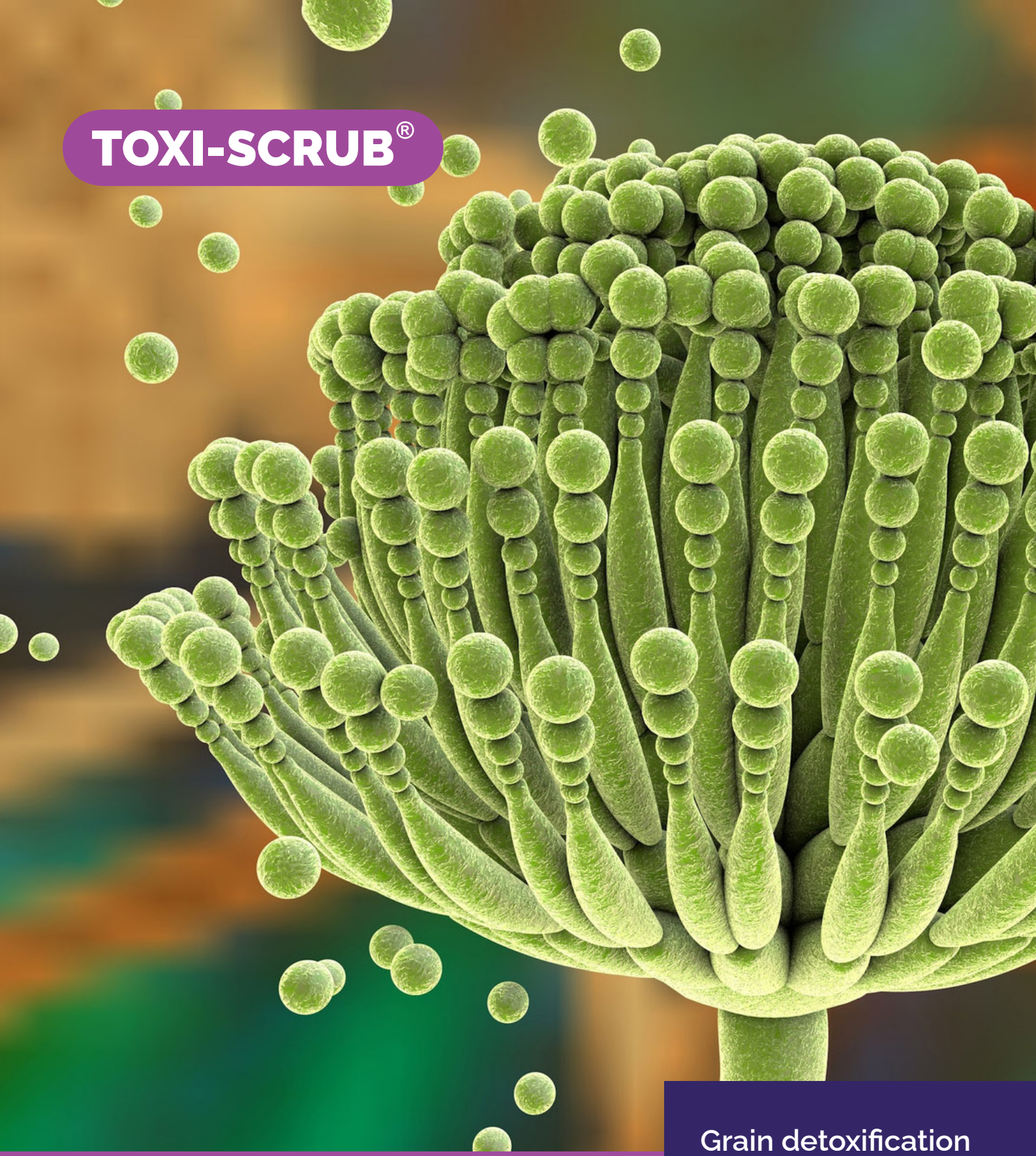


TOXI-SCRUB®
Mycotoxin removal

Grain detoxification
Ozonation technology

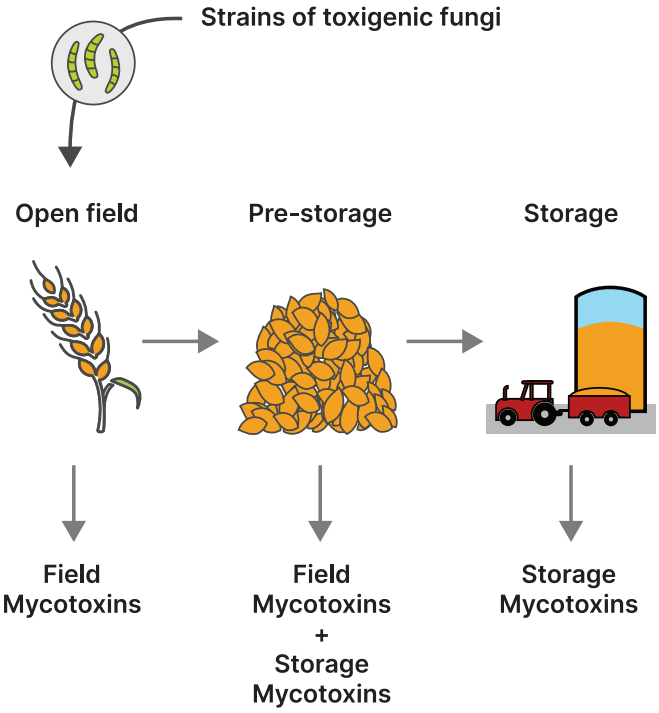
- Maize
- Wheat
- Rice
- Beans
- Seeds
- Peanuts
- Meal
- Lentils
- Barley
- Pistachios

Mycotoxins – a worldwide problem

Mycotoxins appear in the food chain as a result of fungal infestations of crops both before and after harvest. Mycotoxin producing fungi grow on a variety of crops and numerous foodstuffs, including cereals, nuts, spices, coffee, cocoa, beans and lentils, and thrive in warm and humid conditions. These fungi do not merely grow on kernel surfaces; they also penetrate deep into the seeds. When crops are not dried properly and stored safely, the chances of contamination with fungi and their Mycotoxin metabolites are very high.

