



1,4SIGHT[®]

TECHNICAL MANUAL

USE PLANT PROTECTION PRODUCTS SAFELY. ALWAYS READ AND FOLLOW THE COUNTRY LABEL AND PRODUCT INFORMATION BEFORE USE.

DormFresh Limited | +44 1738 633 859 | info@dormfresh.co.uk

www.dormfresh.com

DORMFRESH TECHNICAL MANUAL

1,4SIGHT®

Active Ingredient:

98% 1,4-Dimethylnaphthalene (1,4-DMN)

Introduction

This Technical Manual provides important information on 1,4SIGHT®, a sprout suppressant to prevent and control sprouting of potatoes.

1,4SIGHT® can be applied using currently available fogging equipment. Due to the different chemical and physical properties of 1,4SIGHT® compared to other sprout suppressants, applications of 1,4SIGHT® need careful considerations, which are highlighted within this manual.

This Manual provides practical information to help optimize the use of 1,4SIGHT®. For further clarification or to discuss your specific needs/usage we strongly recommend contacting your 1,4SIGHT® distributor.

As with all plant protection products FOLLOW THE CODE OF PRACTICE FOR USING PLANT PROTECTION PRODUCTS and the International guidance of Good Agricultural Practice.

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1. General

It is essential you follow the approved product label in your country; this Manual provides additional information on 1,4SIGHT®.

The active substance of 1,4SIGHT®, 1,4-Dimethylnaphthalene (1,4-DMN) is naturally produced by potatoes and was originally discovered after analysis of potato volatiles in the 1970's and 80's. Since then naturally occurring levels of 1,4-DMN have been recorded on potatoes.

Other Dimethylnaphthalenes have also been detected or extracted from other foods, such as poppies, corn buds, red beans, raisins, dairy products, smoked cheese, olive oil, tomatoes, and starfruit.

1,4SIGHT® is an effective potato sprout suppressant as a stand-alone product and can give full season control. The dose rates and application timings are dependent on the crop and storage practices.

Early application after harvest and before visible signs of sprout growth, results in optimum efficacy and efficiency of use over a long storage period. 1,4SIGHT® has no negative impact on curing or wound healing so can be applied early and has been shown to reduce respiration, shrinkage, and weight loss.

Commercial usage of 1,4SIGHT® began in the USA as early as 1996. Since then users have reported excellent efficacy as well as a better skin bloom, skin finish, reduction in compression damage and bruising. Fungistatic activity of 1,4SIGHT® on potato tubers has been reported by researchers from Pennsylvania State University in the US in 2019.

2. EU 1,4SIGHT® Label

Crops: Potatoes (post-harvest), excluding seed potatoes

Maximum Individual Dose: 20 ml per 1000 kg

Maximum Total Dose: 120 ml per 1000 kg

Grace Period/Post-Harvest Interval (PHI): Observe a 30-day withholding period before removal of treated potatoes from the store

Number of applications: Maximum of 6 over the season (except in Ireland)

Other specific restrictions: Allow a minimum of 28 days between applications.
Do not feed treated crops to livestock (France, Ireland & Denmark)

Although the label allows a total dose of 120ml/t over the season with a maximum individual dose of 20ml/t, in normal seasons this rate can be significantly reduced.

Optimisation of storage practices and matching application doses to crop requirements have allowed users to reduce rates to as little as 30ml per tonne for long term storage (>7 months).

Commercially, lower individual dose rates (10-15ml/t) and longer retreatment intervals, ranging from 4 weeks to 3 months, have also been used successfully. The success of this is dependent on close observation of crop requirements and the condition/quality of each store.

