

# INTERNATIONAL STANDARD

ISO  
8682

First edition  
1987-12-01



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INTERNATIONAL ORGANIZATION FOR STANDARDIZATION  
ORGANISATION INTERNATIONALE DE NORMALISATION  
МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

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## Apples — Storage in controlled atmospheres

*Pommes — Entreposage en atmosphère contrôlée*

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Reference number  
ISO 8682:1987 (E)

## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 8682 was prepared by Technical Committee ISO/TC 34, *Agricultural food products*.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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# Apples — Storage in controlled atmospheres

## 0 Introduction

Storage in a controlled atmosphere is based on the regulation of three factors: temperature, relative humidity and the chemical composition of the atmosphere in the store.

By using this method of storage, metabolic processes in the fruits are reduced in intensity and ripening is slowed down, while the nutritive value and appearance for sale are maintained; thus the keeping period is prolonged. As a result of the reduction in oxygen content and increase in carbon dioxide content, the development of pathogenic micro-organisms and the appearance of physiological diseases are greatly retarded.

## 1 Scope and field of application

This International Standard gives general guidance for the storage of apples in controlled atmospheres.

Because of numerous factors influencing the quality and keeping characteristics of apples, the optimal conditions of storage in controlled atmospheres differ according to the variety and area of production.

## 2 References

ISO 2169, *Fruits and vegetables — Physical conditions in cold stores — Definitions and measurement.*

ISO 3659, *Fruits and vegetables — Ripening after cold storage.*

ISO 6949, *Fruits and vegetables — Principles and techniques of the controlled atmosphere method of storage.*

## 3 Conditions of harvesting and putting into store

### 3.1 Varieties

For storage in controlled atmospheres over long periods, it is preferable to store apples (notably winter varieties) having good keeping characteristics.

### 3.2 Harvesting

Harvesting of apples intended for storage in controlled atmospheres is carried out when their degree of ripening ensures good keeping characteristics. The principal criteria used to determine, for a given variety, the time of harvesting are as follows:

- a) the shade of colour of the seed;
- b) the presence of starch in the transverse section of the apple (iodine test or potassium iodide test);
- c) the structural firmness and texture of the flesh;
- d) the number of days between flowering and harvesting;
- e) the ground colour (green-yellow) of the skin;
- f) the onset of increase in ethylene production.

Harvesting of apples intended for storage in a controlled atmosphere should only be carried out manually.

At the same time as harvesting, presorting should be carried out to separate the fruits not suitable for storage, particularly those attacked by disease (notably bitter pit) or insects, those showing traces of rot, those damaged or having shape and growth defects.

Apples should be handled and transported to the store in bins or boxes.

### 3.3 Qualitative characteristics of storage

Apples intended for storage in a controlled atmosphere should correspond to quality "I" or "extra" specified in quality standards.

Apples showing the following characteristics are not suitable for storage over long periods in controlled atmospheres:

- a) apples having poor keeping characteristics;
- b) oversized apples;
- c) apples harvested overripe or underripe;
- d) apples which have remained for long periods at ambient temperature after harvesting;
- e) apples taken from orchards which have been fertilized or irrigated 2 or 3 weeks before harvesting.

### 3.4 Putting into store

#### 3.4.1 Chambers

The chambers intended for storage of apples in controlled atmospheres are cells which can accommodate approximately 50 t to 300 t (volume 1 200 to 1 500 m<sup>3</sup>) of apples. These are provided with insulation against escape of the atmosphere, with doors forming hermetic seals and with apparatus for regulating the composition of the atmosphere within the cell.

The chambers should be prepared before starting the storage operation (cleaning, disinfection, extermination of rats, checking of the tightness to gas exchange, checking of the correct functioning of the refrigeration system, etc.).

After harvesting, apples should be put into the refrigerated cells within 24 h.

In general, do not store more than one variety of apple in a cell. However, if two or more varieties have the same keeping characteristics and the same degree of ripeness, they may be stored together.

#### 3.4.2 Arrangement within the cells

The stacking of the packages should ensure good circulation of the atmosphere. The height of the stacks should not exceed about 6 m for boxes and about 7,5 m for bins. Depending on the dimensions of the cooling unit, a space of about 0,5 to 1 m should be left above the stacks.

Orientate the pallets in a system which allows good penetration of the atmosphere circulating in the cell.

Along the wall opposite to that where the refrigeration equipment is installed, leave a space clear so that the atmosphere distributed by the fan can descend to floor level.

In the main direction of flow of the atmosphere, leave a space of about 10 cm between stacks to permit circulation. The orientation of the pallets and bins should allow them to be opened in the direction of atmospheric flow.

The stacking of the packages gives an average loading of 200 to 300 kg/m<sup>3</sup>, which corresponds to about 1,6 t/m<sup>2</sup>.

### 3.5 Precooling

Before storage, cells should be refrigerated to 0°C. Cells should be filled up within 4 days. Then reduce the temperature to that indicated for storage and close the doors tightly.

