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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

SURFACE VEHICLE STANDARD

SAE J1649/1
ISO 8573-1

Issued 1993-06-11

Submitted for recognition as an American National Standard

COMPRESSED AIR FOR GENERAL USE— PART 1: CONTAMINANTS AND QUALITY CLASSES

This document is technically equivalent to ISO 8573-1.

Foreword—SAE J1649/1;ISO 8573-1 Part 1 was prepared by SAE Compressed Air Quality Subcommittee, Manufacturing Technology Division, and ISO/TC 118, Compressors, pneumatic tools and pneumatic machines, Sub-Committee SC4, Quality of compressed air. SAE J1649/1;ISO 8573-1 consists of the following parts, under the general title: Compressed air for general use:

Part 1: Contaminants and quality classes
Part 2: Test methods

SAE J1649/1 Part 1 is technically equivalent to ISO 8573-1. Designations made to either standard will interchange to designations made to the other standard.

It is not possible using most test methods to measure the full flow area of a compressed air stream and therefore it is necessary to take samples of the air. This method of testing has a major drawback in that oil, for example, is not evenly distributed over the flow area.

Measurements should preferably be carried out at the actual operating pressure and temperature of a compressor as otherwise the balance between contaminants in liquid, aerosol, or gaseous form will be altered. Liquid oil and free water in particular tend to cling to pipe and tube walls where they form a film or thin rivulets.

The content of water, oil, and particles in compressed air varies owing to sudden changes in the intake air, to the wear of components as well as to changes in flow, pressure, temperature, and ambient conditions. Therefore the quality classes of a compressed air system have to be based on the mean value of a number of measurements carried out over a specified period of time.

Recommended methods for measuring the oil content of compressed air will be given in SAE J1649/2;ISO 8573-2.

Printed in U.S.A.
90-1202B EG

1. ***Scope***—This part of SAE J1649/1 specifies quality classes of industrial compressed air for general use (e.g., for workshops, the construction industry, pneumatic transport, etc.) without consideration of the quality of the air when it is discharged from the compressor. The quality class of compressed air for a particular application has to be based on the mean value of several measurements carried out over a specific period of time and under defined operating conditions.

This part of SAE J1649/1 is not applicable to compressed air for direct breathing and for medical use.

2. ***References***

2.1 Applicable Documents—The following publications form a part of this specification to the extent specified herein.

2.1.1 ISO PUBLICATIONS—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ISO 3649:1980—Cleaning equipment for air or other gases - Vocabulary
ISO 7000:1989—Graphical symbols for use on equipment - Index and synopsis
ISO 7183:1986—Compressed air dryers - Specifications and testing

2.2 Related Publication—The following publication is provided for information purposes only and is not a required part of this document.

2.2.1 ISO PUBLICATION—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ISO 1219-1:1991—Fluid power systems and components - Graphic symbols and circuit diagrams - Part 1: Graphic symbols

2.3 Definitions—For the purposes of this part of SAE J1649/1, the following definitions apply:

2.3.1 ABRASION—Surface wearing of material by mechanical action between solids.

2.3.2 ABSORPTION—Process of attraction of one substance into another, so that the absorbed substance disappears physically.

2.3.3 ADSORPTION—Attraction and adhesion of gaseous and liquid molecules to the surface of the solid.

2.3.4 AEROSOL—Suspension in a gaseous medium of solid particles, liquid particles, or solid and liquid particles having a negligible fall velocity (generally less than 0.25 m/s).

2.3.5 AGGLOMERATE—Group of two or more particles combined, joined, or formed into a cluster by any means.

2.3.6 BROWNIAN MOVEMENT—Random movement of small particles suspended in a fluid.

2.3.7 COALESCENCE—Action by which liquid particles in suspension unite to form larger particles.

2.3.8 COMPRESSION DRYING—Drying of air by compressing it to a higher pressure, cooling it, and extracting the water condensed, and finally expanding it to the required pressure.

2.3.9 CONTAMINANT—Any material or combination of materials (solid, liquid, or gaseous) which adversely affects the system or the operator.

2.3.10 DEWPOINT—Temperature at which vapor begins to condense.

2.3.10.1 *Atmospheric Dewpoint*—Dewpoint measured at atmospheric pressure.

