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Meeting Your Compressed Air Treatment Needs

How to Select the Right Equipment for Your Application

Typical Air Treatment Configurations

Dryer Selection

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Glossary and Reference Data

Provided as a Service by Kaeser Compressors, Inc.

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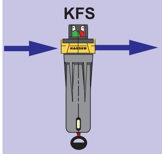
Meeting Your Compressed Air Treatment Needs

Why do we need compressed air treatment? Because ambient air contains contaminants that are drawn into the compressor. These contaminants are compressed and intensified and find their way into the compressed air system. Contaminants are also introduced into the compressed air stream by the compressor, receiver tank, piping, and other installed components. There are three different forms in which contaminants exist:

- *Solids - dirt, dust, pipe scale, compressor wear particles*
- *Liquids/Aerosols - oil and water*
- *Gases/Vapor - water, oil (hydro-carbons), carbon monoxide, chemical pollutants*

Compressed air applications range from shop air to breathing air—with a wide range of applications in between. Because the application determines the type of air treatment required, the first step in meeting your air treatment needs is to look closely at your application and the air quality it requires. Also, remember that individual applications requiring high air quality should not dictate the design of your overall system. Instead, point-of-use care can often be a cost-effective solution.

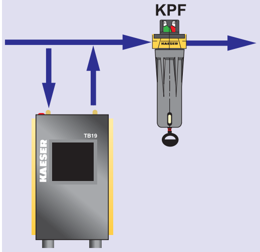
Typical Air Treatment Configurations



Level 1

Filtered Centrifugal Separator removes all solids three microns and larger. Removes liquids: 99% of water droplets, 40% of oil aerosols.

Application: Primary stage for all compressed air treatment levels

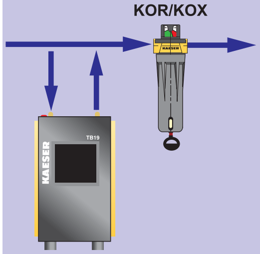


Level 2

Refrigerated Compressed Air Dryer produces pressure dew points as low as 35°F. **Air Line Filter** removes 70% of oil aerosols and all solid particles one micron and larger.

ISO 8573.1 Quality Class: 2.4.4

Applications: Air Tools, Sand Blasting

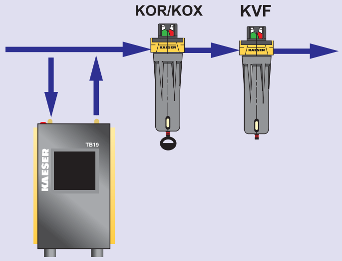


Level 3

Refrigerated Compressed Air Dryer produces pressure dew points as low as 35°F. **Oil Removal Filter** removes 99.999% of oil aerosols and all solid particles 0.01 microns and larger.

ISO 8573.1 Quality Class: 1.4.2

Applications: Instrument Air, Paint Spraying, Powder Coating

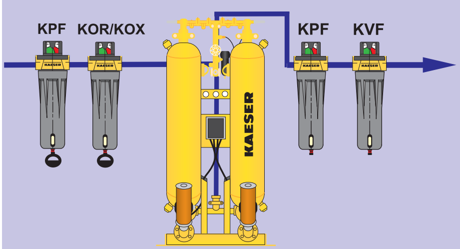


Level 4

Refrigerated Compressed Air Dryer produces pressure dew points as low as 35°F. **Oil Removal Filter** removes 99.999% of oil aerosols and all solid particles 0.01 microns and larger. **Oil Vapor Adsorber** removes oil vapor, oily smell and taste.

ISO 8573.1 Quality Class: 1.4.1

Applications: Food Industry, Chemical and Pharmaceutical Industry

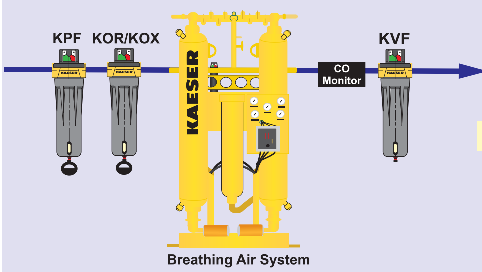


Level 5

Air Line Filter removes 70% of oil aerosols and all solid particles one micron and larger. **Oil Removal Filter** removes 99.999% of oil aerosols and all solid particles 0.01 microns and larger. **Low Dew Point Desiccant Dryer** produces pressure dew points as low as -100°F.

