Food and Beverage Grade Compressed Air
Best Practice Guideline 102

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Foreword

Since the publication of the first edition of this best practice guideline it has been pointed out 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" and 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 prepared this best practice guideline with advice given by the British Retail Consortium Trading Ltd, which will give 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 the 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.

Thanks are extended to not only the BRC Trading Ltd but also those members of the British Compressed Air Society who contributed to the production of this best practice guideline.

List of BCAS member companies participating in revision

ALMiG
Atlas Copco
BEKO Technologies
CORAC
Donaldson
Durr Technik
Factair
Gardner Denver
HPC
Ingersoll-Rand
Mattei Compressors
Motivair
Parker Hannifin
Silicair Dryers

Contents

Introduction (Informative)

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, that 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.

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 – the 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 strong foundation.

That strong 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, 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 into 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 areas legislation.

1 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 (hereafter referenced as a "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.

This guideline expands on the provisions in respect of the supply of compressed air in food/beverage manufacturing as identified in the BRC Global standard for food safety, ISO 22000 and ISO TS 22002-1.

It also identifies the air purity requirements for compressed air for both direct and indirect product contact.

Installation practices are provided as guidance for both existing installations and new installations.

Measurement and testing procedures are identified to verify the purity of the compressed air. Maintenance activities are identified to retain continued performance of the compressed air system.

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

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.

BRC Global Standard for Food Safety

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 8573-7 Compressed air - Test method for viable microbiological contaminant 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
BCAS Installation Guide

3 Definitions

The following definitions are considered essential to the understanding of the terms used in this guideline.

3.1 Critical control point
a step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level. (CAC/RCP 1).

3.2 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.

3.3 Food-grade lubricants
lubricants where under intended use contact with the product cannot be fully excluded.

3.4 Indirect contact
process whereby compressed air is exhausted into the local atmosphere of the food preparation, production, processing, packaging or storage.

NOTE: ISO TS 22002-1 uses the term 'incidental' which is considered to have the same meaning.

3.5 Pre-requisite programme
programme that is required prior to the application of the HACCP system to ensure that the food processing facility is operating according to the Codex Principles of Food Hygiene, the appropriate guideline and appropriate food safety legislation. (Modified from CAC/RCP 52-2003)

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

4.1 General
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 are collectively termed "pre-requisite programs." They form part of the overall activity related to risk assessment identified as Hazard Analysis and Critical Control Points in the food chain.

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

1. The organization 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), including cross contamination between products, 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.

2. 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.

4.3 Compressed air strategy
The strategy to be applied for a pre-requisite programme related to the provision of compressed air shall consider the following:

a) identify areas where compressed air is involved with food/beverage

b) identify which contaminants may adversely affect the food/beverage

c) establish whether the involvement with compressed air is by direct or in-direct contact

4.4 Compressed air purity measures
As the compressed air system is identified to form part of the pre-requisite programme its requirements will already have been identified and applied. The measures applied shall include:

a) the air purity required
i. establish the need for either direct or in-direct contact air purity at a specific point of use.
ii. identify the air purity level for the entire system based on the results of the action identified in 4.4 d) and e).

b) the periodic testing to verify the required air purity

c) the service and maintenance regime necessary to maintain the air purity.
These measures shall be recorded as part of the HACCP process. In addition the following steps should be taken;

d) establish whether the compressed air involvement comes within the provisions of any identified critical control points.

e) if it is within the scope of a critical control point then the steps identified in a) to c) above shall be reviewed to establish if these are adequate.

WARNING - It should be recognised that resulting from the procedure outlined in 4.4 a) ii. the air purity level requirements for the entire compressed air system may result in a level lower than the specification for direct or in-direct contact. Where this is the case it is essential that point of use air purity is carefully considered as in 4.4 d).

5 Competencies

5.1 Provision of equipment
Companies involved in the supply, service and maintenance of compressed air equipment shall have staff qualified in the activities being provided. The competencies of those staff shall include compressed air principles gained from formal training as well as product knowledge gained from manufacturer training. The minimum training and on the job experience shall be 5 years.

5.2 Air purity testing
Personnel involved in providing services related to the testing of compressed air purity shall have competencies in the measurement standards and the practical skills necessary to interpret the results of the testing done.

