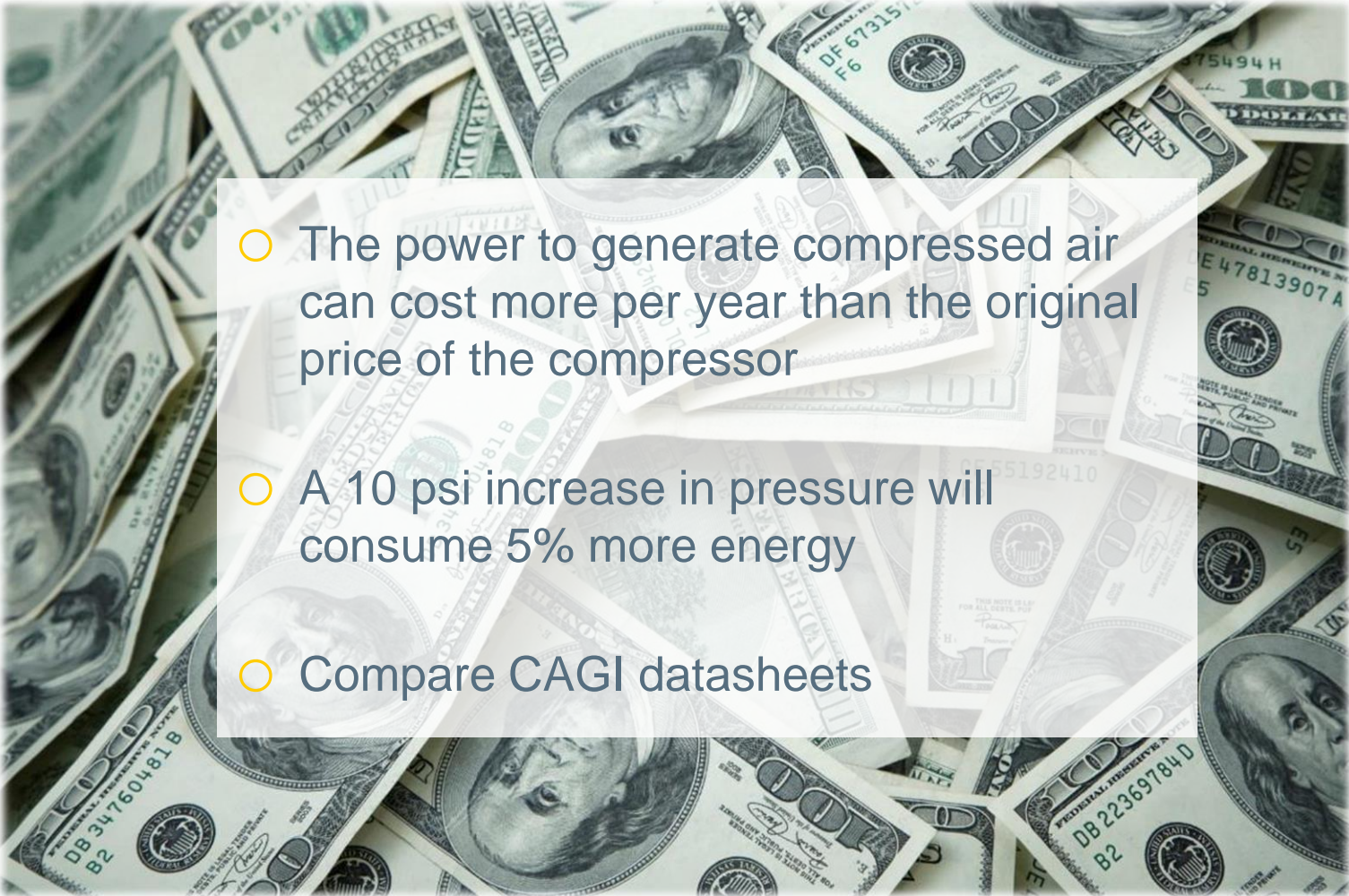


Compressed Air System Design



Greg Ashe, Key Account Manager

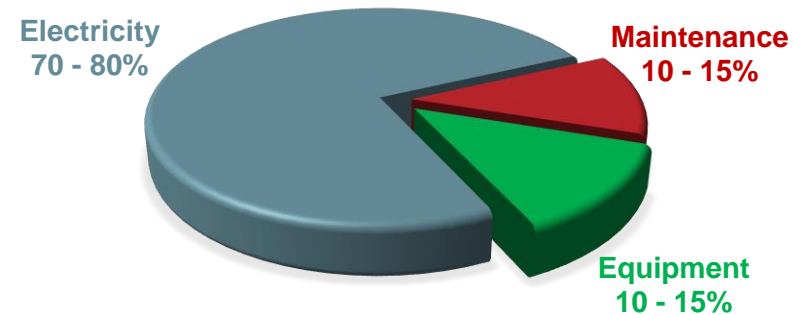
What Does Compressed Air Cost?