Exposure to Mycotoxins can occur directly, by eating infected food, or indirectly through animals that have been fed contaminated feed. Mycotoxins pose serious health threats to humans, ranging from acute poisoning to long-term cumulative effects such as immune deficiency, malnutrition, stunted growth in children and cancer. Mycotoxins also present a significant economic challenge, with farmers, grain dealers and milling companies all experiencing losses due to Mycotoxin poisoning.

Contamination with Mycotoxins



Some Mycotoxins are primarily created in the field during wet seasons. Fungus spores are present everywhere. The growth of other fungus types continues during storage if the crop is not properly dried and stored in dry conditions. Tropical climates present greater challenges than other climates.

Effect on human health

Mycotoxins cause many different diseases in both humans and animals. Some of the most serious toxins are listed below.

Carcinogenic
- Aflatoxin
- Ochratoxin A

Immune suppression
- Aflatoxin
- DON (Vomitoxin)
- ZER (Zearalenone)
- Ochratoxin A

Dermal
- DON
- T-2
- HT-2

Reproductive organs
- DON
- Ergot Alkaloids
- T-2
- HT-2

Pulmonary
- DON
- ZER

Kidney
- Aflatoxin
- DON
- ZER
- Ochratoxin A

Nervous system
- Ergot Alkaloids

Liver
- Aflatoxin
- ZER

Digestive system
- Aflatoxin
- DON
- Ergot Alkaloids
- Ochratoxin A

TOXI-SCRUB® Solution

The **TOXI-SCRUB®** processing line is designed for large scale detoxification of contaminated commodities – generating value in terms of nutritious feed and food, human and animal health, and economic growth.

- The **TOXI-SCRUB®** processing line is configured to process and detoxify anywhere from 2–40 tons of contaminated crops per hour.
- **TOXI-SCRUB®** removes Mycotoxins in commodities such as maize (corn), wheat, rice and any type of nuts or beans. It also eradicates other biologic organisms such as bacteria, mites and insects.
- The **TOXI-SCRUB®** technology uses an ozonation process to remove toxins. Ozonation can be performed pre-storage, to ensure safe long-term storage, or pre-processing, to ensure high quality feed or food.
- Ozonation is a green technology that does not leave any residuals in the detoxified crops. Ozonation is approved for use in the USA on all food and feed, and approved for organic products. Efficient decontamination by Ozonation has been repeatedly demonstrated by scientists at laboratory scale.
- The **TOXI-SCRUB®** processing line is easy to operate and reduces Mycotoxin levels safely below the accepted thresholds for humans and animals.

The Ozone decontamination process

Ozonation is the process in which a commodity is exposed to Ozone, during which Mycotoxin molecules are oxidised and rendered no longer toxic. Ozone is a powerful oxidising agent that "attacks" the Mycotoxins, transforming toxic molecules into harmless molecules.

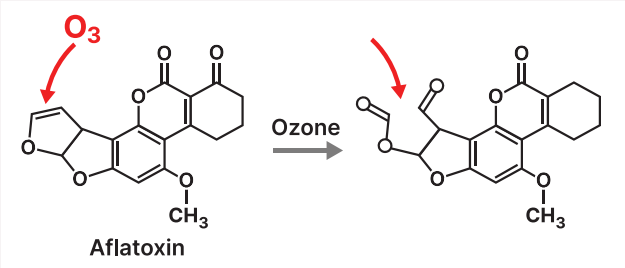
Ozone use is widespread and has been applied for many years in other industries, in particular in wastewater treatment, to reduce BOD (Biologic Oxygen Demand). Ozone is also used in several sanitation applications in the food processing industry. More than one million Ozone generators are produced yearly for a wide variety of applications.

More than 100 scientific articles have confirmed the efficiency of Ozone in eradicating most of the harmful Mycotoxins significant to the food supply chain for grain and feed processing. Ozone also kills bacteria and insects.

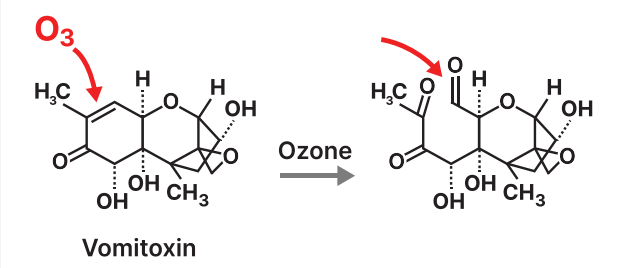
Mycotoxins are toxic for many reasons. Most Mycotoxins are "energy-rich" molecules and chemically reactive due to their chemical double bonds, see below.
Ozone oxidises these double bonds, thereby breaking the molecular structure and creating new non-toxic molecules.

At laboratory scale it has been easy to demonstrate a significant reduction of the Mycotoxins that cause disease in humans and animals. **TOXI-SCRUB®** has developed outstanding technology (Patent pending) to apply Ozonation for the large scale treatment of commodities.

