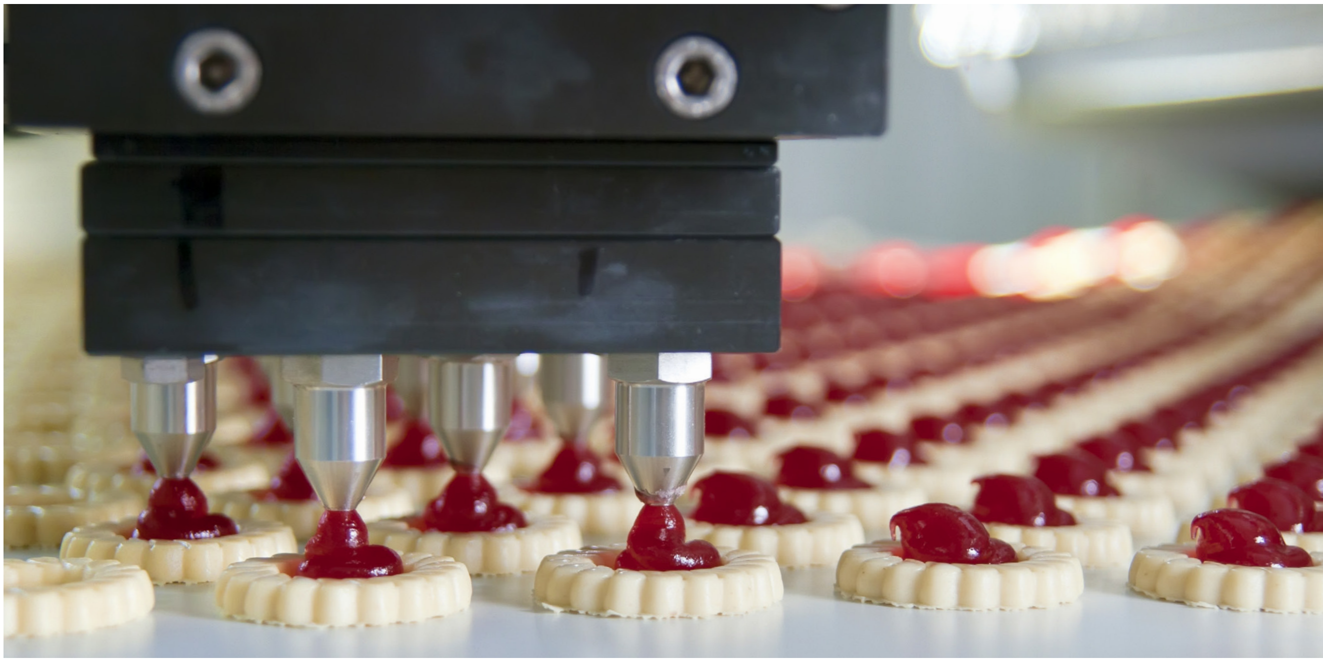

Understanding Food-Grade Compressed Air Standards: Guide to Preventing Risks at Your Plant

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Utmost care is taken by food and beverage manufacturers to ensure that the ingredients going into their products are safe for consumption. All aspects of the manufacturing, processing, packing, transporting, and storing of food must also be scrutinized, to ensure that these products are not unknowingly tainted. A critical component to this is ensuring that the compressed air in your food production facility is free of contaminants, and poses no safety or health risk to the consumer. But how can you be sure that your compressed air is truly suitable for use in food and beverage applications?

What Is Hiding in Your Compressed Air?

The main contaminants that appear in compressed air are particles (debris), water (humidity), and oil (see Table 1).

		Measured	Source
Particles		# particles per m^3, and mass concentration in mg/m^3	Intake air, compressor wear, storage system, delivery system
Water		Pressure dew point ºC, and concentration of liquid water in g/m^3	Intake air, compressor
Oil		Concentration of total oil in mg/m^3	Aerosol -compressor, vapors - intake air

Table 1 – Main contaminants in a compressed air stream.

Managing these three contaminants effectively is important in all industries, but critical in food and beverage. If these items are not sufficiently controlled, food products may be unknowingly exposed to moisture, debris, and oil. At the very least, this could impact the taste of the final product, but more importantly, it could lead to consumer illness and potentially costly, reputation-damaging recalls. Not to mention that when introduced to both the compressed air system and the food product, they can become breeding grounds for microorganisms, bacteria, and mold.

The International Standards Organization (ISO) has created a method by which the levels of these three contaminants can be measured and classified, assigning each an indicator of the severity of the contamination. Refer to Table 2 for the ISO 8573-1:2010 classification table.

