Manual on the use of Automatic DCS

October 2015

‘s Gravendeel, the Netherlands

Inhoudsopgave

1 INTRODUCTION

In the summer of 1997 CA researchers and consultants of the WUR (Wageningen University NL) introduced during a CA congress at the university of Davis (CA USA) the Dynamic Control System for storing apples at dynamic fluctuating ultra low O_2 levels just above varying thresholds in which fermentation would start. Research has pointed out that the best fruit quality, extensively improved shelve life and prevention of internal and external defects can be realized at oxygen storage regimes just above the level were fermentation of the fruit starts.
This introduction has been followed up by several practical applications.
Since then the DCS system is yearly used successfully in hundreds of CA stores by means of manually carried out fruit flesh analyses for measuring the ethanol contents.
Based upon research and practical testing the advantages of storing apples at low DCS oxygen levels can be summarized as follows;

- Maximum reduction of scald, skin spots and pit rot
- Better firmness, better shelf life
- Non chemical treatment
- Natural ripening after storage, better taste
- Better appearance of the product
- **DCS™** represents a quality label

DCS can be used for scald prevention and improving the firmness of the fruit compared with regular ULO storage. DCS is of great interest for organic fruit where no chemical treatments are allowed. DCS offers an alternative for SmartFresh or it can be used in combination with SmartFresh.

Since 1997 several attempts have been made for measuring the ethanol in the atmosphere of the CA stores. This appeared to be rather difficult because ethanol disappears easily by dissolving in present condense water. Also ethanol produced by rotting fruits causes a problem for measuring in a CA room. Since 2009 FBR Wageningen (this is the post harvest research section of the Wageningen University WUR), EMS (manufacturer of highly sensible analyzers and Storex b.v (manufacturer of complete CA systems) are cooperating in developing a system to automate the working of DCS. Since 2011 we have been testing “DCS Automatic”. Based on good results we are pleased to describe the function of this system in this manual.

The basic requirements for Automatic DCS are: good gastight CA rooms, the automatic ethanol measurement system, well calibrated good working CA equipment and adequate technology to implement the system.

Working principle of automatic DCS;
The automatic Dynamic Control System (DCS) is based on the principle of measuring each day during a period of 3 hours the ethanol concentration in the air which is gassed out from a sample of fruit in a closed measuring box according to an automatic programmed measurement procedure. When ethanol is measured on a ppb (parts per billion) level, this is an indicator for the start of the fermentation process. Absence of ethanol measurement in the sample box during the daily measurements is an indicator for the absence of fermentation and the option for further reducing the oxygen level in the CA room. When ethanol production is measured to a certain level the target value for the oxygen level in the CA room has to be increased. The target value of O_2 to be regulated in the DCS CA store is subject to the strategy and policy determined by the owner / operator of the warehouse/fruit and the other involved parties like the CA consultant.

In practice apples have been stored at DCS oxygen levels varying from 0,1%(!!) up to 0,8%. The target level of oxygen which is set for the DCS rooms is a result of the chosen DCS strategy.

The DCS system can be used by following a “safeguard DCS strategy” for the start of fermentation. In this approach the oxygen levels are not maintained at the lowest levels were fermentation starts but a buffer of 0,2% O_2 is maintained and the fruit is not stored below 0,4% Oxygen.
The other strategy we describe as the “active DCS strategy” were the fruit is stored at dynamic varying low O_2 levels (just) above the threshold where fermentation will not start.

The CA settings will be depending on the quality of the fruit at the start of the storage season as a result of the growing season, the origin and the properties of the specific varieties. The basis for a successful storage result is a uniform well matured healthy product. In this manual guidelines are provided.

Automatic DCS is offering unique features such as:

- Fully automatic and daily measurement of a possible presence of ethanol production in the measurement box as warning system.
- Clear presentation in graphs of the ethanol production of the sample and the oxygen level in the CA store during the whole storage period.
- Because of this actual and accurate information it offers a good basis for the optimum DCS storage just above the lowest thresholds were fermentation starts of the most sensible fruits of the sample.
- It offers the possibility to start sooner with DCS and to set the oxygen levels lower as compared with the manual controlled DCS since there is a daily control..

Because of this features a better protection against scald and internal defects is offered resulting in better fruit quality and improved shelf live.

In this manual the most important features for a successful implementation of DCS automatic will be explained. In case of any question please consult your supplier and or your local CA consultant.

We wish you a lot of success with Automatic DCS!

2 BACKGROUND OF DCS.

After the fruit is harvested the process of growing by photosynthesis is stopped. The fruit will continue to ripen caused by the production of ethylene. Because of the continued respiration of the present sugars, energy will be taken from the fruit and this process will continue during storage.

After harvesting it is important to reduce the fruit temperature as soon as possible in order to bring the process of respiration on the desired low level. This is the first important step for preservation of the quality.

The respiration of the fruit is reflected in the simplified formula:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6\ H_20 + \text{energy/volatiles}$$

As a result of the respiration process energy (heat production) and volatiles (ethylene, aromatics etc.) are released as well. By regular CA the O_2% / CO_2% are set for further reducing the respiration process.
When the oxygen level is too low for specific fruits (depending on the sensitiveness of the fruit), fermentation will start. This is reflected in the following simplified formula:

$$C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2 + \text{energy/volatiles}$$

After the fermentation process starts, ethanol is formed in the fruit flesh and it will evaporate from the fruit. The produced ethanol can be measured both in the fruit flesh as in the surrounding air of the fermenting fruit. The presence of (too much) ethanol in fruit is not wanted because of the undesired taste and it could lead to irreversible damage.
Based on research and practical experience it is known that the fruit quality is preserved in the best way at the lowest possible levels of oxygen just above the level were fermentation starts.
The positive effects on the fruit quality are indicated in the previous chapter and we refer for more information on this subject to various publications.

In order to determine at which threshold of oxygen fermentation starts the ethanol presence in either the fruit flesh or the surrounding air can be measured. The level of measured ethanol provides a clear and direct marker for the presence and intensity of fermentation of sugars in the fruit.
When the presence of ethanol is measured, this is a sign to increase the target value of O_2.
Depending on the present ethanol level in the fruit, the ethanol will be gassed out.

For measuring the ethanol level in the fruit flesh FBR is applying a standard laboratory procedure. This standard procedure is carried out by specialized persons and guarantees that the measured results are reflected in a standardized figure of mg. ethanol / 100 gr. Based upon this standard procedure the measured values are easy and reliable to be compared.
This laboratory procedure can be shared with other laboratories.
It is known that there are kits available for measuring the ethanol contents in the fruit flesh in the company with a simplified procedure. The sustainability, accuracy and the possibility for good interpretation of this measured values requires adequate care.

The current DCS system is based on reducing the O_2 level in the CA store in steps of 0,2 or 0,1 % O_2 per 5-7 days. In principle at each interval of 0,2% a samples of the fruit of ca. 2 kg. are taken from the CA store. By means of a destructive test out of this sample a mixture of fruit flesh is made and the presence of ethanol is determined and reflected in mg. ethanol/100 gr. fruit flesh. When there is no ethanol present the O_2 level of the CA room can be reduced again by 0,2% O_2. This process can be

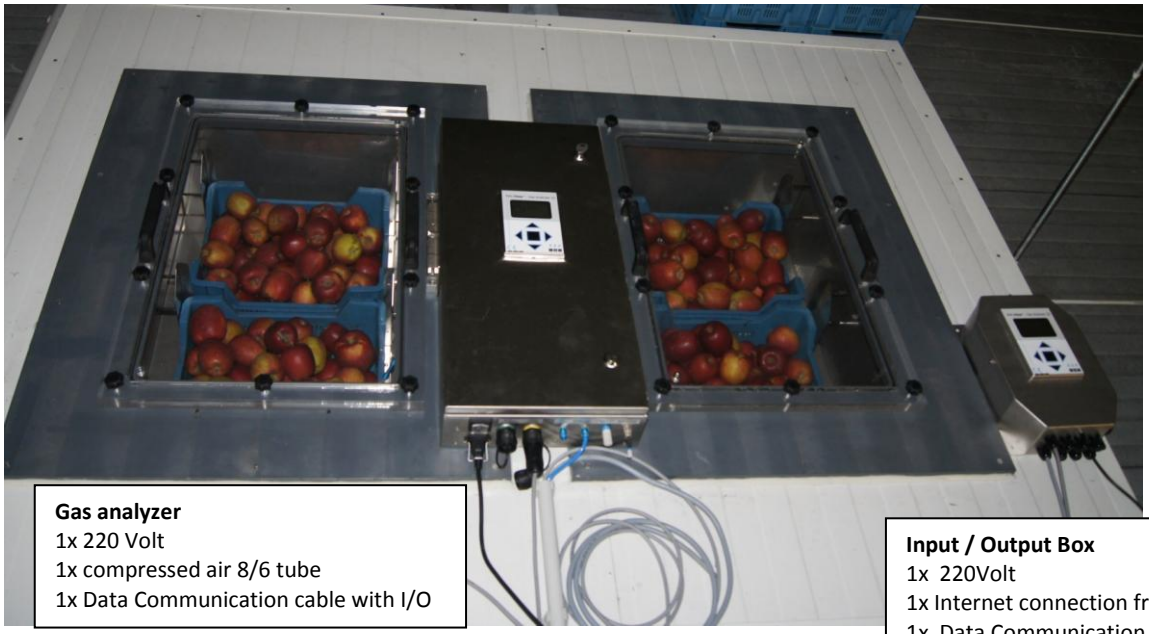
continued until the presence of ethanol is measured. After the registration of ethanol production the storage target level of O_2 can be determined with a safety margin of +0,1 -0,3%% O_2. With this procedure of "DCS regular" experience is gained over a period of nearly 20 years.
Characteristic of this procedure is that the number of measurements is limited due to the labor intensive procedure. Because of this the O_2 levels are not reduced in an earliest possible stage and also not in the most optimum time frame due to these pragmatic reasons. The safety margin which is selected is mostly larger as needed. Despite of this aspects DCS regularly has been applied with success. In many growing seasons DCS stored fruits had the important advantages as indicated.

