Modified Atmosphere Packaging (MAP) in the food industry

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1. Modified Atmospheres in the food industry

In the last decade human life style has changed in a variety of ways as have our expectations. Whilst food is not only a basic need but also a measure of living standards. Today consumers set great importance upon unadulterated taste, longer shelf life and attractive appearance of packed perishable goods. Therefore the food industry has developed new techniques of packaging food over the years to satisfy the customer demands. Due to social developments and the rising demand for higher quality by the customer the packaging of perishable food using modified atmospheres has grown to be a reliable technique.

The contents of this brochure include a short description of typical applications and the effects of modified atmospheres in the packing of food. Whether you are already familiar with modified atmosphere packaging (MAP) or you have just started to learn about this process we hope that this brochure will be of interest to you.

2. Origin of MAP

In principle the packaging of food in modified atmospheres is a well-known and proven method. In the beginning only Nitrogen and Carbon Dioxide were used as single gases for processing and packaging of coffee and cheese among other goods.

In 1976 in co-operation with a leading Danish manufacturer of meat products the companies MULTIVAC and WITT-GASETECHNIK achieved the first packaging of fresh red meat with mixed gases. The mixture consisted of Oxygen (O_2), Carbon Dioxide (CO_2) and Nitrogen (N_2). The shelf life of the meat was 6-8 days and the visual appearance was also satisfying, remaining red and fresh looking.

During further tests in Germany the gas mixer, designed originally for metalwork was modified to the specific demands of the packaging machines. In 1977 WITT-GASETECHNIK was able to place the first gas mixer for food packaging on the market. Since then the gas mixer has been modified and improved continually. Today the gas mixers meet all technical requirements. Modern analysing and metering devices have been added to the product range.

In the meantime WITT-GASETECHNIK has become the greatest manufacturer of gas mixing systems for MAP in Europe.

The principle of MAP is to replace the normal atmosphere by a gas mixture that is suited to the food in question. The method of the atmosphere replacement will be described in more detail in the following chapters. The main gases used for MAP are Nitrogen, Carbon Dioxide and Oxygen. However, Argon, Carbon Monoxide, Helium and other gases are defined as permitted gases for MAP by the European Community. The actual use of these gases depends on the demands of the food manufacturer on the food to be packed. In this brochure only the three most common gases will be discussed in detail.

3. Why MAP?

The door for MAP was opened in principle, by the needs of the customer. People want fresh, attractive and high quality food at any time in any place. To fulfil these expectations the manufacturer or trader has to solve great logistic problems. Transport over long distances assumes high stability of the goods. In addition the packed food has to look attractive enough to be bought. Consistent quality (taste, freshness etc) is absolutely necessary for strong customer loyalty.

The original freshness and durability of perishable goods such as fresh meat, fish and seafood depend not only on the raw materials used but also on the influence of the environment.

Microbiological organisms and biochemical reactions are the cause for the spoilage of perishable food, particularly where fresh red meat or seafood is concerned. The spoilage begins right after slaughter and it is very hard to prevent because the organisms responsible are already present in the food. It is possible to reduce or decelerate their activities. A well-known and proved measure is cold. Certainly deep frozen foods are not regarded as fresh products. In addition the goods have to be chilled constantly during transport which is an added complication compared with MAP.

MAP is dependent on four independent factors:
• the quality of the food and its hygienic handling
• the inert gas or gas mixture
• the packaging machine
• the packaging material (the film)

Product	CO_2	N_2	O_2
Red meat	30%	-----	70%
Pork steak	20%	30%	50%
Beef / venison portion	20%	-----	80%
Game	30%	70%	--
Chicken portions	30%	50%	20%
Hard cheese portion	20%	80%	--
Fish	40%	30%	30%
Trout	15%	65%	20%
Plaice	40%	30%	30%
Fresh pasta	50%	50%	--
Pre-baked rolls	70%	30%	--
Pizza	70%	30%	--
Processed meat rolls	30%	70%	--
Cooked ham in slices	40%	60%	--
Fried sausage	30%	70%	--
Fruit & Vegetable	5%	90%	5%
Ready-made salads	30%	50%	20%

Red meat and fish require different gas mixtures tin order to achieve the best results.