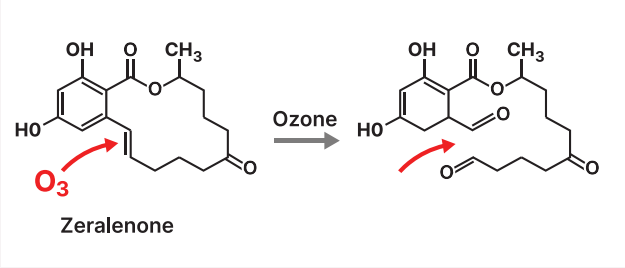
Principle of oxidation of Mycotoxins in the TOXI-SCRUB® reactor



AFLATOXIN B1 – Aflatoxins exist in different structures, but the toxic isomers in cereals all have a double bond that Ozone can attack. The resulting molecules may be different, but none are recognised as toxic. The main reaction shown creates a nontoxic double Aldehyde.



DON or VOMITOXIN – Oxidative detoxification studies showed the transformation of DON to less toxic compounds, namely, de-epoxy DON and 3-keto-DON.

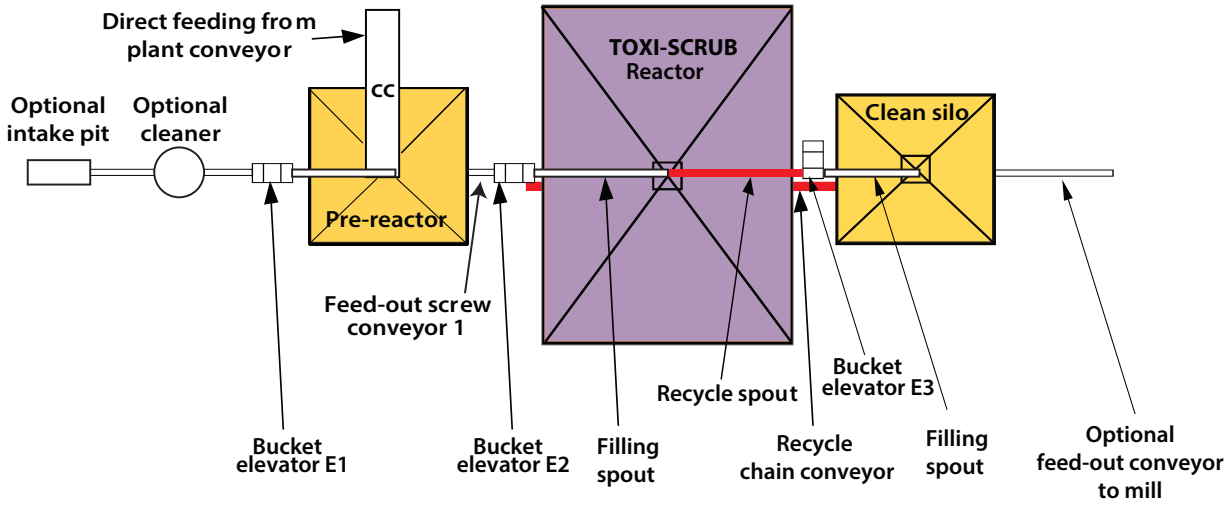


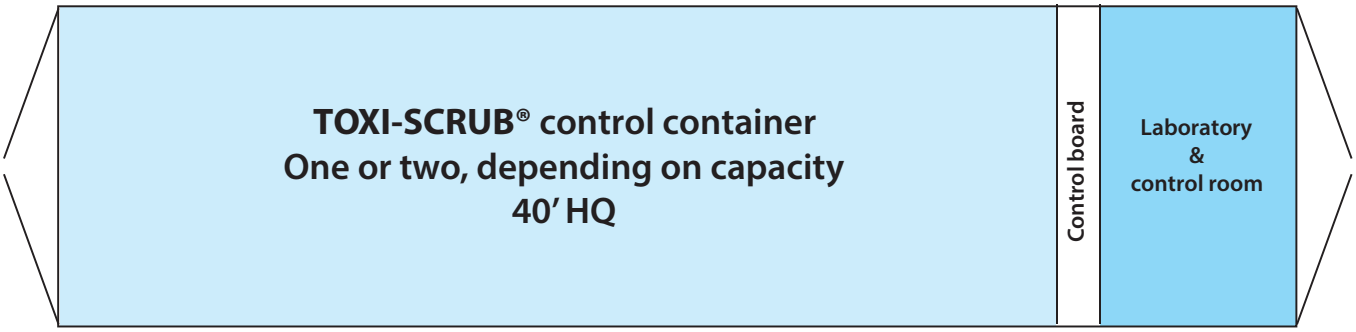
ZEN or ZEARALENONE – Oxidative biotransformation of ZEN results in less toxic compounds, namely, alpha Zearalenol, beta Zearalenol or an Aldehyde.

TOXI-SCRUB® Processing line design

Equipment in a typical processing line, as illustrated below.

- Integration with existing material handling, joint design
- Commodity cleaning, typically a drum cleaner or other suitable cleaner supplied by **TOXI-SCRUB®**
- **TOXI-SCRUB®** reactor unit where the main ozonation process occurs
- **TOXI-SCRUB®** reactor (Patent pending) unit where the main ozonation process occurs
- Bucket elevator for lifting commodity to the buffer silo after decontamination capacity: up to 80 tons
- The control container(s) are pre-assembled in the factory in Denmark with the complete Ozone generation system and the complete control system, for easy on-site installation
- Final configuration depends on decontamination needs and application





Aerial view of a **TOXI-SCRUB®** detoxification line – not to scale.

