CompAir

Using ISO quality standards to plan your compressed air system

A Guide to Benchmarking Performance with ISO 8573, ISO 12500, and ISO 7183

White Paper

Introduction

Often referred to as the 4th utility after electricity, water, and gas, compressed air is the only major industrial power source generated on site by users bearing full financial and legal liability for its quality.

A thorough understanding of compressed air quality and testing standards is therefore indispensable when designing your system to achieve the purity levels your application requires. The International Organisation for Standardisation (ISO) sets three such standards, ISO 8573, ISO 12500, and ISO 7183. Which standards you should apply will depend on the specific contaminants you aim to remove and the purification equipment you will rely on to do so.

This white paper outlines:

- The most commonly encountered compressed air system contaminants
- The types of equipment you can use to remove these contaminants
- The applicable ISO standards you may use to benchmark your equipment's capabilities and results

Also included are:

- Several examples of optimised compressed air network configurations on which to model your own system
- A set of simple guidelines to use when selecting your purification equipment
- A quick reference guide to products used to deliver various compressed air purity levels for different applications

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Compressed air contaminants and their sources

The four main sources of contaminants in a compressed air system are the atmospheric air surrounding the compressor intake, the air compressor itself, the air storage device (the air receiver), and the system's distribution piping. The main types of contaminants are particulates, water, oil, and micro-organisms, with their specific forms and corresponding sources are listed below.

Particulates Atmospheric air

Atmospheric Dirt. Atmospheric air in an industrial environment typically contains 140 million dirt particles for every cubic meter of air. 80% of these particles are less than 2 microns in size and are too small to be captured by the compressor intake filter, therefore passing directly into the compressed air system.

Water Atmospheric air

Water vapor. The ability of compressed air to hold water vapor depends on its temperature. Higher temperatures allow the air to hold more vapor. During compression, air temperature and pressure increases significantly and can subsequently retain more moisture.

Water liquids and aerosols. When cooled after compression, water vapor condenses into liquid water. Condensation occurs at various stages throughout the system as the air is cooled further by the air receiver, the distribution piping and the expansion of air in valves, cylinders, tools and machinery.

Oil Atmospheric air

Oil vapor. Atmospheric air contains oil in the form of unburned hydrocarbons which are drawn into the compressor intake. Typical concentrations can vary between 0.05 and 0.5mg per cubic metre of ambient air.

Oil Compressor

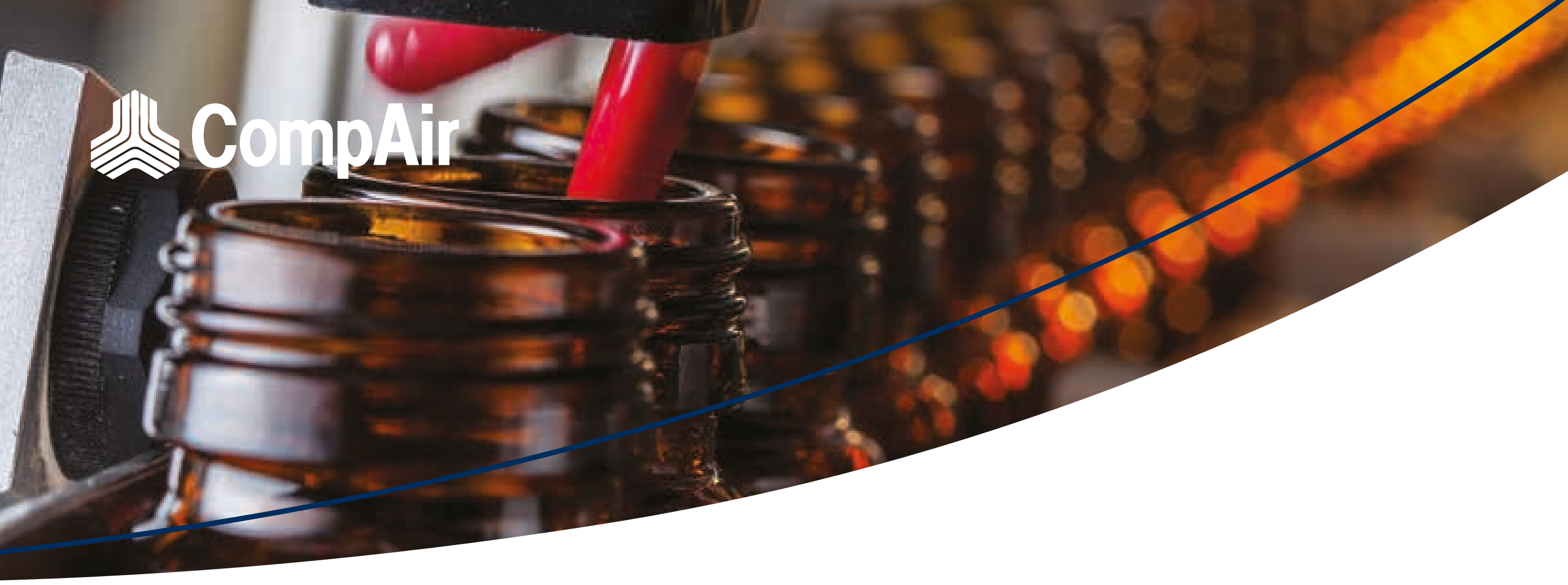
Oil liquids and aerosols. Most air compressors use oil in the compression stage for sealing, lubrication and cooling. During operation, lubricating oil is carried over into the compressed air system as liquid oil and aerosols. This oil mixes with water in the air and is often very acidic. Additionally, once inside the compressed air system, oil vapor will cool and condense, effectively causing liquid oil contamination.