3. Mode of Action

1,4SIGHT[®], even at low levels, initiates positive affects within the tuber

- 1,4SIGHT[®] works by naturally enhancing the potato's ability to turn on or off genes which alter protein levels associated with sprout growth, wound healing, weight loss and pathogen resistance.
- As a general rule, 1,4SIGHT[®] starts to suppress sprouting at a level of 1ppm in the potato. In trials conducted by Pennsylvania State University, residue levels above 4.5 ppm showed a repression of all genes associated with growth. These genes are associated with an increase of inhibitory proteins, stopping sprout growth. As protein levels breakdown and decline, sprouting can occur.
- Pennsylvania State University trials showed that the highest measured residue level of 1,4SIGHT[®] (4.7ppm) from an application of 15-20ppm, resulted in the highest levels of inhibitory protein production.
- Increased inhibitory protein levels give longer sprout inhibition.
- Preventative mode of action:
 - 1,4SIGHT[®] will keep a potato in the dormancy stage which prevents them from sprouting.
- Curative mode of action:
 - In field sprouts
 - 1,4SIGHT[®] has proven to be very effective at 'burning' sprouts initiated in field, turning black as they die, soon after treatment.
 - In store sprouting
 - 1,4SIGHT[®] returns potatoes to a dormant state and the sprouts no longer receive nutrition to grow. 1,4SIGHT[®] will prevent continued growth of the sprouts. Over a period, the sprouts can turn black as they die-off.
- 1,4SIGHT[®] breaks apical dominance. This will delay sprouting or evidence of the end of natural dormancy. All the sprouts receive energy to grow and lateral sprouting will occur with equal vigor to the apical sprout.

4. 1,4SIGHT® physical and chemical properties

- Pale to yellow liquid
- Freezing point
 - 1,4SIGHT® has a freezing point of 5°C
 - Store and transport above 5°C to avoid the product freezing. Frozen 1,4SIGHT® can be warmed back to a liquid and used as normal. The quality and efficacy of 1,4SIGHT® are not affected
 - If required insulate the 1,4SIGHT® container during transportation and use
- During applications prevent 1,4SIGHT® from cooling and in cold external conditions ensure 1,4SIGHT® does not freeze tubes/nozzle of the fogging equipment
- Odour: Characteristic

5. Efficacy management

The dose rates and application timings for full season control are dependent on many factors, such as:

- Seed health/maturity, crop growing/harvesting conditions
- Crop dormancy/quality at harvest
- Variety stored
- Storage duration
- Crop holding temperature
- Ambient ventilation (including CO₂ management) and or refrigeration
- Store construction
- Store fill level – stores should be filled to designed capacity to get the most effective efficient use of applied 1,4SIGHT®

6. Environment and Field Conditions

- Potato management
 - Potatoes are highly influenced by environmental conditions during growing and harvesting. Temperature, water supply, pests and diseases all impact crop physiology. Stress factors influence the dormancy process of potatoes. Under stressful conditions potatoes can start sprouting prior to delivery for storage. Potato growing and harvesting conditions as well as crop quality should be considered carefully as part of a good store management plan.

- Crop temperature in field
 - High ambient growing & harvesting temperature can reduce the innate dormancy and so increase the risk of early sprouting in store.
 - Varieties have vastly different responses to field and storage stress.
 - In the 2018 season crops underwent extreme growing and harvest temperatures and were already sprouted in field. It was critical to control this sprouting during the pull-down phase, prior to reaching holding temperatures.
 - Due to in field sprouting, crop owners treated at the full rate of 20ml/t and then sealed the store for up to 48 hours before continuing with normal store management. This early application allowed sprouting to be controlled and reduce losses.
 - Once treated in-field sprouting was well controlled, providing a curative effect.

- Storage temperature
 - Processing
 - Processing crops are generally stored warmer and may require repeat applications at shorter intervals. Warmer storage temperatures increase sprouting pressure and the volatility of 1,4SIGHT®.

- Due to warmer storage temperatures, the vapour concentration in the store atmosphere is higher and hence excessive ambient ventilation can lead to rapid decline in 1,4SIGHT® levels.
- Fresh/Table
 - Cooling harvested potatoes gradually will minimise crop temperature differentials within the store. This will reduce the risk of 1,4SIGHT® condensing on the coldest potatoes, during an application.
 - Potatoes for the fresh/table market are generally stored colder, below 5°C in well-sealed/insulated stores.
 - As sprouting pressure is lower in colder stores, with relatively low levels of ambient ventilation, doses can be reduced and still give adequate efficacy.