TOXI-SCRUB® application range

The **TOXI-SCRUB®** can be used in a variety of different applications. We design the processing equipment to fit into existing material handling systems, and in most cases, several different commodities can be treated in the same **TOXI-SCRUB®**, if required.
We have developed applications for the following commodities and applications:

General grain storage applications

- Detoxification after intake – for long and safe storage
- Detoxification before delivery – to ensure Mycotoxin regulations are met
- Detoxification of all Mycotoxins
- Complete eradication of all insects, fungus, mites, bacteria etc.

Flour mills

- Detoxification of DON (Vomitoxin) and Aflatoxin in wheat
- Complete eradication of grain weevils

Maize flour mills

- Detoxification of Aflatoxin, Ochratoxin and Trichothecenes (DON, T-2, etc.)
- Complete eradication of grain weevils

Feed mills

- Mycotoxin detoxification of all incoming raw materials
- Oilseed meal detoxification – especially Aflatoxin
- Detoxification of final pellets also possible
- Complete eradication of salmonella and other bacteria

Nut processing

- Mycotoxin detoxification of contaminated nuts
- Application both after intake and before delivery
- Treatment before packaging for consumption

TOXI-SCRUB® Treatment capacities of different commodities

Commodity	TOXI-SCRUB® Capacity
Grains Maize (corn), wheat, oat, rye, barley, rice	5 – 40 tons/hour
Oilseed Soybean, sunflower	5 – 20 tons/hour
Oilseed meal Peanut, soybean, palm, cottonseed	10 – 20 tons/hour
Nuts Peanuts, cashews, pistachios	1 – 2 tons/hour

TOXI-SCRUB® – Design

The **TOXI-SCRUB®** processing line is designed to decontaminate Mycotoxins in the most efficient way. More than 10 years of R&D has led to the design of the patent pending **TOXI-SCRUB®**. **TOXI-SCRUB®** is a complex system of processing equipment adaptable to various applications. The core of the system is the pre-reactor and the main reactor where the ozonation (decontamination) process takes place.

This **TOXI-SCRUB®** can decontaminate 10 tons of commodity per hour. Packaging machines optional.

Maize

Soybean

Coffee

Cocoa

Nuts

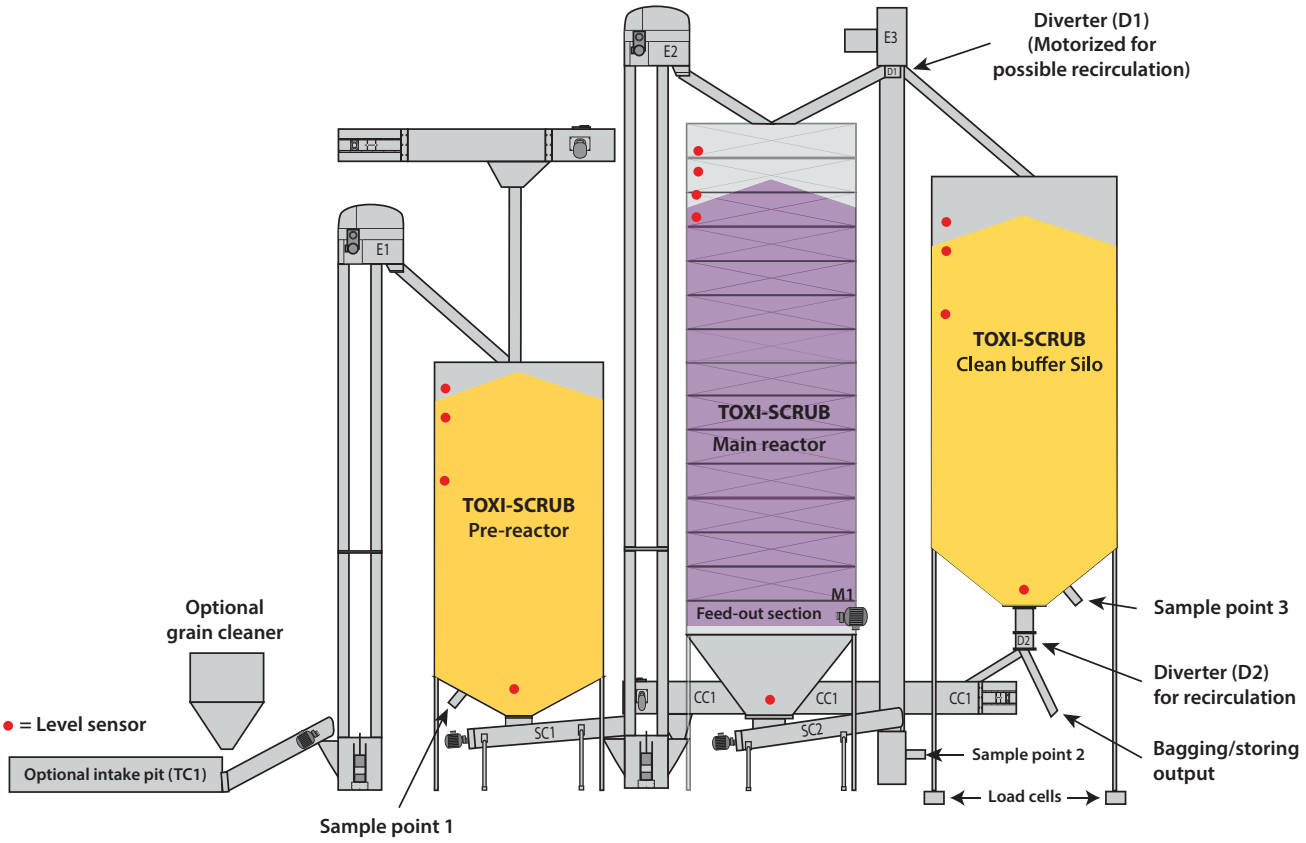
Barley

TOXI-SCRUB® Layout

The treatment principle of the **TOXI-SCRUB®** processing line is based on a special flow process, where the incoming commodity is repeatedly treated through several technological steps in order to decontaminate ("scrub") the commodity of Mycotoxins.