Particulates Air receiver and distribution piping

Rust and pipe scale. Rust and pipe scale occur in air receivers and the piping of "wet systems" (systems without adequate purification equipment) or systems which were operated "wet" prior to purification equipment being installed. Over time, this contamination breaks away to cause damage or blockage in production equipment, which can also contaminate final product and processes.

Micro-organisms Atmospheric air

Micro-organisms. Bacteria and viruses may be drawn into the compressed air system through the compressor intake. A cubic metre of ambient air typically contains around 100,000,000 (100 million) micro-organisms per cubic metre, only a few of which can diminish product quality or even render a product entirely unfit for use and subject to recall.



ISO Compressed Air Quality and Testing Standards

ISO 8573 is a nine-part group of international standards relating to compressed air quality and testing. The first part, ISO 8573-1, specifies compressed air quality classes with regard to each contaminant type. The remaining eight parts, ISO 8573-2 to ISO 8573-9, specify methods to test and verify that a given air sample falls into one of these air quality classes. The most recent revision of ISO 8573-1 took place in 2010, with the current editions of ISO 8573-2 to 8573-9 having come into effect over several years dating back to 1999.

To specify air purity from each type of contaminant, ISO 8573-1 employs 10 classes numbered from 0 - 9. Each class indicates the levels of the specific contaminant allowable in a cubic metre of compressed air. Classes 1 - 9 specify pre-established contaminant levels universally recognised by compressed air equipment manufacturers, suppliers, and users. The use of Class 0 however, allows interested parties to agree their own acceptable contaminant levels for a given compressed air application, provided that the agreed levels surpass Class 1 standards, are measurable according to ISO 8573-2 to 8573-9 testing standards, and are formally documented.

When specifying air purity in accordance with ISO 8573-1 standards, it is necessary to identify:

- The standard itself
- The edition of the standard
- The classes of purity from particulates, water, and oil, respectively, according to the standard

For example, ISO 8573-1:2010 Class 1.2.1 refers to compressed air with Class 1 levels of particulate contamination, Class 2 levels of water contamination, and Class 1 levels of oil contamination as per the 2010 edition of the ISO 8573-1 quality standards. Please see the opposite table for full details on allowable contaminant levels for each ISO 8573-1 class.

ISO 8573-1:2010 Class 0 Compressed Air

- Does not mean zero contamination
- Has purity levels jointly defined in writing by users and / or equipment manufacturers or suppliers
- Does not account for purity levels greater than those measurable by methods defined by the ISO 8573-2 to 8573-9 standards
- Should be specified only at the point of use for the most critical applications to achieve cost-effectiveness

ISO 12500 and ISO 7183 compressed air purification testing standards

ISO 12500 is the group of international standards designed to assess the operational performance of compressed air filter and water separator products. ISO 12500 consists of four parts, ISO 12500-1 to ISO 12500-4, each covering the performance of a different variety of filter or water separator. Similarly, the ISO 7183 standard serves to assess the operational performance of compressed air dryers.