5.3 Food/beverage facility
Personnel employed by the food/beverage facility who are involved in any activity related to the maintenance of the compressed air system shall have sufficient knowledge through appropriate training to appreciate the requirement to maintain the air purity specifications.

5.4 Auditors
It is considered good practice that personnel involved in auditing activities with respect to pre-requisite programmes and HACCP should have sufficient understanding of compressed air systems to be able to follow and complete the guidance given in Annex A to assess compliance with the pre-requisite programme as identified in the HACCP process.

6 Installation

6.1 General
The requirements for the equipment included in a compressed air system for food production shall be such that the air purity specifications identified in clause 7 can be consistently met either for the entire compressed air system or at identified points of use.

For guidance on general compressed air system installation the user should consult the British Compressed Air Society "Installation Guide". Specific information on particular aspects of chosen equipment, e.g. compressor(s), dryers or filters shall be obtained from the supplier. Consideration shall be given to 'point of use' air treatment equipment in addition to that installed at source.

7 Compressed air purity values

The measures identified in 4.4 a) should be applied to determine the level of contamination by the use of the tests identified in clause 8 and then to verify if these levels are within the values identified in clause 7.

If the values are outside of those in clause 7 then remedial action shall be taken.

Whilst observing the requirements for good practice in the food industry for compressed air systems it should not be forgotten to maintain energy efficient and safe solutions.Information on Installation is given in Annex B.

7.1 Contaminant reduction requirements
This guideline identifies acceptable purity values for food/beverage areas. However, consideration should also be given to any specific safety or quality requirements of the site.

7.2 Compromising compressed air purity
In the event of a fault or a service requirement for the air treatment equipment provision should be made based on recognised best practice to maintain the required air purity levels.

Recognised best practice may include the provision of a standby system of the same capacity and air purity specification, however any effective means of maintaining the required air purity shall be considered. It should be noted that in general compressed air applications it is common to fit a by-pass around air treatment equipment to facilitate service or maintenance.

For compressed air systems included in food and beverage plants the fitting of a by-pass should be carefully considered and any procedures necessary to maintain air purity whilst the by-pass is in operation shall be fully documented.

7.3 Compressed air purity groups
Compressed air used in the production of food/beverage products is divided into two groups:

– air that comes into direct contact with the food/beverage;
– air that could come into in-direct contact with the food/beverage.

7.3.1 Reference conditions
The contaminant values for dirt and oil given in clauses 7.3.3 and 7.3.4 below 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.

NOTE – 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.

7.3.2 ISO 8573-1 class designation
The designation of the purity class of compressed air as given in ISO 8573-1 is written as follows, where:

A is the purity class for particles;

B is the purity class for humidity and liquid water;

C is the purity class for total oil.

7.3.3 Direct contact recommendation

Compressed air coming into direct contact with food/beverage should meet or exceed the following classification, Table 1, as identified from ISO 8573-1:2010

Compressed Air Purity Designation
ISO 8573-1:2010 [2:2:1] which translates to;

Table 1 - Compressed Air Purity Designation - Direct contact with food

Class	Maximum number of particles per m^3 **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/m^3)(at reference conditions)		
1	≤ 0,01		

7.3.4 In-direct contact recommendation

Compressed air coming into in-direct contact with food/beverage should meet or exceed the following classification, Table 2, as identified from ISO 8573-1:2010

Compressed Air Purity Designation
ISO 8573-1:2010 [2:4:2] which translates to;

Table 2 - Compressed Air Purity Designation – In-direct contact with food

Class	Maximum number of particles per m^3 **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/m^3)(at reference conditions)		
2	≤ 0,1		
[1] See Annex C.1.2.3 for information on drying of compressed air			

7.4 Microbiological contaminants

7.4.1 General

Many applications within food/beverage processes either require complete sterility or at least a level of control over the presence of micro-organisms.

If compressed air containing micro-organisms is allowed to directly or indirectly contact production equipment, ingredients, packaging materials, partially completed or finished products, then sterility can be lost.

7.4.2 Control of microbiological contaminant

Hazard analysis shall establish the risk of contamination by microbiological contaminants from compressed air. The level of control identified as being required over microbiological contaminants in the compressed air shall be detected using the method described in clause 8.6.

NOTE: Microbiological testing of end products should not be relied upon for compressed air compliance.

A summary of the technologies for purification of compressed air can be found in Annex C.4.

