Best Practice Guide 102-1

Food and Beverage Grade Compressed Air

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Foreword

Since the publication of the first edition of this best practice guideline it has been noted that as compressed air is seen as a utility, then its provision is normally included in the pre-requisite programme, rather than directly as part of the hazard analysis and critical control point (HACCP) activity. This revised best practice guideline is now reformatted to reflect the change of emphasis.

It is still the case that a hazard analysis shall include items subject to a pre-requisite programme to establish whether there is a need to include the compressed air provision at any specific critical control point.

Compressed air is an essential part of many aspects of food / beverage production and processing from the 'farm to table'. With the ever-increasing demands to improve health and hygiene in the food chain, this best practice guideline has been produced to meet those demands.

The British Compressed Air Society produced this best practice guideline to provide useful guidance and allow informed decisions on what type of compressed air equipment is required, how it should be installed as well as maintained and, importantly, the requirements for the air purity.

Following this best practice guideline in association with food / beverage industry requirements to apply the pre-requisite programme and, where applicable HACCP process, will ensure that the compressed air system will not only meet current industry best practice but also contribute to customer confidence in food supplied to market.

Acknowledgements

We worked with leading engineers in the field of air treatment and purification to compile this comprehensive overview. Our thanks are extended to these and the members of the British Compressed Air Society Ltd who contributed to its production.[1]

Foreword

[1] BCAS Member Contributors:

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- Hi-line Industries Ltd
- Ingersoll-Rand Company Ltd
- Mattei Compressors Ltd
- Maziak Compressor Services Ltd
- Parker Hannifin Manufacturing Ltd

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Introduction

NOTE: This Introduction does not form part of the best practice guideline and is provided as information only.

A. Food safety

During the production, processing, handling, packaging and transporting of food/beverage at all stages from source to consumer, the safety of the food/beverage may become compromised. Contaminated compressed air is one potential source of compromise when used in conjunction with the food chain.

B. Ingredients

The variation in requirements for the use of compressed air as an ingredient is considered to be beyond the scope of this document.

C. Contaminants

Contaminants commonly associated with compressed air are categorised in the form of dirt, water, and oil. Other influences are the presence of microbiological organisms such as bacteria, which may be transported through a compressed air system or propagated due to the conditions existing in a compressed air system. Contaminants that may be a potential hazard in food/beverage for human consumption need to be subject to control. Compressed air may come into direct or indirect contact with food/beverage. Where compressed air comes into direct contact with food/beverage, in particular during production or processing, this requires a much higher level of contaminant control.

Particular attention needs to be placed on sources of contaminants entering the system, which may be added during compression or emanating from the distribution system. Due to the variations in design of compressors some require oil in the compression stage and some do not.

For food/beverage production where the compressed air comes into direct contact the amounts of oil present, and type of oil allowed is subject to strict controls. Some food/beverage producers have internal requirements where oil levels are strictly controlled.

Maintenance is a key element in ensuring that the compressor(s) and other equipment maintain acceptable operating conditions. The controls applied to all types of contaminants may either be a customer requirement or one set by regional or national legislation.

Introduction

D. Codex Alimentarius - General principles of food hygiene

The Codex Alimentarius international food standards have become the global reference point for food producers and processors, national food control agencies and the international food trade. The code has had an enormous impact on the thinking of food producers and processors as well as on the awareness of the end users and consumers.

Its influence extends to every continent, and its contribution to the protection of public health and fair practices in the food trade is immeasurable.

The Codex is the source of both the pre-requisite programme and the hazard analysis and critical control point (HACCP) philosophy and is used as the reference source in this document.

E. Pre-requisite programme and HACCP

Part of the application of HACCP will consider and put in place pre-requisite programs such as good hygiene practices and training. These pre-requisite programs should be well established, fully operational and verified in order to facilitate the successful application and implementation of the complete HACCP system.

I. Pre-requisite programme

A food safety management system should start with a solid foundation. That solid foundation consists of procedures that address matters such as the basic operational conditions within the food/beverage operation. These procedures are collectively termed “pre-requisite programs.”

When pre-requisite programs are in place, the focus of attention can then be given to the hazards associated with the food/beverage and its preparation. Compressed air is seen as a basic operational function (utility) such as water and energy supplies in the food chain. The provision of compressed air is deemed to be a pre-requisite and as such its maintained supply and purity is essential.

II. Hazard Analysis and Critical Control Point (HACCP)

The Hazard Analysis and Critical Control Point (HACCP) principles which the food/beverage producer is required to perform are a key practice in the food industry. These principles are designed to ensure the quality of the final product by identifying potential contamination entry points or zones, known as Critical Control Points (CCP’s), and implementing rectification and monitoring procedures.

F. Installation

This guideline sets out recommendations for compressors and associated equipment in terms of their location, also air intake, ventilation, and maintenance. This guideline sets out the minimum recommendation for compressed air purity in existing and new installations. Consideration has been given to the potential contamination issues surrounding compressed air and details acceptable measuring methods for testing the air purity.

NOTE: This guideline does not cover other gases commonly used in the food/beverage industry (such as nitrogen and carbon dioxide), which require separate control.

G. Guidelines and standards

The guideline expands and clarifies the compressed air requirements identified in existing food/beverage safety standards, guidelines and in some area's legislation.

Scope

WARNING: The text of this best practice guideline assumes that the execution of its provisions is entrusted to appropriately qualified and experienced people, for whose use it has been produced.

This best practice guideline identifies the requirements for compressed air systems, operating at a pressure greater than 0.5 bar, as pre-requisites in the production and processing including packaging and transportation for safe food and beverage production.

Its main purpose is to provide:

- Recommendations on the minimum air purity requirements for compressed air used for both direct and in-direct contact applications in food and beverage manufacture.
- Measurement and testing procedures are identified to verify the purity of the compressed air.
- Maintenance activities to retain continued performance of the compressed air system.

This guideline does not cover the use of compressed air as a food/beverage ingredient.

Food and beverage grade compressed air

1 Pre-requisite programme (PRP) and compressed air strategy

A food safety management system should start with a strong foundation. That strong foundation consists of procedures that address matters such as the basic operational conditions within the food / beverage operation.

These procedures, collectively termed 'pre-requisite programs' form part of the overall activity related to risk assessment identified as Hazard Analysis and Critical Control Points in the food chain.