Because of the labor intensive procedure and the limited available amount of information on the ethanol production, the application of DCS regular remained limited. There was a clear need for an automatic DCS system were the ethanol production is automatically measured in the air of a DCS store. FBR, Storex and EMS developed for this purpose "DCS Automatic".

Ethanol is a gas which dissolves very quickly in water. This happens in per example condense water. Logically this ethanol cannot be measured. Ethanol is also produced by rotting fruits. In case we base the settings for the target O_2 level on the ethanol produced by some rotting fruits it would be the wrong basis. Because of this reasons and some other pragmatic reasons it is difficult to carry out reliable direct ethanol measurements in a CA store.
Accurate and reliable measurement of ethanol is demanding conditioned circumstances. For this purpose a concept is designed of a complex of a measuring box + ethanol analyzer and a measuring and control procedure.
It is important to signal the ethanol production in an early stage. For this reason we provide an analyzer which can measure the ethanol in the air at a rather low level of parts per billion, ppb.

This system has been tested since 2011 and we are pleased to describe in this protocol the step by step procedure for using the system.

3 HARDWARE COMPONENTS



Gas analyzer
1x 220 Volt
1x compressed air 8/6 tube
1x Data Communication cable with I/O

Input / Output Box
1x 220Volt
1x Internet connection from client
1x Data Communication cable to Gas analyzer

One unit consists of the following hardware and software parts;
2 pc. Measuring boxes + 2 insulation lids and 4 blue boxes for storing the fruit.
1 pc. Gas analyzer + insulation plate
1 pc. Input/Output box (IO Box) for internet access.
Connection the DCS Portal. This is the platform where all relevant information on your DCS system can be checked.

3.1 The installation of the hardware compromises the following steps:

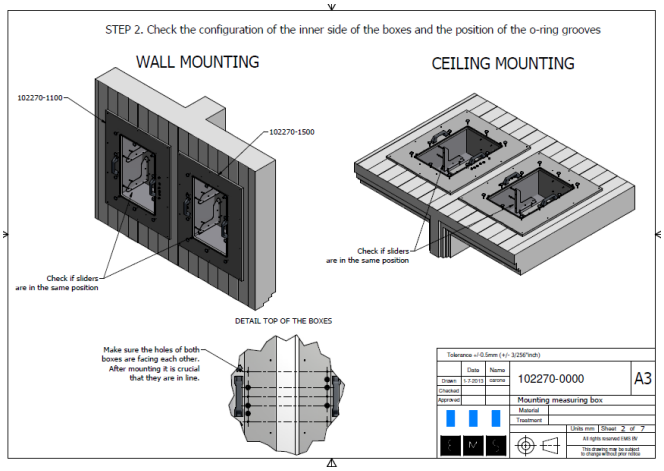
1. Installation of the 2 measuring boxes
2. Placing the insulation plate behind the DSC analyser and the analyser
3. Provide a 220V single phase power supply and a compressed air tub by means of a 8/6mm tube to the analyser.
4. Place the I/Box in a convenient location in the warehouse
5. Make a connection between the I/O box and the analyser by means of a CAT 5 cable according instructions
6. Plug in an internet connection to the I/O box and 220 Volt.
7. Via the internet the system will make automatically contact with a server controlled by EMS
8. You should contact EMS. EMS will check the connection of your analyser to the system.
9. The system will be started up automatically and you will be provided with a username and a password.
10. The operator can log in to the Portal. In the portal the user will find relevant Data on the working of his system.

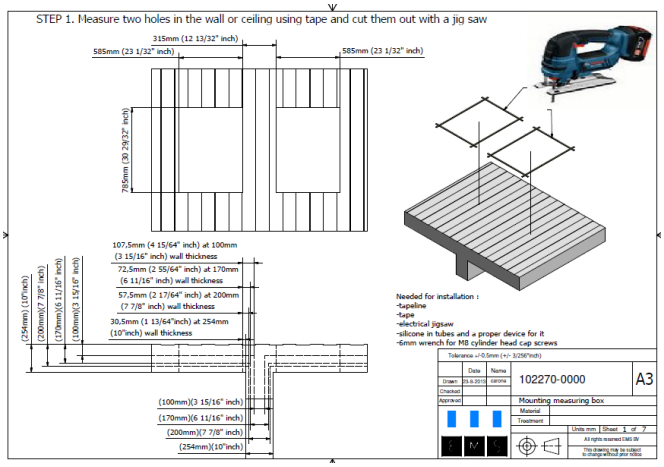
3.2 The measuring boxes.

The 2 measuring boxes can be placed in
2 CA rooms which are positioned next to each other.
The maximum thickness of the separation wall can be 315 mm. The gas analyzer is placed on top of the 2 boxes and connected to the 2 DCS stores.

For the situation that it is not possible to have 2 CA rooms for DCS next to each other it is advised to place the 2 measuring boxes in one CA room.
For the situation were the contents of a specific CA room is over 2-300 tons it can be decided to have 2 measuring boxes placed in one CA room.
This provides then a double measurement in the CA room.

The installation of the measuring boxes is described in an additional manual. The netto distance between the 2 measuring boxes is 315 mm.





3.3 The position of the measuring boxes.

It is required to place the bottom of the measuring boxes in the air flow of the coolers of the CA room. The ventilated air of the coolers passing the bottom of the cooler is having the function of cooling the box and creating air circulation in the measuring box through the opening of the measuring box in the bottom.

The measuring boxes should not be placed at a location under direct influence of a point of a N_2 injection inlet neither from the CO_2 scrubber or a humidification system.

Measuring boxed placed in the ceiling

2 Measuring boxes installed
in the front wall of a CA Store

The top of the measuring box is made out of a pvc plate. This pvc plate is working as a flange for the measuring box. Around the opening in the top of the flange a channel is milled in which a large rubber ring is placed for gas tight closing of the transparent lid.
The lid can be easily fixed and removed by 10 screws.

In the top of the PVC flange at one side there are provided 4 holes / channels. This holes are corresponding with the holes present in the analyzer which will be placed on both flanges. One channel is provided to connect the tube of the membrane in the bottom of the analyzer for supplying and releasing compressed air to the membrane for opening and closing. This is automatically controlled by the analyzer.
The other 2 holes are provided to circulate air from the measuring box through the analyzer.

In the bottom of the measuring box a stainless steel plate is mounted with distance keepers. In the PVC bottom of the measuring box a circle path is milled in which a membrane fits. Between the membrane and the stainless steel plate there is around an opening which provides the contact between the contents of the measuring box and the CA cold store. The membrane is connected with a compressed air tube to a control valve integrated in the analyzer and compressed air can be injected or released. By this function the opening and closing of the bottom hole of the box is performed. With expansion of the flexible membrane the measuring box is closed and isolated from the CA room. Under this condition measurement are being carried out.

Insert 2 new pictures


3.4 Insulation;

In order to prevent a outside temperature influence through the lid of the measuring box, an insulated cover will be placed on top. The analyser has its own heating system since the measurements are performed under temperature controlled conditions. For insulating the DCS analyser for prevention of energy loss to the back wall a insulation board is placed between the CA room and the analyser.


The measuring boxes can contain each a maximum of 4 plastic boxes. In the frame of the measuring box 2 x 2 boxes can be placed.

The dimensions of the plastic box are;
Outside dimensions; lxwxh;397 x 296 x 166 mm (ca. 30 x 40 x 17 cms.)
Inside dimensions; lxwxh: 365 x 265 x 160 mm (36,5 x 26,5 x 16 cms.)

Each box can carry ca. 5-7 kg of fruit.
In case 2 boxes are used the total sample will be ca. 15 kg. of fruit, or when 4 boxes are used the volume will be ca. 20 kg. of fruit. In the standard procedure 2 blue boxes are used / measuring box.

3.5 The gas analyzer + I/O box + Portal software

The gas analyzer is installed on top of the 2 measuring boxes. On both sides of the analyzer the bottom plate of the analyzer is extended with 2 blocks in which channels + holes are provided to fit on top of the holes of the 3 present holes in the pvc flanges of the 2 measuring boxes.

Each analyzer has a unique number and a **Left** and **Right** measuring box.
This is indicated in the daily graph which are sent by mail. In the intake form it has to be registered to which CA rooms nrs. the measuring boxes are connected of this analyzer.

The analyzer is composed out of the following elements;

- The housing with a integrated touchscreen display
- A heating system + temperature control system
- An ethanol analyzer
- An oxygen analyzer with an optical sensor
- Air pressure sensor
- A filter system
- The control valve for opening and closing of the membrane
- An air-pump for sampling
- The PLC control system + all other electronic parts needed for the functions of the analyzer for periodically analyzing the gas in both boxes.

The following connections need to be provided to the gas analyzer and the Input /Output box:
- 1 x 110V/220 Volt power supply for the gas analyzer
- 1 x 110V/220 Volt power supply for the Input / Output box
- Compressed air by a 8/6 tube at 6-8 bar. The compressed air is needed for putting pressure on the membrane and has to have a standard quality for use in pneumatic switches which means pre filtered from oil and water vapor. We advise to use an adsorption drier for compressed air and a paper filter with a condensate collector. This collector needs to be checker regular on the presence of water. The water should be released in time from the collector. In case of the presence of abundant water in the water collector it is advised to install an adsorption drier if not present.
NOTE: damage cause by excess water in the analyzer are not covered by warrantee. Cost for checking and repairing defects will be charge to the user.
- an internet connection (Ethernet) to the Input / Output box.
- a data communication cable between the I/O box and the analyzer

It is important to inform which type of internet connection will be used either GSM or Ethernet, because the I/O box has to be prepared for this connection.
A connection by an ethernet cable with the internet is recommended.
The specifications for the internet speed are:

The analyzer is DCS orientated designed, produced and tested. EMS gained experience during many years in building highly sensible analyzers for the agro industry on cold stores and CA rooms. The analyzer is designed to be installed in the variable conditions which can be present in fruit warehouses. The working of the analyzer is fully automatic.

The ethanol analyzer itself needs a calibration once a year. For the optical oxygen sensor also one time per year calibration is required. This service will be carried out by the agent.