WARNING: *1,4SIGHT® condensing or dripping on potatoes can cause skin damage. Avoid excessive temperature differentials in the store before 1,4SIGHT® applications. Large temperature differentials can cause the potato temperatures to drop below the dew point of the store atmosphere, and as a result increase the risk of 1,4SIGHT® condensing on the cooler potatoes and store surfaces (such as walls, ceiling and materials used within the store) during and after an application.*

7. The Store

- **Store integrity**

To optimise the use of 1,4SIGHT® ensure stores are well sealed with appropriate ventilation. Excessive headspace, free air within the store, can reduce the uptake of 1,4SIGHT® and hence the efficiency of treatment, which may require higher application rates at shorter intervals. In general, the store should be fully closed, with appropriately controlled/managed ventilation, to reduce the loss of 1,4SIGHT®, ensuring sprout control is optimised.

Follow applications advice carefully.

- **Carbon dioxide management**

- Excessive ambient ventilation to control in store carbon dioxide levels can reduce the efficacy of 1,4SIGHT®. 1,4SIGHT® concentration can reduce rapidly due to its volatility.
- If required and ambient conditions are suitable it is good practice to refresh the store atmosphere before an application.
- Control of low levels of CO₂, below 0.5% is often managed automatically and perceived to be of importance for processing crops.
- Commercially available CO₂ extraction systems have proved to be very effective at managing in-store levels with limited ambient air exchange. This ensures that a relatively higher concentration of 1,4SIGHT® remains in the store compared to ambient air exchanged via the main store ventilation system.
- 1,4SIGHT® treated stores have been reported as requiring less ambient ventilation for the control of CO₂, compared to the conventional sprout suppressant.

Reconsider CO₂ management

8. 1,4SIGHT® Treatments – General considerations

- 'Dry Fog'
 - Ensure 1,4SIGHT® is applied as a 'dry fog', there must be no 'dripping' from the fogger outlet to store
 - This can be achieved by adjusting the thermal fogging machine:
 - temperature
 - chemical flow rate
 - air flow
- Particle size
 - 1,4SIGHT® particle size analysis of three commercially available applicators has shown the optimal profile is achieved by using a thermal electric machine (*see Appendix 1 courtesy of Frans Veugen*).
 - If possible, adjust the thermal fog machine so all the aerosol particles are less than 2µm. This will help 1,4SIGHT® vapourise and move throughout the store, reducing the risk of 1,4SIGHT® condensing.
- Nozzles/flow rate
 - Use the most appropriate nozzle to produce a 'dry fog'. This may vary depending on the size of machine, external conditions and internal crop/air temperatures.
 - There must be no dripping from the end of the applicator.
 - There should not be any wet spots on the floor or on components in the store.
- Application rate (Applicator throughput)
 - 5-30 litres per hour depending on the application equipment and the store design.
 - In cold & or small stores with limited air space reduce application rates to avoid the chance of 1,4SIGHT® saturating the store atmosphere and thus reducing the risk of product condensing on the store fabrics or potatoes.

- If the speed of store fans cannot be reduced, consider reducing the rate of application. This will reduce the vapour concentration in the atmosphere and avoid 1,4SIGHT® condensing on the fans.
- Temperature: internal/external air
 - Prior to application of 1,4SIGHT®, ensure temperature differentials of the store air, fridge (if fitted) and store fabrics are minimised to avoid the 1,4SIGHT® fog condensing in store. Large temperature differentials can cause temperatures to drop below the dew point of the store atmosphere, and so increase the risk of 1,4SIGHT® condensing.
 - When applying to cold stores, reducing the chemical flow rate and or increasing the thermal fogging machine air temperature will help 1,4SIGHT® to volatilise and so reduce the risk of condensing in store.
 - Cool outside temperatures and or high humidity levels will require a slower rate of application and/or higher application temperature to ensure a dry fog.
 - Cold outside temperatures of below 5°C increases the risk of 1,4SIGHT® freezing in the container and in the pipes & tubes of the fogging equipment.
- 1,4SIGHT® temperature
 - If possible, warming 1,4SIGHT® prior to and or during an application will help produce a 'dry fog'.
- Thermal applications
 - Petrol Foggers (*e.g. SwingFog, PulsFog, Igeba, ...*)
 - Tend to operate without controls
 - High temperatures
 - Introduce CO₂, ethylene and other combustion gasses into the store
 - Easy to use
 - Very portable and self-contained
 - Low cost and very common