1.1 Pre-requisite programme (PRP) and compressed air strategy

The following shall be observed in the establishment of a pre-requisite programme involving compressed air.

1.2 The organisation shall establish, implement, and maintain PRP(s) to assist in controlling:

a) the likelihood of introducing food safety hazards to the product through the work environment

b) biological, chemical, and physical contamination of the product(s), and

c) food safety hazard levels in the product and product processing environment

d) machinery intended for use with foodstuffs must be designed and constructed in such a way as to avoid any risk of infection, sickness, or contagion

1.3 The Pre-requisite programme(s) shall:

a) be appropriate to the organisational needs with regard to food safety

b) be appropriate to the size and type of the operation and the nature of the products being manufactured and/or handled

c) be implemented across the entire production system, either as programmes applicable in general or as programmes applicable to a particular product or operational line, and,

d) be approved by the food safety team

2 Compressed air strategy

2.1 Pre-requisite programme (PRP) and compressed air strategy

A food safety management system should start with a strong foundation. That strong foundation consists of procedures that address matters such as the basic operational conditions within the food/ beverage operation. These procedures, collectively termed 'pre-requisite programs' form part of the overall activity related to risk assessment identified as Hazard Analysis and Critical Control Points in the food chain.

2.2 Including compressed air in the HACCP Hazard analysis process

It is considered best practice that personnel assigned to the manufacturing facility HACCP team and / or those providing auditing activities with respect to pre-requisite programmes and HACCP, should understand the potential hazards associated with untreated or poorly treated compressed air.

To allow the compressed air system to be integrated easily into the site food safety management system and ensure food safety and compliance for manufacturers, this document will provide the following information to assist with the HACCP process and the implementation of the compressed air strategy (PRP):

1. Identification of potential hazards (compressed air contamination and it sources)
2. Identification of Critical Control Points (CCPs) relating to compressed air usage
3. Prevention / limitation measures (Compressed air treatment technologies)
4. Acceptable hazard limits (compressed air purity specification)
5. Monitoring of prevention measures (verification / indicative testing of compressed air purity)
6. Documentation (minimum documentation requirements)

3 Identification of potential hazards (Compressed air contamination and its sources)

Compressed air is not clean, it contains many hazards, herein referred to as contamination. Compressed air is typically viewed as a utility and is often overlooked during the HACCP hazard analysis. Many of the contaminants found in compressed air are too small to be visible, again resulting in potential risks not being identified and the compressed air system being omitted from the hazard analysis.

Important Note: The compressed air system should always be included as part of the hazard analysis due to the contaminants (hazards) listed on the right.

Contamination in a compressed air system comes from four different sources. In a typical compressed air system, there are 10 main contaminants that require treatment if the system is to operate safely, efficiently and cost effectively and not contaminate production equipment, preparation surfaces, ingredients, finished product or packaging.

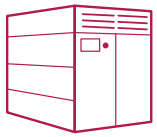
For a detailed description of compressed air contaminants, please refer to BCAS Best Practice Guideline 104 The Filtration & Drying of Compressed Air, section 1, page 1.

3.1 Diagram - The four sources of contamination

Contaminant source No.1 – The atmospheric air

Atmospheric Air

Water vapour
- Atmospheric dirt
- Oil vapour
- Micro-organisms



Air Compressor

Contaminant source No.2 – The air compressor

Air Compressor

Water - Liquid & Aerosol

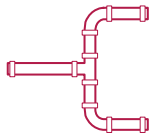
Oil (from compressor oil)
- Liquid
- Aerosol
- Oil
- Vapour
- Vapour (from atmosphere)

Air Receiver

Contaminant source No.3 – The air receiver

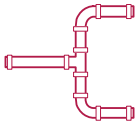
Air Receiver

The air receiver not only stores air, it stores contamination too:
- pipescale
- rust from air receiver walls
- condensate



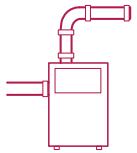
Distribution Piping

Contaminant source No.4 – The distribution piping



Distribution Piping

Distribution piping also stores contamination:
- rust (steel pipes)
- pipescale
- condensate



Compressed Air Treatment

4 Identification of Critical Control Points (CCPs) relating to compressed air usage

Untreated or inadequately treated compressed air will contain the following 10 contaminants which can impact food safety and/or the quality of food and beverage products:

- Micro-organisms
- Water vapour
- Oil vapour
- Oil aerosols
- Rust
- Liquid water
- Water aerosols
- Liquid oil
- Solid particulates
- Pipescale

Compressed air is used frequently as part of the food/beverage manufacturing process and often comes into direct contact with production equipment, preparation surfaces, ingredients, finished product or packaging.

Additionally, the contaminants (hazards) found in untreated or poorly treated compressed air can also in-directly contact the afore mentioned items. For this reason, every point in the manufacturing process where compressed air is used should initially be highlighted as a Critical Control Point (CCP) until adequate measures are put in place to treat the compressed air and reduce the contaminants to acceptable levels (by implementing a compressed air specific PRP / oPRP via the site compressed air strategy and based upon the recommendations in this document).

Important note: food allergens

Typical food allergens include barley, wheat, crustaceans, shellfish, eggs, fish, milk, and nuts. While these would not normally be found in compressed air, they or their by-products may be used in the production of lubricants used in the compressed air system.

As lubricants can often be reformulated, best practice dictates to always use food grade lubricants and to check the material safety data sheet of any lubricant for the presence of allergens before use.

5 Prevention / limitation measures (Compressed air treatment technologies)

It takes a combination of different purification technologies to reduce the 10 identified contaminants to safe, acceptable levels (please note, complete removal of contaminants is typically not achievable or measurable).

Chapter 1

3.1 **Table - Purification technologies**

Purification Technologies	Contaminants				Contaminants					
	Atmospheric Particles	Rust	Pipe Scale	Micro-organisms	Liquid Water	Water Aerosols	Water Vapour	Liquid Oil	Oil Aerosols	Oil Vapour
Water Separator					•			•		
Coalescing Filter	•	•	•	•		•			•	
Adsorption Filter										•
Dryer							•			
Dry Particulate Filter	•	•	•	•						
Sterile Filter				•						

Important Note:
There are many types of air compressors available, using different methods to compress ambient air. Food and beverage grade compressed air can be achieved with all compressor types.