8 Verification of air purity requirements

8.1 General
The methods to be employed to verify the level of contaminants shall follow those test methods described in the appropriate part of ISO 8573. Other methods using chemical indicator tubes may be used to establish the general levels of oil and humidity. Guidance should be sought from the original equipment manufacturer of the compressed air equipment on testing and compliance procedures.

8.2 Periodicity
WARNING: The compressed air purity test procedures require qualified personnel and specialised equipment consult your supplier for advice on suitable air purity measurement providers.

The compressed air purity shall be tested and verified at least twice per year, unless otherwise identified in the HACCP process, or in accordance with manufacturers recommendations using the methods identified in the following clauses.

NOTE: Whenever maintenance work or any activity that may affect the air purity is performed on the compressed air system then as a simple check on the air purity chemical indicator tubes may be used.

This method may be employed where the next scheduled periodic test is not imminent.

8.3 Dirt (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 as indicated in clause 8.6 shall also be done to confirm whether there are any microbiological colonies present in the solid particles from the compressed air.

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

8.5 Total oil
Oil concentration shall be measured using with 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.

8.6 Microbiological
The presence of microbiological contaminants shall be established by the test method specified in ISO 8573-7.

NOTE: 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.

8.7 Documentation
All measurements shall be recorded and documented.

9 Service and maintenance

The compressors and all ancillary components that are involved in producing 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 in order to provide the confidence that original performance can be maintained.

Alternative parts should only be used if the supplier can prove performance of the alternative part is equal to or exceeds the performance of the original. Further information on maintenance is given in Annex D.

10 Documentation

All measurements related to the air purity requirements shall be recorded and documented. All maintenance work 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.

ANNEXES

Annex A Guidance to Auditor (Informative)

When conducting an audit of the food/ beverage facility good practice is to ensure the following items are verified in respect of the equipment providing compressed air in either the direct and/or in-direct contact areas; Auditor should identify evidence of the following;

Activity	Result		Comment or remedial action
	Yes	No	
1. Documentation			
Is the maintenance log up to date?			
Are the air purity certificate / records up to date?			

2. Equipment			
A.1 Compressors			
a. Has the compressor(s) been included on a maintenance programme?			
b. Is there evidence of regular servicing?			
c. Is food grade lubricant used? (Lubricated compressors) (See Annex B.3.3)			

A.2 Filters (see Annex C)			
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?			
2) Filters without condition monitors			
a. Establish from maintenance records if the elements are still within service life			

A.3 Dryers			
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?			
2) Dryers without pressure dewpoint monitors			
a. Establish from maintenance records if the working element (desiccant/refrigerant) is still within its service life			

A.4 Condensate Drains **Warning -** The discharge from any condensate drain shall not be into the local area or onto ground. The discharge from a condensate drain shall be directed to a collection/separation device.			
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?			

2 Automatic			
2.1 Mechanical			
a. Have these been included on a maintenance programme?			
b. Is there evidence of regular servicing?			
c. Are they functioning correctly? – view a selection to identify any that may be leaking.			
NOTE: Any leaking mechanical drain will be the source of contaminants into the local atmosphere and may be the source of microbiological contamination			

2.2 Electronic			
1) Filters fitted with condition monitors			
a. Have these been included on a maintenance programme?			
b. Is there evidence of regular servicing?			
c. Are they functioning correctly? – view a selection to identify any that may be leaking.			
NOTE: Any leaking electronic drain will be the source of contaminants into the local atmosphere and may be the source of microbiological contamination			

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 given in clause 7.

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 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.3.3 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.3.3.1 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" (Refer 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.3.3.2 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.3.4 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 manufacturers' 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 A.4 'Warning' and C.2.1.3 regarding the draining of condensate. The hazard analysis shall consider the need to maintain an appropriate level of stored air purity. (Based on selection of air purity as specified in clauses 7.3.3 and 7.3.4.)

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. Information on compressed air treatment is given in Annex C.

B.6.2 Ambient atmospheric air
Ambient atmospheric air which is used for compression if left untreated may potentially introduce contaminants to the compressed air distribution system such as:

- water vapour;
- air-borne dirt;
- un-burnt hydrocarbons;
- micro-organisms;

NOTE: If the compressor is sited within the production area then any air borne contaminants found in that area will find their way into the compression process.