The inert gas atmospheres indicated above are merely examples and are not binding

3.1 Carbon Dioxide (CO_2)

CO_2 inhibits the increase of most aerobic bacteria and mildew. Without any doubt CO_2 is the most important gas in the packaging of food under modified atmospheres. In general one can say the higher the CO_2 concentration the longer the durability of the perishable food. However fat and water absorb CO_2 gases very easily and excessive CO_2 concentrations cause quality failures regarding taste, loss of humidity and the concentration of the packaging (so called vacuum effect). It should therefore be considered carefully! As to how long the product has to be durable and how acceptable are the reductions caused by CO_2. If CO_2 is intended to regulate the growth of bacteria and mildew a concentration of at least 20% is recommended.

Carbon Dioxide is a natural gas, which is found in small concentrations in the air.

3.2 Nitrogen (N_2)

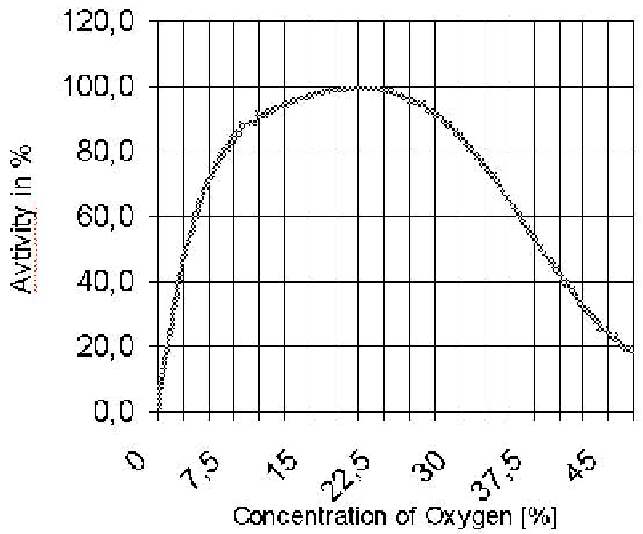
N2 is an inert gas that is used to expel air especially Oxygen out of the packaging. It is also used as a filling gas that equalises the effect of CO_2 absorption by the perishable food. Nitrogen reduces the vacuum effect and is also a natural component of the air.

3.3 Oxygen (O_2)

O_2 is an essential gas for the respiration of all living beings and supports the decay of perishable food. It is the condition for the growth of aerobic micro organisms. In general Oxygen should be excluded for the MAP but in some cases a determined amount of Oxygen brings quite positive results.

- It keeps the natural colour of the perishable food (effect of freshness).
- It makes possible respiration, especially for fruits or vegetables.
- It inhibits the growth of anaerobic micro organisms in several kinds of fish and vegetable.

Influence of Oxygen in packing on the activity of micro organisms



Reference: Jürgen Buchmüller/PeterNobis, „Mit Schutzgasen die Zeit besiegen“, Messer-Griesheim/gas aktuell 51

Modified atmospheres are the most natural way to protect perishable food against spoilage. One is able to prevent the usage of chemical additives for the preservation of perishable goods.

Advantages of MAP

- Longer durability of perishable food / Decrease of spoilage
- Reduces the growth of germs
- The product retains its form and texture.
- The product retains its vitamin content, taste and fat content.
- The natural colour of the product is preserved.
- The need to use preserving agents is reduced if not eliminated.
- The longer the shelf life of the products:
  - the more economical the use of staff and machines as goods can be held in stock
  - extended distribution
  - extended variety of delicate fresh products

Advantages of Mixers

- Flexible - Any specific gas mixture can be mixed by gas mixers in the corresponding locations
- Slight expenditure for the installation
- Product specific trials can be run internally
- Saving of gas costs
- 1 mixer instead of many different pre mixed bottles
- no bottle handling required

4. Applications of MAP

Without doubt one of the most important applications of gas mixtures is the processing and packaging of fresh red meat and fish as an alternative to freezing. The packaging of food is done, for example, by a vacuum chamber machines which evacuate the normal atmosphere out of the package and replaces it with a corresponding gas mixture (change of atmospheres).