The purification technologies required to achieve the direct contact and in-direct contact air purity recommendations shown in this document will be identical for all compressor types, no matter what method is used to compress the air (dynamic compressor, displacement compressor, oil lubricated compressor, oil-free compressor).

Purification equipment should not be installed in the compressor room alone and a careful approach to system design, commissioning and operation must be adopted. It is recommended that compressed air is treated prior to entry into the distribution system and at critical usage points.

This ensures contamination already in the piping and distribution system is also treated.

For a detailed description of compressed air filtration and drying technologies, please refer to the BCAS Best Practice Guideline 104 Filtration & Drying of Compressed Air, section 4, page 13.

6 Acceptable hazard (contaminant) limits (compressed air purity specification)

When performing the HACCP hazard analysis, each usage point for the compressed air must first be designated as:

- Direct contact
- In-direct contact
- Non-Food contact

7 Definitions to be used for determination of usage

7.1 Direct contact

Air that comes into direct contact with:
- Production equipment
- Preparation surfaces
- Ingredients
- Finished products
- Packaging

Examples of Direct contact
- Sparging
- Air knives (cutting / peeling / cooling)
- Spraying / coating
- Conveying (movement)
- Direct cooling
- Packaging
- Drying

7.2 In-direct contact

Air that comes indirectly into contact with or inadvertently encounters:

- Production equipment
- Preparation surfaces
- Ingredients
- Finished products
- Packaging

Examples of in-direct contact
Valves, cylinders & pneumatics operating in the manufacturing environment where the contaminated exhaust air can then inadvertently contact the above

7.3 Non-food contact

Compressed air used outside of the food manufacturing process and / or facility

Examples of Non-food Contact
- Workshop air

Important Note:
Once compressed air usage points are identified and designated as direct contact, in-direct contact or non-food contact, the following recommended compressed air purity values should be used as minimum acceptable limits. These limits can be applied to each usage point individually or specified site wide if required.

8 International standards relating to compressed air - ISO8573 series

ISO8573 series is the most used standard for compressed air (excluding breathing air or medical air). It is made up of nine separate parts. Part one refers to air Purity (quality), whilst parts two to nine provide details on the equipment and methodology to be used to accurately measure for different contaminants in a compressed air system and meet the air purity (quality) classifications shown in ISO8573 part 1.

9 Use of ISO8573-1 classifications in this document

ISO8573-1 provides the user a way of specifying an air purity (quality) required for the entire compressed air system and / or for individual usage points, based upon application requirements. It also allows equipment manufacturers to show product performance and specify purification equipment to meet the end user's air purity (quality) specification.

Chapter 1

9 Continued: Use of ISO8573-1 classifications in this document

In ISO8573-1, compressed air contaminants are grouped into solid particulate, water and total oil. Different levels of contamination are then assigned 'Purity (quality) Classes'.

When using ISO8573-1 to define the air quality required at a usage point, the specification should be written as follows:

First the standard (ISO8573-1) must be written, then the year (revision) stated, then the purity (quality) classes (separated with a colon), e.g., ISO8573-1:2010 [A: B: C:]

Where:

- A is the purity (quality) class for particles; see Table 1
- B is the purity (quality) class for humidity and liquid water; see Table 2
- C is the purity (Quality) class for oil; see Table 3

Table 1 - Compressed air purity (quality) classes for particles

Solid Particulate			
Class	Maximum Number of Particles per Cubic Metre as a Function of Particle Size, *d*		
	0.1 µm < d ≤ 0.5 µm	0.5 µm < d ≤ 1.0 µm	1.0 µm < d ≤ 5.0 µm
0	As specified by the equipment user or supplier and more stringent than class 1		
1	≤ 20,000	≤ 400	≤ 10
2	≤ 400,000	≤ 6,000	≤ 100
3	Not specified	≤ 90,000	≤ 1,000
4	Not specified	Not specified	≤ 10,000
5	Not specified	Not specified	≤ 100,000

Table 2 - Compressed air purity (quality) classes for Humidity

Class	Water	
	Vapour Pressure Dewpoint °C	Liquid g/m3
0	As specified by the equipment user or supplier and more stringent than class 1	
1	≤ -70	-
2	≤ -40	-
3	≤ -20	-
4	≤ +3	-
5	≤ +7	-
6	≤ +10	-
7	-	≤0.5
7	-	≤0.5 – 5
9	-	– 10
X	-	>10

Table 3 – Compressed air purity (quality) classes for total oil

Class	OIL
	Total Oil (Liquid, Aerosol and Vapour) mg/m3
0	As specified by the equipment user or supplier and more stringent than class 1
1	≤ 0.01
2	≤ 0.1
3	≤ 1
4	≤ 5

Important notes:
Reference conditions - the contaminant values are those at the 'Reference conditions' in ISO 8573-1 at a temperature of 20°C, absolute atmospheric pressure of 1 bar and relative water vapour pressure of zero. The actual performance of air treatment equipment shall be as agreed between the supplier and the user, which will involve relating the specified performance at reference conditions and the site conditions. The 'Reference conditions' is a standardised statement of contaminant levels whereas the actual conditions on site will vary. The site conditions, temperature / atmospheric pressure / relative water vapour pressure, will be the ambient atmospheric condition existing at the point of measurement. It will be necessary to correct the actual condition values back to reference condition values to establish compliance with the contaminant levels.

10 Acceptable hazard limits (compressed air purity values for food/beverage grade compressed air)

10.1 Compressed air coming into direct contact with food/beverage (production equipment / preparation surfaces / ingredients / finished products / packaging) should meet or exceed the following air purity (quality) classification as identified from ISO 8573-1:2010

Compressed air purity designation ISO 8573-1:2010 [1:2:1] which translates to:

Compressed air purity designation - Direct contact with food

ISO8573-1:2010	Solid Particulate			Water	Oil
	Maximum no of Particles per m^3			Vapour Pressure Dewpoint	Total Oil (Aerosol liquid and vapour)
	0.1 ~ ≤ 0.5	0.5 ~ ≤ 1.0	1.0 ~ ≤ 5.0	°C PDP	mg/m^3
	≤20,000	≤400	≤10	≤ -40°C	≤ 0.01
Class	1			2	1

10.2 Understanding the specification

A classification of ISO8573-1:2010 Class 1:2:1 for direct contact applications has been chosen for the following reasons:

10.3 Particulate: Class 1

Particulate Class 1 for food & beverage direct contact applications has been selected to primarily assist in the reduction of micro-organisms present in the compressed air. In terms of filtration, micro-organisms can be viewed as a solid particulate and their quantity significantly reduced with filtration (or eliminated if sterile compressed air is required). Viable and non-viable micro-organisms are typically between 0.02µm and 10µm in size (Viruses 0.02µm - 0.2µm / Bacteria 1µm - 5µm / Fungi (Yeasts) 3µm - 10µm).

