specific Power (kW/100 acfm) [d]
	[illegible]		**1801**	**18.04**
	230.8		**1261**	**18.30**
	201.5		**1081**	**18.64**
	172.3		**901**	**19.12**
	[illegible]		**720**	**19.42**
9*	Total Package Input Power at Zero Flow [c, d]		[illegible]	kW
10	Isentropic Efficiency		**81.18**	%
11				

Note: Graph is only a visual representation of the data in Section 8
Note: Y-Axis Scale, 10 to 35, + 5kW/100acfm increments if necessary above 35
X-Axis Scale, 0 to 25% over maximum capacity

*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:

a. Measured at the discharge terminal point of the compressor package in accordance with ISO 1217, Annex E; ACFM is actual cubic feet per minute at inlet conditions.
b. The operating pressure at which the Capacity (Item 8) and Electrical Consumption (Item 8) were measured for this data sheet.
c. No Load Power. In accordance with ISO 1217, Annex E, if measurement of no load power equals less than 1%, manufacturer may state "not significant" or "0" on the test report.
d. Tolerance is specified in ISO 1217, Annex E, as shown in table below:

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

Member

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	+/- 10%
0.5 to 1.5	17.6 to 53	+/- 6	+/- 7	
1.5 to 15	53 to 529.7	+/- 5	+/- 6	
Above 15	Above 529.7	+/- 4	+/- 5	

ROT 031.2

Centrifugal Blower - Standard Conditions Option 1

Centrifugal Blower - Standard Conditions Option 2

The following members of the Air Drying & Filtration, Portable Compressor, and Rotary Positive Compressor Sections have agreed to use the CAGI Data Sheets and post them on their websites:

ROTARY COMPRESSORS	PORTABLE COMPRESSORS	REFRIGERATED DRYERS	BLOWERS
Atlas Copco	Kaeser	Atlas Copco	Atlas Copco
BOGE	Sullair	Hankison	Gardner Denver
Chicago Pneumatic	Sullivan-Palatek	Ingersoll Rand	Kaeser
Elgi		Mikropor	
FS Curtis		Parker Hannifin	
Gardner Denver		ZEKS	
Hertz Kompressoren			
Ingersoll Rand			
Kaeser			
Kaishan			
Quincy Compressor			
Sullair			
Sullivan-Palatek			