4.1 Types of packaging machines

In co-operation with leading manufacturers of packaging machines and renowned institutes WITT-GASETECHNIK has developed devices and systems for the mixing, metering and analysing gases. One is able to incorporate these systems in all types of packaging machines, choosing the model depending on the goods and the method of packaging. Customised solutions are not covered in this brochure.

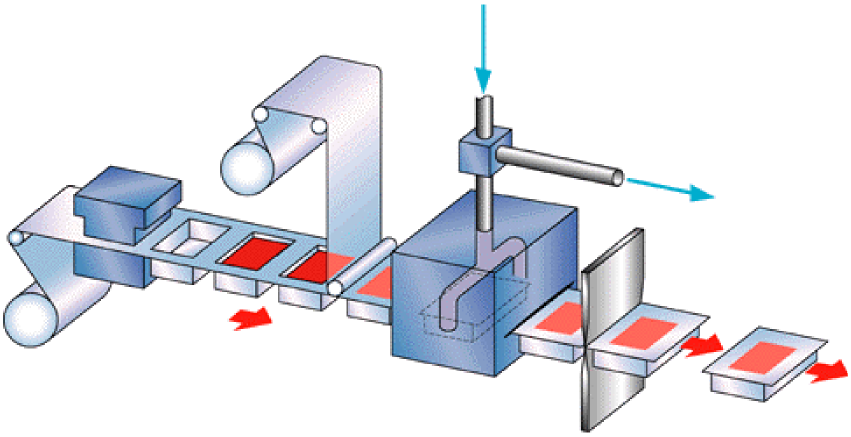
The packaging machines are divided in two main groups.

1. Thermo-forming/chamber machines (vacuum with gas flushing)

2. Vertical and horizontal form, fill & seal machines (gas flushing by lance or tube, venting to atmosphere)

4.1.1 Thermo-forming packaging machines

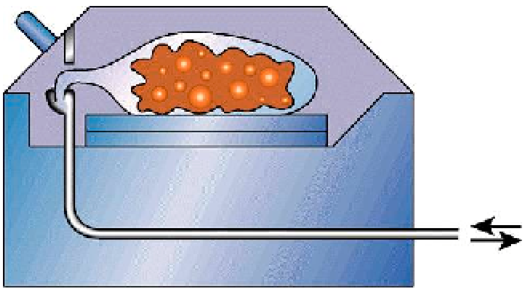
Packaging lanes with single or multi-tracks achieve 4-20 strokes per minute depending on size of pack and kind of product. The typical demand for the gas mixture is approximately 20-100 slm and is also dependent on package size and velocity of strokes. Bigger systems work with gas capacities of up to 200 slm. The standard WITT gas mixing system (for example KM 100-3 MEM) fulfils these demands. A vacuum packaging machine requires a receiver in the system.



Thermo-forming machine

4.1.2 Vacuum Chamber machines

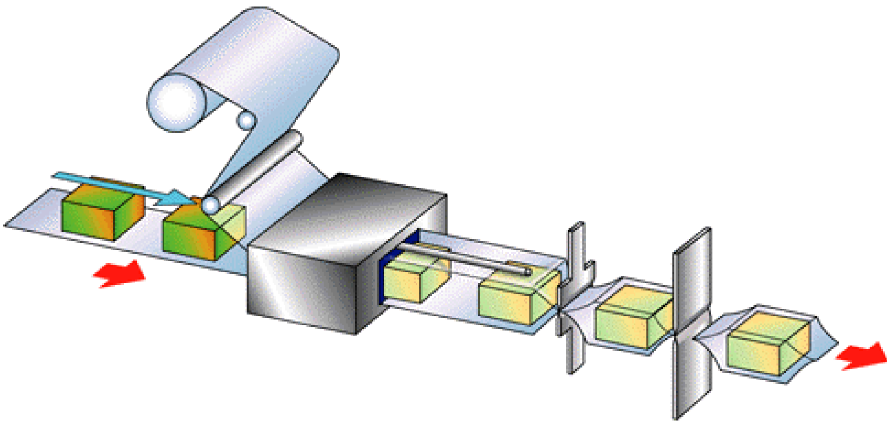
These machines use pre-formed bags and utilise the compensated vacuum technique to replace air. Pre-formed plastic bags are manually placed within the chamber before evacuation, back-flushing with the desired gas mixture, and heat sealing. These machines can be used for small scale production of vacuum or gas flushed catering packs. The figure below illustrates a diagrammatic representation of a VC machine.