NOTE—The term atmospheric dewpoint should not be used in connection with compressed-air drying.

2.3.10.2 *Pressure Dewpoint*—Dewpoint at the actual pressure of the compressed air (this pressure should be stated).

2.3.11 DIFFUSION—Movement of gas molecules or small particles caused by a concentration gradient.

2.3.12 DIRECT INTERCEPTION—Filtration effect in which a droplet or a solid particle collides with an element of a filter medium (e.g., fiber or granule) which is in its direct path or is captured by pores of diameter smaller than the diameter of the droplet or particle.

2.3.13 EFFECTIVE PARTICLE DIAMETER—Diameter of a circle having an area equivalent to the smallest projected area of the particle.

2.3.14 EQUIVALENT PARTICLE DIAMETER—Diameter of a spherical particle having an equivalent "behavior" to that of the considered particle with regard to a given characteristic (e.g., projected area or diameter).

2.3.15 EROSION—Wearing of material caused by the mechanical action of a fluid system with or without solid particles in suspension.

2.3.16 FILTER—Apparatus for separation of contaminants from a fluid stream in which they are present.

2.3.17 FILTER RATING—Parameter expressing a particular characteristic of a filter. This parameter may be the filtration efficiency, the filtration ratio, or the penetration.

2.3.17.1 *Filtration Efficiency E*—The change in concentration across the filter divided by the upstream concentration. It may also be expressed as

$$E = 1 - P \quad \text{(Eq.1)}$$

where:

P is defined in 2.3.17.3

The filtration efficiency is usually expressed in percent.

2.3.17.2 *Filtration ratio β*—For each particle size class, the ratio of the number of particles upstream of the filter to the number of particles downstream. It may also be expressed as

$$\beta = 1/P \quad \text{(Eq.2)}$$

where:

P is defined in 2.3.17.3

The particle class size is used as an index. For example, $\beta_{10} = 75$ means that the number of particles of 10 μm and greater is 75 times higher upstream of the filter than downstream.

2.3.17.3 *Penetration P*—Ratio of the downstream particle concentration to the upstream particle concentration.

2.3.18 Inertial Interception—Process in which a particle impinges on a part of the filter owing to the momentum of the particle.

2.3.19 Particle—A small discrete mass of solid or liquid matter.

2.3.20 Relative Vapor Pressure *p*—Ratio of the partial pressure of water vapor to its saturation pressure at the same temperature.

2.3.21 Van der Waals' Forces—Attractive or repulsive forces between any pair of molecules, caused by the electric fields of the electrons (negative) and nuclei (positive) of which molecules are built up.

2.3.22 Vapor—Gas which is at a temperature below its critical temperature and which therefore can be liquefied by isothermal compression.

3. ***Units***—The SI units of pressure and of volume are the pascal and the cubic meter, respectively. However, for compliance with current practice in the pneumatic field, non-SI units bar[1] for pressure and liter[2] for volume are used in this part of SAE J1649/1. In addition, the non-SI unit parts per million (ppm) is employed for concentration. A summary of the units used in the pneumatic field is given in Table 1.

TABLE 1—UNITS FOR VARIOUS CONTAMINANTS

Contaminant	Pressure dewpoint °C	Particle or droplet size µm	Vapor pressure mbar	Content[1] mg/m^3	Relative vapor pressure	Concentration ppm (by mass)	Concentration ppm (by volume)
Solids:							
size		x					
content				x			
Water:							
liquid				x			
vapor	x		x	x	x		
Oil:							
liquid		x		x		x	
vapor			x	x			x

[1] At 1 bar absolute pressure, +20 °C and a relative vapor pressure of 0.6. It should be noted that at pressures above atmospheric, the contaminant concentration is correspondingly higher.

[1] 1 bar = 10^5 Pa
[2] 1 liter = 10^{-3} m^3

4. *The Compressed Air System*

4.1 A typical compressed-air generating system is shown in Figure 1.

4.2 The maintenance and operation of compressors and their auxiliaries and prime movers shall be in accordance with the manufacturer's instructions and specifications.