Compressed air classified by ISO 8573-1:2010 will be assigned classes in terms of the particle, water, and oil content, using the nomenclature **ISO 8573-1:2010 [A:B:C]**. In this format, **A** represents the classification for particles, **B** represents the humidity class, and **C** is the oil class. For example, ISO 8573-1:2010 [2:4:2] compressed air has class 2 for particles, 4 for humidity, and 2 for oil.

A facility can consistently exceed the minimum requirements for Class 1 for one or more of the contaminants by selecting the proper compressor or accessories such as filters and dryers. In this event, ISO 8573-1:2010 states that Class 0 may be designated *"as specified by the equipment user or supplier and more stringent than class 1."* Class 0 is the purest ISO class achievable, but it should not be confused with zero contaminants.

Particles					Water			Oil	
Maximum number of particles per cubic meter as a function of particle size, *d*				Mass concentration, C_p		Pressure dewpoint	Concentration of liquid water, C_w		Concentration of total oil
Class	0.1 µm < d ≤ 0.5 µm	0.5 µm < d ≤ 1.0 µm	0.5 µm < d ≤ 5.0 µm	mg/m³	**Class**	°C	g/m³	**Class**	mg/m³
0	As specified				0	As specified		0	As specified
1	≤ 20,000	≤ 400	≤ 10		1	≤ -70		1	≤ 0.01
2	≤ 400,000	≤ 6,000	≤ 100		2	≤ -40		2	≤ 0.1
3		≤ 90,000	≤ 1,000		3	≤ -20		3	≤ 1
4			≤ 10,000		4	≤ +3		4	≤ 5
5			≤ 100,000		5	≤ +7		5	
6				$0 < C_p \leq 5$	6	≤ +10		6	
7				$5 < C_p \leq 10$	7		$C_w \leq 0.5$	7	
8					8		$0.5 < C_w \leq 5$	8	
9					9		$5 < C_w \leq 10$	9	
X				$C_p > 10$	X		$C_w > 10$	X	> 5

Table 2 – ISO 8573-1:2010 classification table

Food Safety Laws and Prevention

Throughout the world, food safety organizations are enhancing their efforts to reduce cases of foodborne illness and safety recalls in the form of several updated and refreshed food safety codes. The focus of these food safety laws emphasizes minimizing the risk of contamination. Rather than responding to incidents of food illness and recalls, the effort is to prevent the contaminated food from ever reaching the consumer. For example, the Safe Quality Foods Institute is updating their SQF Code (www.sqfi.com), launching their edition 8 in January of 2018. This SQF Code serves as one of the more popular and widely recognized Global Food Safety Initiative (GFSI) schemes. Similarly, in the U.S., an update was made to the 1938 Food Safety Practices when the FDA launched the Food Safety Modernization Act (FSMA) in 2013. Visit https://www.fda.gov/ for additional information on FSMA. The common focus noted here, as with many other codes, is prevention rather than reaction. In other words, do not allow contaminated food products to ever reach the consumer's table.

What Impact Do These Laws Have on Your Compressed Air Requirements?

These standards and codes do not define acceptable quality thresholds for compressed air used in food-related applications. In most cases, the standard simply reads that the air must be contaminant free, pose no risk, be safe for the consumer, and be regularly monitored and tested. However, no actual limits are given to advise the manufacturer of the definition of safe. For example, the following is an excerpt from the SQF Food Safety Code for Manufacturing Edition 8 with respect to compressed air quality, which can be found on the SQFI website: https://www.sqfi.com/.

> "11.5.5.1 Compressed air or other gasses (e.g., nitrogen, carbon dioxide) that contacts food or food contact surfaces shall be clean and present no risk to food safety.
>
> 11.5.5.2 Compressed air systems and systems used to store or dispense other gasses used in the manufacturing process that come into contact with food or food contact surfaces shall be maintained and regularly monitored for quality and applicable food safety hazards."

What does this mean to the manufacturer? At first glance, it appears as if it is a manufacturer benefit; less regulation is normally positive for the producer. In actuality, the ambiguity places the burden on the manufacturer for determining and defining exactly what is considered suitable compressed air quality for their product. They must assume the risk of ensuring that the compressed air that they are delivering is contaminant free, and safe for use. But without hard and set guidelines from the food safety code, how do you define contaminant-free compressed air?