To achieve ISO8573-1:2010 Class 1 for particulate a high efficiency dry particulate filter providing particle reduction down to 0.01 µm (at an efficiency of 99.9999%) will be required. This will significantly reduce the quantities of micro-organisms in the compressed air and typically to a level below that which is present in the ambient air of the manufacturing facility.

10.4 Water: Class 2

Water vapour Class 2 for food & beverage direct contact applications has been selected to primarily assist in the reduction of micro-organisms present in the compressed air (it will also eliminate liquid water and stop corrosion). For solid particulate Class 1 to be effective, the growth of micro-organisms must first be reduced or inhibited.

To achieve ISO8573-1:2010 Class 2 for water vapour, a dryer providing a constant outlet pressure dewpoint of less than -40°C will be required. The growth of micro-organisms in compressed air will begin to slow and eventually stop when the pressure dewpoint of the compressed air is below -26°C.

Manufacturers of compressed air dryers typically provide products with outlet dewpoints aligned to the ISO8573-1 classifications (e.g., ≤-70°C PDP / ≤-40°C PDP / ≤-20°C PDP). Selecting a dryer that can achieve ISO8573-1:2010 Class 2 for water vapour (constant pressure dewpoint between -69°C and -40°C) will therefore inhibit the growth of micro-organisms, reducing the quantity of micro-organisms entering the dry particulate filter (which allows the high efficiency dry particulate filter to work more efficiently).

Important notes:
When selecting a compressed air dryer, ensure it is designed to provide a constant outlet dewpoint as failure to keep the pressure dewpoint below the level at which micro-organisms will stop growing can result in a quality incident.

Dryer types

There are many different types of compressed air dryers available (examples are described in more detail in the BCAS Best Practice Guideline 104). While it is known that different technologies deliver different outlet dewpoints (for example, refrigeration dryers typically deliver outlet dewpoints above 3°C and adsorption dryers dewpoints below 0°C), they also differ in the consistency of the outlet dewpoint delivered.

Manufacturers design dryers to deliver either a constant outlet dewpoint (which has minimal variation), or a dewpoint suppression (which will have larger dewpoint variations).

10.5 Total oil: Class 1

Total oil Class 1 has been selected for food & beverage direct contact applications to provide 'technically oil-free' compressed air.

Compressed air to ISO8573-1 Class 1 and Class 0 for total oil

Oil free air can be delivered by both an 'oil free' or oil-injected/lubricated compressor, with the correct purification equipment installed downstream.

If using an oil-injected/lubricated compressor, then food grade lubricants should be used and compressed air purification equipment installed downstream must be maintained in-line with the manufacturer's recommendations. Page 17, B.3.2 Lubricants.

If an application requires air purity (quality) to ISO 8573-1:2010 Class 1 for total oil (down to 0.01 mg/m³) or ISO 8573-1:2010 Class 0 for total oil (user specified between 0.01mg/m³ and 0.003mg/m³), coalescing filters (used for the reduction of oil aerosols) will need to be supported by an additional oil vapour reduction filter. The requirement for water separators, general purpose (pre-filter) and high-efficiency coalescing filters should be identical for both oil lubricated and oil-free compressor types.

The additional oil vapour reduction filter, required to achieve ISO8573-1 Class 1 or Class 0 for total oil, may be smaller on the oil-free compressor installation as it does not need to remove oil vapour added by a lubricated compressor.

A combination of general purpose (pre-filter) and high-efficiency coalescing filters plus an oil vapour reduction filter would be classified typically as ISO 8573-1:2010 Class 1.-.1. Some manufacturers are also able to meet ISO 8573-1:2010 Class 0 for total oil.

11 In-direct contact recommendation

Compressed air coming into in-direct contact with food/beverage (production equipment / preparation surfaces / ingredients / finished products / packaging) should meet or exceed the following air purity (quality) classification as identified from ISO 8573-1:2010.

Compressed air purity designation ISO 8573-1:2010 [1:2:1] which translates to:

ISO8573-1:2010	Solid Particulate			Water	Oil
	Maximum no of Particles per m³			Vapour Pressure Dewpoint	Total Oil (Aerosol liquid and vapour)
	0.1 ~ ≤ 0.5	0.5 ~ ≤ 1.0	1.0 ~ ≤ 5.0	°C PDP	mg/m³
	≤20,000	≤400	≤10	≤ -40°C	≤ 0.01
Class	1			2	1

11.1 Understanding the specification

In-direct contact primarily covers compressed air used for instrumentation, automation and control applications based within the food/beverage manufacturing facility.

While the compressed air is not directly in contact with production equipment, contact surfaces, ingredients, finished products or packaging, once it has been used for automation and control, it will be exhausted typically into the manufacturing environment.

Contaminants from un-treated or incorrectly treated compressed air can therefore contaminate production equipment, preparation surfaces, ingredients, finished products and/or packaging materials.

A classification of ISO8573-1:2010 Class 1:2:1 for in-direct contact applications has therefore been chosen to prevent contamination risk.

11.2 Non-food contact recommendation

Non-food contact specification is a recommended minimum specification for compressed air used on a food / beverage manufacturing site (for example in a workshop) and does not have the potential to be used in a direct contact or in-direct contact application. Compressed air should meet or exceed the following air purity (quality) classification as identified from ISO 8573-1:2010.