ISO 8573.1 Quality Class: 1.1.1

Applications: Breweries, Dairy Industry, Electronics Industry



Level 6

Breathing Air System (Continuous or Portable) removes common harmful compressed air contaminants and will produce Grade D breathing air.

ISO 8573.1 Quality Class: 1.2.1

Application: Breathing Air

Refer to ISO 8573.1 Quality Class Chart in glossary (back page).

Dryers

Don't dilute the performance of your compressed air system

Atmospheric air entering a compressor always contains water vapor, or humidity. At 75°F and 75% relative humidity, for example, 20 gallons of water will enter a typical 25 hp compressor during one day of operation. When air is compressed, this water content is concentrated. While the air naturally heats up during compression, the water remains vaporized. When, however, the compressed air travels downstream and cools, the vapor condenses into liquid droplets. This water is unacceptable for many applications and can also contaminate an entire compressed air system and lead to corrosion, air leaks, pressure drops, and scale formation.

Commonly used dryer types include: refrigerated air dryers, desiccant air dryers, deliquescent dryers, and membrane dryers.

Refrigerated Air Dryers: These are the most economical type of dryer. Warm and saturated air from the air compressor is cooled to a temperature of 35°F to 50°F. At these temperatures, the water condenses and can be mechanically separated and discharged from the system. Air, now free of liquid moisture, can be reheated and discharged into the compressed air system. This air now has a 35°F to 50°F pressure dew point, which means the air temperature has to drop below this temperature before further condensation occurs.

Desiccant Air Dryers: These dryers are used in applications that require compressed air at dew points as low as -100°F. Through two identical drying towers, each containing a desiccant bed, air flows alternately. While one tower is on-stream drying, the other is off-stream being regenerated. Purge air is used to regenerate the desiccant.

Diameter and length of desiccant beds determine drying efficiency. Bed diameter controls air velocity through the bed. If velocity is too high, the desiccant will float or fluidize, causing desiccant degradation. Bed length determines consistency of the dew point: the bed must be long enough to ensure sufficient contact time between the wet air and the dry desiccant to

Refrigerated Air Dryer Operation

Warm compressed air (1) entering the dryer is initially cooled in the air-to-air heat exchanger (2) by the cold compressed air leaving the dryer. This allows for greater efficiency by reducing the heat load on the refrigeration system. The air is cooled to the designed dew point temperature in the lower part of the heat exchanger (2) by a refrigerant circuit with a thermal mass (3). The condensate formed by the cooling action is separated from the compressed air by a multi-stage, stainless steel, maintenance-free separating system(4). The automatic condensate drain (4) reliably drains the water without wasting valuable compressed air. The dried air leaving the dryer is reheated in the upper part of the heat exchanger (2) before exiting the outlet (5). Reheating the compressed air eliminates pipe sweating downstream.

The heart of the system

The heart of any compressed air system is the air compressor itself. When selecting an air compressor, the most important factors to consider are quality and reliability. Reflected in quality and reliability are overall cost, efficiency, and easy maintenance. The most cost-effective unit is rarely the lowest priced. Components to evaluate in a compressor include:

- **Airend:** look at the package efficiency and check with the manufacturer for CAGI data sheets. Evaluate proven performance and reliability. For rotary screw compressors, the Sigma Profile developed by Kaeser Compressors can provide up to 20% savings in energy consumption.
- **Drive:** efficiency is critical. Belt drive units offer the most flexibility in pressure selection. While true direct drive units with the airend coupled directly to the motor (as opposed to gear driven units), offer maximum transmission efficiency.
- **Motors:** look for high and premium efficiency motors which meet or exceed the EPAct requirements. While ODP motors might be sufficient for some applications, TEFC motors provide excellent protection from the environment and are better suited for industrial applications.
- **Starters:** reduced voltage starters are becoming more popular even in smaller sizes down to 7.5 hp due to their "soft starting" capabilities. Look for Wye-Delta starters or variable frequency drives.
- **Controls:** system must be reliable, readable, and run the compressor efficiently.
- **Cooling System:** must be adequate to handle extreme ambient operating temperatures.
- **Interconnecting Piping:** look for rigid piping with flexible connections to eliminate leaks.