- 
- The power to generate compressed air can cost more per year than the original price of the compressor
 - A 10 psi increase in pressure will consume 5% more energy
 - Compare CAGI datasheets

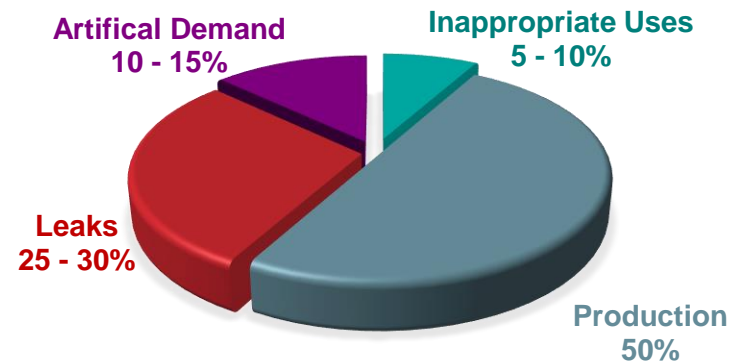
Power Cost and Compressed Air Usage Facts

- Air compressors use as much as 10% of total industrial electricity
- Department of Energy (DOE) estimates as much as 50% of compressed air produced is wasted

POWER COST



COMPRESSED AIR USAGE



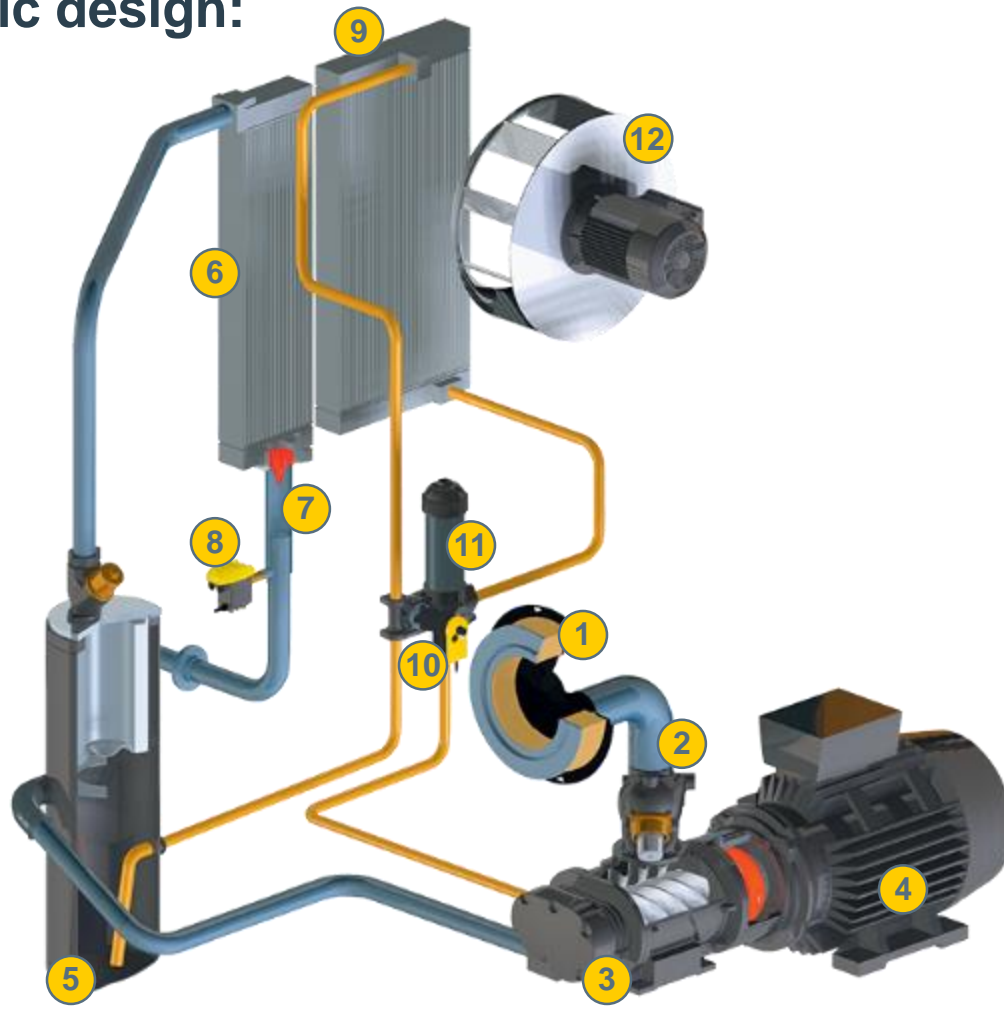
Rotary Screw Compressors

- Most common industrial compressor
- Pressure range: 50 – 250 psig
- Low noise and vibration
- Fluid-filled or “oil-free”
- Single or two-stage
- 100% duty cycle
- Direct, belt or gear driven
- Also used for vacuum
- Maintains efficiency over time



Fluid Injected Screw Compressors

Generic design:

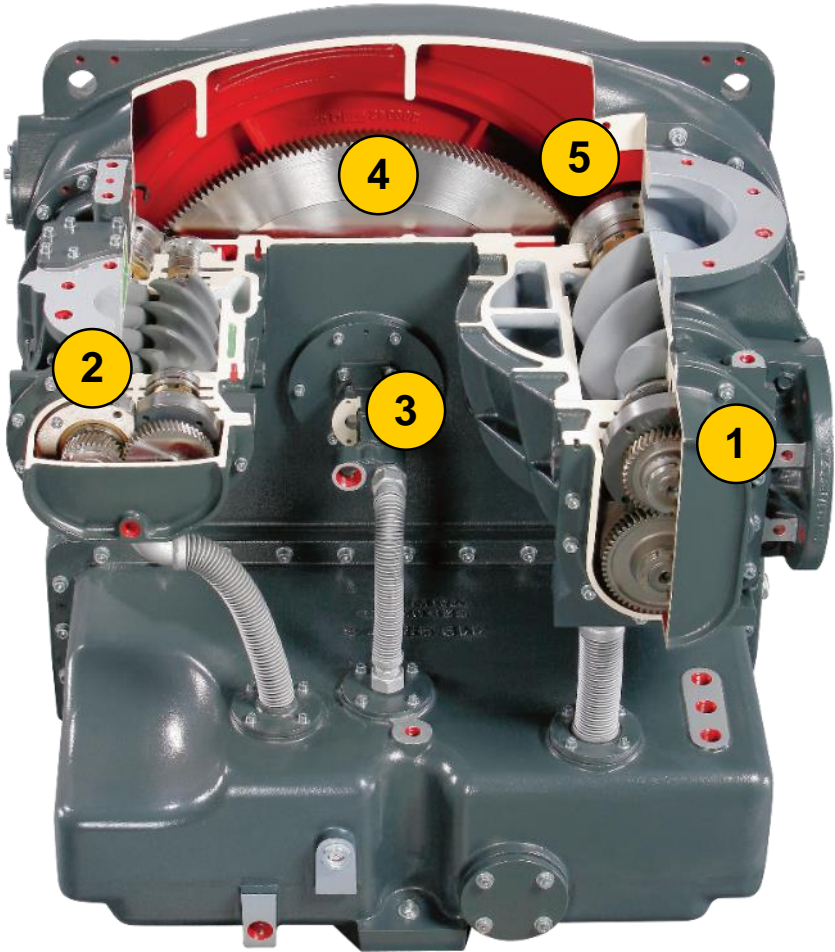


- ① Intake filter
- ② Inlet valve
- ③ Airend
- ④ Drive motor
- ⑤ Fluid separator tank
- ⑥ Compressed air aftercooler
- ⑦ Integral moisture separator
- ⑧ Condensate drain (Eco-Drain)
- ⑨ Fluid cooler
- ⑩ Electronic Thermal Management (ETM) system
- ⑪ Fluid filter
- ⑫ Radial fan

Oil-Free Screw Compressor

Airend:

- 1. LP (Low Pressure)
- 2. HP (High Pressure)
- 3. Oil pump
- 4. Bull gear
- 5. Pinion gear



Compressed Air System Design and Selection

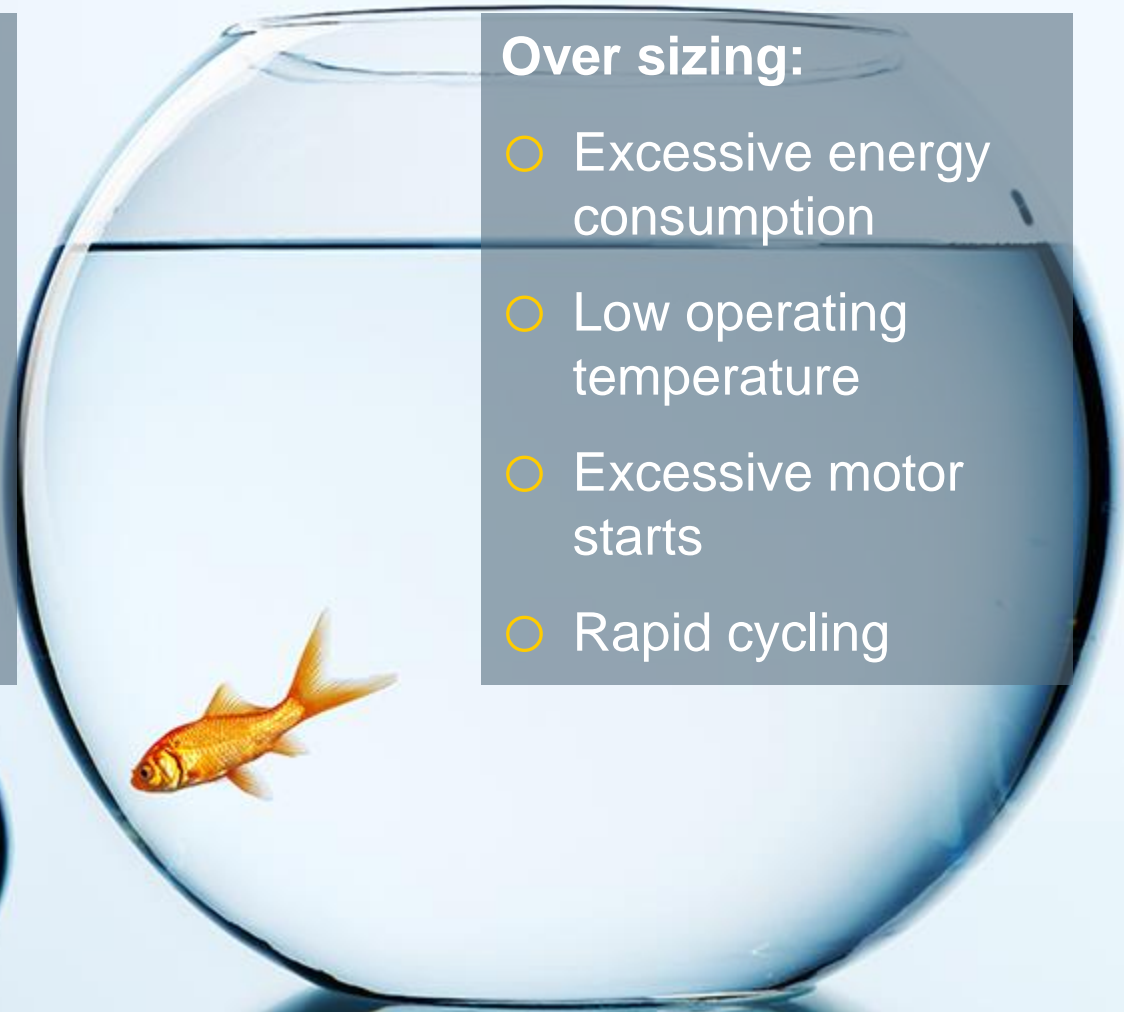
Right Sizing is Critical!