B.6.3 Compressor inlet filtration
Inlet filtration shall be in accordance with the suppliers 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.6.4 Location and air treatment
Additional air treatment equipment may be required downstream of the compressor if the pre-requisite programme requirements identify that the compressor intake location has a detrimental effect on the required 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 be a source of increased microbiological contaminants.

Annex C Compressed Air Treatment (Informative)

Information regarding the treatment of atmospheric air being drawn into the compressor is given in Annex B.6. Information given in this annex deals with the air once compressed and discharged from the compressor outlet to the user's compressed air system. There are various potential sources of contamination in compressed air, some of which are given below.

C.1 Contamination Sources
Possible sources of contamination in compressed air are found to be from:

- ambient atmospheric air
- air compressor
- distribution system
- production area

C.1.1 Ambient atmospheric air
See B.6.2.

C.1.2 Air compressor
In addition to the contaminants drawn in from the ambient atmosphere, compressors will add wear particles and in the case of oil lubricated compressors, will contribute small amounts of oil used in the compression stage of the machine. The oil will be in the form of:

- liquid;
- aerosol;
- vapour;
- hydrocarbon oxidation particulates

After the compression stage, the after-cooler will cool the air, condensing water vapour and introducing it into the compressed air as:

- liquid water;
- water aerosols

C.1.3 Distribution system
The air receiver (storage device) and the system piping that distribute the compressed air around the facility can store contaminants emanating from the compressor. Additionally, they cool the warm saturated compressed air which causes further condensation, adding more liquid water into the system, promoting corrosion and potential microbiological growth. Corrosion products, such as rust and pipescale, along with any microbial agents are then carried within the flow of compressed air.

C.2 Contaminant removal
As a general rule contaminant removal from compressed air should be as close to the point of use as is practicable. Contaminant removal within the compressed air system is commonly done using one or more of the following techniques.

C.2.1 Liquids, aerosols and vapours
Removal of liquids, generally water or lubricants, in compressed air is commonly performed using the following technologies.

C.2.1.1 Water separators
Water separators provide bulk condensed water and liquid oil removal and are used to protect coalescing filters against bulk liquid contamination (for example where excessive cooling takes place in air receivers and distribution piping installed prior to purification equipment).

Water separators will only remove liquids and will not remove water or oil in either an aerosol or vapour phase.

C.2.1.2 Coalescing filters
Coalescing filters are used to remove water or oil in a compressed air system that is in the form of an aerosol.

The aerosols which are in the form of very small droplets are brought together by the coalescing filter media to form larger droplets that are then deposited at the bottom of the coalescing filter bowl.

A purification system will normally consist of two coalescing filters installed in series to remove not only water/oil aerosols but also atmospheric dirt, rust and pipescale. The first filter is a 'general purpose filter' which protects the second, 'high efficiency filter' from bulk contamination.

C.2.1.3 Drying
Compression of air artificially raises the level of water either as vapour or aerosol until it becomes fully saturated and condensation forms in the distribution system and ancillary equipment.

The temperature of the compressed air determines the level of saturation which increases as compressed air temperature reduces.

Compressed air humidity is commonly expressed as a Pressure Dew Point (PDP) temperature at which the air would become fully saturated with moisture and any excess water vapour would condense.

Consideration must therefore be given to the operational temperature of the compressed air distribution system through to final use of the compressed air as to the level of dryness and filtration required.

The review shall include consideration for temperature variation during operation or periods of dormancy of the compressed air system due to variations in seasonal conditions.

Low levels of humidity in compressed air cannot be achieved by use of coalescing style filters alone since these will endeavour to remove liquid water only, leaving the compressed air still fully saturated with water vapour. Reductions in humidity can be achieved in many different ways, for example:

- pressure over generation;
- refrigeration;
- membrane;
- adsorption dryers

Microbiological contaminants such as bacteria require water to maintain viability.

Therefore to reduce viability for microbiological contaminants in the compressed air system it is recognised that the humidity of the compressed air needs to be reduced.

Typically adsorption dryers (commonly described as desiccant dryers) provide the highest levels of compressed air dryness and are best suited for reducing the humidity to levels that are low enough to suppress microbiological activity within the system.

They are not however a replacement for those filters (commonly described as air sterilisation filters) which are capable of removing micro-organisms and other toxins such as viruses and bacteria phage. See C.3.