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Heatless Desiccant Dryer

Membrane Dryer

reach the proper outlet dew point.

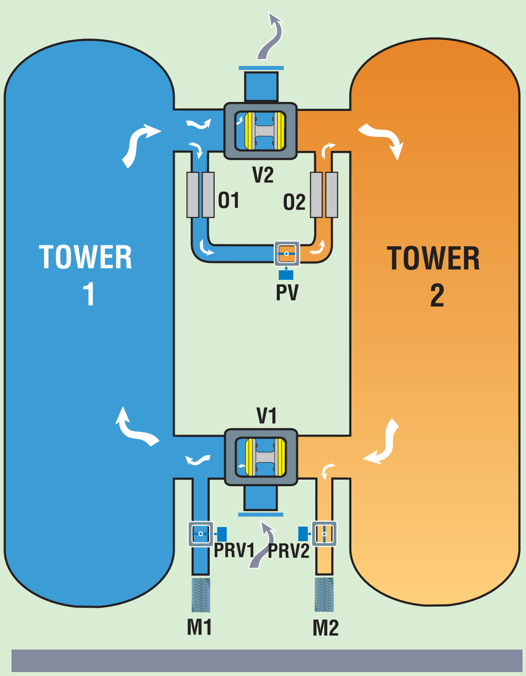
Channeling, when an air stream finds a path through the bed and follows the path instead of flowing evenly throughout the bed, is often a problem with desiccant dryers. Channeling can be avoided by using stainless steel diffusers in the inlet and outlet of the desiccant towers and controlling air velocity through the desiccant bed.

Desiccant dryers are either cold regenerative or heat regenerative. In cold regenerative dryers, 15% of dried compressed air is diverted from the air outlet and is used to purge the wet desiccant bed. In heat regenerative desiccant dryers, purge air is heated to 300 to 400°F and directed through one of the desiccant towers. Depending on the heated dryer type (internally heated, externally heated, blower purge, etc.), only a small percentage of 1 to 7% of purge air is diverted from the dried air stream. Valuable purge air is saved, reducing operating costs up to 40% in applications over 500 cfm.

Deliquescent Dryers: These dryers rely on chemical action and produce a dew point of only 20°F below inlet temperatures. Their condensate is very corrosive. Maintenance requirements are relatively high.

Membrane Dryers: These utilize the newest technology for compressed air drying. The process is quite simple: compressed air passes through a bundle of hollow membrane fibers and the water vapor permeates the membrane walls. The dried air continues down the tubes and into the downstream air system. The main drawback is the relatively large amount of costly and unrecoverable compressed air (sweep air) lost through the membrane walls along with the water vapor.

Heatless Regenerative Desiccant Dryer Operation



The main air stream enters the drying Tower 1 through the Inlet Shuttle Valve (V1), is dried by the adsorptive capacity of the desiccant, and is directed to the dryer outlet by the outlet shuttle valve (V2). A portion of the dried air is throttled to near atmospheric pressure by means of an adjustable Purge Rate valve (PV) and Purge Orifice (02). This extremely dry, low pressure air flows through and regenerates the desiccant in Tower 2. The moisture laden purge air is exhausted through the Purge/Repressurization Valve (PRV2) and exhaust muffler (M2) to the atmosphere. When regeneration is complete, the Purge/Repressurization Valve (PRV2) closes which allows Tower 2 to slowly repressurize. Purge/Repressurization Valve (PRV1) opens, depressurizing Tower 1 through Exhaust Muffler (M1). The pressure imbalance between Tower 2 and Tower 1 causes the Inlet Shuttle Valve (V1) to change positions directing wet compressed air into Tower 2. This pressure imbalance also causes Outlet Shuttle Valve (V2) to change positions directing dry air from Tower 2 to the dryer outlet and allowing a portion of the dried air from Tower 2 to be throttled to near atmospheric pressure by means of the Purge Rate Valve (PV) and Purge Orifice (01). This air then regenerates the desiccant in Tower 1. The moisture laden purge air is exhausted through the Purge/Repressurization Valve (PRV1) and Exhaust Muffler (M1) to the atmosphere.