Under sizing:


- Low and unstable system pressure
- Lack of back-up
- Process fluctuations and shutdowns
- Product quality fluctuations

Over sizing:

- Excessive energy consumption
- Low operating temperature
- Excessive motor starts
- Rapid cycling



Minimum Information Needed



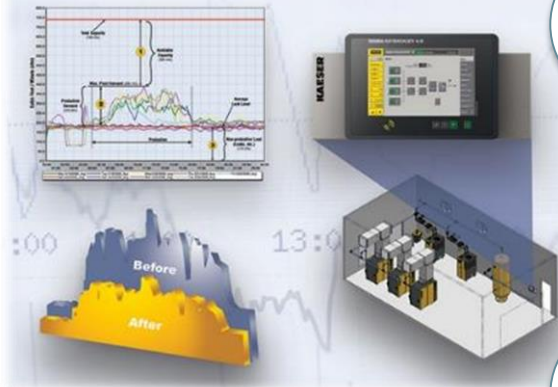
Pressure requirements (psig) of pneumatic tools and equipment

Flow requirements (cfm) of pneumatic tools and equipment

Utilization rate (load factor) of each piece of equipment – average total utilization factor

Air quality requirements

Ambient compressor room conditions



CAGI Data

MODEL DATA – FOR COMPRESSED AIR

Model Number: SFC 75 – 125 psig / 460V/3ph/60Hz

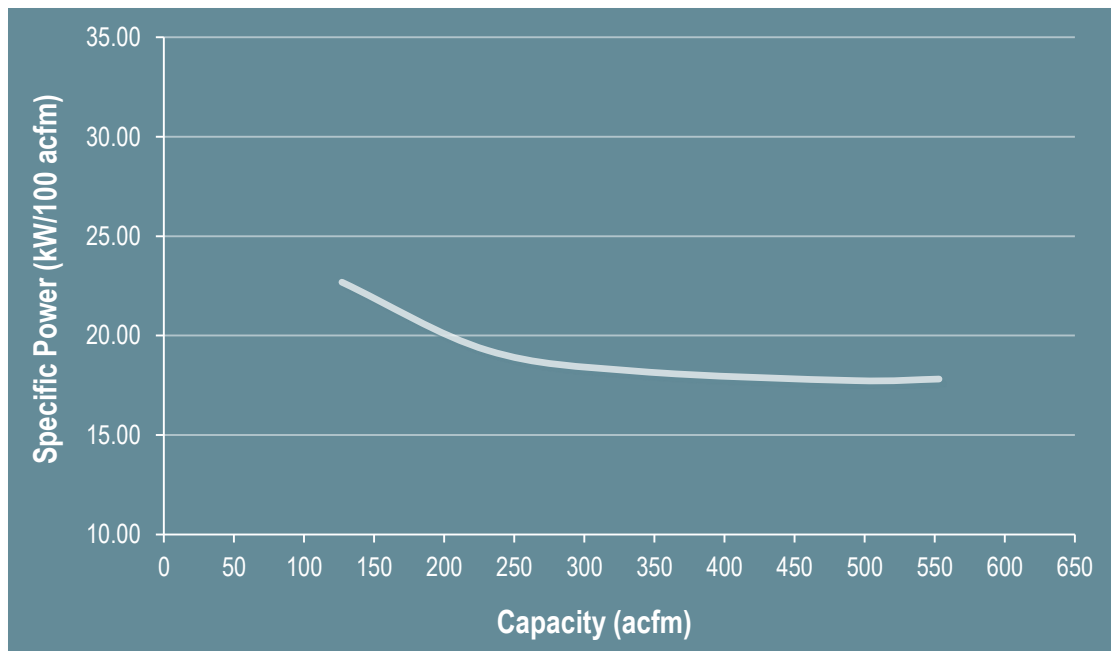
Air-cooled; Oil-injected; Screw

Rated Operating Pressure: 125 psig; Drive Motor Nominal Rating: 100 hp

Drive Motor Nominal Efficiency: 96.2%

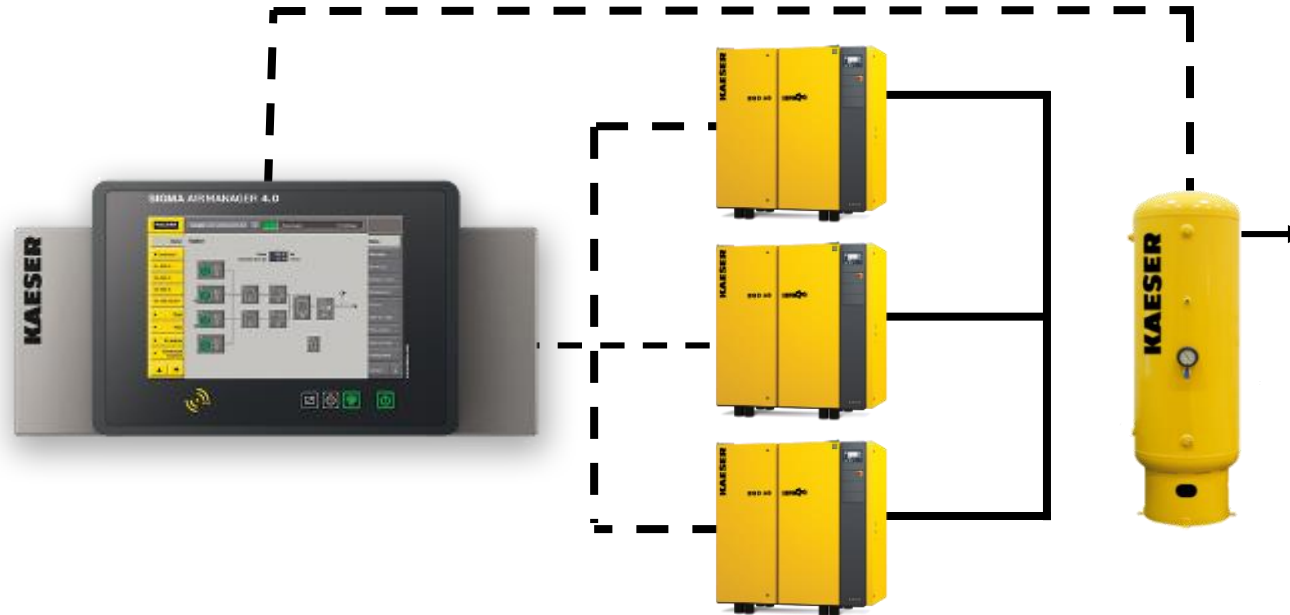


Input Power (kW)	Capacity (acfm)	Specific Power (kW/100 acfm)
98.5 (max)	553	17.81
87.3	492	17.74
61.4	338	18.17
44.6	231	19.31
28.8 (min)	127	22.68