PARTICIPANT DIRECTORIES

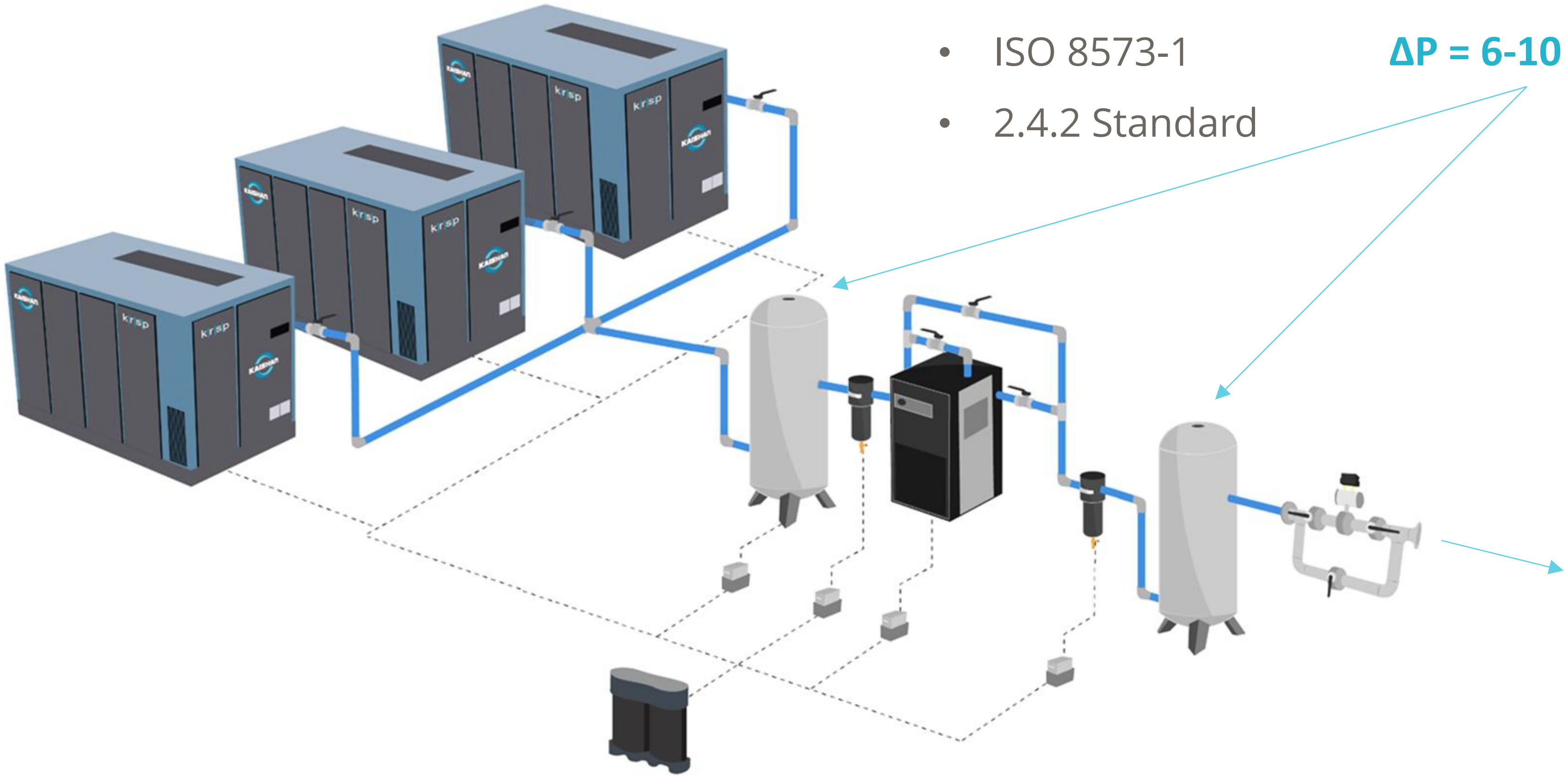
OPTIMIZATION

OPTIMIZATION

COMMON OIL-INJECTED SYSTEM

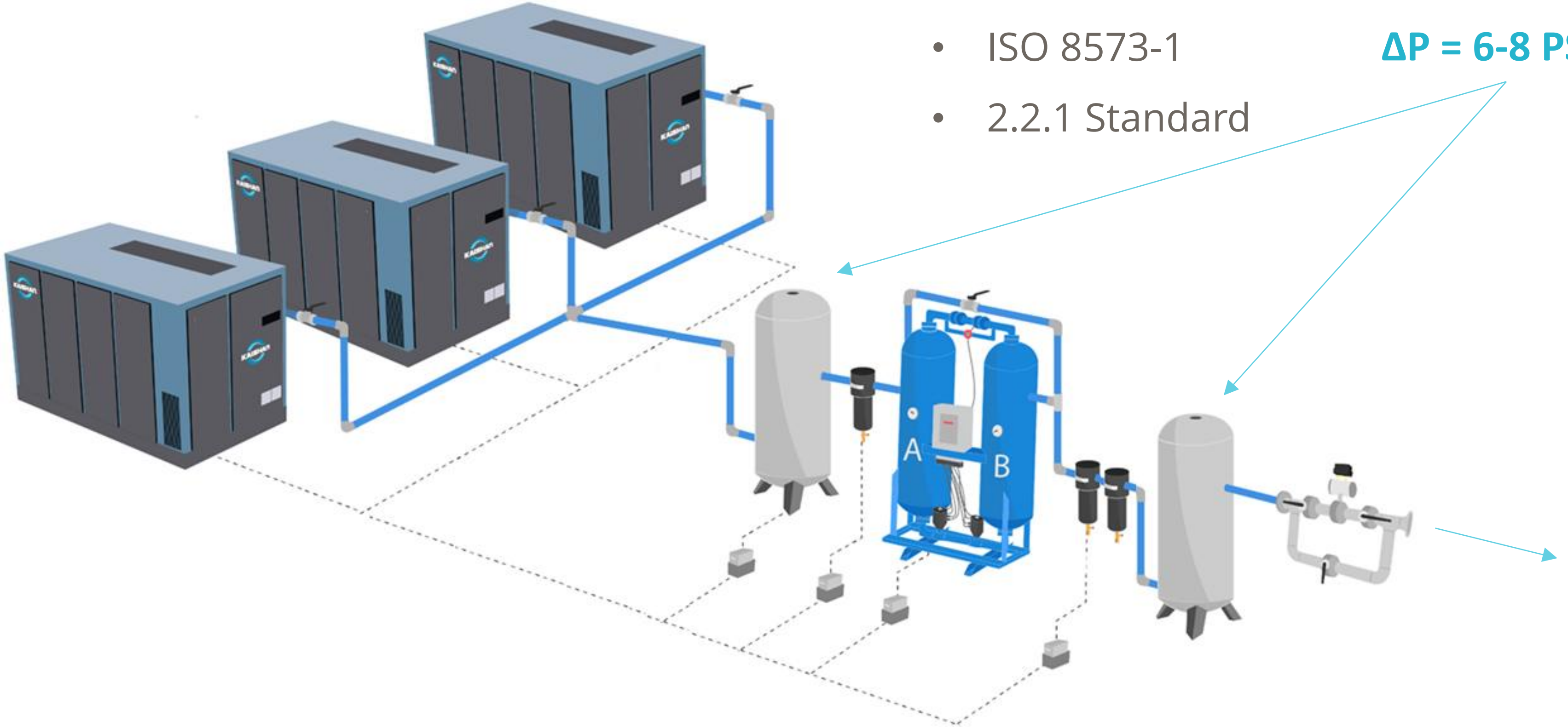
- ISO 8573-1
- 2.4.2 Standard

ΔP = 6-10 PSIG



OPTIMIZATION

COMMON OIL-FREE SYSTEM



- ISO 8573-1
- 2.2.1 Standard

ΔP = 6-8 PSIG

ISOLATING REDUNDANT EQUIPMENT: VALVES, VALVES, VALVES

- As with all mechanical equipment, maintenance will be required in due time
  - Best practices are to valve off each piece of equipment for maintenance
  - A check valve is *not* an isolation valve
    - Check valves protect against backflow when equipment is offline; as such, they should be used in addition to isolation valves

KAISHAN

OPTIMIZATION

DRAINS 101: AVOID LOSS ON COMPRESSED AIR

- Manual drain valves: Simple valve, usually ball or needle type
  - Pros: Economical and easy to use
  - Cons: Labor-intensive and often forgotten, leading to water buildup and potential tank damage
- Float-type mechanical drains: Use an internal float mechanism that rises as condensate collects; the float then triggers the valve to open
  - Pros: No electricity needed, automatic operation
  - Cons: Can clog with debris or oil, requires occasional cleaning and maintenance

KAISHAN

DRAINS 101: AVOID LOSS ON COMPRESSED AIR

- Timer-operated solenoid drains: Electrically-controlled valves that open at preset intervals and durations
    - Pros: Reliable automation with adjustable settings for various applications