ISO 12500 and ISO 7183 both complement the ISO 8573-2 to 8573-9 testing standards, which notably fail to account for challenge concentrations. A challenge concentration is an initial level of compressed air contamination against which post-purification contamination levels can be compared.

Standardisation of these critical performance variables allows consumers to compare the relative performance of compressed air purification equipment from different suppliers. For a detailed description of each ISO testing standard and the type of purification equipment to which it applies, please see the next section.

The below table summarises:

- The most common forms of compressed air purification technologies
- The contaminants they remove
- Their applicable ISO testing standards
- The ISO 8573-1:2010 purity classes used to specify their operational results

Purification technologies	Contaminants									ISO Testing Standards
	Particulates			Water			Oil			
	Rust and Pipescale	Atmospheric Dirt and Particles	Micro-organisms	Liquid	Aerosol	Vapor	Liquid	Aerosol	Vapor	
Coalescing filters	X	X			X			X		ISO 8573-2:2007 ISO 8573-4:2001 ISO 12500-1:2007
Adsorption filters									X	ISO 8573-5:2007 ISO 8573-6:2007 ISO 12500-2:2007
Dust removal filters	X	X								ISO 8573-4:2001 ISO 8573-6:2003 ISO 8573-8:2004 ISO 12500-3:2009
Micro-biological sterile filters			X							
Water separators				X			X			ISO 8573-9:2004 ISO 12500-4:2009
Adsorption dryers						X				ISO 8573-3:1999 ISO 7183:2007
Refrigeration dryers						X				
Dual refrigerant/adsorption dryers						X				

ISO 8573-1:2010 compressed air contaminants and purity classes

Class	Particles				Water			Oil
	By Particle Size (maximum number of particles per m³). See Note 2			By Mass	Vapor Pressure Dewpoint		Liquid	Liquid, Aerosol & Vapor. See Note 1
	0.10 - 0.5 microns	0.5 - 1.0 microns	1.0- 5.0 microns	[mg/m³]	[°C]	[°F]	[g/m³]	[mg/m³]
0	As specified by the equipment user or supplier and more stringent than class 1							
1	≤ 20,000	≤ 400	≤ 10	-	≤ -70	≤ -94	-	≤ 0.01
2	≤ 400,000	≤ 6,000	≤ 100	-	≤ -40	≤ -40	-	≤ 0.1
3	-	≤ 90,000	≤ 1,000	-	≤ -20	≤ -4	-	≤ 1
4	-	-	≤ 10,000	-	≤ +3	≤ +37	-	≤ 5
5	-	-	≤ 100,000	-	≤ +7	≤ +45	-	-
6	-	-	-	0 - ≤ 5	≤ +10	≤ +50	-	-
7	-	-	-	0 - ≤ 10	-	-	≤ 0.5	-
8	-	-	-	-	-	-	≤ 5	-
9	-	-	-	-	-	-	≤ 10	-
X	-	-	-		-	-	>10	>5
	Microbiological Contaminants				Other Gaseous Contaminants			
	No purity classes are identified				No purity classes are identified. Gases mentioned are: CO, CO_2, SO_2, NOX, Hydrocarbons in the range of C_1 to C_5			

Types and examples of purification technology with their respective ISO testing standards