Compressed air purity designation ISO 8573-1:2010 [2:4:2] which translates to:

ISO8573-1:2010	Solid Particulate			Water	Oil
	Maximum no of Particles per m^3			Vapour Pressure Dewpoint	Total Oil (Aerosol liquid and vapour)
	0.1 ~ ≤ 0.5	0.5 ~ ≤ 1.0	1.0 ~ ≤ 5.0	°C PDP	mg/m^3
	≤400,000	≤6000	≤100	≤ +3°C	≤ 0.1
Class	2			4	2

Important note:
When looking to achieve ISO8573-1 Class 4, 5 or 6 for water vapour, a refrigeration dryer is typically installed. The dewpoint delivered by a refrigeration dryer is insufficient to reduce or stop the growth of micro-organisms, therefore this specification is unsuitable for direct or in-direct contact applications and should only be used for non-food contact use.

12 Control of microbiological contaminant

Food/beverage processes either require a level of control over the presence of micro-organisms or in some instances, complete sterility.

If compressed air containing micro-organisms can directly or in-directly contact production equipment, preparation surfaces, ingredients, packaging materials, partially completed or finished products, then control or sterility can be lost.

Hazard analysis should always include the risk of contamination by microbiological contaminants found in compressed air. The level of control identified as being required over microbiological contaminants in the compressed air should be determined by the site HACCP team. For example, if a manufacturing process takes place in a 'clean' environment, where the ambient levels of micro-organisms have been reduced, the HACCP team may want to specify a maximum CFU (colony forming units) count.

Implementing additional control in this way may therefore require the need for additional purification equipment to ensure a higher degree of control or complete sterility. In the case of the above example, introduction of a low or zero CFU count would necessitate the installation of additional point of use sterile air filter(s).

Microbiological testing of compressed air can be carried out by following the methodology and using the equipment shown in ISO8573-7. Testing of end products should not be relied upon for compressed air compliance.

13 Monitoring of prevention measures (Verification / indicative testing of compressed air purity)

Verification / validation of compressed air purity in accordance with ISO8573

The methods to be employed to verify / validate the level of contaminants in the compressed air shall follow those test methods and use the test equipment described in the appropriate part of ISO 8573 series (parts 2 to 9).

Solid particles

Solid particles shall be measured in accordance with ISO 8573-4. In addition to using this method to measure particles, ISO 8573-7 shall also be performed to confirm whether there are any microbiological colonies present in the solid particles from the compressed air.

Humidity (dewpoint)

Water vapour and humidity shall be measured in accordance with ISO 8573-3.

Total oil

Oil concentration shall be measured using the test equipment and methodology shown in ISO 8573-2 (oil aerosol); and ISO 8573-5 (oil vapour). The stated concentration shall be the sum of the oil aerosol and oil vapour.

Microbiological

The presence of microbiological contaminants shall be established by the test method specified in ISO 8573-7. Microbiological particles are considered to be solid particles and therefore will be included as a measurement for solid particles. ISO 8573-7 is a method to detect if the solid particles contain any viable (colony forming units) units.

Important note: Testing fully in accordance with ISO8573 parts 2 to 9 may not always be feasible, available, or cost effective (testing is often lab based and not available 'on-site'). In such instances, indicative testing should be used.

Indicative testing

There are many different types of compressed air test equipment available and not all have the accuracy required to verify the air purity levels shown in ISO8573-1 classifications. The reduced accuracy may be due to the sampling method used, the test equipment itself or a combination of both. If the test methodology and test equipment used is not listed in the appropriate ISO8573 standard, it cannot be used for validation / verification purposes.

It is not always possible to test the compressed air fully in accordance with the test methodology and test equipment shown in ISO8573 parts 2 to 9, therefore whenever alternative test methods and/or test equipment are used, the results should be viewed as 'indicative' testing (not validation).

Equipment such as chemical indicator tubes or digital oil analysers may be used to establish the general levels of oil and humidity, with the caveat that the results are indicative as to the presence of a contaminant. Indicative testing provides a facility with the ability to track trends, identify major changes and enact appropriate counter measures.

Important note: Testing of compressed air purity requires qualified personnel and specialised equipment. Guidance should be sought from the original equipment manufacturer of the compressed air test equipment on usage procedures.

Periodicity

The compressed air purity shall be tested and verified at least twice per year, or more frequently if identified in, the HACCP process, or in accordance with manufacturers recommendations using the methods identified above.

Important notes: Whenever maintenance work or any activity that may affect the air purity is performed on the compressed air system then a simple check on the air purity with chemical indicator tubes may be used. This method may be employed where the next scheduled periodic test is not imminent.

Understanding ISO 8573 training is available via the BCAS website: **www.bcas.org.uk/training**

14 Documentation

A log shall be created and kept updated specifically to assist with maintaining up-to-date information on the compressed air system and for reference during any audit. As a minimum, the following information regarding the generation equipment (compressor) and the purification equipment installed to meet the air purity requirements shown in this document shall be recorded:

- A compressed air system map (plan of the facility showing location of compressors, purification equipment, storage devices (air receiver), distribution piping and points of use.
- The purification equipment installed
- The hazards (contaminants) the purification equipment is designed to treat
- The air purity levels provided by the equipment
- The air purity levels required at each usage point (CCPs)
- Product serial numbers if applicable
- Installation date
- Date of last maintenance
- Date of next maintenance
- Equipment provider
- Service provider (if different from equipment provider)
- All measurements related to the air purity testing shall be recorded and documented
- All maintenance work on the compressed air system shall be recorded and documented
- All documentation received with any equipment included in the compressed air supply shall be kept in a log created specifically to assist with maintaining up-to-date information on the system and for reference during any audit.

15 Service and maintenance

The compressors and all ancillary components that are involved in producing food and beverage grade compressed air to the purity levels stated in this guideline shall be maintained to the level identified by the original equipment manufacturer.

It is a requirement of this guideline that service and maintenance shall be performed by qualified personnel using industry best practices. Industry best practices should extend to the use of replacement parts as provided by the original manufacturer to provide the confidence that original performance can be maintained.

16 Annex A - service and maintenance (informative)

A planned preventative maintenance programme shall be in place for all equipment involved in providing compressed air. National, regional, or international requirements in respect of maintenance may also need to be observed, as well as any additional hygiene requirements.

A.1 Service and maintenance

contamination prevention procedures shall be put into place that establish the practices to be adopted by persons undertaking service and/or maintenance activities on equipment involved in the production of compressed air. Those procedures shall as far as is practicable ensure that no contamination of the compressed air, pipe work or associated equipment occurs.

A.2 Air outlets

When any service and/or maintenance to equipment are complete, a representative selection of air outlets shall be tested to confirm that the compressed air meets the specification.

