ASME Professional Development

Types of Compressors

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Compressor Technologies

- Oil Free
  - No oil within the compression chamber
  - No oil carry over
  - Highest quality of air
  - Lowest risk of product contamination
  - Lowest risk for product scrap
  - Higher initial cost
  - Higher initial maintenance costs
  - Moderate total cost of ownership
  - Technology can be Oil Less as well

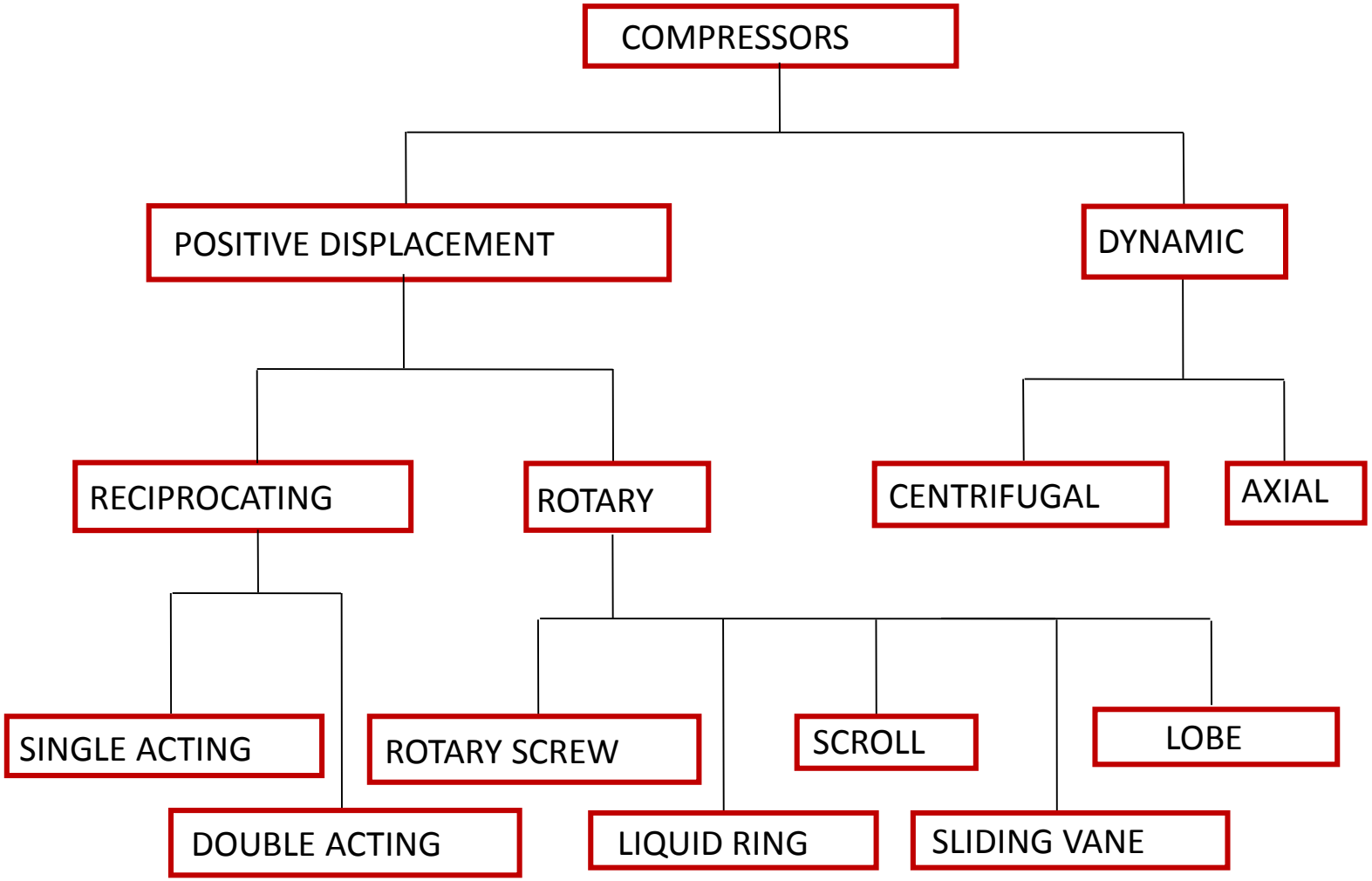
- Oil Flooded
  - Oil within the compression chamber
  - Oil carry over
  - Lower quality of air
  - Highest risk of product contamination
  - Higher risk for product scrap
  - Moderate initial cost
  - Lower initial maintenance costs
  - Lower total cost of ownership

Compressor Technologies

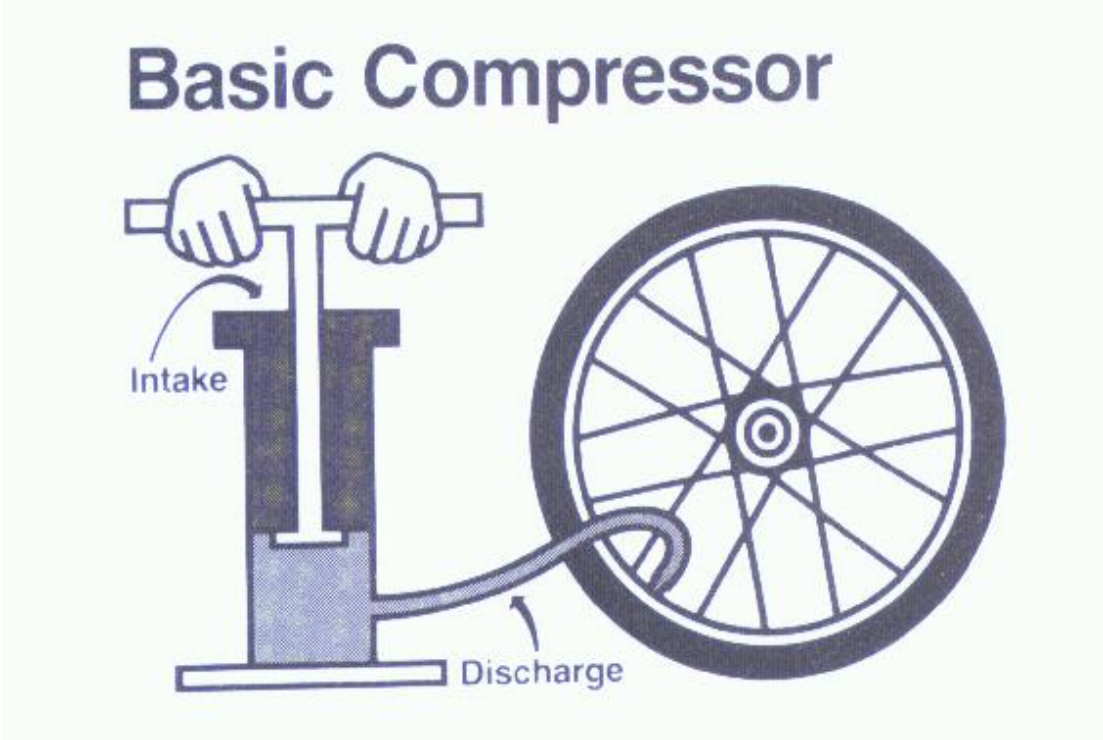
- Oil Free Industries
  - Food & Beverage
  - Pharmaceutical
  - Aviation
  - Chemical
  - Power Generation
  - Petrochemical
  - High Technology
  - Medical
  - Laboratory
  - Nitrogen Generation