- Electric Foggers (e.g. Synofog, Electro-Fog...)
 - Have good control over all the parameters of the machine
 - Chemical flow rate
 - Process air temperature
 - Process airflow volumes
 - Require appropriate electricity supply
 - No combustion gases introduced into store
- Cold application
 - Pay close attention when using cold fogging equipment
 - **High risk of producing a 'wet fog'**, due to larger particles being produced, and reduced ability of the fog to volatilise
 - If the output is above the potatoes, use precautions to ensure 'wet fog' does not come into contact with the potatoes
 - Not suitable in cold stores due to freezing of 1,4SIGHT®
 - Ensure the volume and capacity of air required for the applicator is uninterrupted

1,4SIGHT® must only be applied by appropriately trained competent/qualified users. Users must follow the fogger/applicator manufacturers current best practice guidelines.

WARNING: The applications & application rates must be adapted to ensure there is no condensation of 1,4SIGHT® on store fabrics or potatoes, which could lead to reduced efficacy, skin damage and damage to store fabrics. If in doubt please consult your machine manufacturer or 1,4SIGHT® distributor.

9. 1,4SIGHT® Applications in COLD STORES

- a. Relative humidity control (if present): disable up to 24 hours prior to application to ensure screen and store fabrics are dry.
- b. Ensure there is no ice or moisture on the fridge coils.
- c. Disable fridge, disable ambient louvre and run internal recirculation for up to 24 hours before application. This will ensure crop, fridge and store fabric temperature differentials are minimised, and hence reduce the risk of 1,4SIGHT® condensing.
- d. Applying the 1st application before store/crop temperatures drop below 5°C will help volatilisation and hence the risk of 1,4SIGHT® condensing in store.
- e. Before the start of application switch store fans to run with internal recirculation at around 30% of their full capacity. This will help move 1,4SIGHT® away from the point of entry into store during an application.
- f. Carefully choose the fog introduction point in the store. The fog should be introduced and allowed to mix with store air, to aid vaporisation, before being drawn into the ventilation fans/ducts for distribution around the store. Avoid moving the densest fog over the top of the potatoes, to reduce the risk of 1,4SIGHT® settling on potatoes.
- g. Pre-heat the applicator and hoses/pipes outside the store for 5-10 minutes.
- h. Apply the dose appropriate for the store with the internal recirculation fans running at reduced speed, maintain a consistent fog temperature to ensure product is applied as a 'dry fog' and does not drip from the end of the application nozzle. The fog temperature required for a 'dry fog' will vary, depending on chemical flow rate, machine make & model and outside conditions.
- i. During applications ensure 1,4SIGHT® remains above 5°C, protect pipes and tubes around the fogging machine so 1,4SIGHT® can flow freely throughout. In cold external conditions (<5°C) 1,4SIGHT® can freeze and create a blockage in the chemical lines.
- j. Continued gentle internal recirculation of 1,4SIGHT® fog, during and for a period (up to 12 hours) after application will help the distribution through the store and subsequent uptake in the potatoes.
- k. If required, the refrigeration can be run 24 hours after application to maintain crop temperature.

- l. Return store to normal control mode 24 to 48 hours after application (fridge & ambient cooling enabled).
- m. In well-sealed cold stores application rates can be reduced, providing efficacy as well as reducing the potential of saturating the store atmosphere.