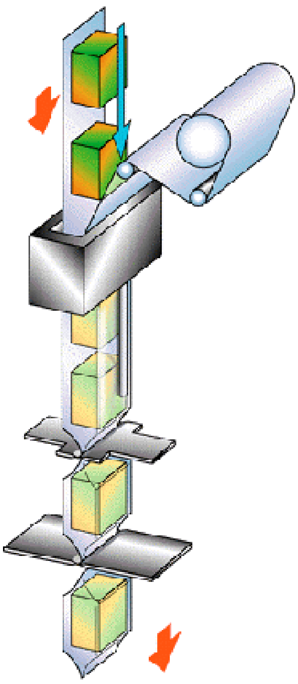
Chamber machine

4.1.3 Form, fill and seal machines

Are able to achieve a throughput up to 120 packs per minute (depending on pack size). In contrast to thermo-forming / chamber machines the pack is not evacuated but permanently flushed with gas mixture before sealing. The atmosphere in the pack is replaced via lances or tubes. The consumption of gas mixture in this case is much higher than for evacuated packs, because a part of the gas mixture is lost. The consumption of gas mixture for a standard form, fill and seal machine amounts 30-300 slm. The WITT systems KM 100 and KM 300 in M version are used in such a machine.



Horizontal form-fill-seal



Vertical form-fill-seal

In general each packaging machine will be equipped with a separate gas mixer. The WITT product range contains simple systems (without energy supply and control functions), and also sophisticated high tech devices (the constant monitoring of the gas mixing as well as the recording of these values). WITT-GASETECHNIK also offers gas mixing systems that automatically regulate the amount of gas mixture by measuring the residual Oxygen concentrations.

In the case that the same gas mixture is used for several packaging machines in line it is possible to work with a central gas mixing system with a gas distribution of 300 Nm3/h and higher (WITT type MG). All machines will be delivered with the gas mixture by the central supply unit. If it necessary to supply one machine with a special mixture sometimes an additional smaller system is required.

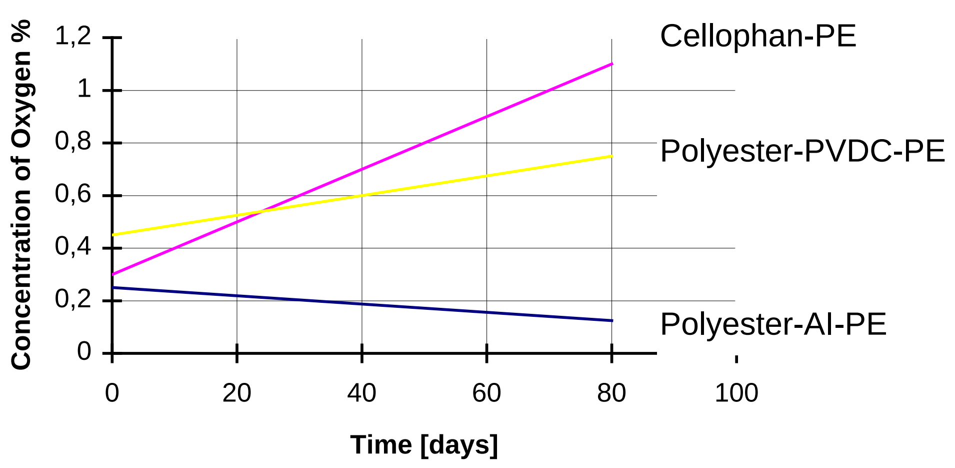
4.2 The diffusion feature of the common gases used for MAP