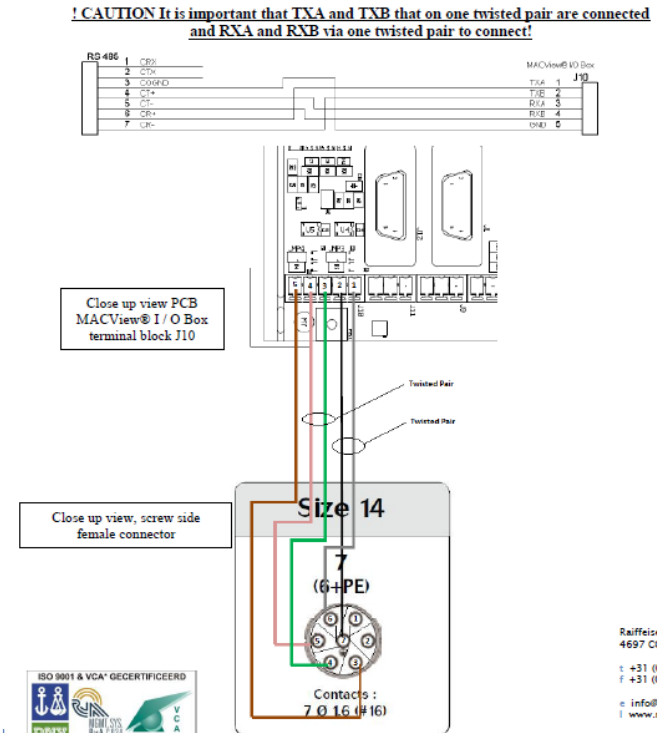
3.6 The I/O (Input / Output) box

The I/O box is the switch between internet and the gas analyzer. The I/O box can be placed near to the gas analyzer or in a specific room apart from the analyzer. The I/O box has a display which works simultaneously / synchronic with the display on the analyser. So it is convenient to place the I/O box in a technical rooms where the operator has easy access and where the ethnernet for connection to the internet can be plugged in easily. This can be convenient for checking purposes.

The I/O box can be prepared either for 3G or 4G wireless data internet connection or an Ethernet connection to be provided by the client. An Ethernet connection is advised.
It has to be known for preparing the hardware before delivery.

Between the I/O box and the analyser a communication cable have to be installed. The user have to organize this cable since we do not know the distance between the location of the analyser and the I/O Box. For connection of this cables there is an Instruction chart provided.

A standard UTP CAT 5e cable (4 x 2 twisted pair, 8 wires total, only 5 wires are used), network cable can be used. This cable is not supplied. The connector on the side of the DCS Analyzer is included. On the side of the I / O Box, the cable can be connected to terminal block J10.



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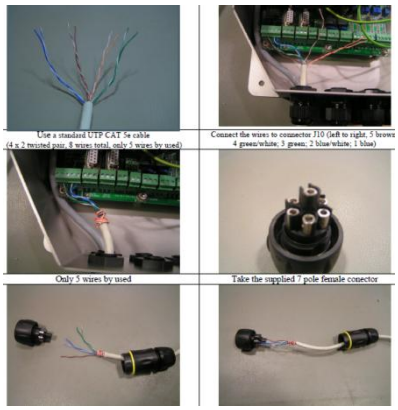
7p female RS485	Function analyzer	UTP CAT 5e Used wire color	Used wire color (check)		Function IO-Box	IO-Box J 10
1	RS232-TXD (not used)	N.A.	N.A.		N.A.	N.A.
2	RS232-RXD (not used)	N.A.	N.A.		N.A.	N.A.
3	OGND	Brown			OGND	5
4	RS485-TXA+	green			RS485-RXA+	3
5	RS485-TXB-	Green/white			RS485-RXB-	4
6	RS485-RXA+	blue			RS485-TXA+	1
7	RS485-RXB-	Blue/white			RS485-TXB-	2



4 START-UP AND PORTAL

After finishing the procedure for the installation of hardware parts the system can be started up. This process works automatically as soon the power supply is connected, the compressed air is hooked on and the internet connection is provided. The system will make automatically make contact with the server of EMS.
At this time please contact with EMS.
They will check the connection and carry out the settings to install the system on the Portal.

The user will be provided with a **user name** and **a password**.
With this information the user have access in the portal to his own DCS website.
In case the username and password are forgotten, please contact EMS and the can make a reset and provide another password.

The Portal is provides a DCS website for the user. The following parts are present:

- Location settings
- Configuration settings
- Seasons
- Graphs
- Devices
- Employees settings

A separate instruction is provided to insert the right settings for these parts, see chapter 7.

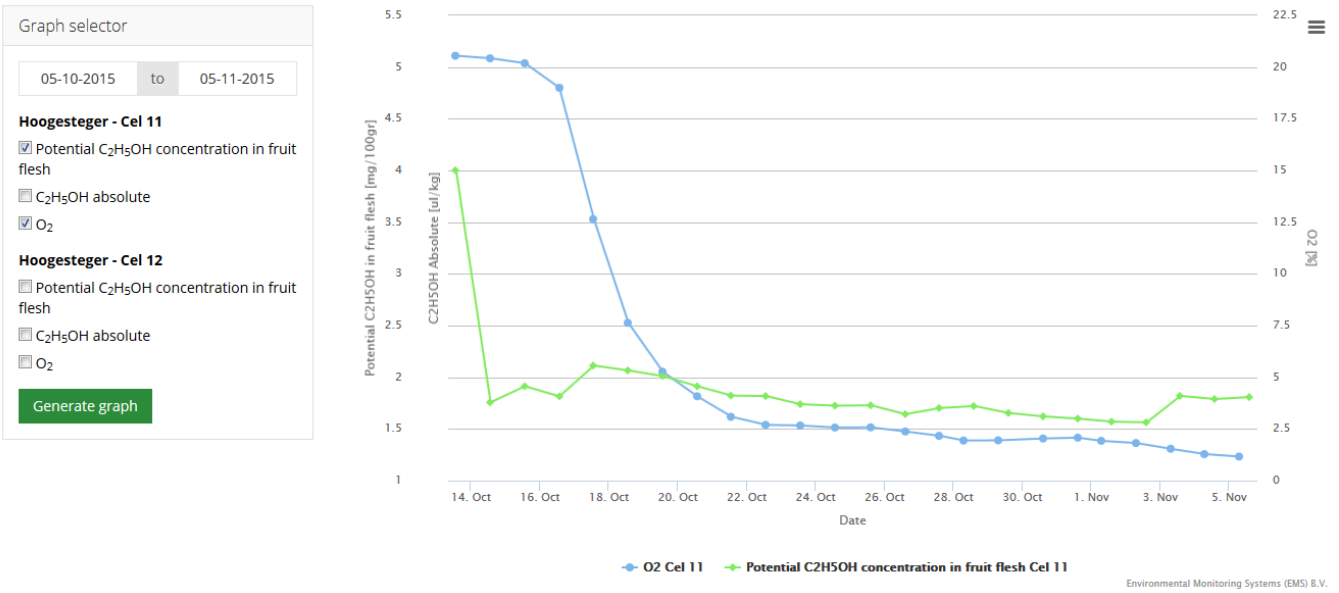
5 ETHANOL MEASUREMENT AND PRESENTING THE RESULTS

The ethanol production of the apples is measured each day one time in both measuring boxes.
The moment of measuring the oxygen level in the measuring box is just before the closing of the measuring box for the ethanol measurement procedure.

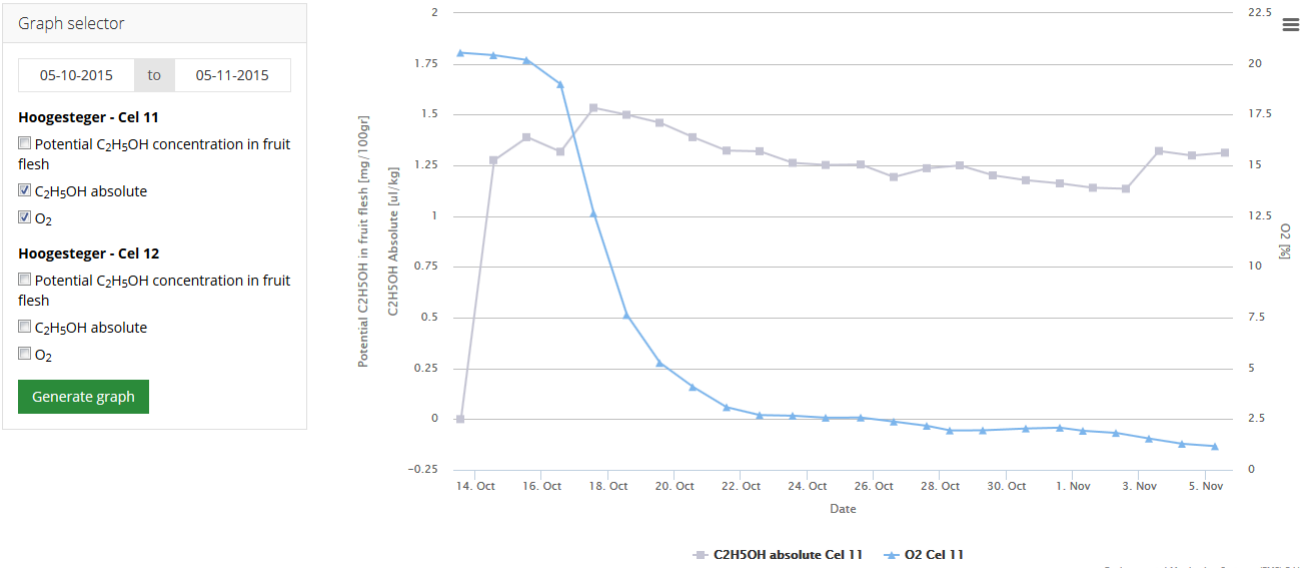
The ethanol measurement procedure starts with closing the bottom hole and a filtering process of the air in measurement box in order to create standardized starting conditions. The apples will continue to respire and to gas out the volatiles and, if present, the ethanol. The measurement procedure takes a period of 3 hours. During this measuring the box is closed. In the remaining period when no measurement takes place, the measuring box is connected to the climate of the DCS room in order to allow the DCS rooms conditions to be present in the measuring box.