Purification technology	ISO testing standards
Water separators remove >90% of liquid water ("wall flow") to protect coalescing filters systems with excessive cooling in distribution piping.	ISO 8573-9:2004 specifies the test method for liquid water content. ISO 12500-4:2009 provides guidelines on testing the water-removal efficiency and operational pressure drop of a wall flow removal device in accordance with ISO 8573-2.
Coalescing filters usually comprising a compressed air system's most important purification equipment, rely on mechanical filtration techniques.	ISO 8573-2:2007 specifies the test method for oil aerosol content. ISO 8573-4:2001 specifies the test method for solid particle content. ISO 12500-1:2007 introduces 40mg/m³ and 10mg/m³ oil aerosol challenge concentrations for testing coalescing filters in accordance with ISO 8573-2:2007. It requires the filter to be "wetted out" as it would be in operation. The filter's initial saturated pressure drop is recorded in order to indicate the filter's operational costs. Three filters of each size must be tested and each filter tested three times. Published performance data is then an average of all these tests.
Adsorption dryers, or desiccant dryers, rely on regenerative adsorbent material. They require coalescing filters to work efficiently.	ISO 8573-3:1999 specifies the test method for the measurement of humidity. ISO 7183:2007 specifies the standard criteria required to test compressed air dryers, namely: pressure dew point, flow rate, pressure drop, compressed air loss, power consumption (including partial-load tests) and noise emission (operating and loading conditions).
Refrigeration dryers work by cooling the air. They require the use of coalescing filters to work efficiently.	ISO 8573-3:1999 specifies the test method for the measurement of humidity. ISO 7183:2007 specifies the standard criteria required to test compressed air dryers, namely: pressure dew point, flow rate, pressure drop, compressed air loss, power consumption (including partial-load tests) and noise emission (operating and loading conditions).
Dust removal filters retain particulates where no liquid is present and exhibit particulate removal performance similar to coalescing filters.	ISO 8573-4:2001 specifies the test method for solid particle content. ISO 8573-6:2003 specifies the test method for viable microbiological contaminant content. ISO 8573-8:2004 specifies the test method for solid particle content by mass concentration. ISO 12500-3:2009 provides a guide for rating the performance of solid particulate removal filters according to particle size. It specifies the layouts and procedures for completing a "type-test" on filters to represent a range. The guide identifies two filter ranges: 0,01 < 5,0 µm, and ≥ 5,0 ≤ 40 µm.
Absorption filters rely on a large bed of activated carbon adsorbent to reduce oil vapour contamination.	ISO 8573-5:2007 specifies the test method for oil vapour. ISO 8573-6:2007 specifies the test method for gaseous contaminant content. ISO 12500-2:2007 is an accelerated test of a filter's adsorption capacity, which is finite and is used up over time. Results do not indicate the actual lifetime of the filter element or cartridge. Instead, they indicate which filter has the largest adsorption capacity and will therefore require less frequent replacement.

Cost-effective compressed air system design

To achieve the stringent air quality levels required for today's modern production facilities, a careful approach to system design, commissioning and operation must be employed. Treatment at one point alone is not enough and it is highly recommended that the compressed air be treated prior to entry into the distribution system to a quality level suitable for protecting air receivers and distribution piping. Point of use purification should also be employed, with specific attention being focused on the application and the level of air quality required. This approach to system design ensures that air is not "over treated" and provides the most cost effective solution for high quality compressed air.

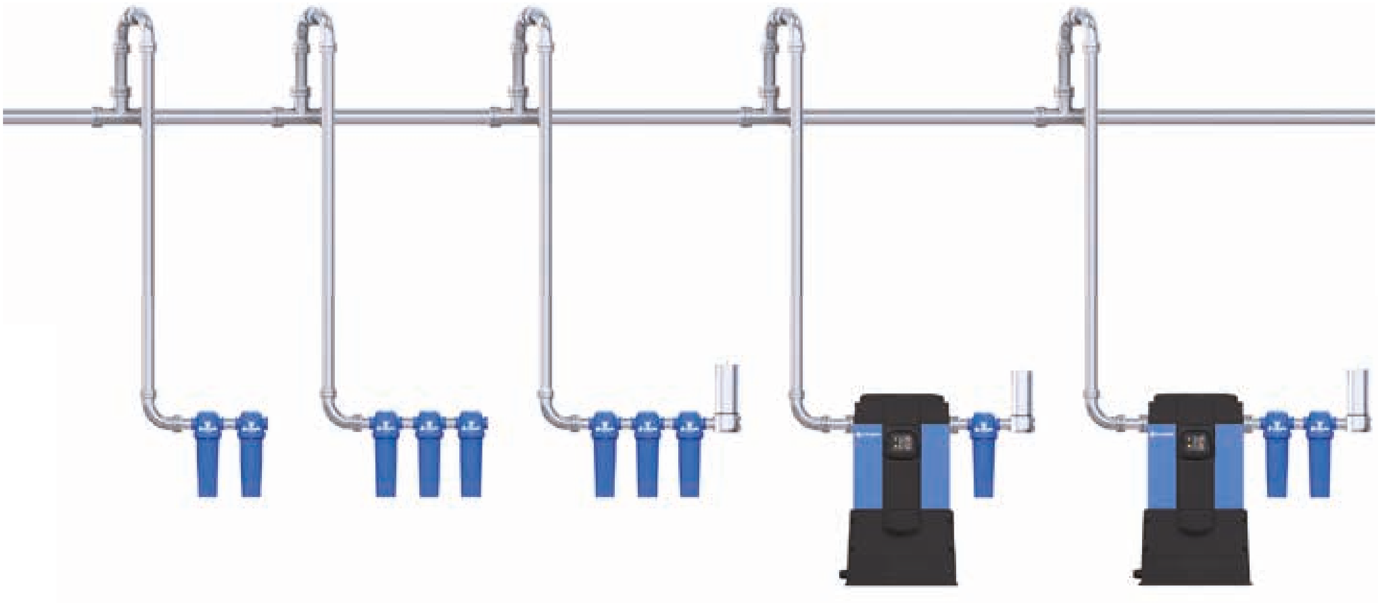
The following are examples of cost-effective compressed air system configurations:

Example configurations: Compressor room

A. With Adsorption Dryer and Oil Vapour Removal Filter

B. With Refrigeration Dryer

Example configurations: Point of use application protection.



	C	D	E		F	G
	ISO 8573-1: 2010	ISO 8573-1: 2010	ISO 8573-1: 2010		ISO 8573-1: 2010	ISO 8573-1: 2010
From Compressor Room A	Class 2-1-2 Class 2-2-2 Class 2-3-2	Class 2-1-1 Class 2-2-1 Class 2-3-1	Class 1-1-1 Class 1-2-1 Class 1-3-1	From Compressor Room A or B	Class 1-1-2 Class 1-2-2 Class 1-3-2	Class 1-1-1 Class 1-2-1 Class 1-3-1
From Compressor Room B	Class 2-4-2 Class 2-5-2	Class 2-4-1 Class 2-5-1	Class 1-4-1 Class 1-5-1			

ISO Air Quality Class ISO 8573-1 :2010	Compressor	Water separator	Air Reciever	1 micron filter	0.01 micron filter	Adsorption dryer -20c pdp	Adsorption dryer -40c pdp	Adsorption dryer -70cpdp	Refrigeration dryer +3c pdp	Refrigeration dryer +5c pdp	1 micron filter	0.01 micron filter	Activated carbon tower	Sterile Air filter
1.1.0	✓	✓	✓	✓	✓			✓			✓		✓	✓
1.2.0	✓	✓	✓	✓	✓		✓				✓		✓	✓
1.3.0	✓	✓	✓	✓	✓	✓					✓		✓	✓
1.4.0	✓	✓	✓	✓	✓	✓			✓		✓		✓	✓
1.5.0	✓	✓	✓	✓	✓	✓				✓	✓		✓	✓
2.1.0	✓	✓	✓	✓	✓			✓			✓		✓	
2.2.0	✓	✓	✓	✓	✓		✓				✓		✓	
2.3.0	✓	✓	✓	✓	✓	✓					✓		✓	
2.4.0	✓	✓	✓	✓					✓		✓		✓	
2.5.0	✓	✓	✓	✓						✓	✓		✓	
2.1.2	✓	✓	✓	✓	✓			✓				✓		
2.2.2	✓	✓	✓	✓	✓		✓					✓		
2.3.2	✓	✓	✓	✓	✓	✓						✓		
2.4.2	✓	✓	✓	✓					✓			✓		
2.5.2	✓	✓	✓	✓						✓		✓		

Example configuration: Critical applications

A + C, D or E

B + F or G

Typical Applications:

- Pharmacetical products
- Silicon water manufacturing
- TFT / LCD screen manufacturing
- Optical storage devices (CD, CD/RW, DVD, DVD/RW)
- Optical disk manufacturing (CDs/DVDs)
- Hard disk manufacturing
- Foodstuffs
- Dairies
- Breweries
- CDA systems for electronics manufacturing
- Blow moulding of plastics e.g. P.E.T. bottles
- Film processing
- Critical instrumentation
- Advanced pneumatics
- Air blast circuit breakers
- Decompression chambers
- Cosmetic production
- Medical air
- Dental air
- Lasers and optics
- Robotics
- Spray painting
- Air bearings
- Pipeline purging
- Measuring equipment
- Blanketing
- Modified atmosphere packaging
- Pre-treatment for on-site gas generation

Example configuration: General Usage

B + C, D or E

Typical Applications:

- General ring main protection
- Pre-filtration to point of use adsorption air dryers
- Plant automation
- Air logistics
- Pneumatic tools
- General instrumentation
- Metal stamping
- Forging
- General industrial assembly (no external pipework)
- Air conveying
- Air motors
- Workshop (tools)
- Garage (tyre filling)
- Temperature control systems
- Blow guns
- Gauging equipment
- Raw material mixing

Important note:

Equipment recommendations are identical for both oil-free and oil lubricated compressors.
The requirement for both breathable quality air are not covered in ISO 8573.1. Refer to breathing air standards for the country of installation.