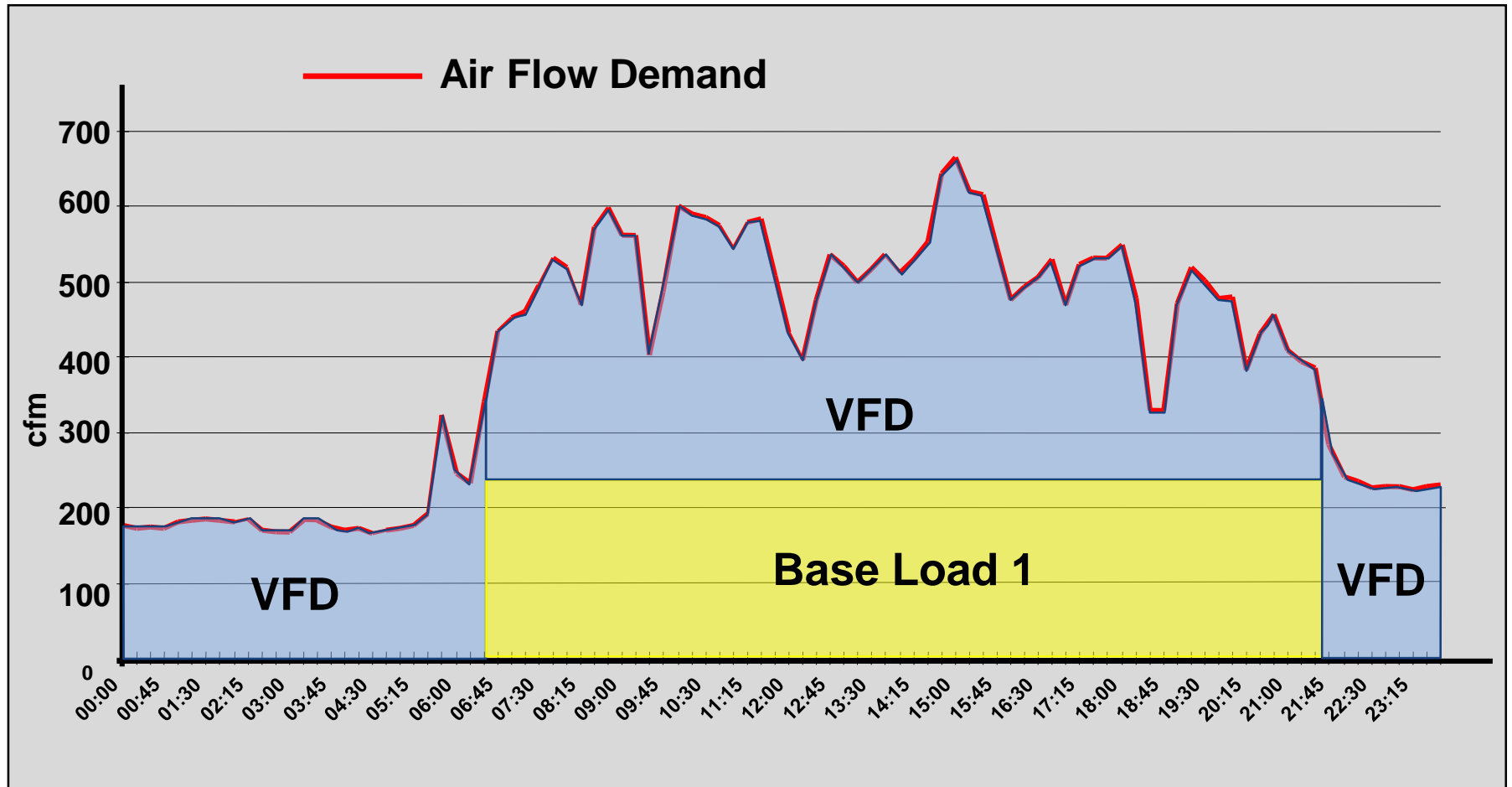


Sequenced Load Splitting

- All on-line compressors are evenly loaded in a microprocessor controlled rotating sequence
- A narrow pressure band is attained by using one common pressure sensor