Filters

Protect System Components and Maintain Product Quality

Compressed air systems contain contaminants that increase operating costs by:

- contaminating product
- damaging air-operated equipment
- clogging air lines and restricting air flow to equipment

The right filter depends on the needs of your particular application. The most basic filtration is provided by a **Filtered Centrifugal Separator**, which combines separation and filtration in one housing. Using principles of centrifugal force and impaction, a well-designed filter's first stage is 99% efficient in removing particles 10 microns and larger. The second stage is a replaceable coalescing sleeve filter which removes solids and liquids down to 3 microns.

Particulate filters should be used primarily to remove rust, scale, dirt, and other solid particles one micron and larger. These operate with two stages: a first stage of coarse media collects larger particles and a second stage of finer media separates smaller particles as well as water and oil-aerosols. Particulate filters are very versatile and can be used with either lubricated or non-lubricated compressors. In lubricated systems, this filter will remove oil aerosols with over 70% efficiency and can be used to protect filters having finer media from heavier particulate and liquid loading. In non-lubricated systems air line filters can be used upstream of heated or heatless desiccant dryers and downstream of heatless desiccant dryers to capture desiccant fines.

Coalescing Oil Removal Filters remove oil aerosols that contaminate end products, ruin paint jobs, and gum up air tools. In a typical 100 psig air system, 72% by weight of oil aerosols are less than five microns and 50% are below one micron. These droplets will pass right through a mechanical separator and cannot be completely removed by an air line filter. A good coalescing oil removal filter has a liquid oil removal rate of over 99.999%. Air is directed through a maze of submicronic glass fibers where the oil aerosols are coalesced into larger droplets and continuously removed.

Oil Vapor Adsorbers are final stage filters which adsorb oil vapor by passing the compressed air through two levels of activated carbon. They eliminate smell and taste by removing oil vapors as well as any other gaseous hydrocarbons normally adsorbed by activated carbon. They should be installed after the oil removal filter because liquid oil aerosols will prematurely saturate the activated carbon and significantly reduce adsorptive capacity.

High Temperature Afterfilters are primarily designed as afterfilters for heated desiccant dryers, but can be used wherever large amounts of solid particles are present in dry air. They can hold a large number of desiccant fines without plugging. Large dust particles settle in the bottom of the filter housing due to reduced velocity and a sharp shift in direction. Medium-size particles are collected on the surface of a layer of glass fiber cloth, while fines one micron and smaller are collected on beds of in-depth fiber glass media.

Moisture Separators are important for removing bulk liquids and are typically installed after the aftercooler, where up to 80% of the total moisture is removed.

What Size Contaminants are Found in a Compressed Air System?

If .01 micron is this big

Then .1 micron is this big

And 1 micron could not fit on this page!

Measured in microns (µm)
1 millionth of a meter or 0.000039 inches

Human Hair (section):	30 to 200 µm
Visible to eye:	50 µm
Water aerosols:	1 to 20 µm
Bacteria:	0.25 to 20 µm
Oil and oil aerosols:	0.01 to 5 µm
Solid particles:	0.5 to 5 µm
Tobacco smoke:	0.01 to 1.0 µm
Viruses:	0.003 to 0.05 µm

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Extra-fine filter shown

Filtered Centrifugal Separator

The Kaeser Filtered Centrifugal Separator uses centrifugal separation and mechanical filtration to remove bulk liquids from a compressed air system.

Particulate Filter

Available in models from 20 scfm to 21,250 scfm, the Kaeser Particulate Filter removes liquid aerosols, rust, scale, dirt, and other solid particles one micron and larger.

Coalescing Oil Removal Filter

Used within its rated design conditions, the coalescing Kaeser Oil Removal Filter eliminates the oil aerosols contained in a compressed air system. Its unique, continuously stabilized filter medium plus outer foam sleeve ensure 99.999+% efficiency for the life of the cartridge.

Oil Vapor Removal Filter

Oil vapor removal filters are final stage filters which adsorb oil vapors and other gaseous hydrocarbons in compressed air. In Kaeser Oil Vapor Removal Filters compressed air passes through two levels of activated charcoal to remove gaseous oil contamination and related odors.