    - Cons: Can waste air if not properly set
- Zero-loss (no-loss) drains: Detects when condensate has filled a chamber and then releases it without releasing compressed air
    - Pros: Energy-efficient with no compressed air loss
    - Cons: Higher cost, may require power and maintenance depending on brand / style




RAPID CYCLING

KAISHAN

RAPID CYCLING

AND HOW TO STOP IT

- What is rapid cycling?
    - When constantly turning your compressor on and off, loading and unloading
- Rule of thumb is that anything over 6-8 cycles per hour is considered excessive
- Common causes
    - Not enough storage
    - Pressure bands are too tight
        - Be careful; increasing the discharge pressure by 2 psi increases the main motor power consumption by ~1%
    - Compressor is oversized
    - Lack of modulation on the compressor, poor control strategy

KAISHAN

AND HOW TO STOP IT

- Consequences of rapid cycling
    - Extra wear and tear on the motor, valves, bearings and other internal parts
    - Overheating
    - Carryover of moisture and oil
    - Wasted energy
    - Additional maintenance
    - A shorter lifespan

Featured blog: *How often should an air compressor cycle?*

KAISHAN

CAGI SIZING GUIDELINES: HOW MUCH STORAGE?

- Per CAGI (Compressed Air and Gas Institute)
  - Enough storage to reduce compressor cycle to <= 10 cycles per hour
  - Rule of thumb is 10 gallons per cfm of the largest trim compressor
  - But every application is different
- Rule of thumb is 1/3 wet with 2/3 dry storage