- Oil Flooded Industries
  - Food & Beverage
  - Power Generation
  - Government
  - Manufacturing
  - General Industry
  - Technology
  - Laboratory

Compressor Technologies

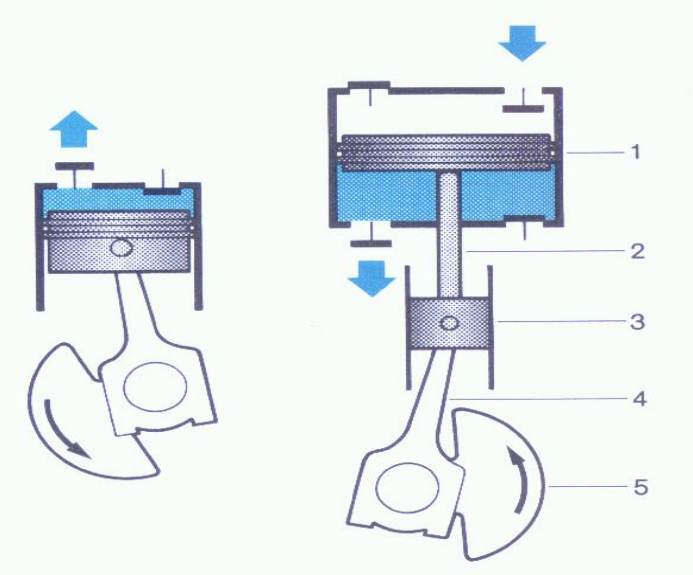


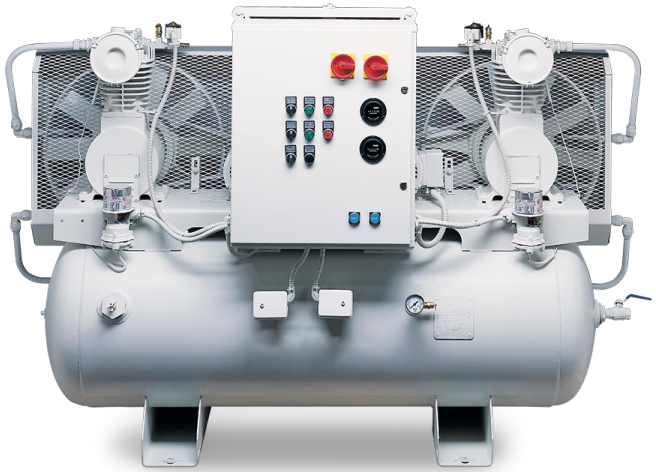
Positive Displacement Compression



- Positive Displacement units are those in which successive volumes of gas are confined within a closed space and elevated to a higher pressure
- Best used on loads with a fixed or varying demand
- High efficiency

Reciprocating Compressors

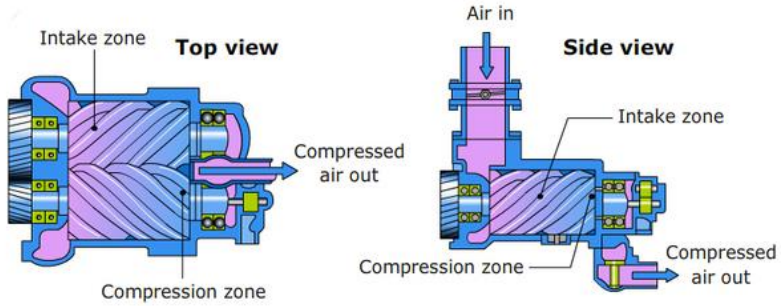


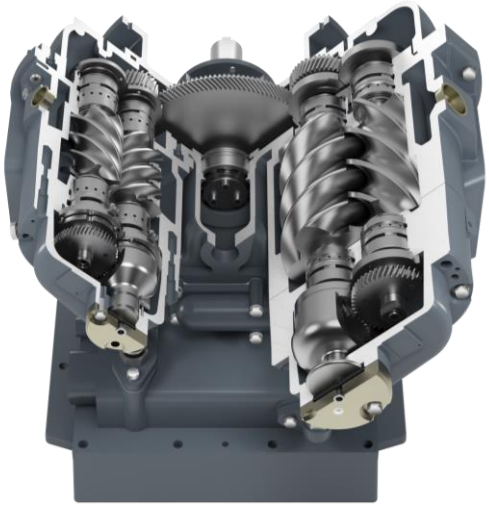


- Single Acting
  - Air is drawn in via the inlet valve
  - Compression done on one side of piston
  - Air is discharged via outlet valve
  - Low to moderate pressure
  - Low flow
  - High noise
  - High outlet temperature