General Compressed Air Treatment Sizing Considerations

<table>
<tr><th rowspan="2">Component</th><th colspan="5">Sizing Considerations</th></tr>
<tr><th>Compressed Air Pressure</th><th>Compressed Air Temperature</th><th>Compressed Air Dew Point</th><th>Ambient Air Temperature</th><th>Air Quality Level Required at Inlet</th></tr>
<tr><td>Filters</td><td>Capacity increases as pressure increases</td><td>Capacity does not change</td><td>Capacity does not change</td><td>Capacity does not change</td><td>Separators: no requirement
Particulate: MAY require pre-filtration
Oil coalescing: SHOULD have prefiltration
Oil vapor: MUST have pre-filtration</td></tr>
<tr><td>Aftercoolers</td><td>Capacity does not change</td><td rowspan="2">Capacity decreases as temperature increases</td><td rowspan="2">Capacity decreases as dew point increases</td><td>Discharge air temperature increases as ambient air temperature increases</td><td>No requirement</td></tr>
<tr><td>Refrigerated Dryers</td><td rowspan="7">Capacity increases as pressure increases</td><td>Capacity decreases as ambient air temperature increases</td><td>Pre-filtration may be necessary to protect extended surface heat exchangers. Check with dryer manufacturer.</td></tr>
<tr><td>Heatless Regenerative Desiccant Dryers</td><td>Capacity does not change</td><td>Capacity does not change</td><td rowspan="6">Capacity does not change</td><td>Inlet air must be free of oil aerosols and particulates larger than 3 micron. (Also requires 1 micron after-filter)</td></tr>
<tr><td>Heat Reactivated Desiccant Dryers</td><td>Capacity decreases as temperature increases</td><td>Capacity decreases dramatically as dew point increases</td><td>Inlet air must be free of oil aerosols and particulates larger than 3 micron. (Also requires 1 micron, high temp, after-filter)</td></tr>
<tr><td>Membrane Dryers</td><td rowspan="4">Capacity does not change</td><td>Capacity decreases as dew point increases</td><td>Inlet air must be free of oil aerosols and particulates larger than 0.01 micron</td></tr>
<tr><td>Nitrogen Generators</td><td rowspan="2">Capacity does not change</td><td>Inlet air MUST be free of oil aerosols, oil vapor and particulates larger than 0.01 micron</td></tr>
<tr><td>Breathing Air Purifiers</td><td>Should be no requirement as a breathing air purifier should include all necessary component, BUT CHECK WITH MFR.</td></tr>
<tr><td>Deliquescent Dryers</td><td>Capacity decreases as dew point increases</td><td>No requirement</td></tr>
</table>

Drain Traps and Aftercoolers

Drain Traps reduce plant operating costs, lower maintenance, and prevent air lines from flooding. They eliminate bleeding expensive compressed air through pet-cocks or manually draining compressed air lines and equipment. A ball valve should precede all drain traps to facilitate routine maintenance without interruption.

Demand-Operated Drain Traps automatically discharge moisture and oil-containing condensate from the system. Drain traps should discharge only liquids, not costly compressed air, and do not require a maintenance-intensive strainer upstream of the condensate inlet. They can be used on air receivers, inter- and after-coolers, refrigerated dryers, separators, filters, and header piping.

Timed Electric Traps are not a practical option. Not only do they release costly compressed air in addition to condensate, but the discharge process can create a stable emulsion which cannot be easily separated and increases disposal costs.

Aftercoolers are necessary to reduce discharge temperatures to levels acceptable for further air treatment (generally less that 120°F). They can be either air-cooled or water-cooled.

Air Suitable for Breathing

Air for face masks, hoods, helmets, and other externally supplied-air breathing apparatus require air treatment specifically designed for breathing air. These must remove excessive moisture, particulates (dust and dirt), oil and oil vapor, carbon monoxide, and other hydrocarbon vapors commonly found in ambient air. They must also monitor and provide an alarm signal for excess carbon monoxide. Properly design breathing air systems product “Grade D” level air, which is suitable for breathing under OSHA standards.

Air Main Charging Valve

Compressed air dryers and filters are designed to treat specific volumes of air at specific conditions. If system pressure is not maintained all the time, air moves through clean air treatment equipment at unusually high velocity when the system is re-started. When this occurs, dryers and filters will not perform to specification until full operating pressure is reached and air velocity drops to within normal limits. This is not likely to be an issue in 24 hour operations, but it may be for systems that are shut down overnight or on weekends. Kaeser’s Air Main Charging System prevents excessive velocity by automatically opening and closing to slowly charge the main distribution piping. This not only ensures correct air quality but also protects and extends the life of treatment devices.