10. 1,4SIGHT® Applications in PROCESSING STORES (ambient ± fridge)

- a. Relative humidity control (if present): disable up to 24 hours prior to application to ensure screen and store fabrics are dry.
- b. Disable fridge (if present), disable ambient louvre and run internal recirculation before application to ensure crop, fridge and store fabric temperature differentials are minimised, and hence reduce the risk of 1,4SIGHT® condensing.
- c. Ensure there is no ice or moisture on the fridge coils (if present).
- d. Before the start of application switch store fans to run with internal recirculation at around 30% of their full capacity, if possible. This will help move 1,4SIGHT® away from the point of entry into store during an application.
- e. Pre-heat the applicator and hoses/pipes outside the store for 5-10 minutes.
- f. Apply the dose appropriate for the store with the internal recirculation fans running at reduced speed, maintain a consistent fog temperature to ensure product is applied as a 'dry fog' and does not drip from end of the application nozzle. The fog temperature required for a 'dry fog' will be vary depending on chemical flow rate, machine make & model and outside conditions.
- g. During applications ensure 1,4SIGHT® remains above 5°C, protect pipes and tubes around the fogging machine so 1,4SIGHT® can flow freely throughout. In cold external conditions (<5°C) 1,4SIGHT® can freeze and create a blockage in the chemical line.
- h. Avoid saturation of store atmosphere to reduce the risk of 1,4SIGHT® condensing in store. This can be achieved by reducing the chemical flow rate (reducing chemical pump speed or by the use of a smaller nozzle), increase the application temperature, apply into store open space and by ensuring good air movement throughout the store.

- i. Continued gentle internal recirculation of 1,4SIGHT® fog, before, during and for a period (up to 30 minutes) after application will help vaporisation and distribution of 1,4SIGHT® and the uptake by the potatoes.
- j. 24-48 hours after application return store ventilation to normal control mode (fridge & ambient cooling enabled). For instance, if treating a sensitive processing variety with a petrol/gas fogger then consider 24 hours, to reduce the risk of sugar accumulation due to the response of potatoes to the combustion gases. If using electric applicators that do not produce combustion gases, then 48 hours should not be an issue.

11. Principles of good 1,4SIGHT® applications

- Ensure 1,4SIGHT® is applied as a 'dry fog', with no dripping from the fogging machine, to improve vapourisation.
- Check and maintain fogging equipment/nozzles at regular intervals before, during and after the application.
- Stores should be filled to designed capacity to ensure efficient use of product.
- For improved efficacy and efficiency, potatoes should be dry and as free from soil as possible.
- Preference is to use thermal applicators, to help vapourisation of 1,4SIGHT® in store.
- Run fogging equipment prior to use to ensure all parts are warmed and working as required.
- Ensure there are no droplets or condensing of liquid on potatoes, as skin damage can occur.

12. Suggested Applications

- **1st application**

- The first application can be made soon after store loading, as long as potatoes are dry (minimum surface moisture).
- Early applications in commercial stores have not demonstrated a negative impact on curing/wound healing and help reduce crop respiration rates with the benefits of reduced weight loss, shrinkage and maintenance of tuber turgor.

- **Repeat applications**





- Second and subsequent applications can be made when potato eyes start to open. At the 'Blinking/Peeping' stage (See pictures below).
- In stores with multiple varieties carefully monitor each variety and manage to the *first to sprout*.

- **Application rates**

- Suggested Programs of 1,4SIGHT® (ml/t) as a starting point.

Store type	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Refrigerated	10-15			10-15			10-15			10-15		
Ambient	15-20		10-20		10-15		10-20		15-20			

Dose rates can be optimised, with regular close inspection, to ensure the most effective and efficient use to meet crop requirements.