SFC Unit: First to Load – Last to Unload



Compressed Air Piping

Compressed air velocity should be kept to:

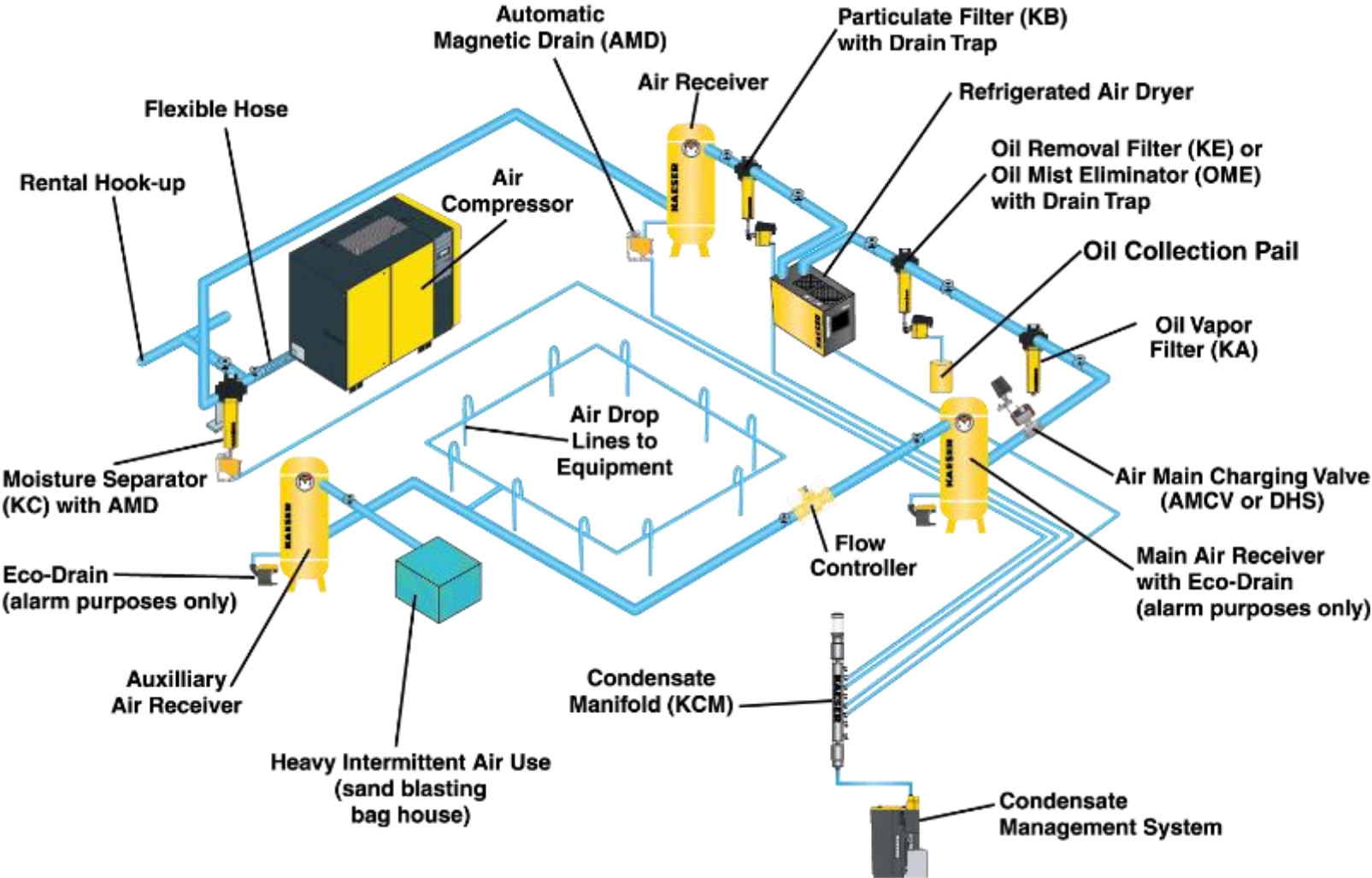
- 14 feet per second in the compressor room
- 30 feet per second in the main header
- 45 feet per second in the air drops