The **TOXI-SCRUB®** processing line is an ALL-IN-ONE design comprising:

- Intake pit (optional)
- Incoming dirty buffer silo – pre-reactor
- **TOXI-SCRUB®** Ozone reactor
- Outgoing clean buffer silo
- Including all material handling equipment
- **TOXI-SCRUB®** control board
- Laboratory equipment
- **TOXI-SCRUB®** Ozone generation systems in one or two 40' HQ containers:
  - Air compressor with air filtration
  - Air storage tank with filter
  - Refrigerated air drier with filter and condensate drain
  - Molecular sieve to produce pure Oxygen for the Ozone generator
  - Ozone generator
  - Water chiller (may be put on the roof of the container upon installation)



Cross-section view of the TOXI-SCRUB® processing line and the associated material handling

TOXI-SCRUB® at a glance

The entire handling and decontamination process is monitored and controlled automatically by the **TOXI-SCRUB®** control board (Siemens PLC/HMI touch screen computer). The entire processing line can be controlled by one person, and it may be monitored remotely via the mandatory connection to the internet or LAN.

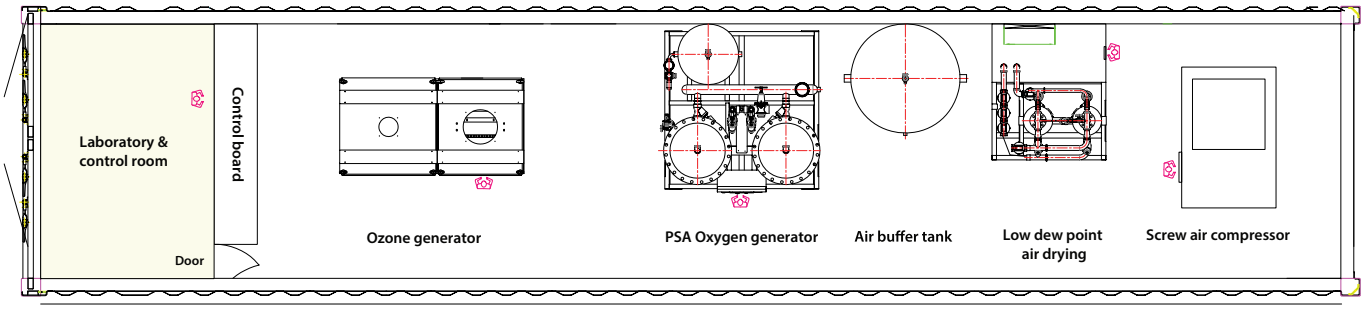
For efficient decontamination, the throughput is adjustable via the HMI control panel: high throughput can be selected for low input contamination, whereas heavily infested commodities require longer ozonation in the reactor, so a lower throughput should be selected.

Incoming and outgoing commodity must be monitored for moisture, impurities and Mycotoxin levels frequently – ideally every 30 to 45 min. – in order to obtain optimum throughput. For that purpose, the control container is also equipped with Ozone analysers and Mycotoxin laboratory equipment.

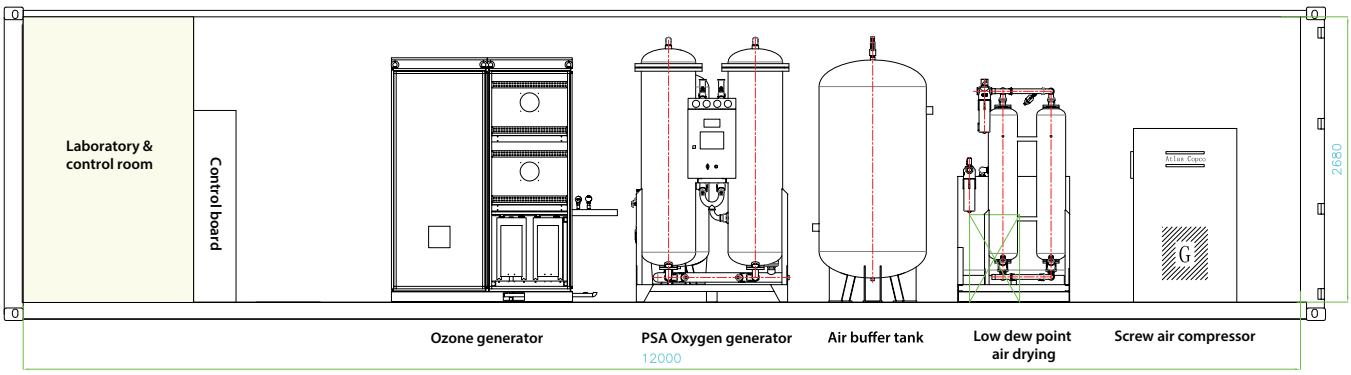
The Ozone generation system and the control board for material handling are delivered in a 20' or 40' HQ container, pre-assembled and ready to commission. On-site installation requires a solid concrete foundation for the full processing line and the control containers.

When selecting the appropriate capacity for a
TOXI-SCRUB® processing line, both the storage capacity and the commodity must be considered.