Dormant	Blinking	Peeping	Sprouting
			
<i>Colour is even across the whole tuber</i>	<i>Lightening colour of eye, hint of growth, small peeping</i>	<i>Eyes lighten in colour first sign of 'peeps' emerging, > 1mm</i>	<i>Eyes are whitened, sprouts are evident</i>

13. Other crops - Cross Contamination

- During application: 1,4SIGHT® is a volatile product. Avoid movement of atmosphere from treated stores to untreated stores used for seed potatoes, seeds, bulbs, or other crops which can lead to cross contamination.
- After application: Cross contamination can also occur when untreated potatoes, seed potatoes, seeds, bulbs, or other crops are stored near potatoes, boxes or stores previously treated with 1,4SIGHT®.
- With regards to residues on other crops: we cannot guarantee there will be no cross contamination to subsequent crops stored in 1,4SIGHT® treated stores or boxes.
- 1,4SIGHT® is a volatile product, and increased ambient ventilation will help remove residues from crops, store fabrics, ventilation units and boxes, especially with warm external conditions.
- 1,4SIGHT® does not have approval for other crops, residue levels must remain below 0.01 mg/kg (LOQ)

14. Operator and worker protection

- During handling of the product, the operator must wear suitable gloves and eye or face protection.
- During treatment: In the unlikely event that operators need to enter treated areas during or following application, and prior to ventilation or settling of aerosol fog, they must wear: coveralls over long-sleeved shirt, long trousers, closed toed shoes and socks, and chemical resistant (such as nitrile or butyl) gloves; face-sealing goggles or full-face protection and respirator.
- After treatment and for regular inspections: After the post treatment sealing phase of 24-48 hours, the store should be entered with personal protective equipment (coveralls over long-sleeved shirt, long trousers, closed toed shoes and socks, and chemical resistant gloves; face-sealing goggles or full-face protection and respirator). Personal protective equipment can only be avoided if the store has been ventilated with outside air for at least 30 minutes.

15. Grace Period/Post-Harvest Interval (PHI)

Currently potatoes can only be removed from store a minimum of 30 days after treatment.

DormFresh Ltd. submitted data in Spring 2020 to the Evaluating Member State to review the current PHI. Reducing the PHI is expected to help with shelf-life and will also provide a greater level of flexibility to store managers, who may need to remove crops at short notice.

16. Store fabrics, sensors, lights & cables

If 1,4SIGHT[®] liquid comes into contact with certain plastics then damage to these plastics can occur. This can occur if applied 1,4SIGHT[®] condenses onto the plastic (exposed or cold surfaces) or drips directly on to the plastic surface as droplets through poor application technique.

These effects can be eliminated if proper steps are taken during the application process.

Application of 1,4SIGHT[®] as a 'dry fog', ensuring temperature variations throughout the store are eliminated and ensuring adequate air movement during applications will reduce the risk of 1,4SIGHT[®] condensing and hence risk of damage.

17. Phytotoxicity

As with store fabrics, condensation or dripping of 1,4SIGHT[®] on the potatoes can cause phytotoxic damage. Again, this damage can be avoided by using the proper application techniques.

18. Appendix 1: Particle size analyses (courtesy of Frans Veugen)

Veugen Synofog 1H (Electric Thermal Applicator)