Automatic Magnetic Drain Traps

Eco-Drain Series Drain Traps

Air Main Charging Valve

Breathing Air System

Rules of Thumb

- Most water-cooled aftercoolers will require about 3 gpm per 100 cfm of compressed air at discharge pressures of 100 psig.
- The water vapor content at 100°F of saturated compressed air equals about two gallons per hour for each 100 cfm of compressor output.
- For every 20°F temperature drop in saturated compressed air, 50% of the water vapor condenses into liquid.
- Under average conditions, every 100 cfm of air compressed to 100 psig produces 20 gallons of condensate per day.
- Locate filters and dryers in the air line before any pressure reducing valve (highest pressure) and after air is cooled to 100°F or less (lowest temperature).
- Compressed air filters can produce air that is up to 250,000 times cleaner than the air we breathe.

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USGUIDE2

Compressed Air Treatment Glossary

- **Aftercooler:** Heat exchanger for cooling air discharged from air compressors; can be either water-cooled or air-cooled.
- **Air/Oil separator:** A device in the compressor that separates oil from the air/oil mixture compressed in the airend.
- **Breathing air systems:** Air purifying systems that produce compressed air meeting OSHA standards for Breathing Quality Compressed Air.
- **Cubic feet of air per minute (cfm):** Volume delivery rate of air flow

  Cubic feet of air per minute, free air (cfm fad). cfm of air delivered to some specific point and converted back to ambient (free air) conditions.

  Actual cubic feet per minute (acfm). Flow rate of air measured at some reference point and based on actual conditions at that reference point.

  Inlet cubic feet per minute (icfm). cfm flowing through the compressor inlet filter or inlet valve under rated conditions.

  Standard cubic feet per minute (scfm). Flow of free air measured at a reference point and converted to a standard set of reference conditions (e.g., 14.7 psia, 68°F, and 36% relative humidity).
- **Drain Traps:** Collect and discharge liquids from aftercoolers, separators, receivers, dryers, filters, and drip legs.
- **Dryers:** Remove moisture from compressed air.

  Refrigerated dryers cool air to remove moisture by using a refrigeration cycle.

  Desiccant dryers reduce dew point by flowing wet air through desiccant beads; heat reactivated desiccant dryers use heat to regenerate the desiccant bed and are more economical at higher cfm ratings than cold regenerative desiccant dryers.

  Deliquescent dryers reduce dew point through chemical reaction of air with desiccant tablets.

  Membrane dryers reduce dew point by passing compressed air through a bundle of hollow membrane fibers; water vapor and a portion of the compressed air permeates the membrane walls and vents to atmosphere.
- **Pressure:** Force per unit area.

  Pounds per square inch (psi). Force exerted by compressed air equal to 1 pound applied evenly

  Pounds per square inch absolute (psia). Absolute pressure above zero pressure.

  Pounds per square inch differential (psid). Pressure difference between two points.

  Pounds per square inch gauge (psig). Gauge pressure, measured as the difference between absolute pressure (psia) and ambient pressure.
- **Pressure dew point:** Temperature at which water will begin to condense out of air at a given pressure. To ensure that no liquid water is present, the pressure dew point must be less than the lowest temperature to which the compressed air will be exposed.

ISO 8573.1 Quality Classes

ISO 8573.1 was developed in 1991 by ISO (International Organization for Standardization) to help plant engineers specify desired compressed air quality globally by providing "Quality Classes" for solid particulates, humidity and oil. Quality classes provide engineers with an internationally accepted unit of measure. A typical pharmaceutical plant, for example, would have a compressed air specification of ISO Quality Class 1.2.1. This is equivalent to 0.1 micron particulate filtration, -40° F (-40°C) dew point, and 0.008 ppm (0.01 mg/m³) oil filtration.

Quality Classes	SOLIDS Maximum particle size (microns)	MOISTURE Dew Point °C	°F	OIL Liquid and Gas mg/m³	ppm$_{w/w}$
0	as specified	as specified		as specified	
1	0.1	-70	-94	0.01	0.008
2	1	-40	-40	0.1	0.08
3	5	-20	-4	1	0.8
4	15	3	38	5	4
5	40	7	45	—	—
6	—	10	50	—	—