Rule of thumb:

A well designed piping system will have less than a 2 psi pressure drop in the entire system, not counting air treatment equipment



Compressed Air System Layout



Receiver Tanks



- Sizing receivers – total storage should be at least 4 to 6 gallons per cfm of the cycling compressor's capacity
- Storage can be shared with multiple tanks and piping
- Pressure rating must exceed highest system pressure
- Must have safety relief valves sized for pressure and total flow
- Pipe in low and out high to prevent liquid carry-over
- Large automatic drains on wet tanks

Compressed Air Treatment

Refrigerated Dryers

- For systems with an aftercooler
 - Inlet temp approx. 100°F
- Achieve 35° - 50°F dew points
- Often have filters and automatic drains built in



Applying Dryer Correction Factors

Dryer performance impacted by pressure, ambient temperature and compressed air temperature

Example:

- Flow: 200 cfm
- Pressure: 120 psig
- Ambient temperature: 95°F
- Inlet temperature: 110°F

$$0.83 \times 1.05 = 0.8715$$

$$200 \text{ cfm} \times 0.8715 = 174 \text{ cfm}$$

At these worst-case conditions, upsizing the dryer to a 240 cfm dryer would be required to meet a compressor flow of 200 cfm.

Capacity Correction Factors for Operating Conditions

Pressure (psig)	Temperature (°F)											
	75	80	85	90	95	100	105	110	115	120	125	130
60		0.96			0.86	0.77	0.67	0.60	0.53	0.47	0.41	0.37
80		1.11			0.99	0.89	0.78	0.69	0.61	0.54	0.48	0.42
100		1.25			1.12	1.00	0.88	0.78	0.69	0.61	0.53	0.48
115		1.32			1.18	1.05	0.93	0.82	0.73	0.64	0.57	0.50
120		1.33			1.19	1.06	0.94	0.83	0.73	0.65	0.57	0.51
125		1.35			1.21	1.08	0.95	0.84	0.75	0.66	0.58	0.52
140		1.39			1.25	1.11	0.98	0.87	0.77	0.68	0.60	0.53
160		1.46			1.31	1.16	1.02	0.91	0.80	0.71	0.63	0.56
180		1.51			1.35	1.21	1.06	0.94	0.83	0.73	0.65	0.58
200		1.55			1.39	1.24	1.09	0.97	0.85	0.75	0.67	0.59
230		1.59			1.43	1.27	1.12	0.99	0.88	0.77	0.68	0.61

Capacity Correction Factors for Ambient Temperature

Factor	Ambient Air Temperature (°F)							
	75	80	85	90	95	100	105	110
		1.09			1.05	1.00	0.96	0.92

Regenerative Desiccant Dryers

- Provides very dryer air with dew point as low as -100°F
- Moisture sensitive processes
- System exposed to sub-freezing temperatures
- Use purge air to recharge desiccant bed so you lose compressed air to this operation:
 - As much as 15% of dryer's rated flow
 - Need to oversize entire system to provide deliverable cfm
- Desiccant must be replaced as a normal maintenance item
- Requires coalescing and particulate filtration

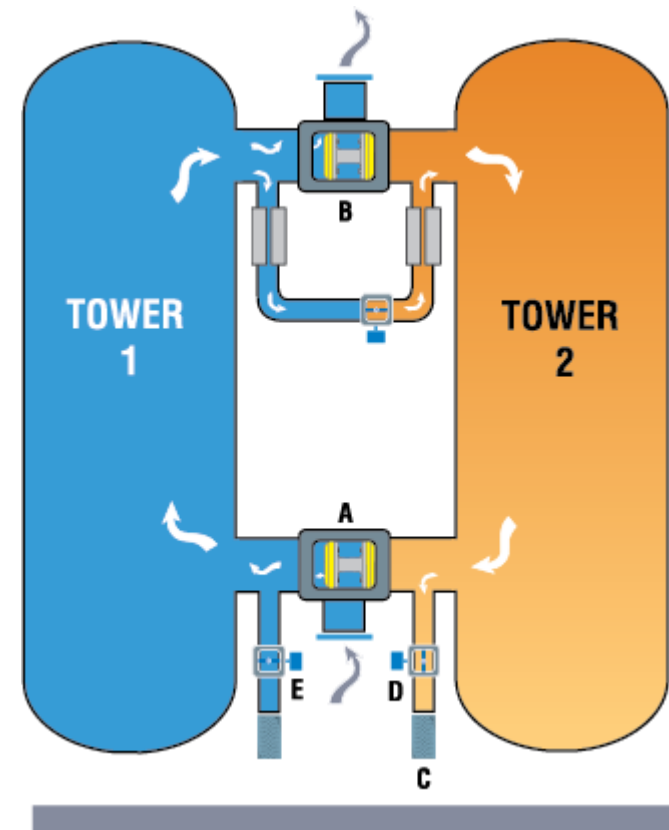


Desiccant Dryer Basic Operation

Uses the principles of adsorption and desorption and alternately cycle the compressed through twin desiccant towers