HELOS Particle Size Analysis
WINDOX 5

Identification: Synofog 1H
10:54:51

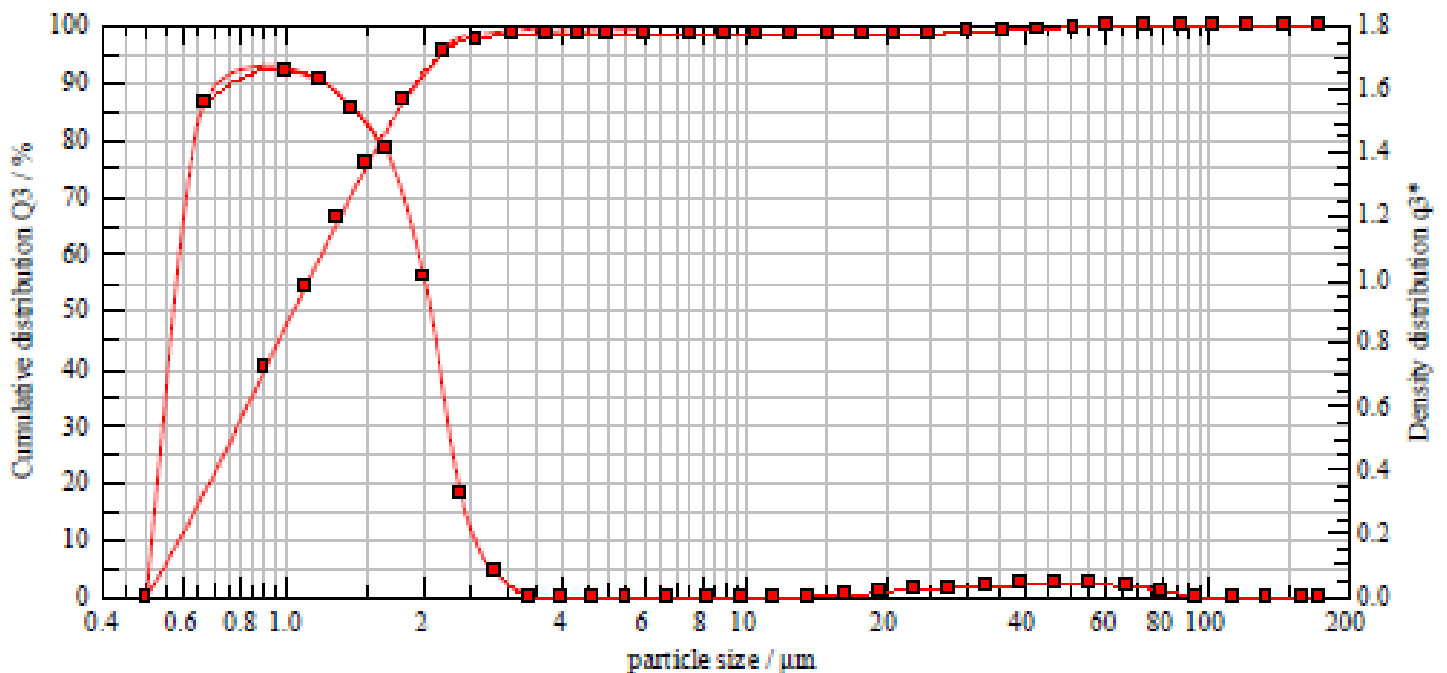
2019-06-04,

User parameters:

User: RVEU
Identification: Synofog 1H
Counter: 3
Serienummer:
Product: 1,4Sight - 1,4 DMN

Batch number:
Parameter 7: 0
Parameter 8: 0
Parameter 9:
Parameter 10:

$x_{10} = 0,60 \mu\text{m}$ $x_{50} = 1,04 \mu\text{m}$ $x_{90} = 1,96 \mu\text{m}$ $C_{opt} = 46,07 \%$
 $x_{16} = 0,66 \mu\text{m}$ $x_{84} = 1,73 \mu\text{m}$ $x_{99} = 41,94 \mu\text{m}$



PulsFog K10 (Petrol Thermal Applicator)