Rotary Screw Compressors

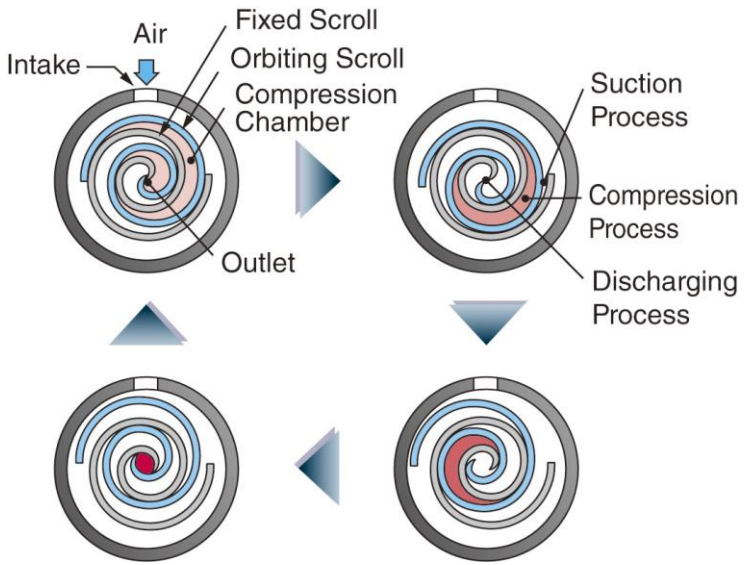
- Single /Two Stage
  - Air is drawn in, rotors revolve and inlet sealed
  - Air is trapped between male / female rotors and compressed as volume decreases
  - Compressed air smoothly exits stage at outlet port
  - Low to moderate pressure
  - All flows
  - Low noise
  - Low to moderate outlet temperature

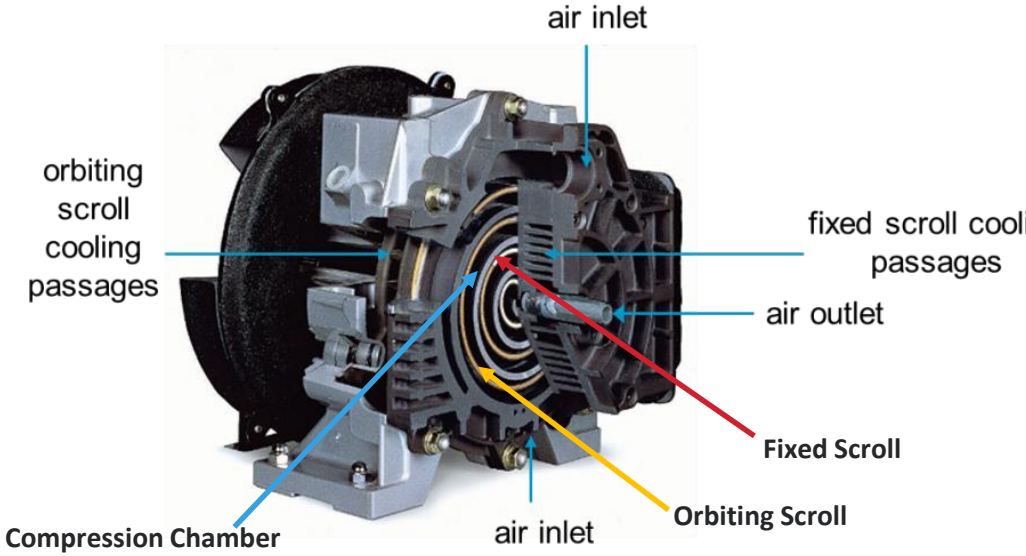




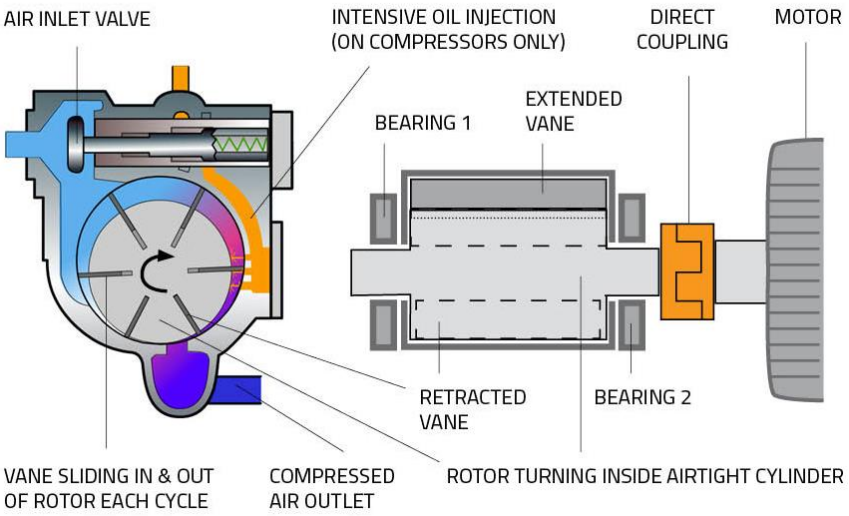
Scroll Compressors

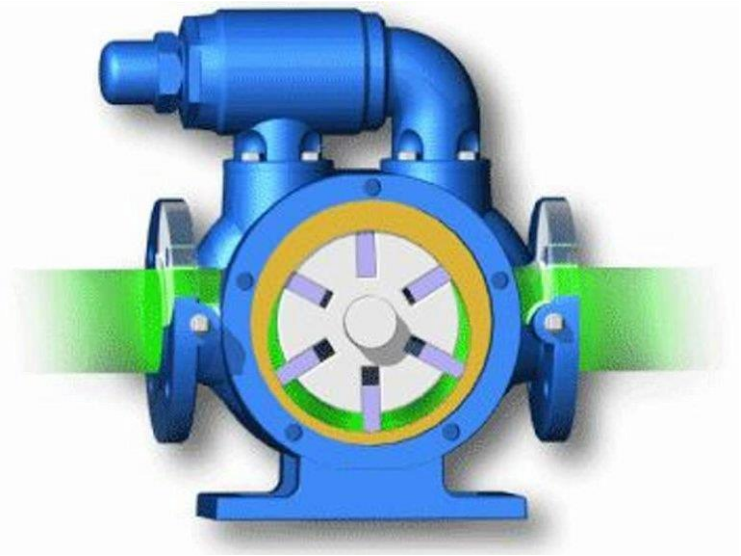
- Single /Two Stage (Oil Less)
  - Air is drawn in as the orbiting scroll head eccentrically rotates
  - Air is trapped between the fixed and orbiting scroll heads from the outside in compressing as volume decreases
  - Compressed air smoothly exits center port
  - Low to moderate pressure
  - Oil Less
  - Low flows
  - Low noise
  - Low to moderate outlet temperature