Vapor-laden air flows through one tower, moisture is adsorbed onto desiccant

Other tower, “purge air” flows through, evaporates the water on the desiccant and carries it out of the tower as vapor



A Inlet valve
B Outlet valve

C Muffler
D & E Purge valves

ISO 8573-1

Purity Classes of Compressed Air

SOLID PARTICLES / DUST			
If particles greater than 5µm have been measured, class 0-5 cannot be applied			
Class	0.1 - 0.5 µm	0.5 - 1 µm	1 - 5 µm
0	As specified and more stringent than Class 1		
1	≤ 20,000	≤ 400	≤ 10
2	≤ 400,000	≤ 6000	≤ 100
3	---	≤ 90,000	≤ 1000
4	---	---	≤ 10,000
5	---	---	≤ 100,000
6	≤ 5 mg/m ³		
7	5.. - 10 mg/m ³		
8			
9			
X	> 10 mg/m ³		

HUMIDITY AND LIQUID WATER		
Class	Pressure Dew Point	
0	As specified and more stringent than Class 1	
1	≤ -70°C	≤ -94°F
2	≤ -40°C	≤ -40°F
3	≤ -20°C	≤ -4°F
4	≤ 3°C	≤ 38°F
5	≤ 7°C	≤ 45°F
6	≤ 10°C	≤ 50°F
Concentration of liquid water		
7	≤ 0.5 g/m ³	
8	0.5 - 5 g/m ³	
9	5 - 10 g/m ³	
X	≥ 10 g/m ³	

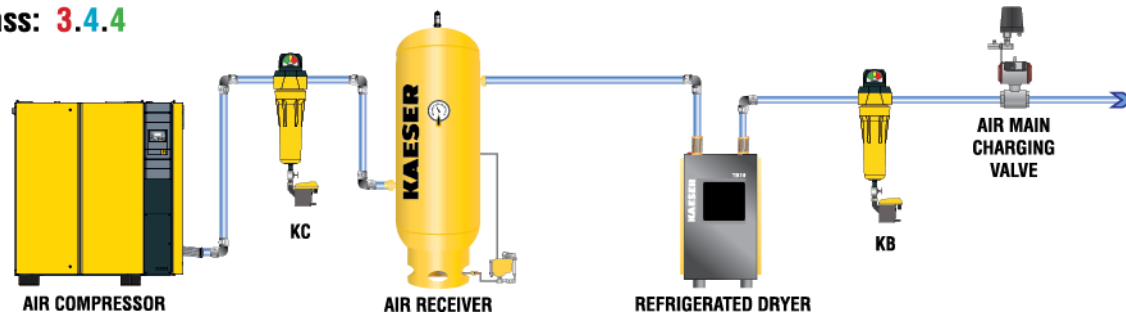
TOTAL OIL		
Liquid, aerosol, and vapor		
Class	mg/m ³	ppm w/w
0	As specified and more stringent than Class 1	
1	≤ 0.01	≤ 0.008
2	≤ 0.1	≤ 0.08
3	≤ 1.0	≤ 0.8
4	≤ 5.0	≤ 4
5		
6		
7		
8		
9		
X	> 5.0	> 4

Reference conditions: 68°F (20°C), 14.5 psia (1 bar), 0% relative humidity

Example Air Treatment Configurations

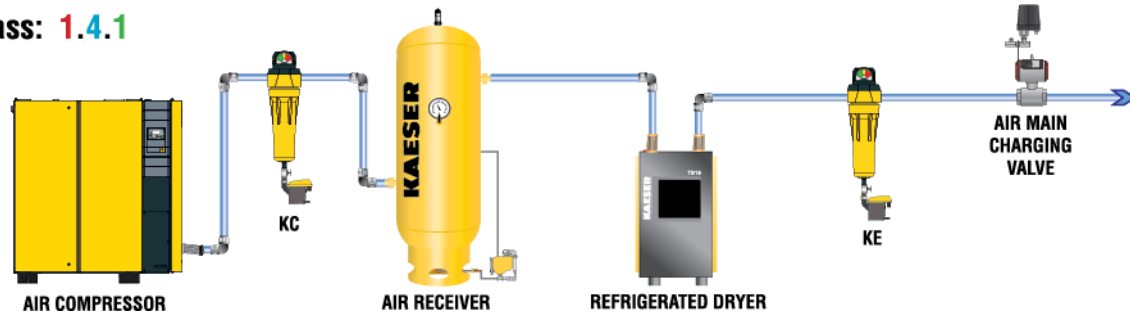
ISO 8573.1 Quality Class: **3.4.4**

Examples:
General Shop Air
Air Tools
Sand Blasting



ISO 8573.1 Quality Class: **1.4.1**

Examples:
Food and Beverage
Laboratories



ISO 8573.1 Quality Class: **1.2.1 or 1.1.1**

Examples:
Food and Beverage
High-tech Clean Rooms
Pharmaceutical
Chemical Industries
Laboratories