The **TOXI-SCRUB®** laboratory in Copenhagen, Denmark can analyse contaminated samples to assess the ideal decontamination capacity and suggest the most suitable **TOXI-SCRUB®** model.



Aerial view of the control container



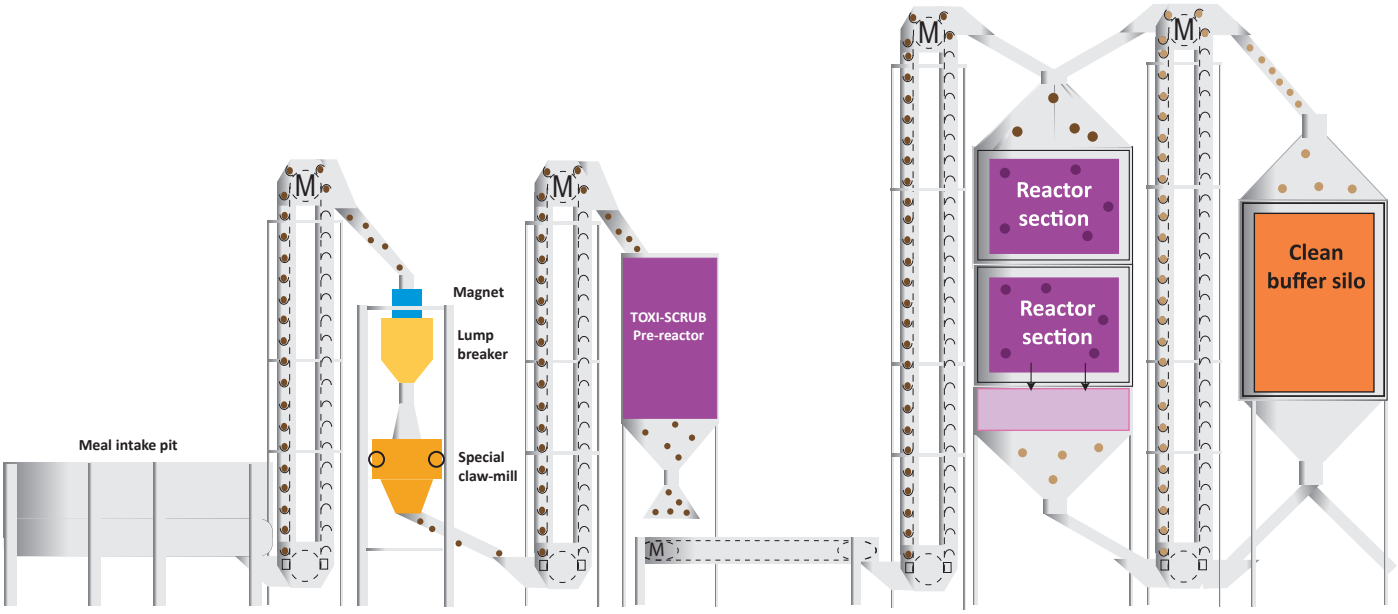
Cross-section view of the control container

Detoxification of oilseed meal

Meal is the residual product in oil mills. The meal is very nutritious because of the high concentration of protein and lipids, and it is used in feed mills as an important feed ingredient in all types of animal feed. Yet because the meal is so nutritious and moist, fungi also thrive immediately after oil extraction. This often leads to very high Mycotoxin concentrations in the meal. High Mycotoxin concentrations decrease the value of the meal and are a problem for both the oil mill selling the meal and the feed mill buying the meal.

TOXI-SCRUB® offers a special solution to this problem. The solution involves two additional milling steps to break the meal down to the correct size to make it fit for passage through the **TOXI-SCRUB®** reactor. These milling steps are crucial to ensure a successful decontamination.

TOXI-SCRUB® application for decontamination of oilseed meal



Oilseed meal may come in a variety of different sizes depending on the oil extraction process used