Class	Maximum number of particles per m³ **for particle sizes, d (µm) (at reference conditions see 7.3.1)**		
	0.1 < d ≤ 0.5	0.5 < d ≤ 1.0	1.0 < d ≤ 5.0
2	≤ 400,000	≤ 6,000	≤ 100
	Pressure Dew-point (°C)		
2	≤ -40		
	Concentration total oil (liquid, aerosol, and vapour) (mg/m3) (at reference conditions)		
1	≤ 0.01		

Table 3 – ISO 8573-1:2010 guidelines for direct contact

Class	Maximum number of particles per m³ **for particle sizes, d (µm) (at reference conditions see 7.3.1)**		
	0.1 < d ≤ 0.5	0.5 < d ≤ 1.0	1.0 < d ≤ 5.0
2	≤ 400,000	≤ 6,000	≤ 100
	Pressure Dew-point (°C)		
4[1]	≤ +3		
	Concentration total oil (liquid, aerosol, and vapour) (mg/m3) (at reference conditions)		
2	≤ 0.1		

Table 4 – ISO 8573-1:2010 guidelines for indirect contact

[1] See http://bcas.org.uh for information on drying of compressed air.

So as a Manufacturer, What Are Your Options?

The British Compressed Air Society has developed a useful document to offer advice to those seeking assistance; Food and Beverage Grade Compressed Air Best Practice Guideline 102. This document can be found on their website, http://bcas.org.uk/. The purpose of this document is to make recommendations to the food and beverage industry on suitable air quality levels and advise the structure of a monitoring and verification program. The guideline uses ISO 8573-1:2010 as the point of reference, and it suggests class [2:2:1] for cases of direct contact and [2:4:2] for indirect contact (see Tables 3 and 4). It also makes recommendations on what methods to use to reduce each type of contaminant and suggests how and when to test, and how to record the results. It is not a law or code, but simply a suggestion of best practices.

The Key: Identify Your Risk, Manage It, and Monitor It

The basis for complying with the various GFSI schemes and food safety laws lies in risk prevention, which first starts with proper planning. Setting up a HACCP plan (Hazard Analysis and Critical Control Points), while identifying the appropriate prerequisite measures is an important step. HACCP is a concept in which the facility identifies, manages, monitors, and mitigates hazards utilizing a methodical approach. In the case of compressed air, any point at which the air makes contact with the food, direct or indirect, represents a risk for contamination and therefore must be scrutinized under a HACCP program. See Figure 1 for the seven principles of HACCP.

The GFSI schemes call for a HACCP plan as part of their requirements. The benefit of a HACCP plan includes drawing the focus to areas of possible risk (CCP), dictating that you create the appropriate measures and pass/fail criteria for these points based on critical limits, monitoring them, and developing corrective action plans for instances when they fall outside of the allowable limits. Meanwhile, strict documentation is being kept for each CCP allowing for traceability and a more thorough investigation in cases where the control limits are exceeded.

Let Us Focus on Oil for Now

Whereas the majority of particles and water content are present in the ambient air that is brought into the compressor through the intake, oil, on the other hand, is most commonly introduced into the air from the compressor itself through the use of oil-flooded rotary screw and reciprocating compressors. Of course, if you are bringing oil vapors into the compressor through the intake air, this will also add oil to your compressed air, but selecting a location that allows fresh air to be brought into the compressor will reduce this risk, allowing you to focus on the main source of oil: ***the compressor.***

All air compressors have moving parts, which must be lubricated. Oil flooded rotary, and reciprocating compressors utilize a compression technology called positive displacement.