Simple guidelines for the selection of purification equipment

When evaluating compressed air filters or dryers, you can best serve your operational and financial interests by emphasising the following two criteria:

- **The quality of the compressed air reliably delivered over the equipment's life cycle.** The purpose of compressed air purification equipment is to eliminate the problems and costs associated with contamination by delivering high-quality, clean, and dry air. When selecting this type of equipment, the delivered air quality and the verification of performance must always be the primary decision drivers.

- **The equipment's total cost of ownership.** Equipment with a low purchase cost may turn out to be a very costly investment over the longer term. Always consider the initial purchase cost, plus the cost of operating and maintaining the purification equipment. In addition, consider the cost to your business of poor air quality.

Note that while the equipment's purchase price may be an important and easy-to-understand criterion, it should not be the primary factor affecting your decisions. Instead, to select air purification equipment optimised for your application, you should undertake a broad review of your system requirements that includes the following ten considerations:

1. As the purpose of purification equipment is to ensure air quality, you must first identify the quality of compressed air required for your system. Depending on your application, each usage point in the system may require a different quality of compressed air. Using the ISO 8573-1:2010 quality classifications will allow your equipment supplier to identify the correct purification equipment quickly and easily for each part of your system.

2. ISO 8573-1:2010 is the latest edition of the standard. Ensure it is written in full when contacting suppliers. Specifications of air quality as "ISO 8573-1" or "ISO 8573-1:1991" likely refer to a previous edition of the standard and may result in a lower quality of compressed air delivered.

3. Ensure that the equipment under consideration will in fact deliver air quality in accordance with the quality classifications you have selected from ISO 8573-1:2010.

4. When comparing coalescing filters, ensure that they have been tested in accordance with ISO 8573-2:2007, ISO 8573-4:2001 and ISO 12500-1:2007.

5. Ask for independent, 3rd party validation of product performance.

6. For peace of mind, ensure that the manufacturer provides a written guarantee of delivered air quality.

7. Oil-free compressor installations require the same filtration considerations as oil-lubricated compressor installations.

8. When comparing the operational costs of coalescing filters, consider only the initial saturated pressure loss. Dry pressure loss is not representative of performance in a normally wet compressed air system. ISO 12500-1:2007 requires pressure losses for coalescing filters to be recorded when the element is saturated.

9. Look at the blockage characteristics of the filter. Just because it has a low starting differential pressure, doesn't mean it will remain low throughout the filter element's lifetime. Energy costs should always be calculated based upon the blockage characteristics of the filter, not just initial saturated differential pressure.

10. Look at the total cost of ownership for purification equipment, including the costs of purchase, operation, and maintenance cost. A low initial purchase price may look inviting but may result in high operational costs and other complications due to poor air quality.

Useful Links:

Learn more about our compressed air offering and how customers saved money with Gardner Denver/CompAir:
http://www.compair.com/products/oil-free/

How do I audit my compressed air system?
http://www.compair.com/service-and-support/aftermarket-and-service/air-audits/

References & Further reading:
ISO8573, ISO12500, ISO7183
Guide to the Selection & Installation of Compressed Air Services, British Compressed Air Society
FDA – Code of Federal Regulations, Title 21, Food and Drugs Pts 100-169, Revised April 1, 2012
Factors to consider when selecting compressed air treatment, Mark White, Parker Hannifin Manufacturing Ltd
European Hygienic Engineering & Design Group (EHEDG) 23 Production and use of food-grade lubricants, Part 1 and 2 (2009)
Introduction to ISO Compressed Air Quality Standards By Mark White -
Applications Manager, Parker Hannifin Manufacturing Ltd 2016

About CompAir

With over 200 years of engineering excellence, the CompAir brand offers an extensive range of highly reliable, energy efficient compressors and accessories to suit all applications.

An extensive network of dedicated CompAir sales companies and distributors across all continents provide global expertise with a truly local service, ensuring our advanced technology is backed up with the right support.

As part of the worldwide Gardner Denver operation, CompAir has consistently been at the forefront of compressed air systems development, culminating in some of the most energy efficient and low environmental impact compressors on the market today, helping customers achieve or surpass their sustainability targets.

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