4.3 The lubricant shall meet the specifications for the compressor.

4.4 The compressor or the remote intake pipe should be located in an uncontaminated area, i.e., in an area with the lowest possible contamination from engine exhaust, process discharge, etc. The intake air should preferably be as cool and dry as possible.

4.5 It is advisable to place a suitable filter in the compressed-air pipeline as close as possible to the point of use. Samples should, whenever possible, be taken at the point of use.

*5. **Contaminants***—The three major contaminants in compressed air are solids (dust), water, and oil. These contaminants have an influence on each other (e.g., dust particles agglomerate in the presence of oil or water to form larger particles, oil and water emulsify) and are sometimes deposited or condensed (e.g., oil vapor or water vapor) inside the pipework.

5.1 Solids

5.1.1 GENERAL—Dust is always ingested by the compressor with the intake air. In addition, further solid particles (wear debris, rust, etc.) may be added to the intake air during its passage through the compressor and its associated pipework; although some particles will be suspended in the lubricant and thus removed by the outlet filters.

When compressor pipework is in good condition, the concentration of rust and scale does not usually exceed 2 mg/m^3 to 4 mg/m^3, but peak concentrations can occur when airflow starts or when the pipes are subjected to mechanical shock.

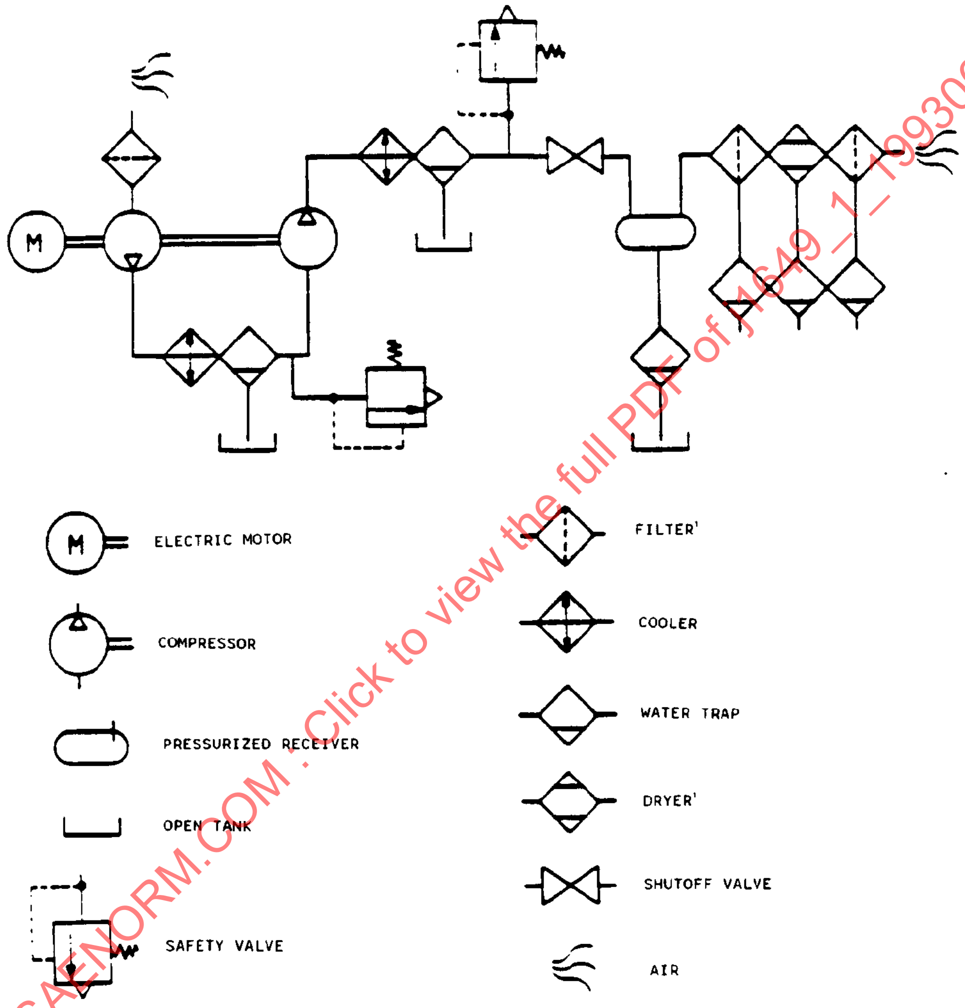
The average particle size of the dust tends to increase with the dust load, which can vary from a negligible value up to over 1.4 mg/m^3.