The data of the daily measurement is automatically sent to a server of EMS. This data is processed and the results of the ethanol measurement is presented in a figure reflected as the production rate ethanol in *Potential mg ethanol per 100gr fruit* or as a *absolute value for ethanol (in µl/kg.)*. By tipping with the cursor the desired buttons and then to activate 'Generate graph' a graph of the selected items is created. The graph is each day updated with the new measurement results.

Example of 2 graphs



Graphs Hoogesteger



For the value 'Potential mg ethanol / 100gr fruitflesh' we have developed an algorithm in which the measured ethanol value in the air is recalculated based on the present weight of the sample into value of 'Potential mg ethanol / 100gr fruitflesh'.
If the weight of the samples is not filled in the program 'Season, samples', the present weight will be presumed in the box on 20 kg. Note, if the nr. Of samples and its individual weight are not filled in, an inaccurate value for the produced 'Potential mg ethanol / 100gr fruitflesh' will be reflected.
For this reason it is important to fill in this record.

The C_2H_5OH absolute is based on the measured ethanol in mg. produced in the measuring box. Since it is common use to reflect the ethanol in the fruit in mg. ethanol / 100 gr. Fruitflesh we present this information as 'Potential mg ethanol / 100gr fruitflesh'. It is potential, because it reflects an average for the present fruits in the measuring box. There will still be a difference of the ethanol content per each individual fruit depending on its own state of condition. However this average value of 'Potential mg ethanol / 100gr fruitflesh' provides a usable standard to control the oxygen level in the CA room.

On the horizontal X as the date is presented. In the graph selector another time period can be selected.
On the Y as on the left side the scale is indicating mg ethanol. Depending in which range we are measuring the ethanol level, the scale will adapt itself automatically.
On the right side the O_2% is displayed.

The interpretation of the measured values will be discussed later.

The O_2 and CO_2 level are not automatic controlled by the DCS system. The ethanol measurement provides information on which the decision can be based for increasing or decreasing the target O_2 level during storage in a specific CA room. The adaption of this settings has to be made manually in the control panel of the CA system (p.e. the CO_2 scrubber)

6 PREPARATION OF THE CA STORES AND THE CA TECHNIQUES FOR THE STORAGE SEASON

The gas tightness of the CA rooms has to be checked carefully before the CA season starts.
If the gas tightness does not meet with the standards it will either not be possible to reach the DCS low O_2 levels or it will create extra cost for N_2 injection.

In proper gas tight CA stores in combination with a good working low oxygen content scrubber, any low DCS O_2 level can be regulated.

The total leak opening should be lower than < 0,1cm²/100m³ CA room volume.
Or the pressure drop should be after start with an over pressure of ca. 8 mm water column less than 4 mm water column in 18 minutes.

A CA room with a small leakage will need aeration during the storage season.The CA operator will already have a good impression of the gas tightness of a CA room based on the level of aeration needed.

It is important that the low oxygen content working of the scrubber can be controlled and will be controlled. Points of attention are:

- Gas tightness of the scrubber and the piping system
- Settings for adsorption and regeneration time and low oxygen content working.
- Good calibration of the O_2 and CO_2 sensor

This points are important to have the minimum number of scrub actions and also to have a the lowest possible oxygen input during a scrub action.

In case the CA rooms are not tight enough, N_2 injection has to be regulated. The available capacity has to be evaluated. In principle there is an option to rinse the vessels with active carbon of the scrubber with Nitrogen after the regeneration cycle of the CO_2 scrubber. This requires a large source of Nitrogen. The other option is to have a small flow of Nitrogen injected in the CA store regulated by a timer which switches an electric valve open / close.

It is advised to implement the common known working methods for optimum cooling and CA storage of apples. In case of questions please consult your supplier or CA consultant.

Control of the DCS system.

Keep the measuring boxes clean.
Remove old samples after the finishing the CA storage season.
Please note that if rotting fruits are present in the measuring box and still measurements are taken place of ethanol and high levels or ethanol and ethylene are present, this will lead to an increased altering of parts in the analyser.

The analyzer of the DCS system has to be calibrated once a year. This has to be carried out by a representative of the supplier.

Temperature measurement and control

- Product temperature is important and leading. Preferably product temperature measurement is done at the hot and cold spot of the room (hot spot=under the evaporator; cold spot=in front of the evaporator).
- Maximum temperature difference (dT) between hot and cold spot of 0.5°C is allowed. In CA stores which are having a size less than 150 tons a dT of 0.3°C is feasible.

- The above means that the two air temperature probes (‘warm and cold bin’) must be placed in the bins, in between the product, not necessarily inside a fruit.
- Room temperature will be measured in the outlet of the evaporator.
- Precooling of a CA store is recommended 2-3 days before loading the room.

7 INSTRUCTIONS FOR STARTING THE DCS / CA STORAGE SEASON

7.1 Important steps to be taken for a successful DCS storage season:

1. Organize according common standards the production of good quality fruit in the orchard. Prepare proper decision making on good timing and organization of harvesting for having getting the fruit in the right quality in the DCS store.

- Select the right origins and the right type of picking (1st / 2nd or 3rd picking) for long term storage and the filling of the DCS rooms.
- Only the fruits in an optimum maturity stage are suitable for the long term CA storage according to the general recommendations
    - **Use only fruits with a long storage potential**
    - **Fruits should not much vary in ripening stage, size, color and firmness**
    - **Fruits should not be sensitive or infected witch fungi**
    - **It is is preferable to measure the initial quality as brix (> 12), firmness (> 6 kg) and starch level (2-3)**
- Fill the room in an optimum time schedule according to the cooling capacity of the room/cooling installation. After filling a partial volume of apples in a CA room the desired storage temperature has to be reached within 24hours. Adjust the volume of fruit loaded in a CA room according to this demand. This procedures allows quick and good cooling down of the fruit.
- The method of cooling and the O_2 pull down has to follow the recommendations which are specific for the variety to be stored.

2.
3. Decide and determine together with your CA consultant the DCS storage protocol for settings and timing on temperature and O2/CO2 control and water loss (if present).
4. Program the Storage protocol in the DCS portal page
5. Prepare per DCS room:
    a. 3 sample of 20 kg. with an equal dividing of kg. per origin
    b. Prepare 8 bags with each 12 pcs. of fruits for quality inspection during the DCS storage season
    c. **->** Fill in the Intake form on the DCS portal page.
6. After filling of the DCS room, cool down the product. (Cooling down is finished when the temperature of the warmest product sensor is not higher as 2°C above the target temperature.
7. Follow the instructions on O_2 pulldown and control of the oxygen level according the determined DCS storage protocol.
8. Carry out the regular inspections on the functioning of the DCS system and the measurement results according standard practice of CA storage.
9. Adapt the settings for the O_2 and CO_2 level if the measurement results and the storage protocol indicate to do so.
10. Carry out regular quality inspections of the samples of fruit to determine the maximum period for storing the fruits without having quality issues.
11. Please note the CA room is not a hospital in which the fruit gets better. The target of the CA /DCS storage technology is to preserve the fruit quality in the best way for the best possible quality after CA/DCS storage. Carry out good product inspections. Do not wait too long with opening of the CA room for in time selling of the product to the clients. Carry out this activities based on the common known level of technology for CA storage.

7.2 How to compose 3 x 20 kg. Sample for each DCS measuring box.

For the DCS system we suggest to make 3 samples for each measuring box.
1 sample will be filled in the box at the start of the season.
The other 2 samples are available of carrying out a test for the ethanol measurement or for replacement of the sample.

The measuring box contains 4x a blue box. Each box can be filled with ca. 5 kg. of apples. In total we will have then 20 kg. per measuring box.

The selected fruits should represent the stored apples regarding :

- The state of ripeness
- The size of apples
- The color of the apples
- The harvest-period
- The fruits should be free from defects, damages and dents.

The composition of apples per sample is related to the nr. Of origins which are going to be placed in the cold store. In principle we divide the nr. Of origins by 20 kg.
If 2 origins, 10 kg. per origin
If 3 origins, 6,7 kg. per origin
If 4 origins, 5 kg. per origin and so on.
If there is a large nr. Of origins then define a nr. Of sample to be made and make samples of apples of the "weakest origins". We suggest not more than 6 samples.

For example considering a 100 ton DCS – room.
Origin 1 : 45 tons = 5 kg of the sample origin 1
Origin 2 : 20 tons = 5 kg of the sample origin 2
Origin 3 : 20 tons = 5 kg of the sample origin 3
Origin 4 : 15 tons = 5 kg of the sample origin 4

Per room we select 4 x 5 kg = ca. 20 kg per measuring box. In this case the samples can be easily separated. In case of uneven dividing, it is suggested to use nets. Please add to the boxes with fruit a good labeling, indicating the origin.
The nett weight of the sample have to be weighed and filled in the DCS portal.
It is suggested to fill the measuring boxes with cooled down fruit.
The fruit should be placed in the measuring box before the DCS pull down of Oxygen starts.

7.3 Preparing 8 samples of 12 pcs. apples for periodically quality inspections.

During long term storage it is advised to check and inspect the quality of the fruits according to a time schedule. The frequency and interval timing can vary based on local practice. We suggest to start with the inspections ca. 3 – 4 months after the start of the CA storage and to begin not later than in January. Then use an interval time of 4 weeks until the next inspections. When there are quality issues, shorten the inspection period to 1-2 weeks and be critical on good timing for finishing the end of the CA/DCS storage season. Do not store the fruit too long.

During loading of the CA room select from each origin 2 big bins and place them separately in a cold store. Take the bins with the latest picking date for the samples. Out of this bins a number of nets/bags will be filled.

Prepare for each origin 8 nets/bags with 12 pcs. of apples each. This can be done when the samples for DCS measuring boxes are prepared. These bags are kept, for carrying out quality inspections and keeping record on the development of the quality of the fruit. A main target is to be informed about the quality of the fruit during the storage season and to have a good basis for the timing for unloading the room before there will be quality issues.

Place the samples in the room in a way that a sample can be taken easily from the room. This can be done by placing boxes on a pallet behind the door of to have the nets with samples below or behind the inspection window.
If there are a lot of origins, prepare at least samples from the weakest origins.

In the DCS Portal there is an Intake Form page for filling in relevant information of the fruit quality of different origins and other relevant information for DCS storage.
All of this information will be available on the webpage of the DCS portal for authorized persons.