C.2.1.3 Condensate
Condensate is formed in various parts of the compressed air system and will contain dissolved and emulsified contaminants from the compressed air and will need to be drained and disposed of on a regular basis.

The air receiver and other points around the compressed air system, e.g. air treatment points where condensate is removed, act as collection points for condensate deposited from the air.

Where oil lubricated/injected compressors are used the resulting condensate discharge may need to comply with local legislative provisions governing disposal, where these are in force. In some countries legislative provisions exist that identify lubricants as hazardous waste.

Where such provisions exist it shall be established that compressed air condensate containing lubricants, including food grade lubricants is suitable for disposal as a trade effluent to foul sewer.

If lubricants including food grade lubricants are identified as a hazardous waste then proper disposal shall be identified.

C.2.2 Solids
Dust removal filters are used for the removal of dry particulates. They generally have equivalent particulate removal performance to that of the coalescing filter and would use the same mechanical filtration techniques.

C.3 Air sterilisation by filtration

Filtration is the method of choice for the sterilization of compressed air which will be used in food and beverage production processes. Absolute-rated, steam-sterilisable, PTFE or borosilicate filter cartridges are commonly used within the food and beverage industry. The hydrophobic nature of PTFE and borosilicate prevents wetting thereby maximizing microbial retentiveness during gas filtration.

Absolute removal of solid particulates and micro-organisms is performed by a sieve retention or membrane filter. They are often referred to as sterile air filters as they also provide sterilised compressed air. Filter housings are manufactured from stainless steel where in-situ steam sterilisation of the filter housing, element and downstream pipework is required.

It is important to note that the piping between the sterile filter and the application must also be cleaned and sterilised on a regular basis. To maintain sterility a regular regime will need to be adopted to maintain sterility with the assistance of the equipment manufacturer.

C.4 Summary of the technologies for purification of compressed air

The table identifies the relationship between contaminants and technologies available for their removal.

Contamination reduction / removal									
		Atmospheric					**Compression**		**System**
Purification equipment technologies		Water			Dirt and solid particulate	Micro organisms	Liquid oil and oil aerosol	Oil vapour	Rust and pipe scale
		Bulk condensed	Aerosol	Vapour					
Water separators		**X**							
Filters	Coalescing		**X**		**X**	**X**	**X**		**X**
	Adsorption							**X**	
	Dust removal				**X**	**X**			**X**
	Micro-biological					**X**			
Dryers	Adsorption			**X**					
	Membrane			**X**					
	Refrigeration			**X**					

Annex D 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.

D.3 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.

D.4 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 given in clause 7.

D.5 Non-food grade lubricant replacement
The following information has been supplied by the European Hygienic Engineering & Design Group (EHEDG), who has given permission for the use of the text and flow chart.