The dust concentration may be limited by the use of appropriate filters, chosen in accordance with the concentration of dust in the intake air and the compressor technology.

In addition to the dust load, the dust characteristics are also important. Dust is characterized not only by its shape and size but also by its hardness.

Very generally, small dust particles will often form deposits, whereas particles larger than 5 μm will lead to erosion if the flow velocity is sufficiently high.

It should also be borne in mind that certain solids can have a catalytic effect and that corrosion can occur owing to their chemical properties.



1 DEPENDING ON THE APPLICATION, THE DRYERS AND FILTERS MAY BE LOCATED UPSTREAM OF THE RECEIVER TO ALLOW DRY AIR TO BE STORED.

NOTE: THE SYMBOLS USED, WITH THE EXCEPTION OF THAT FOR AIR, ARE IN ACCORDANCE WITH ISO 1219-1. THE SYMBOL FOR AIR IS IN ACCORDANCE WITH ISO 7000.

FIGURE 1—TYPICAL COMPRESSED-AIR GENERATING SYSTEM

5.1.2 MEASURING METHODS

5.1.2.1 Particle Size—The particle size of solid contaminants can be measured using the following methods:

a. Cascade impactor, which can be operated at high pressures and temperatures

b. Particle counter, which employs microscopic scanning in combination with retention on a membrane of suitable pore size

5.1.2.2 Concentration—The concentration of solid contaminants can be measured using the following methods:

a. Gravimetric methods, which can be used at high pressures
b. Particle counters and light dispersion photometers, which are normally operated at atmospheric pressure

Various standardized test dusts may serve as references. Sampling carried out upstream and downstream of a test filter should be isokinetic and effected in such a way that the velocity distribution in the main pipe is not affected.

NOTES—Such methods of measurement require special equipment and operator skills and are therefore normally only carried out by filter manufacturers or scientific institutions.

The measurements are as a rule carried out at atmospheric pressure.

When stating the contaminant concentrations determined using these methods, the test method should be specified because different methods do not necessarily give comparable results.

5.1.3 INFLUENCE OF OTHER CONTAMINANTS—Oil and water will cause dust to agglomerate and to adhere to surfaces. If several contaminants are present simultaneously, special care needs to be taken for their individual determination.

5.1.4 METHODS OF REMOVAL—The following methods of solids removal may be employed:

a. Pipeline strainers (for particle sizes above 100 μm)
b. Separators of the cyclone or impingement type, for particle sizes of 15 μm and 20 μm, respectively
c. Granular porous filters (e.g., sintered metal, glass, porous plastic, and ceramic), for particle sizes about 5 μm
d. Fibrous depth type filter, for particle sizes of 1 μm
e. Submicronic fiber coalescer, for particle sizes of 0.01 μm

5.2 Water

5.2.1 GENERAL—Atmospheric air always contains water vapor. When atmospheric air is compressed the partial pressure of the water vapor is increased but, owing to the increase in temperature caused by the compression, no water precipitates. When the air is subsequently cooled (e.g., in an intercooler or aftercooler, in the distribution pipework or during the expansion process in a pneumatic tool), water will condense to liquid, but the air will be fully saturated with water vapor.

Moisture can lead to corrosion, freezing, etc., and adversely affect the final product, e.g., in spray painting.

5.2.2 MEASURING METHODS (FOR WATER VAPOR)—The concentration of water vapor can be measured using the following methods:

a. Psychrometers

b. Electric or electronic hygrometers (see ISO 7183), in which a change in resistance or the temperature of a mirror surface is measured at the time that frost formation begins

c. Piezoelectric sorption hygrometers

When using such instruments, care shall be taken as water droplets, supersaturated vapor and oil can produce erroneous readings.

NOTE—Such methods of measurement require special equipment and operator skills and are therefore normally only carried out by compressor and filter manufacturers or scientific institutions.