We suggest to start with the quality inspection after 3-4 months after DCS storage has started.
Per example after filling the rooms in September – October to start in January.
Take the sample of the fruit of the different origin out of the room by respecting the health and safety rules for taking samples from CA rooms. Always make sure that there are 2 persons present when taking this samples out of the room.

During each inspection the 12 apples per origin will be evaluated. A nr. Of apples will be stored for 7 days at a temperature of 20°C and evaluated again.
The inspection criteria are the firmness and the internal and external defects.

Observe the fruit for

- external quality issues,
- cut some of the apples for observation of the internal quality,
- carry out the regular firmness test
- do a shelf live test and
- other inspections if applicable.

It is appreciated if this results are filled in logbook on the portal of the DCS system of that specific room. This is useful information for the consultants and others with access to the system to follow the results of quality of the stored fruit during the DCS storage season.

In case the quality of the fruit provides information quality issues, then do shorten the interval time for quality inspections to a period of 2 weeks.
In case the quality of the fruit gives indication for quality issues, like internal rot, scald, aging, loss of weight, increase of the nr. Rotting fruits it should be decided to open the room and to market the fruit in time.

7.4 The start of the DCS storage season.

The DCS room will be filled with fruit from the different origins.

In advance of the DCS storage seasons, the Storage protocol should be agreed with the CA consultant, or being determined on available experience and information of the operators.

The details for the different steps for cooling, oxygen pull down and DCS pull down should be filled in the relevant page of the DCS portal.

In this portal it is also possible and needed to program individual aspects such as:

- Sending a daily report by email and programming to which persons; Settings can be made at the schedule program in the 'Storage Configuration'
- Sending alert emails to a selection of persons. To be made in the Portal under Seasons.
- Adding the variety to the room + specific information in the Seasons part of the Portal

We define the following understandings:

- **Harvesting time = Filling period of the CA room**: the period in which the CA room is being filled.
- **CA Room closed**: the date the CA room is filled with fruit and the cooling down process will continue.
- **Oxygen pull down**: The oxygen pull down is the date that the oxygen in the CA room will be lowered from 21% to 5%. This can start when the fruit is cooled down well. Or after finishing the term for a waiting period for pull down if this applies.
- **Respiration pull down**: The pull down from 5 (or 3)% O_2 towards the:
- **Regular CA/ULO target value** of per example 1,2% O_2.
- **Standard CA conditions:** The regular CA conditions which are applied for CA storage of fruit according to the local recommendations of CA consultants, CA research institutes, and or common practice.
- The **DCS pull down;** The date at which the first DCS pull down step is programmed. In general the first steps are based on decreasing the O2% with 0,2% O_2 until a level of 0,6% is reached. In between those steps, after realizing the target value, a waiting time of ca. 3-5 days is programmed to allow the fruit to get used to this conditions and to observe if ethanol production will start. If this is not observed to following O_2 step can taken. After a level of 0,6% is reached then steps are taken of p.e. 0,1% for reducing the O_2 level.
- **DCS Storage protocol**: The program describing at which O_2 level we start with the DCS pull down and describing the steps for its settings for O_2% / CO_2%, the temperature and the interval timing in days. This protocol have to be concluded with the your local CA consultant.

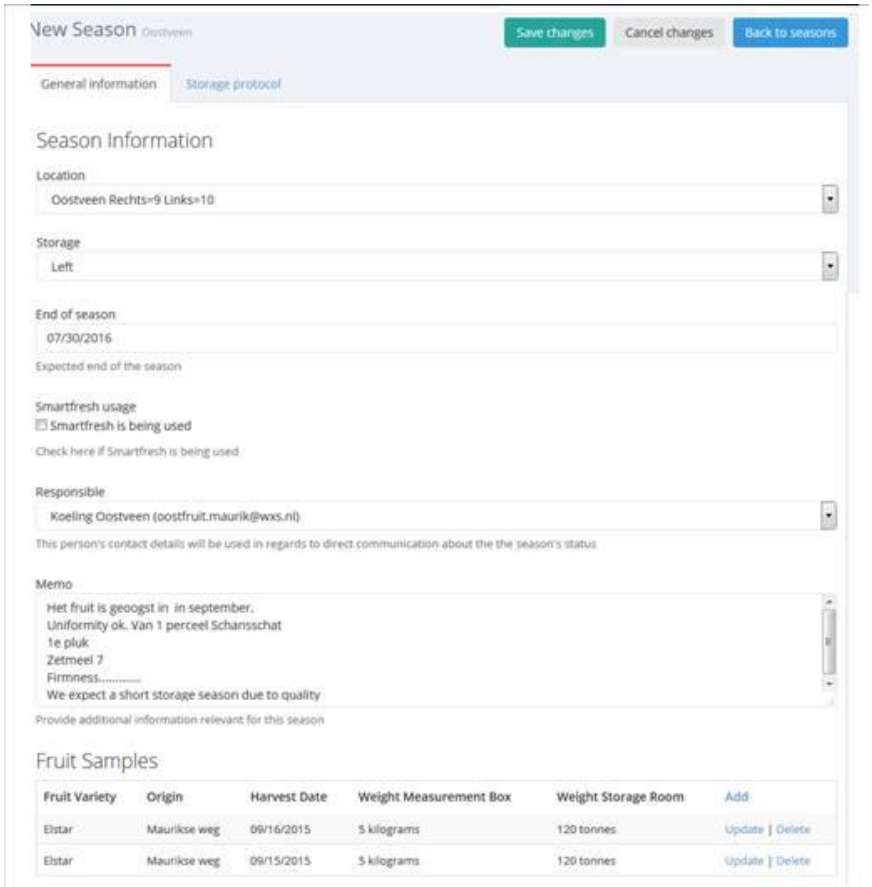
After filling the DCS rooms the fruit will be cooled down. Cooling down will be done according the instructions relevant for the specific variety in the specific region.
The oxygen pull down, and DCS pull down will be carried out by respecting the determined waiting days if this applies for the specific variety. Consult your CA consultant.

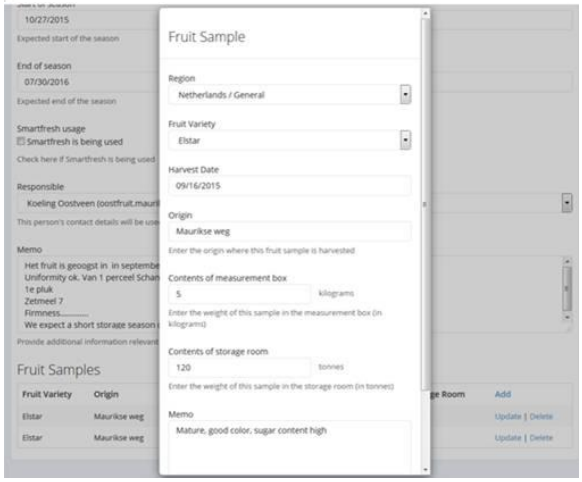
When starting the oxygen pull down, the DCS system is switched on for carrying out daily ethanol measurement in each measurement box. In the portal in the part 'Seasons' the settings have to be made for:

- The specific 2 stores nr. left and right from the analyser
- The settings for the specific samples which are filled in the measuring box
- The storage protocol.

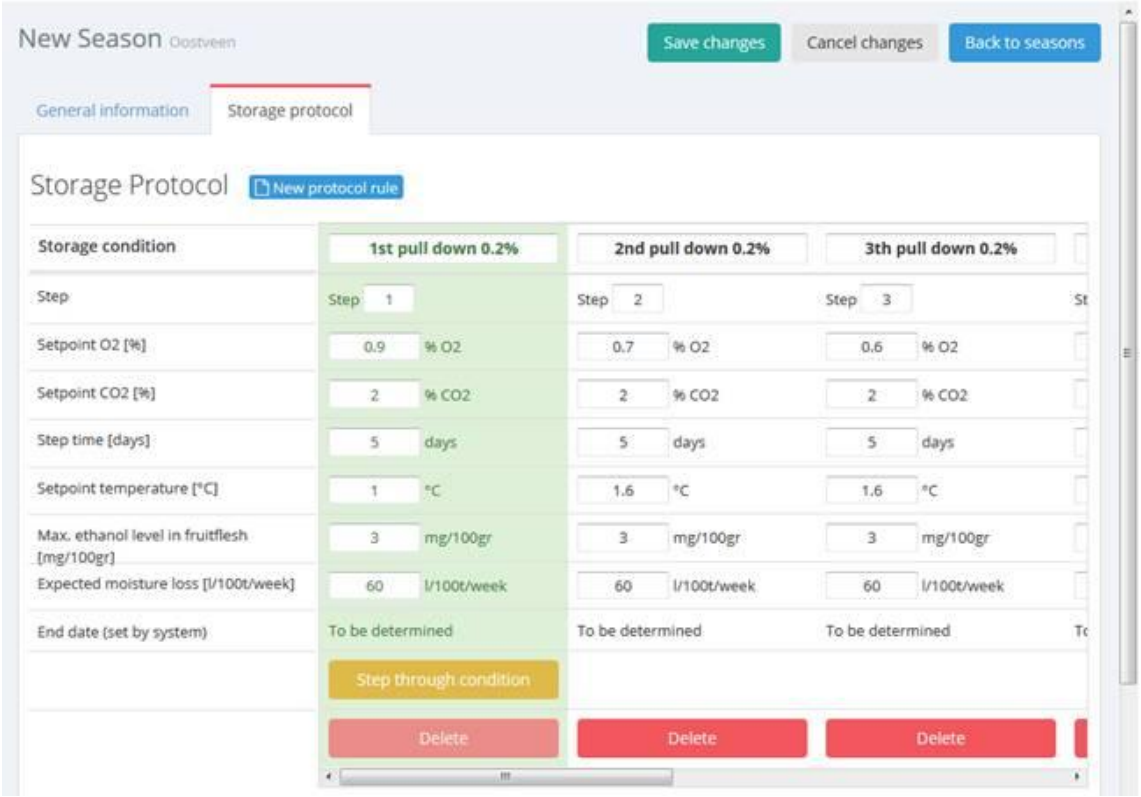
At a menu 'Samples', per sample relevant information have to be added.
In the menu Storage protocol the planned steps for pulling down have to be programmed and also the threshold value for ethanol in mg ethanol/100gr/apples have to be inserted.
Based on this information the portal will provide information be sending emails with instructions on the steps to be taken for the pulldown.
When the measured value of ethanol is trespassing this value an alarm will be given by email.