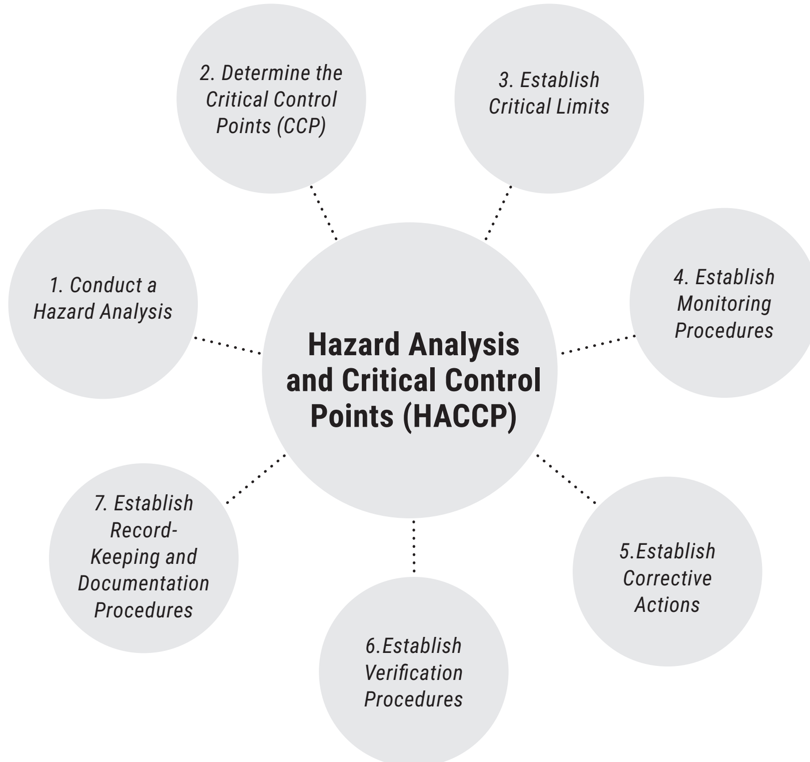

Figure 1 – Seven principles of HACCP

Direct Contact

Process whereby compressed air is in contact as a part of the production and processing including packaging and transportation of safe food production.

Indirect Contact

Process whereby compressed air exhausted into the local atmosphere of the food preparation, production, processing, packaging or storage

These definitions for Direct and Indirect contact appear in the BCAS best practice guideline.

The working principle of this type of compressor is that air is squeezed, either by using a piston or interlocking threaded screws, to increase the pressure. Due to the moving parts of the compression chamber, there are several opportunities for friction between metal components. The lubrication ensures that the screws will continue to turn, or the piston will continue to pump, without seizing. This lubrication occurs in the same chamber at which the air compression takes place. Therefore, as the compressed air is discharged from this type of compressor, it has been contaminated with oil. This is a critical control point, which must be identified in the HACCP plan, and proper oil removal steps must be taken after the air leaves the compressor, in order to bring it to safe levels. In summary, these compressors add oil aerosols to the compressed air inherently in the compression process.

Using Centrifugal Technology to Deliver Class 0 Oil-Free Air

It is counterintuitive to add oil, a contaminant, in the compression process only to require removal downstream. That is precisely what is happening with the previously discussed oil-flooded compressors: the oil and air coexist in the same chamber. Remember the theme of the food safety laws – prevention. If you could prevent this unnecessary contamination from ever entering the air in the first place, wouldn't that be the best solution? It is possible, by simply selecting the right air compressor type, a compressor with centrifugal technology. A centrifugal compressor producing ISO 8573-1:2010 Class 0 oil-free air eliminates the confusion of knowing the acceptable level of oil in the air, by producing compressed air, which is oil-free. Although lubrication is required due to the high-speed rotation of the main bull gear and stage pinions, the oil remains in the gear casing section of the compressor, and cannot penetrate beyond the barrier of the seals, giving this type of compressor the ability to offer Class 0 oil-free air.

Understanding Centrifugal Compressors

A common misconception is that centrifugal technology is exclusively for high flow applications. In reality, centrifugal compressors as small as 250HP are being used in all industries, from automotive to food and beverage. These units operate with a concept called dynamic compression, as opposed to positive displacement, discussed earlier. Rather than squeezing the air to create pressure, centrifugal compressors create pressure by using impellers to move the air radially at high velocity, and abruptly slowing it with diffusers, converting the energy from the high velocity into increased pressure. The air is then moved into a cooling system, which will lower the temperature of the high-pressure air as well as remove moisture. Depending upon the specific flow and discharge pressure required, a centrifugal compressor can have as many as three or four compression stages. The multiple stages are driven with a single motor, making it a highly efficient method of compression.

In addition to producing oil-free air, centrifugal compressor technology offers many other benefits, with the most prominent being reduced energy consumption compared to that of rotary and reciprocating compressors. Manufacturers see annual energy savings of 10% or greater upon switching from other technologies to centrifugal. Considering that the energy expense makes up roughly 75% of the total life-cycle cost of an air compressor, it may make sense to decommission existing rotary compressors, as the payoff period for the capital investment of a new centrifugal unit can be only a few years.

Centrifugal compressors also require less maintenance, leading to lower upkeep expense, and less downtime. Whereas rotary compressors require at least an annual oil change, centrifugal compressors can operate for three years on the same oil. Similarly, the airend on a rotary compressor will last roughly five years, and then require a costly rebuild, plus extensive downtime. When maintained properly, a centrifugal compressor airend is designed for 20+ years of use without any major care required. And because the oil and air never meet, the condensate water which is removed from the compressed air is not contaminated.