O_2	≈	15 cm^3 / m^2 and day
N_2	≈	10 cm^3 / m^2 and day
CO_2	≈	55 cm^3 / m^2 and day

As mentioned before one has to pay attention to the fact that CO_2 is absorbed by liquids and dry grainy foods very well. The result is that the CO_2 pressure falls in the pack over time. CO_2 escapes much faster from foil packaging since Nitrogen is not able to enter from the surrounding air. A vacuum in the CO_2 pack develops. For many products this effect is desired because it supports the impression of fresh vacuum packed food. Other products (for example sharp edged goods) require Nitrogen as a protecting atmosphere because the escape of CO_2 will be replaced by Oxygen and the visual impression of the package is kept.

<u>PLEASE NOTE</u>

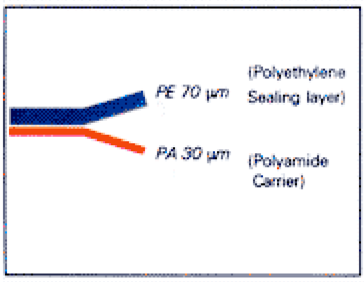
The concentration and composition of the gas mixture could vary after packaging. Deviations can appear when analysed later. In such cases it has to be taken into consideration that the Oxygen deviation is caused by diffusion through the foil over a longer period of storage and not by faulty gas mixture.

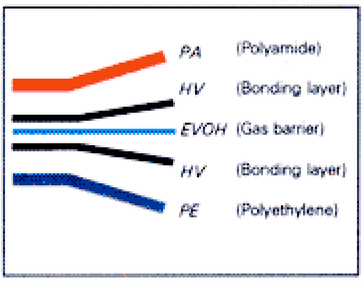


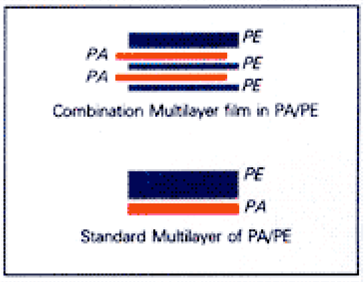
Source: Jürgen Buchmüller/PeterNobis, „Mit Schutzgasen die Zeit besiegen“, Messer-Griesheim/gas aktuell 51

		flexible	semi-rigid	thermoformable	limited thermoformable	oxygen barrier	moisture vapour barrier	heat sealable
Polyamide	PA	•		•		•		
Oriented Polyamide	OPA	•			•	•		
Polyethylene	PE	•		•			•	•
PE high density	HDPE	•	•	•			•	•
Amorphous Polyester	A-PET		•	•		•	•	
Polyester	PETP	•		•				
Oriented Polyester	PETP	•			•			
Polyester Foam	EPET		•	•		•	•	
Polypropylene	PP	•	•	•			•	•
Oriented Polypropylene	OPP	•			•		•	
Polypropylene Foam	EPP		•	•			•	•
Polystyrol	PS		•	•				
Oriented Polystyrene	OPS		•	•				
Polyvinylchloride	PVC		•	•		•	•	
Polycarbonate	PC		•	•				
Polyacrylinitril	PAN		•	•		•		
Cellophane		•			•			
Surlyn		•		•			•	•
Heat Seal Lacquer	HS-Lacq							•
Cold Seal Lacquer	KS-Lacq							•
Ethylenevinylalcohol	EVOH			•		•		
Aluminium foil < 20 µ	Al				•	•	•	
Aluminium foil > 20 µ	Al				•	•	•	
Polyvinylidenchloride	PVDC			•		•	•	

For packaging perishable goods in particular, films which have good barrier properties in themselves, for example PA, PVC or A-PET, are used. Films made from PAN (Barex) offer an even better gas barrier. The addition of EVOH to the film increases the gas barrier further. An absolute gas barrier can be achieved with the inclusion of aluminium.







PA/PE-films are increasingly offered as a multi laminate where PA and PE layers are joined in several thin layers. They are stronger, more resistant and offer constant barrier properties. Should a peel-quality be required, this is achieved by a special mixture of the relevant PE layer.