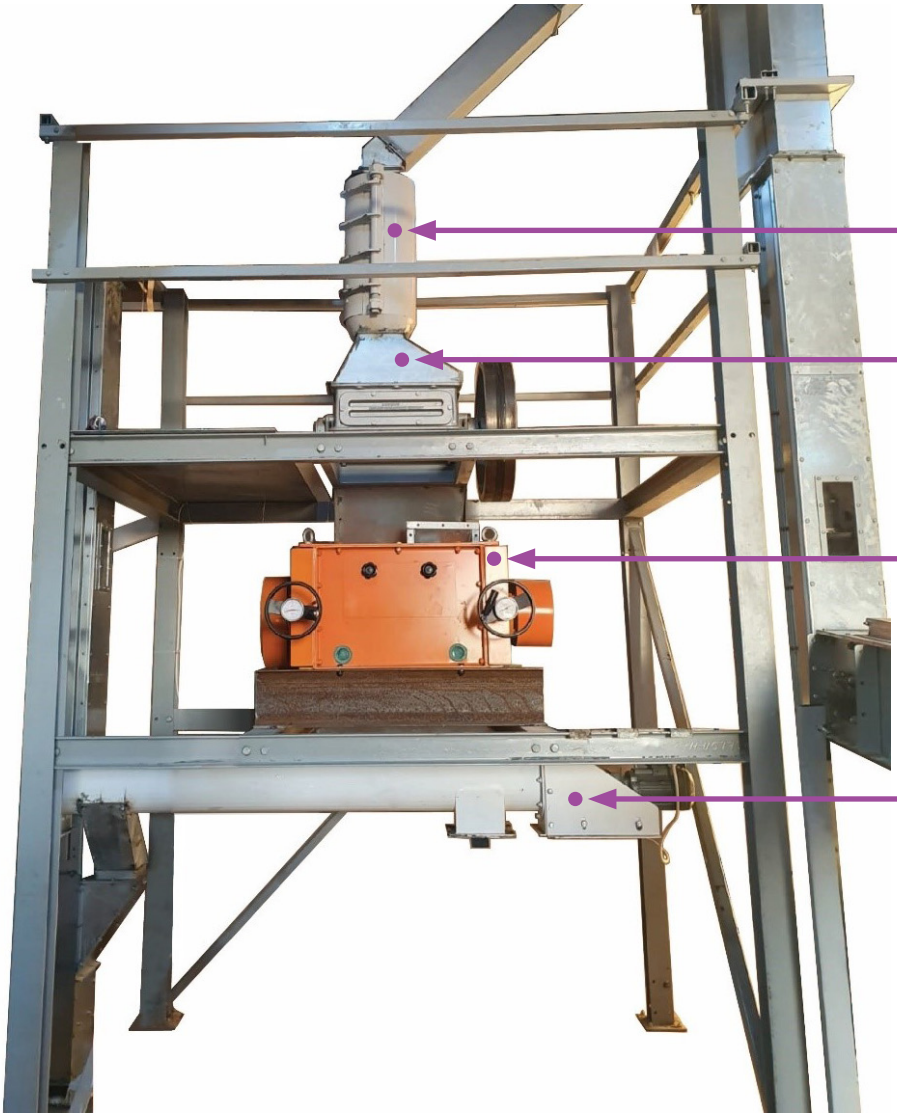
TOXI-SCRUB® oilseed line design

Although the steps of meal processing are simple, the mill design developed by **TOXI-SCRUB®** is advanced.

The intake pit is convenient for delivery of contaminated oilseed meal. Conveyers take the meal to the special meal milling tower (See picture).

The intake pit, where all meal can be delivered regardless of chunk size

TOXI-SCRUB® meal milling tower



Process magnet to trap any metal parts in the meal

Lump breaker

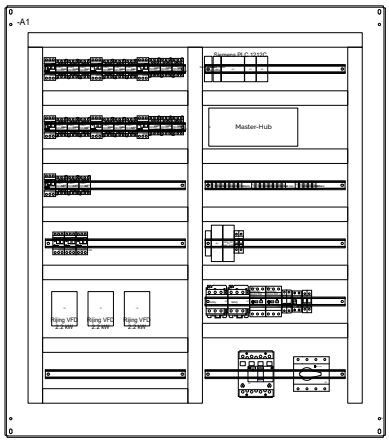
Special TOXI-SCRUB® claw mill

Screw conveyer to transport the meal to the decontamination reactor

PLC control system

The complete **TOXI-SCRUB®** detoxification line has a central control board in the combined laboratory and control room in the 40' HQ container. From here, the complete Ozone generation system, the **TOXI-SCRUB®** Reactor and the material flow through the system is monitored and controlled. A powerful Siemens S7 PLC unit and SCADA software enabling an overview of the entire processing line form the heart of the system.

The entire processing line can be controlled by one person and may be monitored remotely via the mandatory connection to the internet. Control from a remote control room on-site can also be enabled. The line may be started or stopped only from the container control room.



Container section with Ozone generator board and control panel

The **TOXI-SCRUB®** control software is easy to operate because it is fully menu-driven. The user can select the operational mode required:

- **Start:** filling of the reactor and starting of the ozonation process
- **Detoxification** mode
- **Recirculation** process mode, if decontamination was incomplete
- **Stop:** finalising of the process and emptying of the reactor and buffer silos

Advanced process control

The **TOXI-SCRUB®** processing line includes advanced process control of the automatic material handling including the 7 – 12 conveyors and the correct flow of the commodity through the reactor to the decontaminated buffer silo.

The detoxification process requires advanced process control as it involves many inputs/outputs and complex multi-parameter computing. The process is automatically controlled by the PLC and can be followed on the HMI screen or remotely.

The automatic process control makes it easier to optimise throughput if contamination levels in the intake fluctuate. Based on input from sample testing, the detoxification throughput can be adjusted manually. Regular measurement of the Mycotoxin level of incoming and outgoing commodity ensures that throughput can be optimised while staying below the desired Aflatoxin/Mycotoxin target concentration thresholds.

Molecular Oxygen seive

Freeze dryer and drying columns

Compressor

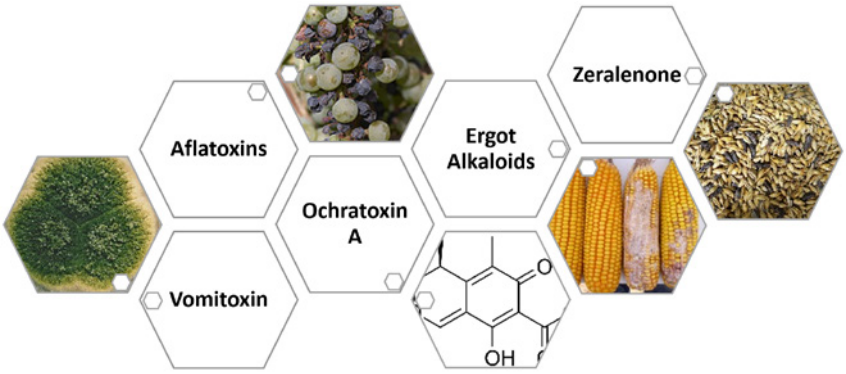
Process support

To secure the best operational support, a diagnostic program can check the control system. It is also possible to receive additional online support from the **TOXI-SCRUB®** Service Center in Copenhagen – via the same service platform that services 500+ clients with silo monitoring systems, Chillers or Nitrogen Generators from the **iGRAIN®** organisation.