Sliding Vane Compressors





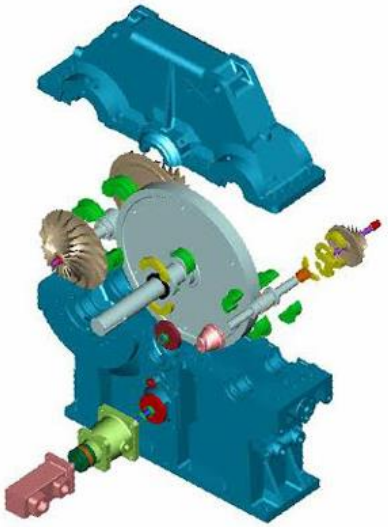
- Single Stage
  - Air is drawn in and trapped as main eccentric rotor rotates in housing
  - Push pin activated sliding vanes contact housing wall compressing air as pockets gradually reduce
  - Lubrication is injected to protect internals and remove heat and is separated post compression but carry over is present
  - Compressed air smoothly exits at outlet
  - Low to moderate pressure
  - Lower flows
  - Low noise
  - Low to moderate outlet temperature

Dynamic Compression

- Dynamic Displacement compressors are those that speed up air to a higher velocity and then restrict the flow such that the reduction in velocity increases pressure
- Best applied on larger loads with a fixed demand
- Highest efficiency

Centrifugal Compressors

- Single / Multi Stage
  - Air is drawn in via fixed / adjustable guide vanes
  - As high speed impeller spins air velocity increases whereby a diffuser converts kinetic energy into static energy or pressure
  - Compressed air exits via casing volute
  - Low to moderate pressure
  - All flows
  - Low – moderate noise
  - Low to moderate outlet temperature



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Air Compressor Selection

Parameters to Define

- Required maximum pressure
- Required maximum flow or power rating (horsepower)
- Air or water cooled
- Voltage
- Oil lubricated or oil free
- Dedicated process or general utility
- Enclosed or open
- Sound level

Reciprocating

- 1 – 30HP
- Up to 200 CFM (duplex models)
- 4 CFM per HP
- Air cooled only
- Oil lubricated or oil free
- Enclosed or open
- 80% duty cycle
- Best choice for intermittent duty
- Most common choice up to 10HP

Rotary Screw – Oil Flooded

- 5 – 500HP
- Up to 2450 CFM
- 4 - 5 CFM per HP
- Air or water cooled
- Oil lubricated
- Enclosed or open
- 100% duty cycle
- Best choice for continuous duty
- Most common choice 15HP and above

Rotary Screw – Oil Free

- 20 – 425HP
- Up to 1705 CFM
- Air or water cooled
- Enclosed only
- 100% duty cycle
- No oil in the compression chamber
- Less efficient than oil flooded, twice the intial cost, more expensive long term maintenance

Rotary Scroll – Oil Free

- 3 – 10HP simplex, up to 40HP quadraplex, larger configurations as custom
- Up to 126 CFM
- 3 CFM per HP
- Air cooled only
- No oil in machine
- Enclosed or open
- Industrial or Medical (meets NFPA 99) packages
- 100% duty cycle
- Most popular oil free compressor choice below 100 CFM

Centrifugal

- 200 – 6000HP
- Up to 28,000 CFM
- 5+ CFM per HP
- Water cooled only
- Oil free
- Enclosed or open
- 100% duty cycle
- Turn down to 80% of full load capacity due to surge (causes back flow in machine and destroys)
- Best choice for high flow applications
- Most common choice 600HP and above, generally not practical below 400HP

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Air Treatment – ISO Quality

Agenda

- ISO Quality
- Dryer Technologies
- Compressed Air Filtration

ISO Quality 8573.1

Contaminates Found in Compressed Air

- Solid particulates
  - Dust
  - Dirt
  - Rust and scale
- Humidity and water
  - Condensed water droplets
  - Acidic condensates
- Compressor lubricant carryover
  - Oil vapor
  - Hydrocarbon vapor(s)

Risks of Not Properly Removing Contaminants

- Increased downstream equipment maintenance costs
- Decreased longevity of downstream equipment
- Instrumentation and control failures
- Poor downstream product fit and functionality
- Ultimate risk is contaminating the end use process

ISO 8573.1: 2010 Air Quality

- What is ISO 8573.1 Air Quality?
  - International standard for compressed air quality
  - Defines the amount of contamination permissible in one (1) cubic foot of compressed air
  - Classifies three primary forms of contamination in compressed air
    - Solid particles
    - Water
    - Oil
  - Contaminates are assigned a quality class – Class 0 to Class 9
    - Class 0 being the cleanest purity level
    - Class 9 being the most relaxed
  - Air Treatment manufacturers present technical data in an easy to understand ISO 8573.1:2010 table
    - Ask your suppliers to provide this table if not readily available

ISO 8573.1: 2010 Air Quality Examples

ISO Air Quality Classes	Solid Contaminants	Humidity & Water		Oil	
	Maximum Particle Size in Microns	Maximum Pressure Dew Point		Maximum Oil Content Droplets, Aerosols & Vapor PPM	
		°F	°C	W/W	mg/m^3
0	As specified by the equipment user or supplier. More stringent than Class 1				
1	0.1	-94	-70	0.008	0.01
2	1	-40	-40	0.08	0.1
3	5	-4	-20	0.8	1
4	15	+38	+3	4	5
5	40	+45	+7	21	25
6	-	+50	+10	-	-