17 Annex B - installation (informative)

B.1 New installations

For new installations, the considerations for the equipment to be installed will be based solely on the application and the chosen air purity specification.

The combination of equipment will then be chosen in accordance with the general advice on compressed air systems given in the British Compressed Air Society 'Installation Guide,' or another national guideline and the advice from the supplier, as well as any specific requirements given in this guideline.

B.2 Existing installations

Where existing installations are modified to improve the operation of the compressed air system, then it should be recognised that where equipment is introduced to reduce the levels of any particular contaminant at source the benefits to the system may not be immediate. The contaminants, including oil, water, and solids as well as bacterial growths may still be present in the system and will take some time to be removed. Filtration of the compressed air should be as close to the point of use as is practicable.

B.3 Compressor

The compressor requirements shall include the following.

B.3.1 Location

B.3.1.1 Outside

Where the compressor is located outdoors it may require additional considerations, including weatherproofing in accordance with the manufacturer's recommendations.

B.3.1.2 Inside

Where the compressor is located inside the food/beverage processing area, consideration should be given to both the air treatment to be applied and the possibility that the discharge of fluids or heat from the compressor into the local atmosphere may be detrimental to the processing of the food/beverage.

B.3.2 Lubricants

References to lubricants in this guideline will in general identify the contamination of the compressed air itself. Lubrication, for example, is used in thermo transfer, load transmission or corrosion protection of machinery, machine elements and equipment for manufacturing and processing foodstuffs, food commodity goods, beverages, cosmetics, tobacco products, pharmaceutical products, and animal feeding stuffs.

If applicable, they usually meet the general technical requirements for lubricants based on ISO 6743 and the indicated requirements. Food grade lubricants are not intended for human consumption or for contact with the skin or mucous membranes. The following points shall be considered in a hazard analysis:

a) Where lubricated or oil-injected compressors are in use and non-food grade oil is used and the hazard analysis identifies a risk at a critical control point then the oil shall be replaced with food grade oil in-line with the procedures identified in the EHEDG Document 23.

b) Where oil-free compressors are used, no lubricant is involved in the compression process, therefore the procedures identified in the EHEDG Document 23 will not be required.

c) Compressors that employ lubricants in those parts not involved in the actual compression of the air will be subject to the hazard analysis to determine the risks to the food production process.

B.3.2.1 Food grade lubricant classification

The US Department of Agriculture (USDA) formerly approved lubricants as H1 ('for incidental food contact') and published the list commonly known as the 'White Book'. The USDA ceased this activity in 1998, and third party,

Michigan-based NSF International, has since replicated the 'White Book' procedures, registering food grade lubricants as H1 food grade in their 'USDA Listing Book' **www.nsf.org**. As registration of food grade lubricants with NSF by lubricant manufacturers is voluntary, a food and beverage manufacturer either needs to check with a third party certifier such as NSF, or request a written declaration of the formulation from the lubricant supplier in order to check whether the components used in the lubricants are indeed food grade.

B.3.2.2 Food grade lubricant

Class H1. Confirmation that a lubricant is 'food grade' can be achieved by checking that it is registered by NSF as Class H1 – for use where there is potential for incidental food contact.

NSF H1 products contain only substances permitted under US 21 CFR 178.3570, 178.3620 and 182 for use in lubricants with potential incidental food contact. To comply with the requirements of US 21 CFR 178.3570, lubricant contact with food should be avoided wherever possible.

In the case of incidental food contact, the concentration of food-grade lubricant in the food must not exceed 10 parts per million (10mg/kg of foodstuff).

B.3.3 Ventilation and cooling

Compressors produce heat when in operation and therefore they should be provided with sufficient ventilation to operate efficiently, within safety margins and be able to meet air purity requirements.

Depending on the location of the compressor plant, ventilation and cooling arrangements will need to meet not only the compressor requirements but also the constraints of the location. Therefore, the following points should be noted and be in accordance with manufacturers' requirements:

a) The compressor will require cooling air and / or an adequate water supply to maintain the optimum operating temperature

b) The compressor inlet will require air at a temperature low enough to maintain manufacturer's performance. The facilities necessary to meet these conditions shall be agreed with the supplier at the time of the contract agreement.

B.4 Compressed air storage

The air receivers used shall be in compliance with either national, regional, or international codes. The materials of construction of the air receiver shall not contribute to the contamination of the compressed air, which may either come into direct or indirect contact with food/beverage in any food/beverage production area. Where a carbon steel air receiver is in use it will deteriorate due to rusting. See 1.4 Condensate Drains Page 22. The hazard analysis shall consider the need to maintain an appropriate level of stored air purity. (Based on selection of air purity as specified.)

NOTE: Examples of applicable pressure vessel codes are given in the bibliography.

B.5 Distribution

Compressed air is commonly distributed through carbon steel pipes that corrode in the presence of water in the compressed air.

Other piping materials readily available include aluminium, copper, stainless steel, or a number of plastic alternatives. Where hygiene is of prime consideration then stainless steel to relevant standards, e.g., ISO 2037 and ISO 2851 is the preferred option.

Copper pipes to EN 12449 can also be used although these are generally limited to systems where the pipe bore does not exceed 40mm.

NOTE: The use of copper pipes to inhibit the growth of bacteria is considered to be effective. Studies have shown that a copper surface can not only inhibit the growth of bacteria but can also kill bacteria. Where non-metallic piping is used for distribution systems then it should be noted that this material is subject to temperature limitations and that it should not be used at or close to the compressor discharge. Advice should be sought from the pipe supplier as to the temperature acceptance of the pipe material.

B.6 Air Treatment

B.6.1 General

The type and configuration of installed air treatment required will depend on the application and the air purity specification. In addition, the ambient conditions, type of compressor used and the material of the equipment to the point of use will all have a bearing on the combination of air treatment required.

For a detailed description of compressed air filtration and drying technologies, please refer to the BCAS Best Practice Guideline 104 Filtration & Drying of Compressed Air, section 4, page 13.

B.6.2 Compressor inlet filtration

Inlet filtration shall be in accordance with the supplier's recommendations based on site conditions specified at the time of the contract agreement, with at least the following provision. The air intake must be placed in a position away from sources of steam, chemical vapour, engine exhaust (hydrocarbons), dust and other contaminants.