Mycotoxins and their toxic effects

The term Mycotoxin is derived from the Greek mykes: "fungus" and toxikon: "poison".

While several hundred individual Mycotoxins have been identified, about a dozen of these – found in food and known to have severe adverse effects on human and animal health – have gained the most attention. The most commonly observed Mycotoxins posing a risk to the health of humans and livestock are Aflatoxins, Ochratoxin A, Fumonisins incl. Zearalenone (ZER) and Nivalenol/ Deoxynivalenol (DON), and Ergot Alkaloids.



- **Aflatoxins** are amongst the most poisonous Mycotoxins and are produced by certain moulds (Aspergillus flavus and Aspergillus parasiticus) that grow in soil, decaying vegetation, hay and grains. Crops frequently affected by Aspergillus spp. include cereals (corn, sorghum, wheat and rice), oilseeds (soybean, peanut, sunflower- and cottonseed), spices (chili peppers, black pepper, coriander, turmeric and ginger) and tree nuts (pistachio, almond, walnut, coconut and Brazil nut).
- **Ochratoxin** is produced by several species of Aspergillus and Penicillium and is a common food-contaminating Mycotoxin. Contamination of food commodities such as cereals and cereal products, coffee beans, dry vine fruits, wine and grape juice, spices, and liquorice, occurs worldwide. Ochratoxin A is formed during the storage of crops and is known to cause several toxic effects in animal species.
- **Fumonisins** are toxins produced by Fusarium fungi common to soil and include a range of different toxins, including Trichothecenes such as Deoxynivalenol (DON or Vomitoxin), Nivalenol (NIV) and T-2 and HT-2 toxins, as well as Zearalenone (ZER). The moulds and toxins form on a variety of different cereal crops, and different Fusarium toxins are associated with different types of cereal. Both DON and ZER are often associated with wheat, T-2 and HT-2 toxins with oats, and Fumonisins with maize.
    - **DON** can be acutely toxic to humans, causing rapid irritation of the skin or intestinal mucosa and leading to diarrhoea. Reported chronic effects in animals include suppression of the immune system.
    - **ZER** has been shown to have hormonal, estrogenic effects, and high intake levels can cause infertility, particularly in pigs. Fumonisins have been related to oesophageal cancer in humans, and to liver and kidney toxicity in animals.
- **Ergot Alkaloids** are compounds produced as a toxic mixture of Alkaloids in the Sclerotia of certain species of Claviceps that commonly affect various grass species. The ingestion of Ergot Sclerotia from infected cereals, commonly in the form of bread produced from contaminated flour, causes ergotism (St. Anthony's Fire). Modern mechanical methods of grain cleaning have significantly reduced ergotism as a human disease, however it remains a significant veterinary problem.

TOXI-SCRUB® technical specifications

Model	TS-02	TS-05	TS-10	TS-20	TS-30	TS-40
Capacity	2 tons/hour	5 tons/hour	10 tons/hour	20 tons/hour	30 tons/hour	40 tons/hour
Commodity	Nuts or beans	Grains or beans	Grains, oilseed or meal	Grains, oilseed or meal	Grains	Grains
Pre-cleaning – Drum cleaner	Optional					
Pre-cleaning – Sigma cleaner	Optional					
Intake pit 2×2 meters with elevator	Optional					
Conveying capacity	5.9 tons/hour	9.8 tons/hour	11.6 tons/hour	14.7 tons/hour	18.4 tons/hour	23.6 tons/hour
Height	6 m	8 m	10 m	13 m	16 m	18 m
Capacity pre-reactor (holding)	1-2 tons/hour	5 tons/hour	10 tons/hour	20 tons/hour	30 tons/hour	40 tons/hour
Screw conveyer	Included					
Bucket elevator capacity	4 tons/hour	10 tons/hour	16 tons/hour	30 tons/hour	40 tons/hour	60 tons/hour
TOXI-SCRUB® Ozone reactor	Included					
Material	Stainless steel ANSI 304					
Weight	6 tons	10 tons	20 tons	40 tons	60 tons	80 tons
Dimensions (L x W x H)	3.0 × 1.4 × 4.5 m	3.0 × 1.4 × 5.7 m	3.0 × 2.3 × 6.8 m	3.0 × 2.3 × 9.8 m	3.4 × 2.3 × 12.6 m	3.4 × 2.3 × 14.8 m
Bucket elevator – Reactor out	Included					
Height	6 m	8 m	10 m	13 m	16 m	18 m
Height of discharge outlet above ground level	0.80 m	0.80 m	1 m	1 m	1 m	1 m
Screw conveyer	Included					
Chain conveyer (recycle)	Included					
Power consumption	16 kW	54 kW	134 kW	188 kW	266 kW	330 kW
Containers supplied	1 × 20’	1 × 40’	1 × 40’	1 × 20’ & 1 × 40’	2 × 40’	2 × 40’
Estimated treatment cost per ton*	10–14 USD	7–9 USD	6–8 USD	5–7 USD	4–6 USD	4–5 USD

*** Depending on e.g., electricity costs, labour costs, quality of incoming grain, cost of test strips etc. Content of the table is subject to change without notice.**

The above specifications are for reference and subject to change depending on application, commodity type, commodity condition, climate etc. Each **TOXI-SCRUB®** processing line comes with a detailed project description for the application it is intended for.

Monitoring and
control of grain silos

Removal of Aflatoxin
and other Mycotoxins

Safe storage of crops
with cooling

Safe storage of crops
with nitrogen

Manufacturer

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