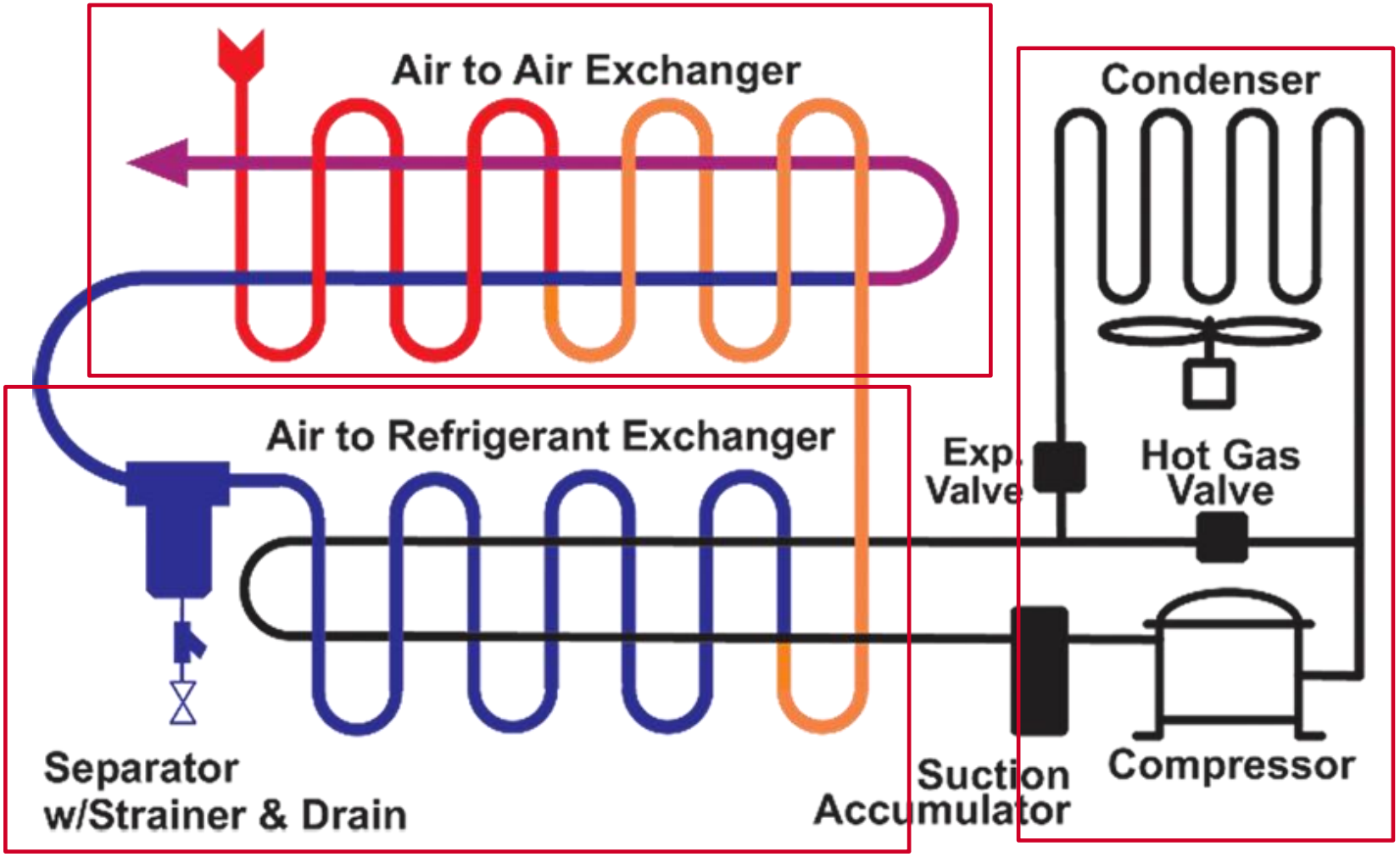
- Example 1 – Pharmaceutical (ISO Class 1.2.1); may see 1.1.1 or class 0 specified
- Example 2 – General Shop Air (ISO Class 3.4.4)

Dryer Technologies

Refrigerated Dryers

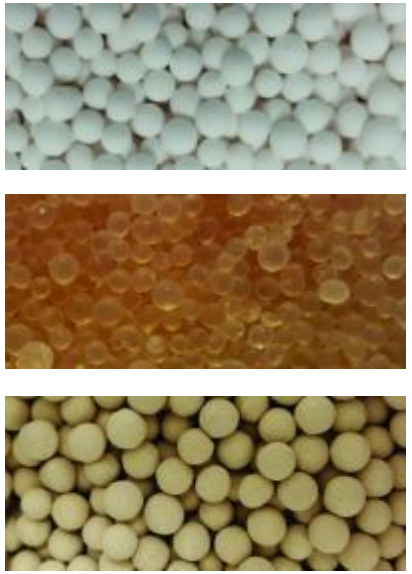
- What is a Refrigerated Dryer?
  - Product to remove moisture from compressed air
  - Typically contain three process areas
    - Air to Air Heat Exchanger
    - Air to Refrigerant Exchanger
    - Refrigerant Circuit
  - Achieves class 4-6 pressure dew point performance (+38 to +50°F)
- Refrigerated Dryer Technologies
  - Non-cycling
  - Cycling (energy savings)
  - High inlet temperature
  - High pressure