B.6.3 Location

The compressor intake location may have a detrimental effect on the required compressed air purity. Those detrimental effects may include proximity to areas where vehicles pass or may be parked with engines running due to unburnt hydrocarbons.

Other detrimental effects may be due to location such as food/beverage producing facilities located in rural agricultural settings where crops such as maize are grown. These can also be a source of increased microbiological contamination.

Auditors briefing notes

The following notes are intended to assist the auditor in understanding compressed air issues.

1 General

Activity	Information
a. Documentation	If any of the equipment key to the maintenance of the required air purity is within one month of a scheduled service at the time of the audit, then confirmation of the service shall be provided after the auditor's visit.
b. Is the maintenance log up to date?	PSSR Reg. 12, PUWER Reg. 5 The guidance on the Provision and Use of Work Equipment Regulations contains information on maintenance management techniques, e.g., keeping a log. The purpose of maintenance under the PSSR is to ensure the safe operation and condition of the system.
c. Are the air purity certificate/records up to date?	Compressed air purity is verified by testing at regular intervals. The testing results are kept providing a record of this activity.

1.1 Compressors

Activity	Information
a. Has the compressor(s) been included on a maintenance programme?	Maintenance is usually based on hours run. The manufacturer provides statements on what has to be done and at what intervals.
b. Is there evidence of regular servicing?	Inlet filters which may be located either on one face of the enclosure or directly mounted at the compressor inlet may be of the maintainable type, where they can be cleaned and then re-used, or they may be of the single use replaceable type. For oil-lubricated rotary compressors these will have some form of air/oil separator which in many cases employs a cartridge filter much like the type fitted to a motor vehicle. These have an expected service life so should be subject to regular service and replacement. Lack of regular maintenance of this item may lead to higher-than-expected oil discharge in the delivered compressed air.
c. Is food grade lubricant used? (lubricated compressors)	Where food grade lubricant is used and this has replaced the original compressor oil, note shall be taken of the guidance given in the BCAS BPG 102. Taking special note of the 'Warning' and 'Recommendation' to establish if point-of-use oil removal filters have been installed.

1.2 Filters

Activity	Information
1.2.1. Filters fitted with condition monitors	
a. **Is the gauge/indicator in the green zone or below any maximum value indicated?** b. **If alarms are fitted, are they correctly functional?**	The indicators/alarms provide a visual/audible warning of the build-up of retained contaminant by measuring the pressure drop across the filter media. While the indicator is in the operationally acceptable zone, e.g., green zone, the filter is performing satisfactorily. If the indicator goes outside of the operational zone, it is possible that any functional feature in the filter mechanism may activate a by-pass for the compressed air, and un-filtered air may contaminate the downstream compressed air supply. Where such features are not fitted, then the filter media may collapse and allow un-filtered air downstream.
c. **Are the air purity certificate/records up to date?**	Compressed air purity is verified by testing at regular intervals. The testing results are kept providing a record of this activity.
1.2.2. Filters without condition monitors	
a. **Establish from maintenance records if the elements are still within service life**	Taking note of the above, vigilance is required to review the maintenance records for this type of filter.

1.3 Dryers

Activity	Information	
1.3.1. Dryers fitted with pressure dewpoint monitors		
a. **Is the indicated value at or close to the required value?** b. **If alarms are fitted, are they correctly functional?** c. **Is the current calibration certificate still within date?**	The following is an indication of the type of information that may be available on the control panel of a dryer; - Current pressure dewpoint - Maintenance required - Operation hours - Alarm signal - Alarm history	Some dryer types only have an indicator that identifies that a pressure dewpoint has been reached. This does not necessarily confirm that it is at the desired pressure dewpoint. Membrane dryers which may be fitted at a point of use do not normally have any form of indicators that identify the delivered pressure dewpoint.
1.3.2. Dryers without pressure dewpoint monitors		
a. **Establish from maintenance records if the working element (desiccant / refrigerant) is still within its service life.**	Refrigerant dryers – these rely on the charge of refrigerant gas to maintain the pressure dewpoint. Therefore, the gas charge records should be reviewed where these exist. The expected pressure dewpoint is +3°C. Desiccant dryers – the operation of this type of dryer is dependent on the life expectancy of the desiccant material. Information on the life expectancy should be available from the supplier. Pressure dewpoints for this type of dryer may be as low as -70°C. Identify what value is being employed and find evidence to confirm this. Instrumentation for the measurement of pressure dewpoint is readily available and in some compressed air installations may have been fitted by the user.	

1.4 Condensate drains

Warning: The discharge from any condensate drain shall not be into the local area or onto ground.

a) Either the discharge from a condensate drain shall be directed to a collection/separation device.

b) Or, where the site has a licence to discharge trade effluent to the foul sewer, then the untreated condensate may be directed to the foul sewer.

Activity	Information
1.4.1. Manual	
a. **Have these been included on a daily maintenance programme?** b. **Are there current records of daily draining and are these up to date?**	A build-up of condensate may result in conditions that allow the growth of microbiological organisms. It is therefore essential that a daily maintenance programme includes manual drainage when fitted and that there is a daily log of the action having been carried out.

Activity	Information
1.4.2 Mechanical	
a. **Have these been included on a daily maintenance programme?** b. **Is there evidence of regular servicing?** c. **Are they functioning correctly? View a selection to identify any that may be leaking.**	Float activated mechanical drains provide the simplest form of automatic drain but can suffer from leakage faults. This will not only be in the form of continual drainage but may allow escape of compressed air into the local atmosphere. It is important that these devices are subjected to regular servicing to maintain efficient operation.

Activity	Information
1.4.3 Automatic	
a. **Have these been included on a dailymaintenance programme?** b. **Is there evidence of regular servicing?** c. **Are they functioning correctly? View a selection to identify any that may be leaking.**	Electronic drain operation relies on the sensing of a level of condensate by electronic means rather than simple mechanical devices. This allows for a precise discharge and what is termed 'zero loss' of compressed air to atmosphere. This control method does provide for convenient operation; however, it should be noted that the automatic function can fail and lead to either an accumulation of water in the drain if closed, or to a continual exhausting of compressed air to either atmosphere or to the condensate collection device where fitted.

Important note: Any leaking mechanical drain will be the source of contaminants into the local atmosphere and may be the source of microbiological contamination.