HELOS Particle Size Analysis WINDOX 5

Identificatie: Pulsfog K10
08:58:29

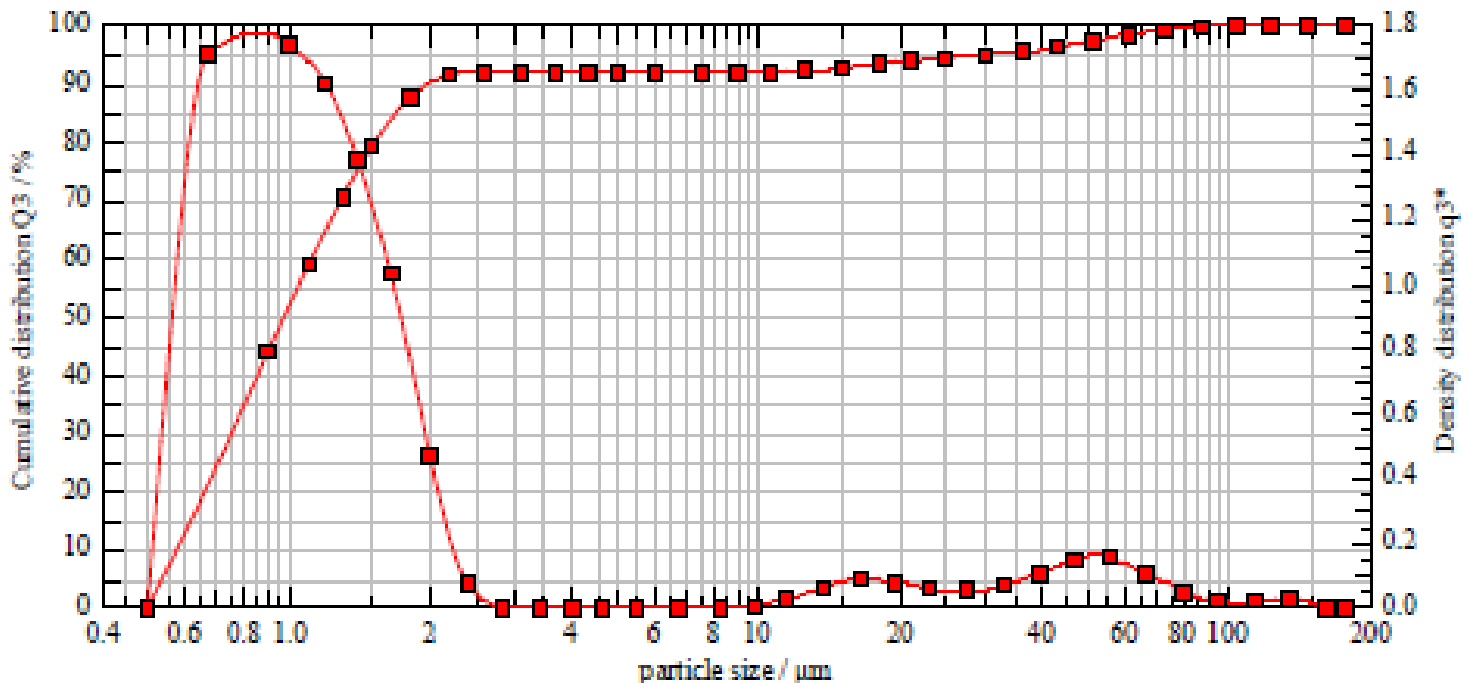
2011-04-14,

User parameters:

Gebruiker: Jos Veugen
Identificatie: Pulsfog K10
Teller: 0
Serienummer: NVT
Druk kop: NVT

ml/min:
Lucht flow:
Gebruikte vloeistof: 1,4Sight
Parameter 9:
Parameter 10:

$x_{10} = 0.59 \mu\text{m}$ $x_{50} = 0.98 \mu\text{m}$ $x_{90} = 2.06 \mu\text{m}$ $C_{\text{cor}} = 82.93 \%$
 $x_{16} = 0.65 \mu\text{m}$ $x_{84} = 1.68 \mu\text{m}$ $x_{99} = 70.00 \mu\text{m}$



Veugen PotatoFog (Cold fog applicator)



HELOS Particle Size Analysis
WINDOX 5

Identificatie: Koudvernevelaar
08:39:11

2011-04-14,

User parameters:

Gebruiker: Jos Veugen
Identificatie: Koudvernevelaar
Teller: 0
Serienummer: 100320
Druk kop: 3.50 bar

ml/min: 15 ml/min
Lucht flow: 156.00 l/min
Gebruikte vloeistof: 1,4Sight
Parameter 9:
Parameter 10:

$x_{10} = 1.90 \mu\text{m}$ $x_{50} = 16.20 \mu\text{m}$ $x_{90} = 27.46 \mu\text{m}$ $C_{opt} = 17.46 \%$
 $x_{16} = 2.89 \mu\text{m}$ $x_{84} = 24.64 \mu\text{m}$ $x_{99} = 37.14 \mu\text{m}$