Refrigerated Dryers – Typical Flow Schematic

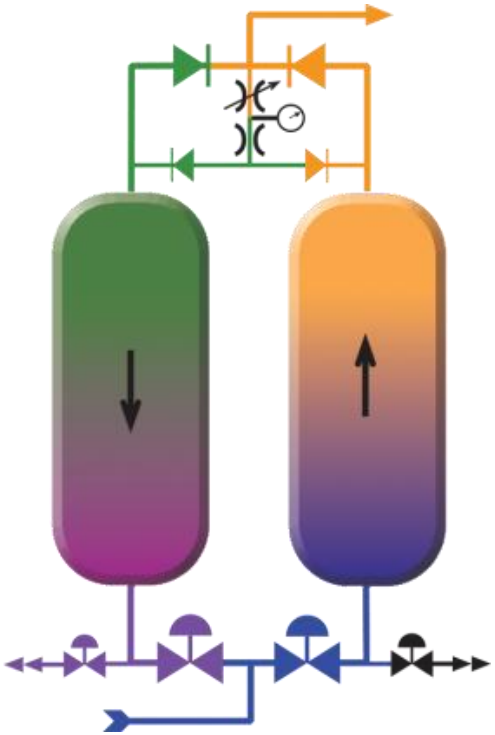


Desiccant Dryers

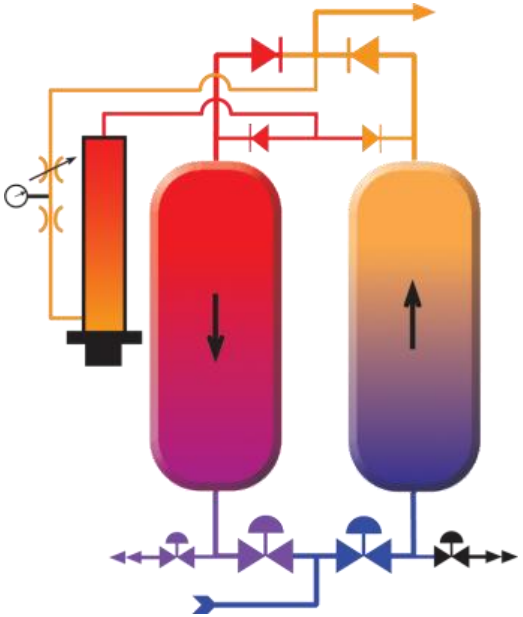
- What is a Desiccant Dryer?
  - Product to remove moisture from compressed air
  - Typically contain twin tower vessels or modular design
  - Activated alumina, silica gel, molecular sieve
  - Achieves class 0-3 pressure dew point performance (-100 to -4°F)
- Desiccant Dryer Technologies
  - Heatless
  - Externally Heated
  - Blower Purge
  - Heat of Compression
  - Single Tower



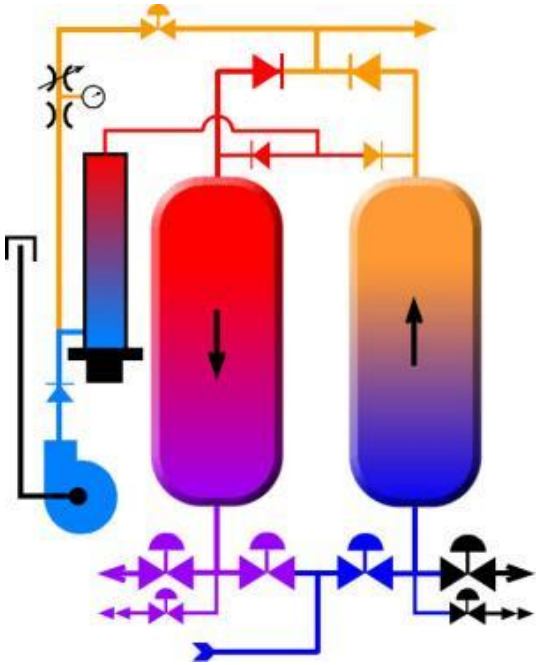
Desiccant Dryers – Typical Flow Schematic



Heatless



Externally Heated



Blower Purge

Refrigerated vs Desiccant

- Refrigerated dryer advantages over desiccant
  - Lower initial capital cost
  - Does not require purge air
  - Low on-going maintenance costs
  - Not susceptible to damage from lubricant carryover

- Desiccant dryer advantages over refrigerated
  - Achieve much lower dew point performance
  - Minimal to no risk of freeze up

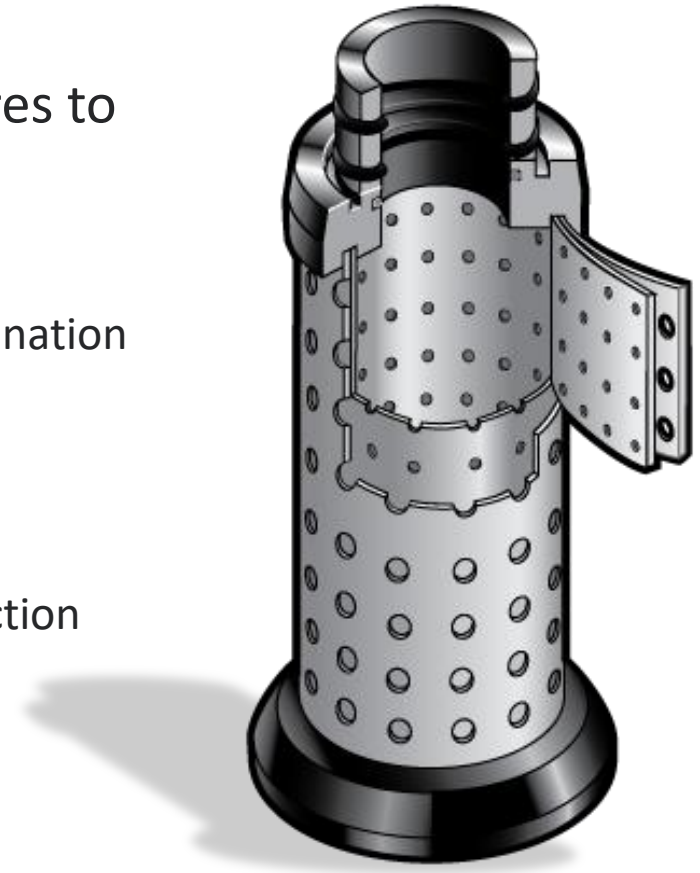
Compressed Air Filtration

Compressed Air Filtration

- What filtration is best for my application?
  - Dependent on ISO Quality class requirement of end use
  - Various levels of contaminants will require different filter selection
  - Application specific
- Typical filters
  - Moisture separator
  - Separator/filter
  - General purpose
  - Dry particulate
  - High and ultra high efficiency oil removal (coalescing)
  - Oil vapor

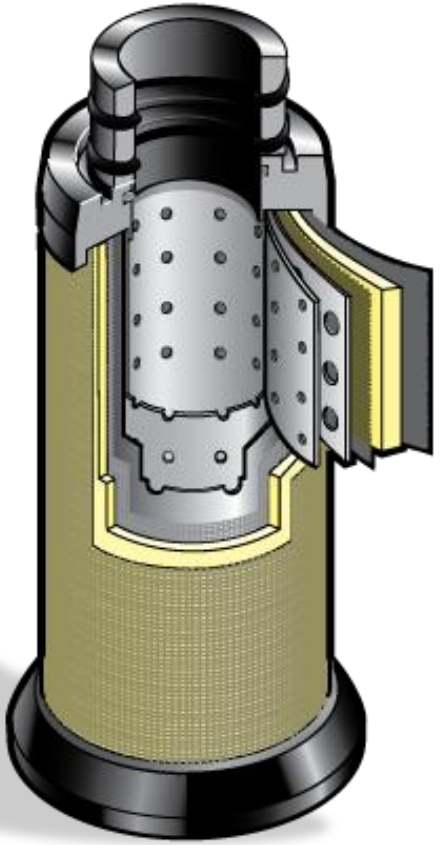
Moisture Separator

- Utilizes two stainless steel support cores to remove liquid from air stream
- Performance
  - Removes up to 30,000 ppm liquid contamination at efficiencies greater than 90%
- Application point
  - Downstream of after-coolers
  - Long pipe-runs require point of use protection