KAISHAN

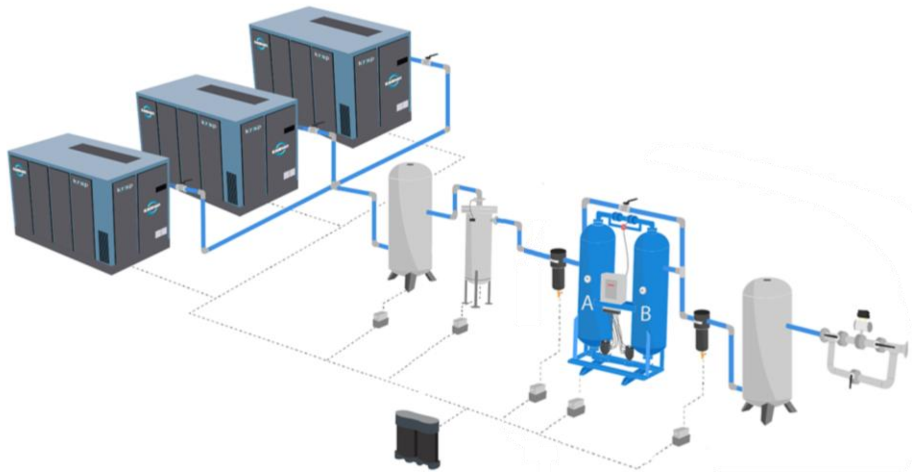
CONTROL STRATEGIES

KAISHAN

CONTROL STRATEGIES

FOR REDUNDANT SYSTEMS

- What are the types of compressor communication protocols as standard?
    - Cascade sequencing
    - Base load + trim compressor
    - Target pressure band control
    - Time-based load sharing (equal runtime)
    - Advances cloud-based sequencing



KAISHAN

CONTROL STRATEGIES

FOR REDUNDANT SYSTEMS: CENTRIFUGAL

- Centrifugal technology has the ability to turndown as well
- Sequencing via a networked system, load sharing, extended throttle range and pressure control

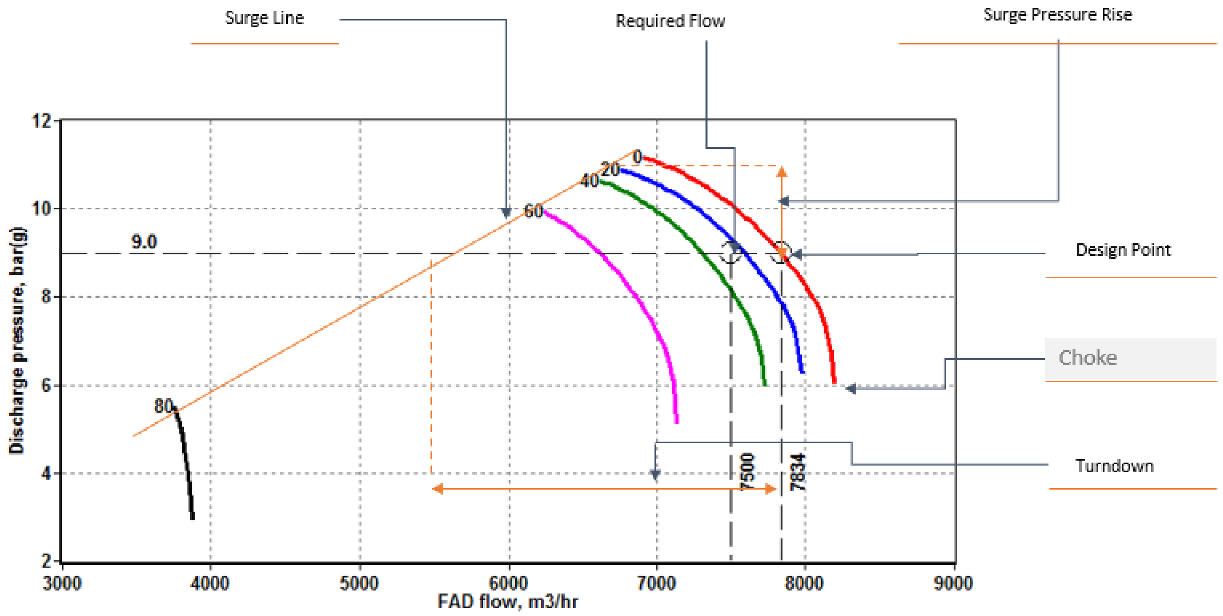


TABLE OF CONTENTS

SECTION 1 — **PRE-PLANNING**
Before the purchase

SECTION 2 — **AIR COMPRESSOR TYPES**
A brief overview

SECTION 3 — **OPTIMIZATION**
Setting up redundancy

SECTION 4 — **RAPID CYCLING**
And what to do about it

SECTION 5 — **CONTROL STRATEGIES**
For redundant systems

THANK YOU

KAISHAN

Manhar Grewal
mgrewal@kaishanusa.com

Follow us on LinkedIn

COMPRESSED AIR BEST PRACTICES

PLANNING FOR REDUNDANCY AND RELIABILITY IN CRITICAL AIR APPLICATIONS

JANUARY 15, 2026

Planning for Redundancy and Reliability in Critical Air Applications

Q&A

Please submit any questions through the Question Window on your GoToWebinar interface, directing them to 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!

Sponsored by

KAISHAN

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.

January 2026 Webinar
Tracking Predictive Maintenance KPIs for Rotary Screw Air Compressors

Josh Wamser
The Analysts
Keynote Speaker

Sponsored by FS CURTIS

Thursday, January 29, 2026 – 2:00 PM EST
Register for free at
www.airbestpractices.com/webinars