## 4 Optimal storage conditions

(see ISO 2169 and ISO 6949)

### 4.1 Temperature

The optimal storage temperature (see annex A) should be attained within 1 week after the cells have been filled and should be maintained throughout the storage period.

During the storage period ensure that the cell temperature does not vary by more than  $\pm 1$  °C.

### 4.2 Relative humidity

The relative humidity of the atmosphere in controlled atmosphere cells should be between 90 % and 95 %. To attain these high values, the difference between the temperature of the evaporator and that of the atmosphere in the chamber should be as small as possible (2 to 4 °C).

### 4.3 Atmosphere circulation

#### 4.3.1 Rate of flow

The velocity of storage atmosphere circulation between the stacks should be at least 0,25 m/s.

#### 4.3.2 Rate of atmosphere circulation

The rate of circulation should be equal to 40 times the volume of the empty store per hour during cooling and 20 times the volume of the empty store per hour when the fruits have cooled down.

### 4.4 Chemical composition of the atmosphere

Regulation of the composition of the atmosphere in the storage chambers should be carried out immediately after the optimal storage temperature is attained. By using installations for maintaining controlled atmospheres (oxygen converter, scrubber for absorption of carbon dioxide), this regulation may be realized in 2 to 3 days.

The chemical composition of the atmosphere in the chambers should be kept between the optimal limits for the variety stored.

The carbon dioxide and oxygen content in the chambers should be maintained constant during the keeping period, or the proportions of these two components should be modified according to the physiological state of the apples (dynamically controlled atmosphere).

### 4.5 Checking

The keeping conditions (temperature, relative humidity and atmosphere composition) should be checked daily, using either a direct reading or recording instrument.

Periodic checks of the quality of the product should be carried out, the frequency increasing to once per week towards the end of the storage period. (The samples for quality control are obtained through the control window of the door.) Analyse the deterioration in quality of the apples (see annex B) and from that determine the storage life.

### 4.6 Storage life

The storage life depends on the period for which the apples maintain their eating quality and on their degree of ripeness to allow handling and transportation in good condition (see annex A).

## 5 Operations at the end of storage

Before taking apples out of store, open the doors and leave the fans operating for 1 to 2 h. Excess carbon dioxide is thus dispersed, making it safe for workers to enter without a protective mask.

To avoid condensation, increase the temperature in the chamber to that recommended for storage in air.

If it has not been done before storage, grade the apples by category, variety, size and quality, in accordance with the relevant quality standards.

For ripening after cold storage, see ISO 3659.

## 6 Bibliography

- [1] RYALL and LIPTON. *Handling, transportation and storage of fruits and vegetables, Volume 1: Vegetables and melons*. De Avi Publishing Company, Westport, Connecticut, 1972.
- [2] RYALL and PENTZER. *Handling, transportation and storage of fruits and vegetables, Volume 2: Fruits and tree nuts*. De Avi Publishing Company, Westport, Connecticut, 1974.
- [3] SMOCK, Robert M. Nomenclature of internal storage disorders of apples. *Hort. Sci.*, August 1977 (Vol. 12, No. 4).

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## Annex A

### Optimal conditions for storage in controlled atmospheres and storage life for the principal apple varieties

(This annex does not form an integral part of the standard.)

Table 1

Variety	Temperature	Relative humidity	Carbon dioxide content in the atmosphere in the chamber	Oxygen content in the atmosphere in the chamber	Storage life (estimated)
	°C	%	% (m/m)	% (m/m)	days
Belle de Boskoop	3 to 4	92 to 95	0 to 3	2 to 4	180 to 240
Reinette du Canada	4	90 to 92	3	3	180 to 240
Cox's Orange	3 to 4	92 to 95	1 to 4	1,5 to 3	120 to 150
Golden Delicious	0 to 2	90 to 95	1 to 4	1,5 to 3	210
Granny Smith	0 to 4	90 to 95	2 to 5	2 to 3	180 to 240
Richared	0 to 4	90 to 93	2 to 5	2 to 3	180 to 240
Jonathan	0 to 4	90 to 95	1 to 4	1,5 to 3	180 to 240
McIntosh	2 to 4	90 to 95	1 to 4	1,5 to 3	150 to 210
Morgenduft (Imperatore)	0 to 2	90 to 95	2 to 3	2 to 3	180
Mutsu	0 to 2	90 to 95	3 to 5	3	210
Delicious	0 to 1	90 to 95	1 to 4	1,5 to 3	210
Stayman Winesap	0 to 1	90 to 95	2 to 5	2 to 3	—
Spartan	0 to 2	90 to 95	2 to 3	2 to 3	180 to 210
Gravenstein	2 to 4	90 to 95	3 to 5	2 to 3	150
Cortland	0 to 3	90 to 95	3 to 5	2 to 3	180 to 210

NOTE — The optimal conditions for storage may vary according to local cultivars.