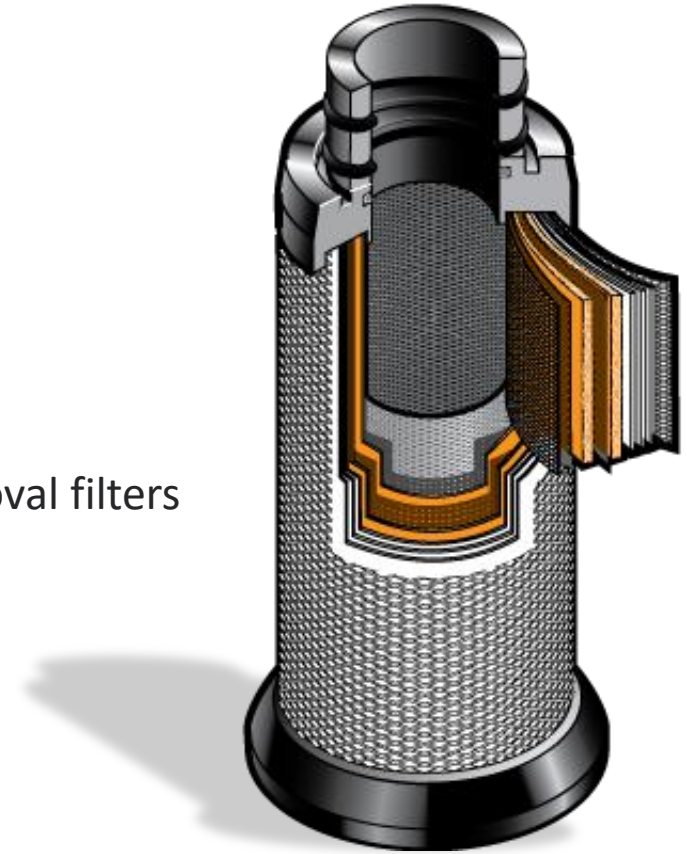
Separator/Filter

- Separator/filter for removing bulk liquids and solids
- Performance
  - 99% efficient at removing up to 25,000 ppm liquid water from air stream
  - Removes solids 3.0 micron and larger
  - Remaining oil content 5.0 mg/m^3
- ISO Quality Class
  - Solids – Class 3
  - Remaining Oil – Class 5
- Application point
  - Downstream of after-coolers
  - At point-of-use if no after-cooler/separator used upstream



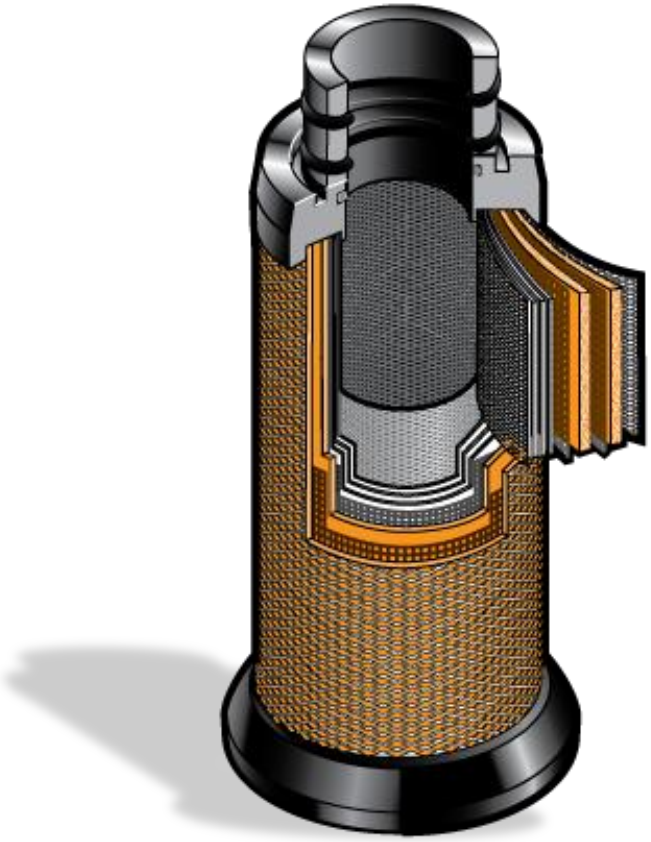
General Purpose

- General purpose filtration for solid and oil removal
- Performance
  - Removes solids 1.0 micron and larger
  - Remaining oil content 1.2 mg/m^3
- ISO Quality Class
  - Solids – Class 2
  - Remaining Oil – Class 4
- Application point
  - Upstream of ultra high efficiency oil removal filters
  - Upstream of refrigerated dryers
  - Downstream of heatless desiccant dryers