Below we show 3 screenshots.





Storage protocol page for filling in. See for further instruction this protocol



The results of the daily measurement will be sent by internet to a central server. In this server the data will be processed and reflected on the internet page which is available for the authorized persons with a password.
When the gas analyzer has no internet connection for some days, the results of the daily measurements will be stored in an internal memory. As soon as the internet is available again this results will be automatically sent to the central server and become available for the operator.

7.5 Applying the Standard CA conditions and the 'DCS Storage protocol'

In general the Storage protocol have to be determined in correspondence with the local prevailing recommendations for CA and DCS/DCA storage in the region were the DCS is used. We advice to contact for this your local CA consultant or to consult the specialist/advisors of the nearest CS research institute for fruit. For CA/DCS there are various publications available.

We have a selection of publications and examples of Storage protocol for CA /DCS storage available. Storage conditioning and handling for regular CA is applied according to the local prevailing recommendations. Below we provide an **example procedure** (source FBR Wageningen) of a storage protocol for cooling down fruit and applying regular CA conditions for 3 groups of fruit.

Group 1 (Jonagold, Gala, Golden, Granny S. Red Delicious)

- Fast (within 2 days) equal reduction of product temperature to 1.0 – 1.5 degree (product temperature)
    - so each load will be cooled in 2 days. The filling of the room may take more time (in practise 7-10 days); shorter is better.

- Control of product temperature during room loading with hand tool (spread < 1.0 degree), coldest and warmest expected places
- After filling the room difference in product temperature to be accepted is 0.5 K (1.0 to 1.5 degree)
- During filling
    - CO_2 control at maximum 1.0 %
    - O_2 control at minimum 19.5 %
- 3 days after harvest moment last product & temperature right : CA closing of room
- Starting O_2 reduction with N_2 injection to 5 % O_2 (this will take 2-3 days)
- At level of 5 % O_2 new setting oxygen is 1.2 % (lowering will take < 7 days)
- No N_2 injection (oxygen must lower at normal respiration of product). After 2 days starting N_2 injection (when needed) to reach the final O_2 level of 1.2 %.
- Set final CA condition 2.0 % CO_2 and 1.2 % O_2

Group 2 (Elstar, Idared, Fuji, Pink Lady)

- Fast (within 2 days) equal reduction of product temperature to 1.5 – 2.0 degree (product temperature)
- Control of product temperature during room loading with hand tool (spread < 1.0 degree), coldest and warmest expected places
- After filling the room difference in product temperature to be accepted is 0.5 K (1.5 to 2.0 degree)
- During filling
    - CO_2 control at maximum 1.0 %
    - O_2 control at minimum 19.5 %
- 3 days after harvest moment and last product & temperature right : CA closing of room
- Starting O_2 reduction with N_2 injection to 5 % O_2
- At level of 5 % O_2 new setting oxygen is 1.2 %.
- No N_2 injection (oxygen must lower at normal respiration of product). After 2 days starting N_2 injection (when needed) to reach the final O_2 level of 1.2 %.
- Set final CA condition 1.5 % CO_2 and 1.2 % O_2

Group 3 (Breaburn)

- Fast (within 2 days) equal reduction of product temperature to 1.0 – 1.5 degree (product temperature)
- Control of product temperature during room loading with hand tool (spread < 1.0 degree), coldest and warmest expected places
- After filling the room difference in product temperature to be accepted is 0.5 K (1.0 to 1.5 degree)
- During filling
    - CO_2 control at maximum 1.0 %
    - O_2 control at minimum 19.5 %
- 3 weeks after harvest moment and last product & temperature right : CA closing of room
- Then starting O_2 reduction with N_2 injection to 6 % O_2
- At level of 6 % O_2 new setting oxygen is 1.5 %
- No N_2 injection (oxygen must lower at normal respiration of product). After 1 week starting N_2 injection (when needed) to reach the final O_2 level of 1.5 %
- Set final CA condition 0.8 % CO_2 and 1.5 % O_2

Please note the above conditions are only meant as an example. Due to local experiences, conditions common practice the CA values can be set different.

It also have to be considered if SmartFresh (SF) is applied or not? If yes, follow the SF-protocol. This generally means a lower CO_2 concentration due to a higher carbon dioxide sensitivity and/or higher storage temperature. If not the standard CO_2 concentration are applicable.
In general a pulldown from 21% to 5% is recommended. A fast pulldown means the pull down with Nitrogen injection is made to a target level of 3% O_2. This can apply for scald sensible varieties.

The DCS protocol can starts after the regular CA condition are reached in the CA stores.
Following points have to be considered.

1. The oxygen concentration can be lowered stepwise with 0.2% or 0.1%. Stepwise because of the response time of the fruit in giving a possible ethanol signal. Normally 3-5 days after changing the set-point it is clear if fermentation is started or not.
2. Depending on the variety CO_2 concentration must be lowered together with the O_2 steps until a minimum concentration of 1% for the reason that storage under DCS-conditions increases the sensitivity of CO_2.

Strategies for specific varieties

- For varieties sensitive to scald (p.e. Gala, Golden Delicious) it is important to reach O_2 concentration below 0.7% as soon as possible. This also means that pre cooling must be accurate (directly after harvest and with a high cooling capacity) in order to start O_2 pulldown as soon as possible.
- In general in order to prevent Scald an O_2 concentration below 0.7% is desired.
- For varieties sensitive to high CO_2, a fast O_2 pulldown is desired to reach DCS conditions (in case no SF is applied). DCS-conditions will compensate the limited firmness retention due to low CO_2 concentrations.
- Varieties which are sensible for low oxygen like Breaburn, McIntosh an adapted strategy for Oxygen pull down will be followed. Most of the time a waiting period of several weeks is advised. The strains of a variety can also be of influence
- Gala is suitable for a fast pulldown.
- In general DCS can be applied in combination with SF. It will result in a higher retention of Scald and a longer shelf life.

7.6 DCS storage protocol based on a 'Safeguard strategy' or an 'Active DCS strategy'

The aim of automatic DCS is to determine the minimum O2 level needed for the respiration of the fruit based on ethanol measurements. The actual O2 level in a CA room is dynamically adjusted based on the results of the ethanol measurements.

The responsible persons for the storage of the apples have to determine which DCS storage protocol and strategy will be followed. This will be a result from experience, the type of fruit / growing season and the contact with the CA consultant. In principle a "safeguard DCS strategy" or an "active DCS strategy can be followed.
Applying the **safeguard DCS strategy** means that the ethanol measuring system is used to check if ethanol production will occur at chosen low O_2 levels at which under normal circumstance no ethanol production is expected. An example is per example Breaburn which is stored under normal CA at 1 – 1,2% O_2. However at this O_2 levels Breaburn is sensible for internal defects. When the target

values is set on 0,8 to prevent internal defects there can be a risk of ethanol production. The ethanol sensor is providing information if ethanol production will start either by fermentation or by internal defects (rotting). In this case the lowest level of O_2 for respiration is not searched for.

It is also possible to make a careful pulldown of the fruit in steps of decreasing either 0,2 or 0,1% during a period of 3-5 days to a O_2 level were fermentation can be signalized by the sensor. At this O_2 level per example 0,2% O_2 is added and the fruits are then long term stored at this O_2 level including the safety margin. The fruits are not stored at oxygen levels lower than 0,4% O_2. Checking ethanol production remains each day.

It is also known from other DCS systems that they practice no lower target levels of O_2 as 0,4%O_2. For the situation this safeguard DCS strategy is preferred to be followed, the ethanol sensor has the important function to measure if ethanol production appears at this O_2 level. If there is no signal of ethanol production this gives daily information for the warehouse manager. Beside this observation still the periodically quality observation of samples of fruit have to be carried out.
For double-checking if there is no ethanol production in the fruit present there are several options. The first option is tasting samples of the fruit for checking if the typical prickling taste of ethanol is present. The other option is to send a sample to a laboratory for an analysis of the fruitflesh. The 3rd option is to refresh the sample of the fruit in the measuring box with one of the spare samples. . It has to be to be decided with the CA consultant if and when a fruit flesh analysis has to be carried out for a double checking.

In case the **active DCS strategy** is applied depending on the circumstances the target value is chosen and adapted dynamically based on the ethanol measurement. The safety margin is normally 0,1 or 0,2 %. Or the target value is kept as low as possible, and kept that low as long there is no ethanol production observed. This strategy can be followed for areas and varieties were there is already previous experience with DCS storage of that variety. The decision for applying either the active or the safeguard DCS strategy is the responsibility of the owners/responsible persons for the apples. It requires a good level of observation and checking in order to control the process and to prevent problems. In return to the higher level of risks at a lower O_2 level by the active DCS strategy a better fruit quality can be reached after taking the fruit from the CA store compared to the fruit stored at higher levels of O_2.

We give below 2 examples of procedures for storage conditioning and handling of fruit for cooling down + regular CA setting and applying a DCS protocol.