Summary of Centrifugal Compressor Benefits

- ISO 8573 Class 0 oil-free air
- Energy efficient
- Low maintenance cost
- Less compressor downtime
- Oil-free condensate water

What About Your Other Risk for Contamination?

While a Class 0 oil-free centrifugal compressor will eliminate your worries about oil in your air, you will still need to effectively manage particles and water through other means. An inlet filter will capture some of the particles before they are brought into the unit from the ambient air, while the air coolers will reduce the water level in the air, but for applications such as food and beverage, it will not be enough. Debris and water can be managed downstream from the compressor through the use of additional filtration.

A coalescing filter will help remove aerosol water, as well as remove some debris along with it. The coalescing filtration system may employ two inline filters, with the first one capturing some of the larger contaminants, and the second serving as a high-efficiency filter. Furthermore, a dryer will reduce the amount of water vapor in the air. Dryer types include refrigeration, adsorption, and membrane, with each having its unique properties for efficiency and effectiveness. A membrane filter will aid in the reduction of any debris that remains after the water has been brought to a manageable level.

Keep in mind that while oil-free centrifugal compressors only require that you filter and manage water and debris, oil-flooded rotary screw, and reciprocating compressors demand that you deal with these contaminants while also removing oil. Furthermore, oil-flooded compressors may also require the use of a water separator to remove bulk liquid water.

Table 5, taken from the BCAS Best Practice Guideline, summarizes the filtration available for each type of contaminant remembering that, if an ISO8573-1 Class 0 oil-free compressor is used, the air will already be oil-free, provided that the inlet air is oil-free.

Contamination Reduction / Removal									
		Atmospheric					Compression		System
		Water							
Purification Equipment Technologies		Bulk-condensed	Aerosol	Vapor	Dirt and solid particulate	Micro-organisms	Liquid oil and oil aerosol	Oil vapor	Rust and pipe scale
Water separators		•							
Filters	Coalescing		•		•	•	•		•
Filters	Adsorption							•	
Filters	Dust removal					•	•		•
Filters	Micro-biological						•		
Dryers	Adsorption			•					
Dryers	Membrane			•					
Dryers	Refrigeration			•					

Table 5 – BCAS Best Practice Guidelines summarizes the filtration available for each type of contaminant.

Monitoring and Verification, a Continuous Cycle

Once you have established that oil aerosols can be prevented through implementation of an ISO 8573-1:2010 Class 0 oil-free compressor, and have employed the appropriate filtration and dryers to manage water and particles, a plan for monitoring must be put into place. This is another aspect in which the food safety laws, such as SQF and FSMA, do not specify required testing methodologies and frequency, but only that monitoring must be done on a regular basis to ensure that the air is contaminant-free.

The BCAS Best Practice Guideline offers assistance in this respect as well, as it presents recommendations for monitoring and testing practices. Depending upon each unique situation, these suggestions may or may not be applicable to you. It first suggests that the purity testing methods comply with ISO 8573-2:2010 through ISO 8573-9:2010, with each individual standard corresponding to the methods for testing a different contaminant. For example, ISO 8573-2:2010 provides the testing method for oil aerosols while ISO 8573-5:2010 is for oil vapors.

The BCAS guideline also recommends that testing and verification of air purity be done twice per year as a minimum. However more frequent testing may be required if prescribed through the HACCP plan, or the manufacturer’s recommendation. Because these contaminants are invisible, the more frequently the air is tested, the better. This is even more important as the seasons of the year change, other external variables fluctuate, and variances in compressor usage patterns and maintenance may influence compressed air quality.

Conclusion

Food safety laws are ambiguous with respect to acceptable levels of contaminants in compressed air for food applications. The manufacturer assumes the responsibility of developing a food safety plan to ensure that their consumable products are not compromised by contaminants in the compressed air. A good starting point is preparing a HACCP plan to identify the critical control points at which compressed air is in either direct or indirect contact with food, establishing critical limits for these control points, and establishing the proper processes for monitoring, testing, improving evaluating, and recording data on these control points.

By selecting an ISO 8573-1:2010 class 0 oil-free centrifugal compressor, you can rest assured that you are not adding oil into your compressed air process, leaving you free to direct your attention and efforts to reduce the risks posed by particles and humidity. Centrifugal technology also boasts other user benefits including reduced operating expense, lower maintenance costs, and less downtime.