5.2.3 INFLUENCE OF OTHER CONTAMINANTS—Oil has an adverse influence on some types of air dryers (e.g., cooling surfaces become fouled, or the pores of the adsorbent become clogged and cannot be reactivated). Some hygrometers are similarly affected.

5.2.4 METHODS OF REMOVAL—The following methods of removal of water may be employed:

a. Condensation with separation (by cooling or compression drying)
b. Sorption (absorption or adsorption) (see ISO 7183)
c. Filtration (only for water in the liquid phase)

5.3 Oil (Mineral or Synthetic)

5.3.1 GENERAL—In compressors with a lubricated compression space, the air unavoidably picks up some oil. Also, the air from nonlubricated (dry) compressors may contain traces of oil aspirated with the intake air. In some industrial applications (e.g., bakeries) a nontoxic lubricant (e.g., white liquid paraffin) is used.

Oil in compressed air can belong to one of three categories as follows:

a. Bulk liquid
b. Aerosol
c. Vapor

Only a small fraction of the oil fed to the compression space of a displacement compressor remains in the delivered air. A considerable portion is drained off with the condensate from the intercoolers and aftercoolers. Whether oil degradation products and any oil entrained in the compressed air can be filtered out depends on the type of compressor and on the type of oil and its treatment inside the compressor, as these factors influence the size of the oil particles and their composition.

5.3.2 MEASURING METHODS—One method of measuring the oil content is by absorption spectroscopy using infrared or ultraviolet light. The compressed-air filter sample is scrubbed with a suitable solvent such as 1,2,2-trichloro-1,1,2-trifluoroethane which is then examined for condensable hydrocarbons.

NOTE—Such methods of measurement require special equipment and operator skills and are therefore normally only carried out by compressor and filter manufacturers or scientific institutions.

Special care shall be taken when the type of oil used in the compressor is changed as small amounts of the oil used previously can remain in the system for a considerable time and may influence subsequent measurements of oil content.

5.3.3 METHOD OF REMOVAL—Oil may be removed by high-efficiency filters.

5.4 Oil (Vapor)

5.4.1 GENERAL—The vapor pressure of conventional compressor lubricants is low. Therefore, below approximately 35 °C, the oil vapor content may be disregarded, except in cases where the compressor is employed in connection with the handling of food, beverages, etc., or when condensed oil vapor can accumulate with time, e.g., in compressed air bottles.

5.4.2 MEASURING METHODS—The concentration of gaseous hydrocarbons can be determined using the following methods:

a. Flame ionization analyzer
b. Gas-cell-equipped infrared analyzer
c. Oxidation of the hydrocarbons to carbon dioxide which then may be determined by
   (1) Classic chemical methods
   (2) Infrared equipment
   (3) Adsorption techniques, or
   (4) Gas chromatography

NOTE—Such methods of measurement require special equipment and operator skills and are therefore normally only carried out by compressor and filter manufacturers or scientific institutions.

5.4.3 METHODS OF REMOVAL—Various adsorbent materials can be used to adsorb oil vapor. Activated carbon has a selective preference for nonpolar molecules (mineral oil vapor) over polar molecules (water and synthetic oil vapors). Carbon particles of a size suitable for bed packing can efficiently purify compressed air. Practically all residual oil vapor can be removed by the use of fine-particulate activated carbon bonded with a web or self-supporting filter candles of fritted activated carbon.

NOTE—To obtain a good efficiency it is necessary first to remove all oil and water droplets.

6. Compressed-Air Quality Classes—The designation of the quality class of compressed air shall include the following information in the order given:

a. "Air of quality class"
b. The solid contaminants class (see 6.1)
c. The water class (see 6.2)
d. The total oil (droplets, aerosols and vapors) class (see 6.3)

When a class for any particular contaminant [b, c, or d] is not specified, the numeral designating the class shall be replaced by a hyphen.

6.1 Solid Contaminants Classes—The solid contaminants classes are defined in Table 2.

Particles smaller than one-third of the smallest clearance they will have to pass, can, from a mechanical point of view, generally be accepted. For average use in airlines supplying mechanical equipment, a filter size of 40 μm is usually adequate.