<u>Example</u> DCS Storage strategy for Elstar

Procedure for cooling down + regular CA settings and applying an DCS storage protocol with an 'active' strategy for the regulation of the O_2/CO_2 %;

1. Fast (within 2 days) equal reduction of product temperature to 1.5 – 2.0 degree (product temperature)
2. Control of product temperature during room loading with hand tool (spread < 1.0 degree), coldest and warmest expected places
3. After filling the room difference in product temperature to be accepted is 0.5 K (1.5 to 2.0 degree)
4. During filling
    a. CO_2 control at maximum 1.0 %
    b. O_2 control at minimum 19.5 %
5. 3 days after harvest moment and last product & temperature right : CA closing of room
6. Starting O_2 reduction with N_2 injection to 5 % O_2

7. At level of 5 % O_2 new setting oxygen is 1.2 %.
8. No N_2 injection (oxygen must lower at normal respiration of product). After 2 days starting N_2 injection (when needed) to reach the final O_2 level of 1.2 %.
9. Set final CA condition 1.5 % CO_2 and 1.2 % O_2
10. Observe the ethanol production during this period. In case there is no ethanol production go to step 1
11. **DCS Storage protocol** O_2 pull down for DCS . **Oxygen pull down Step 1**; to go to 1,0% O_2. Check ethanol production in the graph if no ethanol increase is detected, then after 3-4 days the next O2 pull down can be programmed.
12. 3-4 days later after 1,0 % O_2 is realized and no ethanol production is observed above a level of 3 mg ethanol / 100 gr fruitflesh. **Oxygen pull down Step 2:** to go to 0,8 % O_2. Check ethanol sensor and after 4 days optional test by taste.
13. 3-4 days later after 0,8 % O_2 is realized and no ethanol production is observed above a level of 3 mg ethanol / 100 gr fruitflesh. **Oxygen pull down Step 3:** to go to 0,6 % O_2. Check ethanol sensor and after 4 days optional test by taste.
14. 3-4 days later after 0,6 % O_2 is realized and no ethanol production is observed above a level of 3 mg ethanol / 100 gr fruitflesh. **Oxygen pull down Step 4:** to go to 0,5 % O_2. Check ethanol sensor and after 4 days optional test by taste.
15. 3-4 days later after 0,5 % O_2 is realized and no ethanol production is observed above a level of 3 mg ethanol / 100 gr fruitflesh. **Oxygen pull down Step 5:** to go to 0,4 % O_2. Check ethanol sensor and after 4 days optional test by taste.
16. 3-4 days later after 0,4 % O_2 is realized and no ethanol production is observed above a level of 3 mg ethanol / 100 gr fruitflesh. **Oxygen pull down Step 6:** to go to 0,3 % O_2. Check ethanol sensor and after 4 days optional test by taste.
17. 3-4 days later after 0,3 % O_2 is realized and no ethanol production is observed above a level of 3 mg ethanol / 100 gr fruitflesh. **Oxygen pull down Step 7:** to go to 0,2 % O_2. Check ethanol sensor and after 4 days optional test by taste.
18. 3-4 days later after 0,2 % O_2 is realized and no ethanol production is observed above a level of 3 mg ethanol / 100 gr fruitflesh. **Oxygen pull down Step 6:** to go to 0,1 % O_2. Check ethanol sensor and after 4 days optional test by taste.

For the active DCS strategy a value of +0,1% O_2 above the threshold value were ethanol production is started will be programmed in the CA control program. When not ethanol production is measured and the ethanol production remains on a very low level below 1 mg ethanol/100gr fruitflesh it can be decided to store to fruit at either 0,1 or 0,2% O_2.

For the safeguard DCS strategy a value of +0,2% O_2 above the threshold value were ethanol production is started will be programmed for the target O_2% in the CA control program. The minimum level of O_2 is 0,4% O_2.

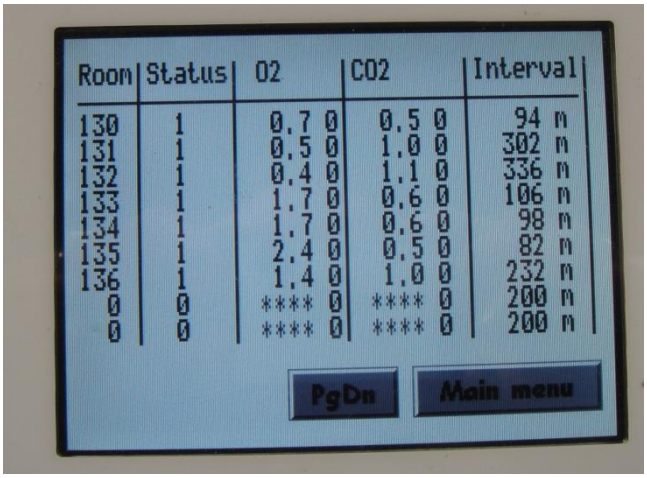
Based on the available information on the growing season / other relevant information about the fruit quality in this CA store and the chosen character of the DCS storage regime it can be decided to continue the DCS storage at this level of % O_2 /CO_2. For specific varieties also the CO_2 level can be adapted. Check this with the local CA consultant.
Product inspections have to be done on regular basis. In case there are quality issues, always stop the CA storage of your fruit in time and market your fruit.
The moment and frequency of fruit flesh analysis is to be agreed with the CA consultant.

DCS Storage strategy for Breaburn
Procedure for cooling down + regular CA settings and applying Safeguard DCS strategy / regulation of the O_2/CO_2 %;

1) Temperature choice as normal (1 ºC)
2) After cooling down and a waiting time of 21 days
3) Until start of pull down; O_2 > 20.0 %, CO_2 < 1.0
4) Then O_2 drop to 6 % with Nitrogen
5) The make a new setting for the O2% on 1,5%
6) The O_2 decrease by respiration. After a week N2 injection can be switch on to reach 1,5 %.
7) Waiting time of 3-7 days after realization of 1,5 % O_2
8) CO_2 max 1 %, preferred 0,8%. and Temp. 1 ºC
9) Observe the ethanol production during this period. In case there is no ethanol production go to step 1
10) **DCS Storage protocol** O_2 pull down for DCS . **Oxygen pull down Step 1**; to go to 1,3% O_2. Check ethanol production in the graph if no ethanol increase is detected, then after a week the next O2 pull down can be programmed.
11) 1 week later after 1,3 % O_2 is realized and no ethanol production is observed above a level of 3 mg ethanol / 100 gr fruitflesh. **Oxygen pull down Step 2:** to go to 1,1% O_2. Check ethanol sensor and after 4 days optional test by taste.
12) 1 week later after 1,1 % is realized and no ethanol production is observed above a level of 3 mg ethanol / 100 gr fruitflesh. **Oxygen pull down Step 3** to go to 0,9% O_2. Check ethanol sensor and after 4 days optional test by taste.
13) 1 week later after 0,9 % is realized and no ethanol production is observed above a level of 3 mg ethanol / 100 gr fruitflesh. **Oxygen pull down Step 4** to go to 0,7% O_2. Check ethanol sensor and after 4 days optional test by taste.

Based on the available information on the growing season / other relevant information and the chosen character of the DCS storage regime it can be decided to continue the DCS storage at this level of % O_2 /CO_2. For specific varieties also the CO_2 level can be adapted. Check this with the local CA consultant.
Product inspections will be done on regular basis. In case there are quality issues, always stop the CA storage of your fruit in time and market your fruit.
The moment and frequency of fruit flesh analysis is to be agreed with the CA consultant.

Photo of a touchscreen with DSC values in room 130, 131 and 132.



7.7 Measuring ethanol during the storage season

Each origin is equally represented in the measuring box. Following this principle the volume of the measured ethanol in the headspace of the measuring box can be produced by apples out of 1 or more samples present in the box. We developed an algorithm which shows the potential amount of mg ethanol present in 100gr fruitflesh. This is then an average for the present weight of the sample in the box. The accuracy is in tenths of mg. A clear sign of being on the threshold of fermentation occurs when we can measure during a period of 2-3 a clear increase of ethanol of ca. 0,5-1 mg ethanol/100 gr. Fruitflesh / day. If this situation appears the following steps can be taken:

When the ethanol production is started it has to be analyzed if the level of ethanol production is logical for the present circumstances.
Following factors are evaluated:

- Variety
- Growing season / quality of the sample
- Which picking 1st, 2nd or 3rd
- Period in the storage season
- Fruit quality
- Pull down procedure
- Other experiences with ethanol production of this variety at the specific O_2 level during that season

Then carry out the following steps:

1. Inspect if there are no rotting fruits in the measurement box.
2. Some apples can be taken either from the sample or out of the store for tasting
3. A fruit flesh analysis can be carried out.
4. Contact with the CA consultant.
5. The target value of the DCS store can be adapted.
6. Applying the safeguard DCS strategy the target value will be set on +0,2 % O_2 on top of the O_2 % were the ethanol production has started. The minimum O_2 level will be 0,4% O_2. During the next days the ethanol production in the graph has to be followed. In case the ethanol production is lowered it can be decided to continue the storage system on the selected O_2 value in this stage. It remains advised to carry out the regular inspection / observation of the fruit. Depending on the level of O_2 it can be decided to repeat a pull down in order to determine the target value of O_2.
7. Applying the active DCS strategy the target value will be set on +0,1 % O_2 on top of the O_2 % were the ethanol production has started. During the next days the ethanol production in the graph has to be followed. In case the ethanol production is lowered it can be decided to lower down either the O_2 level with 0,1% or to continue the storage system on the selected O_2 value in this stage. It remains advised to carry out the regular inspection / observation of the fruit. Depending on the level of O_2 it can be decided to repeat a pull down in order to determine the target value of O_2.

8. Alternatively it can be decided to wait more days on the same O_2 level and follow the ethanol production. When the ethanol production in the graph is exceeding 3-4 mg the procedure as described above has to be evaluated again.

If there is a clear increase of ethanol production due to fermentation (and not by rotting fruits in the measuring box) then the oxygen level should be increased by 0,1 or 0,2 %. After a nr. Of 3-5 days it should be visible that the increase of ethanol production is stopped and shows a trend of decrease. Based on the measurement results it can be decided to install the oxygen level on a level of 0,1 or 0,2% above the threshold O_2% where the fermentation started.
When the ethanol production is stabilized again on a low level 0-2 mg/100 gr. fruitflesh it can be decided to store the fruit at that present O_2 level. Depending the present level of O_2, it can also be decided to start once more a DCS pull down procedure by respecting the conditions as described above in this chapter.
Sampling and testing by means of tasting fruits can be done on the basis of regular interval. This and the frequency of making an analyze of fruit flesh to be discussed with the CA consultant.

- Note 1: It can be that ethanol production is caused by one or more apples which have defects or show rotting. In order to check this, the lid has to be opened for a short period and all the fruits have to be inspected. In case there is an apple with a defect or rot, it needs to be removed.

- Note 2: It can happen that in two regions were the same variety is stored under DCS conditions the threshold value of O_2% for ethanol production can differ up to 0,2-0,4%O_2. In other words, it can happen that a DCS room with Red Delicious in the north of a region will start with ethanol production at 0,6%O_2 were the same variety in the south will ethanol production will only start at 0,3%O_2.