2 References

The following documents are considered essential to the successful implementation of the provisions of this guideline.
All documents are undated therefore the latest version applies.

- **BCAS Installation Guide 6**
- **BCAS Best Practice Guide of Filtration & Drying of Compressed Air (BPG104)**
- **Codex Alimentarius - CAC/RCP 1 - General principles of food hygiene**
- **EHEDG Doc. 23 (2nd Edition) Part 1 - Use of H1 registered Lubricants**
- **ISO 8573-1 Compressed air - Contaminants and purity classes**
- **ISO 8573-2 Compressed air for general use - Test methods for aerosol oil content**
- **ISO 8573-3 Compressed air - Test methods for measurement of humidity**
- **ISO 8573-4 Compressed air - Test methods for solid particle content**
- **ISO 8573-5 Compressed air - Test methods for oil vapour and organic solvent content**
- **ISO 8573-6 Test methods for gaseous contaminant content**
- **ISO 8573-7 Compressed air - Test method for viable microbiological contaminant content**
- **ISO 8573-8 Test methods for solid particle content by mass concentration**
- **ISO 8573-9 Test methods for liquid water content**
- **ISO 22000 Food safety management systems - Requirements for any organization in the food chain**
- **ISO TS 22002-1 - Pre-requisite programmes on food safety - Food manufacturing**

3 Bibliography

The lists given on the following pages are indicative and not exhaustive, other codes and standards may apply. Standards listed below are undated therefore the latest version applies.

- **Legislation**
- **Food**

Australia/New Zealand

- Food Standards Australia New Zealand Act 1991 (and as amended)
- Food Act 1981 (New Zealand)
- Food Act 1984 (Victoria)
- Food Act 2001 (Australian Capital Territory)
- Food Act 2001 (South Australia)
- Food Act 2003 (New South Wales)
- Food Act 2003 (Tasmania)
- Food Act 2004 (Northern Territory)
- Food Act 2006 (Queensland)
- Food Act 2008 (Western Australia)
- Imported Food Control Act 1992 (Commonwealth)

UK / EU

The following EU regulations are applicable in all Member States either as the EU regulation directly or as enabled into national law.

- 1935/2004/EC Regulation of the European Parliament and of the council of 27 October 2004 - Materials and articles intended to come into contact with food.
- 852/2004/EC Regulation of the European Parliament and Council of 29 April 2004 - Hygiene of Foodstuffs.

At the time of publication the UK is still adopting these regulations.

South Africa

- The Foodstuffs, Cosmetics and Disinfectants Act no. 54 of 1972 (and as amended)

US

- CFR - Code of Federal Regulations Title 21 - Food and Drugs: Parts 1 to 1499

Equipment Australia

- South Australia - Boilers and Pressure Vessels Act, 1968, No. 43 of 1968 (and as amended) Australian Capital Territory - Boilers and Pressure Vessels Regulation 1954 (and as amended)

4 Standards

Food

- CAC/RCP 52-2003 Best practice guideline for fish and fishery products.
- EN ISO 21469 Safety of machinery. Lubricants with incidental product contact. Hygiene requirements.
- EN ISO 22000 Food safety management systems. Requirements for any organisation in the food chain.

5 Contaminant testing

- ISO 8573-2 Compressed Air for general use - Test methods for aerosol oil content
- ISO 8573-3 Compressed Air - Test methods for meaurement of humidity
- ISO 8573-4 Compressed Air - Test methods for solid particle content
- ISO 8573-5 Compressed Air - Test methods for oil vapour and organic solved content
- ISO 8573-6 Compressed Air - Test methods for gaseous contaminant content
- ISO 8573-7 Compressed Air - Test methods for viable micro-biological contaminant content
- ISO 8573-8 Compressed air - Test methods for solid particle content by mass concentration
- ISO 8573-9 Compressed

Equipment

- ISO 6743 Lubricants, industrial oils, and related products (class L) - Classification - Part 3: Family D (Compressors)
- ISO 2037 Stainless steel tubes for the food industry
- ISO 2851 Stainless steel bends and tees for the food industry
- ISO 2852 Stainless steel clamp pipe couplings for the food industry
- ISO 2853 Stainless steel threaded couplings for the food industry
- EN 12449 Copper and copper alloys. Seamless, round tubes for general purposes
- EHEDG Document 8 Hygienic equipment design criteria (Free download from EHEDG)

6 Pressure Vessel Codes

Australia

- AS 121 Pressure vessels

UK / EU

- EN 286-1 - Simple unfired pressure vessels designed to contain air or nitrogen. Pressure vessels for general purposes
- EN 13445 - Unfired pressure vessels (8 parts)
- 2009/105/EC (formerly 87/404/EEC) Simple Pressure Vessels Directive
- 97/23/EC Pressure Equipment Directive

South Africa

- No. R. 734 15 July 2009 Pressure Equipment Regulations

UK

- S.I. 128/2000 Pressure System Safety Regulations

US

- 29 CFR 1910 Subpart M, Compressed gas, and compressed air equipment - 169, Air receivers
- ASME Boiler and Pressure Vessel Code – Section VIII (commonly used for air receivers)

ISO

- ISO 16528 - Boilers and pressure vessels (2 parts)

7 Codes of practice

Australia/New Zealand

- Australia New Zealand Food Standards Code

8 Publication sources

Standards

- BSI, for BS, EN and ISO standards
  Tel: +44 (0) 20 8996 9001
  http://www.bsigroup.com/en-GB/standards/
- European Hygienic Engineering & Design Group (EHEDG)
  Email: secretariat@ehedg.org
  www.ehedg.org
- Food Standards Agency (FSA)
  http://www.food.gov.uk/

9 Legislation

Australia - http://australia.gov.au/topics/law-and-justice/legislation

UK - http://www.opsi.gov.uk/

EU - http://eur-lex.europa.eu/RECH_legislation.do?ihmlang=en

US - http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfCFR/CFRSearch.cfm

- PDA Journal of Pharmaceutical Science and Technology. Technical Report No.40 Sterilizing Filtration, January/February 2005 Supplement, Volume 58 No. S-1.
- Improved Food Safety through Sterility of Air in Food Processing and Packaging. Dr. D.J. O'Callaghan, End of project report 1998: DPRCNo.21, Teagasc. Dairy Products Research Centre

Chapter 2

Notes

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