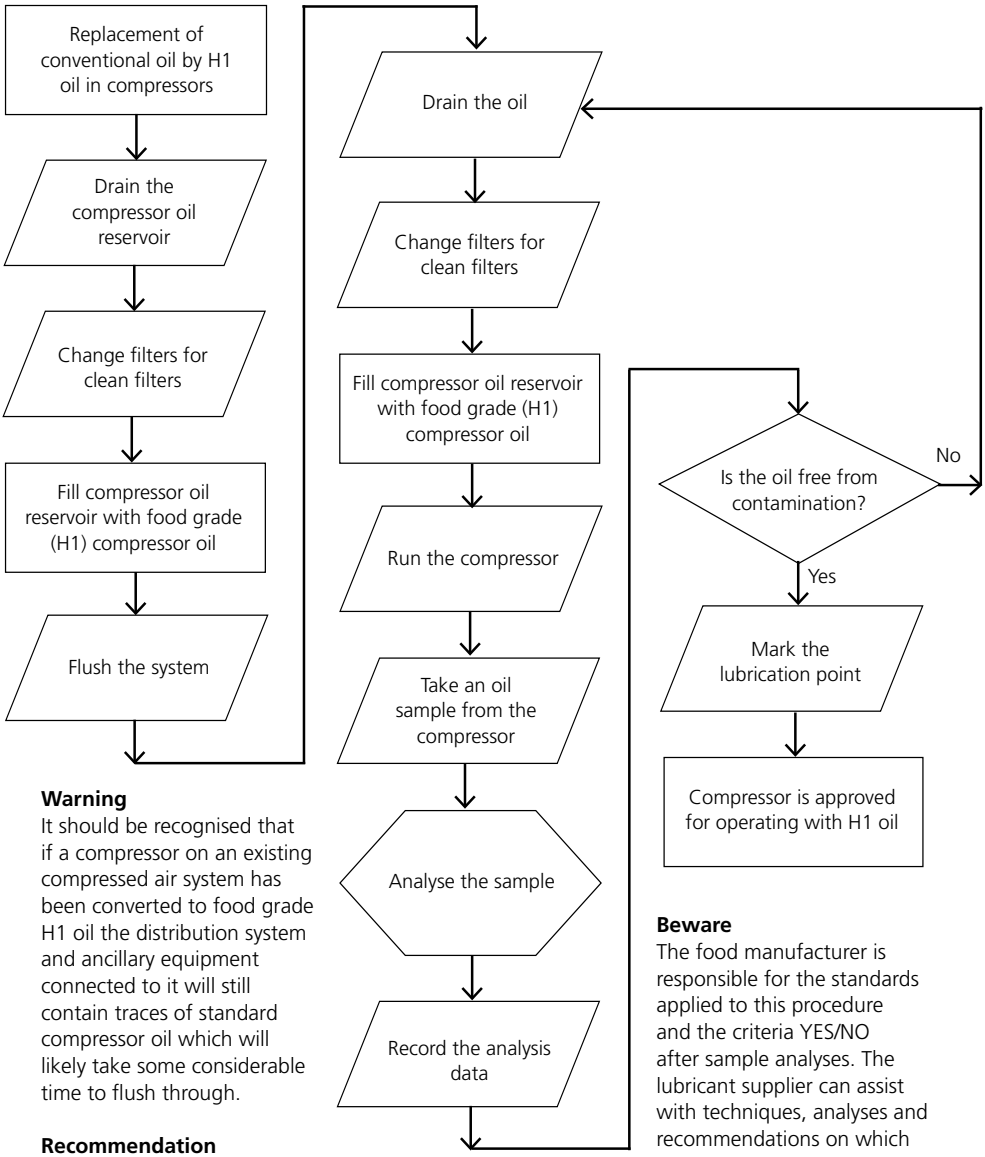
It is recommended that the user of this best practice guide obtains a copy of the document from which this information is extracted to ensure a full understanding of the procedures involved.

The following flow diagram describes the sequential steps which the maintenance department can use to effectively replace conventional lubricants with food grade (H1) lubricants. The food manufacturer is responsible for the changeover procedure.

It is highly recommended to carry out a proactive validation process with the help of the lubricants supplier to ensure that each replacement of conventional lubricants by H1 lubricants is correct for the application.

The lubricants supplier should assist you with the latest recommendations and analyses needed for the on-going use of H1 lubricants.

Replacement of conventional oil with H1 oil in compressors



Warning
It should be recognised that if a compressor on an existing compressed air system has been converted to food grade H1 oil the distribution system and ancillary equipment connected to it will still contain traces of standard compressor oil which will likely take some considerable time to flush through.

Recommendation
Point of use oil removal filters should be used to help prevent further migration of oil in the distribution system and possible food contact.

Beware
The food manufacturer is responsible for the standards applied to this procedure and the criteria YES/NO after sample analyses. The lubricant supplier can assist with techniques, analyses and recommendations on which oils to use and how long to flush.

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Food
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- 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)

EU
The following EU regulations are applicable in all 27 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.

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)

EU
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

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 organization in the food chain

Contaminant testing

ISO 8573-6 Compressed air - Test methods for gaseous contaminant content

ISO 8573-8 Compressed air - Test methods for solid particle content by mass concentration

ISO 8573-9 Compressed air - Test methods for liquid water content

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)

Pressure vessel codes

Australia
AS 121 Pressure vessels

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)

US
ASME Boiler and Pressure Vessel Code – Section VIII (commonly used for air receivers)

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

Codes of practice

Australia/New Zealand
Australia New Zealand Food Standards Code

Publication sources

Standards
BCAS 33-34 Devonshire Street, London, W1G 6PY, UK - Tel: +44 (0)20 7935 2464
Email: enquiries@bcas.org.uk
BRC http://www.brc.org.uk/standards/index.htm

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Email: secretariat@ehedg.org
www.ehedg.org

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http://www.food.gov.uk/

Legislation

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

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