- Note 3: When there are 2 measuring boxes in one CA room, extra information will be provided. In principle the 2 measuring boxes should reflect the trend for ethanol production and the measured synchronic. In case the values differs to a large extend, investigate if there are no apples in the sample with defects.

- Note 4: There is an option to replace the samples of fruit which are present in the CA store with the samples which are present in the measuring box. When the samples out of the CA store provide the same ethanol production figures during the next days, this provides information about the rate of fermentation.

- Note 5: In the end of the storage life of a certain variety it can appear that signs of altering appears. Altering of apples can cause internal deterioration, internal browning and causing ethanol production. This ethanol production is then not related to fermentation. This should be considered. Start opening and selling the fruit in time, in order to have quality issues.

- Note 6: The temperature setting of a specific variety can be evaluated with the CA consultant. It is known from certain varieties that they are stored at a higher temperature under DCS storage conditions. Per example Elstar can be stored at a higher temperature and a lower CO2 level.

Note 8: When a production of 3mg ethanol/100gr fruitflesh is measured for a period of 3 days we advise to increase the oxygen level 0,1% until the ethanol production is below 1-2 mg ethanol/100gr fruitflesh. In case the ethanol production continues to rise, increase the oxygen level again with 0,1%.

Ethanol presence in fruits.
A threshold for being able to taste ethanol in the fruit is ca. 1-2 mg/100 gr. Fruit flesh.

When the oxygen level is increased by 0,1 or 0,2% Oxygen the fermentation process will be stopped/reduced. In the days after the O_2 level has been increased it has to be observed if the ethanol production will stop to increase and start to reduce. The start of ethanol production and the process of stopping producing ethanol is a slow moving process which can take several days. In case the stabilization of the ethanol production cannot be observed within 2-4 days the O_2 level has to be increased with an additional 0,1 or 0,2% O_2.

It is known that in case, for whatever reason a low content of ethanol is present in the fruit the ethanol can be removed from the fruit flesh when the fruit is kept a somewhat higher O_2 levels as indicated above. The speed of removal of the ethanol is depending at which stage of the storage period (product activity) it takes place and the level of ethanol in the fruit. It is advised to check the procedure with your CA consultant.

Reading a negative production of ethanol production in the graph

- The analyzer at the beginning of the storage season is calibrating itself and determines a specific level of ethanol as the specific zero level for the Y axis. After this calibration the ethanol production is presented each day on a scale of 0-1 PPB, then a scale of 1-5 PPB or a scale of 0-25 ppb. The analyzer program is doing this automatically. It can also appear that the measured ethanol production has a lower level as the initial zero level on the Y axis. In this case also the scale of the Y axis will be adapted and show per example a scale of -1 PPB up to 2 PPB. The ethanol production will be presented as a negative figure. Please note that this changing of ethanol production figure has to be seen in relation to this.

7.8 After the DCS storage

When the DCS room is opened for sales of the product it is advised to determine the firmness of the fruit and to make an observation of the fruit quality and to reflect this data in the portal of the DCS system.

It is also advised to take a sample of the different origins and to store the fruit for 1 week at 18-20°C and to measure the firmness of the fruit.

After storage:

- The shorter the distribution time the better.
- Temperature control is important after CA-storage. The lowest possible storage temperature must be set.
- In case a longer period of regular air (mechanical refrigeration) is expected CA-conditions can be established again.
- Instead of applying SF directly after harvests also applications at the end of the storage period is possible. Depending on market price, distribution time and storage quality the decision can be made to invest in SF or not.

7.9 Attention CA/ULO-Storage - Product Liability

The Automatic DCS system has been developed for appliances used in the preservation of horticultural products, especially apples. A specific well-known form of CA (Controlled Atmosphere) preservation is the DCS, (Dynamic Controlled Atmosphere) system. The optimum storage -conditions are dependent on the product and can range from 0.1% to 2% O_2, and from ca. 0.5% to 4% CO_2%. Applying this preservation method the assimilation process of agricultural and horticultural products is accomplished on the lowest possible levels until fermentation starts. It is important to use fruit

which is suitable for long term storage according the regular technology for applying CA storage of fruit. The aim is to prevent quality loss and the appearance of storage diseases resulting in internal and external defects. At the same time it is aimed to have the best fruit quality after storage as possibly under CA conditions without additions. It is necessary that the user has an adequate working-knowledge of the CA/ULO preservation method for agricultural and horticultural products, especially apples. In case this knowledge is not present for the application the user has to make sure that he organizes the presence of this know-how for the application. Lack on skilled application of the DSC storage method can lead to product damage. The use and operation of the DCS system is for the the responsibility of the user. The procedures for using the DCS are designed in such a way to enable a safe working method for the storage of the fruits. It is advised to follow the instructions and to remain alert on preventing a case of product damage.

The daily measuring of the O_2- and CO_2 + temperature.
It is highly recommended that the user is checking daily the automatically measured and registrated value of the O_2% / CO_2% and temperature in the DSC stores. The automatic O_2/ CO_2 measurement has to be checked by a calibrated O_2/CO_2 meter according to the current technology of CA storage. The temperature readings of the automatic system has to be checked with an extra temperature sensor. Using the DCS system requires also active daily control of the ethanol sensor. In case ethanol production is started at a level of 0,5-1mg ethanol /100gr fruitflesh and a threshold value of 3 mg ethaol/100gr fruitflesh has been trespassed the target value of the O_2 has to be corrected.
If the desired temperature, O_2% and/or CO_2% level in the rooms deviates from the desired value, the user must take action immediately to determine the cause of this fluctuation and to resolve it so that the desired storage conditions will be restored. This must be performed in accordance with the current technology of CA/ULO storage.
In case for a period of time gas-conditions are present in the room that deviates from the desired target values and depending of the product, damage to the preserved product can come about. If you have questions about various preservation-methods, please turn to STOREX or her representatives or to the local extension services in the field of CA/ULO storage.

Restriction of product Liability ;
Storex has no influence on the quality of the product which has been grown during the growing season. Storex has no influence on the selection of fruits which is selected for CA / DCS / DCA storage. Storex has no influence on the circumstances in which the DCS system is used. Storex has no influence on the evaluation of the quality inspections. For the use of the DCS system and its components Storex shall in no case be liable for any direct or any indirect, incidental or consequential damages (including without limitation, lost business or profits, damage or loss of value of the stored products, loss of data or loss of use of equipment). The liability of Storex for damages of the other Party is in any case limited to direct damages up to a maximum of hundred percent (100%) of the price of the DCS system for the specific CA store to which the damages relate. For the delivery and application of the DCS system and its components the delivery conditions of Storex and EMS apply. The user of the DCS system is responsible himself for a safe use and application of the DCS system in combination with the application of the CA control system. The user have to respect and take in account the common safety instructions for applying CA and DCS / DCA technology such such as;

- Standard settings being well programmed and applied on the CA climate control system, also for alarm settings.
- Apply the advised maintenance and service instructions.
- Daily visible inspections and checks on measured values and carrying out of quality inspections.

8 GENERAL RECOMMENDATIONS FOR AUTOMATIC DCS STORAGE.

- It is advised to follow for the specific varieties like Red Delicious, Breaburn, Fuji and Cripps Pink, Pink Lady the additional recommendation as advised for DCA-CF (Dynamic Control Atmosphere with Chlorophyll Fluorescence response measurement).
  Note: in this chapter we refer in several cases to practical experience which is gained with this system. DCS-CF is applied in Southern European countries over the last years and some specific experience with some specific varieties has been gathered. Research station Laimburg has collected several research results which are used in this manual. DCA-CF was introduced based on the good experiences with DCS. However DCA-CF is applying an indirect method for measuring low oxygen stress by observing spikes of fluorescence caused by stress in the chlorophyll in the skin a apples. This is apart from the original DCS system were ethanol is measured as a direct marker sign for fermentation. With the DCS it is aimed to have a better and more clear measurement system for the threshold of fermentation in order to provide a better quality management system.

- For the varieties Gala, Golden Delicious, Jonagold, Granny Smith, Winesapp, Morgenduft the pull down is carried out without waiting period after the fruits are cooled down to a target value of 2ºC..

- For DCS the O_2 concentration will have to be set in the CA control program for the DCS store that there will never appear conditions which can lead to product damage because of fermentation.
  Depending on the strategy which is followed the O_2 level is adjusted.

- For the safeguard DCS strategy on a value of +0,1% O_2 above the threshold value were ethanol production is started. (Within a period of 3 days > 3 mg Ethanol / 100 gr fruitflesh). The minimum level of O_2 is 0,4% O_2.

- For the active DCS strategy on a value of +0,1% O_2 above the threshold value were ethanol production is started. (Within a period of 3 days > 3 mg Ethanol / 100 gr fruitflesh).

- Varieties which are sensitive for skin diseases like scald the DCS values have to be installed within 2 weeks after the start of filling CA room with apples. The first rule applies for scald sensible varieties that the DCS lowest O_2 level has to be reached as soon as possible and anyway below 0.7%
  In case this does not happen, the Scald prevention working of low oxygen is not initiated and can fail. The specific CA storage recommendations for the variety have to be respected.

- It is especially advised to control the CO_2 concentration. The CO_2% should, before the O_2 Pull down, never exceed the maximum value of 1% CO_2. For the Automatic DCS storage we recommend the special table which is also used for DCA-CF and designed by Fruit Reasearch Station Laimburg (IT). See enclosure.

LAIMBURG

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CO_2 Empfehlungen für die DCA-CF Lagerung 2012-13

%CO_2 / %O_2	Gala	Stark	Granny Morgenduft, Winesap	Golden Jonagold	Braeburn Fuji	'Pink Lady'
0,4	1,2	0,9	0,9	0,9	0,6	0,6
0,5	1,3	0,9	1	1	0,7	0,7
0,6	1,4	1	1	1,1	0,7	0,7
0,7	1,6	1	1	1,2	0,8	0,8
0,8	1,8	1	1	1,4	0,8	0,8
0,9	2	1	1	1,6	0,9	0,9
1	2	1	1	1,8	1	1

Nach Schließung der Zelle soll auch **vor dem Pull-Down** Ethylen und der CO_2-Gehalt auf niedrige Werte (<1%) gehalten werden, daher CA-Steuerung und Ventilation einschalten!