4.3 Fundamental operation of WITT gas blender

1. Gas mixer for a distribution between 0 up to the maximum output rate has to be operated together with a receiver (buffer tank). Example: The recommended receiver volume for the WITT model MG 50-2ME is 100 litres.

2. Gas mixers for a constant and defined output volume (depends on the type used) are able to work without a receiver. The accuracy of the gas mixture is constant within the specified tolerances, provided the flow is within the defined capacity. Example: for a KM 60-2 system the capacity is 10-60 l/minute.

5. Cost reduction due to the usage of WITT systems

The following example calculation shows how much one is able to save due to the usage of a WITT gas mixing system instead of using gas premixes. The prices used in the calculation are only examples. Actual prices should be obtained since there are major variations down to volume, carriage charges and supplier.

Step 1
The mass indication of Carbon Dioxide is always given in kg. Please convert the mass in m³ according to the below mentioned procedure.

	Amount of CO_2 in kg	**Conversion factor 1m³ = 1,848 kg**	**Amount of CO_2 in m³**
Example:	30	30 kg **/ 1,848** = 16,23m³	16,23
Your data:			

Step 2
Example: Calculation of the price for 1 m³ gas mixture

Type of gas	**price/m³ [EURO]**	**Concen-tration**	**Calculation**	**Costs per m³ mixture [EURO]**
Gas A (e.g. CO_2):	7,--	30%	7,-- x 0,3 = 2,10 Euro	2,10
Gas B (e.g. N_2):	6,50	30%	6,50 x 0,3 = 1,95 Euro	1,95
Gas C (e.g. O_2)	5,50	40%	5,50 x 0,4 = 2,20 Euro	2,20
			Mixture A B C total price /m³	**6,25**

Please enter your data

Type of gas (conversion of CO_2 in m³ as described in step 1)	**Price/m³ [EURO]**	**Concen-tration**	**Calculation**	**Costs per m³ mixture [EURO]**
Gas A:				
Gas B:				
Gas C:				
			Mixture A B C total price /m³	

Step 3

In the third step you are able to calculate your amount of the cost reduction.

Gas comsumption of your machine(s) ______ litres per minute

x 60 minutes

comes to ______ litres per hour

divided by 1000 litres

amount to ______ m³/hour

X

you produce ______ hours/day

X

normally ______ days a month

X

for ______ month a year

=

Your consume is ______ m³ gas mixture a year

X | X

price/m³ of Gas Premix [EURO] (inquired at your gas supplier) ______ | ______ price/m³ of mixture [EURO] (calcultated in step 1 and 2)

= | =

______ comes to your annual cost for the producing of own gas mixtures

- (minus)

______ costs/year Pre-mixes [EURO]

=

Your cost reduction per year in EURO ______

Please use the following questionnaires for a specific quotation about WITT system for gas mixing.

PF 2550 • D-58415 Witten • ☎ +49-2302-89010 • Fax +49-2302-89013
email: sales@wittgas.com • http://www.wittgas.com

QUESTIONNAIRE FOR GASMIXER SPECIFICATIONS

Customer: ____________________ ☎ ____________________ **Date**

____________________ Fax ____________________ __________

Please cross X or fill in the key information! Thank You!

1. Application?	

		Gas 1	Gas 2	Gas 3	Gas 4
2. Gases / mixing components?					
3. Fixed mixture desired	fix	%	%	%	%
or variable mixture?	min.	%	%	%	%
	max.	%	%	%	%
4. The inlet pressures are:		bar gauge	bar gauge	bar gauge	bar gauge

5. Gas mixture flow capacity required? Nl/min oder Nm³/h?	min.		O Nl/min
	max.		O Nm³/h
6. Required mixed gas outlet pressure at point of use or at mixed gas supply pipe-line system in (in bar gauge)	bar gauge		
7. Which voltage is needed?	O 230 V AC	O 115 V AC	O 24 V DC
8. The gas mixer will be installed?	O indoors	O outdoors	
9. Miscellaneous			

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