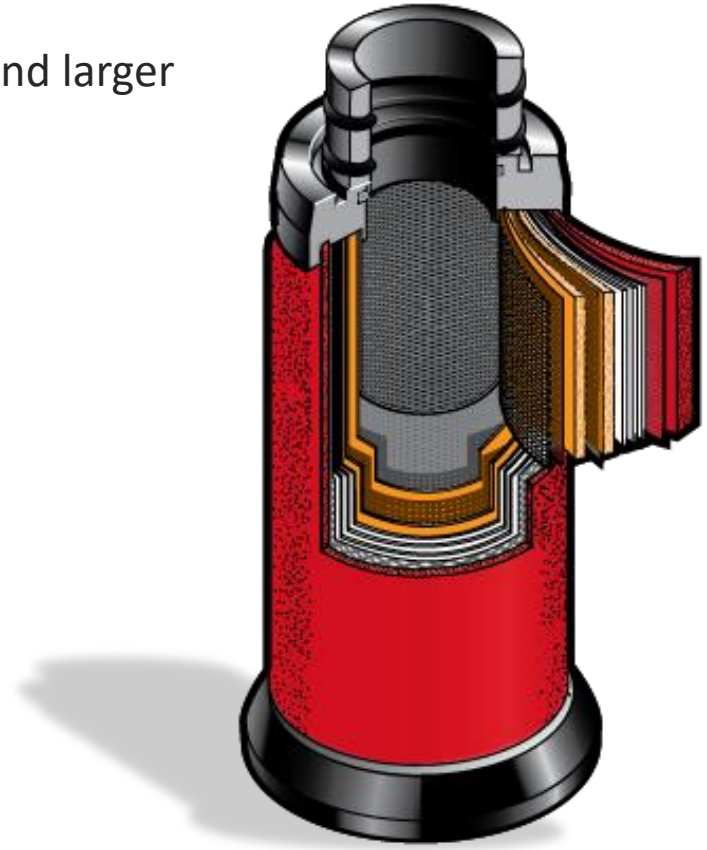
Dry Particulate

- Reverse flow (outside to inside), general purpose filtration for solid removal
- Performance
  - Removes solids 1.0 micron and larger
  - Remaining oil content 1.2 mg/m^3
- ISO Quality Class
  - Solids – Class 2
  - Remaining Oil – Class 4
- Application point
  - Downstream of heatless desiccant dryers



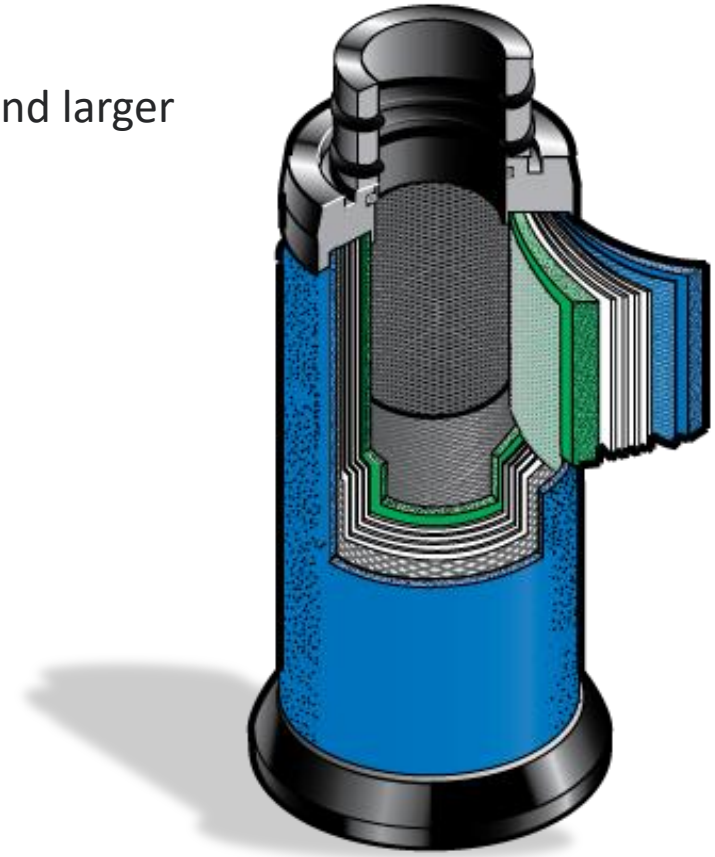
High Efficiency Oil Removal

- Fine coalescer provides high efficiency oil removal
- Performance
  - Removes 99.999+% of solids 0.01 micron and larger
  - Remaining oil content < 0.002 mg/m^3
- ISO Quality Class
  - Solids – Class 1
  - Remaining Oil – Class 1
- Application point
  - Upstream of desiccant dryers
  - Downstream of refrigerated dryers



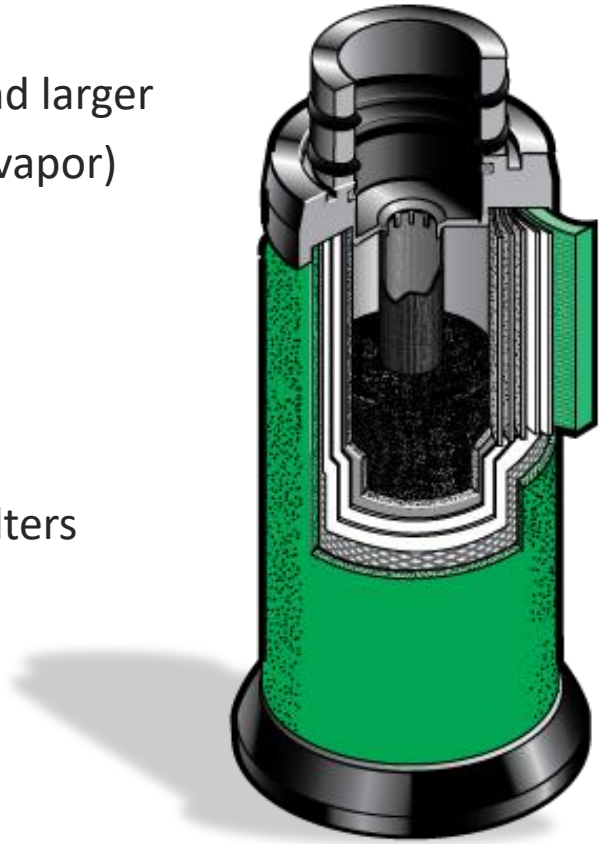
Ultra High Efficiency Oil Removal

- Ultra fine coalescing filter for critical applications
- Performance
  - Removes 99.999+% of solids 0.01 micron and larger
  - Remaining oil content < 0.0006 mg/m^3
- ISO Quality Class
  - Solids – Class 1
  - Remaining Oil – Class 1
- Application point
  - Upstream of desiccant dryers
  - Upstream of membrane dryers
  - Downstream of refrigerated dryers



Oil Vapor Removal

- Vapor removal filter for odor free air
- Performance
  - Removes 99.999+% of solids 0.01 micron and larger
  - Remaining oil content < 0.002 mg/m^3 (as a vapor)
- ISO Quality Class
  - Solids – Class 1
  - Remaining Oil – Class 1
- Application point
  - Downstream of high efficiency coalescing filters



Thank You!