

# Clean Air Technology

## Clean Air Technology for Landfill Gas Engines

Advanced Emission Reduction  
System Exceeds Landfill Directive  
Regulations

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# Landfill Directive/ The Challenge

The Landfill Directive sets out stringent emissions limits for landfill gas engines. The technologies currently available are complex, requiring regular maintenance, filters, chemicals and additives.

[www.crystaltechnica.com/crystalair](http://www.crystaltechnica.com/crystalair)

Reduce NOx, Co and VOCs

Reduce land-fill site emissions

Increase generating capacity on high emission sites

Provide a highly efficient solution for sites requiring more stringent emissions quality

# The Challenge/ The Answer

Co-generation Retro-fittable Controllable

Crystal-Air's™ patented technology uses an innovative and highly efficient process to reduce emissions to levels significantly lower than its competitors.

NOx, CO and VOCs are reduced to negligible levels, particulate matter is virtually eliminated.

No filters, no moving parts, no operator intervention.

## Controllable

Crystal-Air™ has a central computerised control system which can be integrated into any engine management system.

This allows for on-site and remote monitoring and management of the system.

## Retro-fittable

Crystal-Air™ is fully retro-fittable on existing engines and configurations, no modifications to the engine are required.

## Co-generation

Crystal-Air™ is available with co-generation option to generate power from the heat it produces, increasing efficiency and profitability.

# Gas Analysis/ Results

## Diesel Engine

### Without Crystal-Air™

Fuel Type	Diesel Oil		
Air Temp	17°C	16°C	16°C
Gas Temp	218°C	94°C	103°C
O2	15.2 %	18.4 %	18.8 %
CO2	4.3 %	1.9 %	1.6 %
CO	1250 ppm	1250 ppm	1280 ppm
NO	376 ppm	220 ppm	181 ppm
NO2	72 ppm	95 ppm	82 ppm
NOx	448 ppm	315 ppm	263 ppm

### With Crystal-Air™

Fuel Type	Diesel Oil		
Air Temp	17°C	17°C	17°C
Gas Temp	761°C	702°C	832°C
O2	18.2 %	18.1 %	19.2 %
CO2	2.1 %	2.1 %	1.3 %
CO	1 ppm	1 ppm	1 ppm
NO	76 ppm	80 ppm	48 ppm
NO2	7 ppm	3 ppm	3 ppm
NOx	83 ppm	83 ppm	51 ppm

Test data, not indicative of individual configurations

## Landfill Directive Emission Requirements for Landfill Gas Engines

### Engines Commissioned 1998-2005

### Engines Commissioned after Dec 05

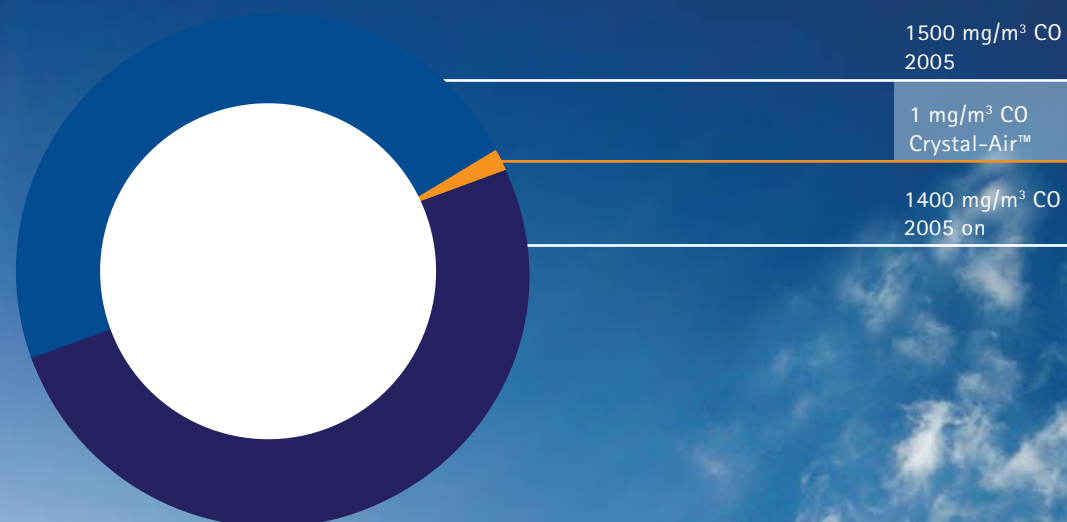
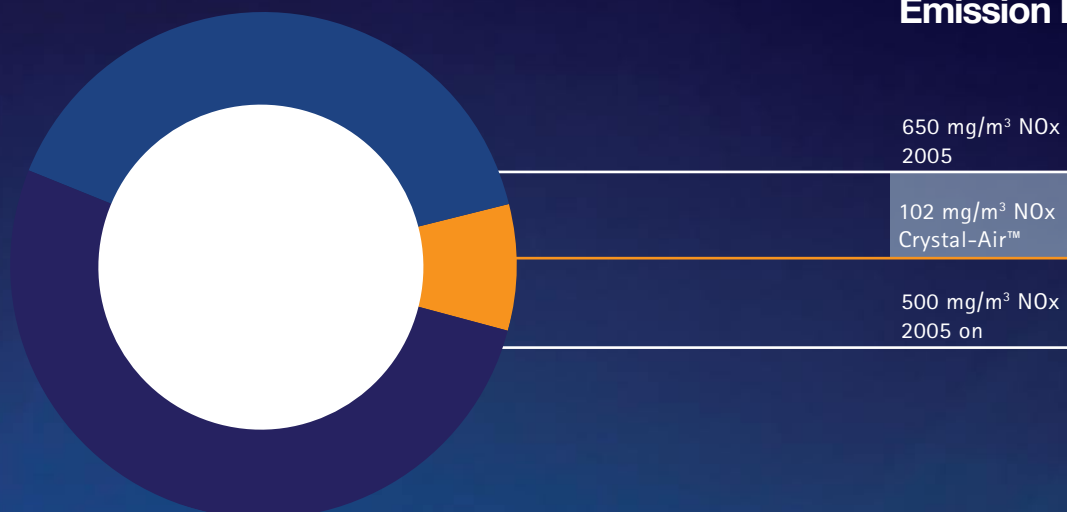
### Crystal-Air™

	ppm	mg/m <sup>3</sup>		ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
NOx	316	650	NOx	243	500	51	102
CO	1200	1500	CO	1120	1400	1	1

Guidance for monitoring landfill gas engine emissions, Environment Agency 2004



## Landfill Directive Emission Requirements



All conversions using Environment Agency formula:

$$\text{mg/m}^3 = \text{ppm} \times \frac{\text{molecular weight}}{22.4}$$

# air

# Sequential/ System

## Sequential Chamber System

Crystal-Air™ is a sequential chamber system; a series of external combustion chambers that reduce pollution.

### 1. Mixing Chamber

Air and fuel are mixed as they enter the chamber. The mixed gases rotate longitudinally down the chamber. The rotation causes the combining gases to dwell longer in the chamber.

### 2. Combustion Chamber

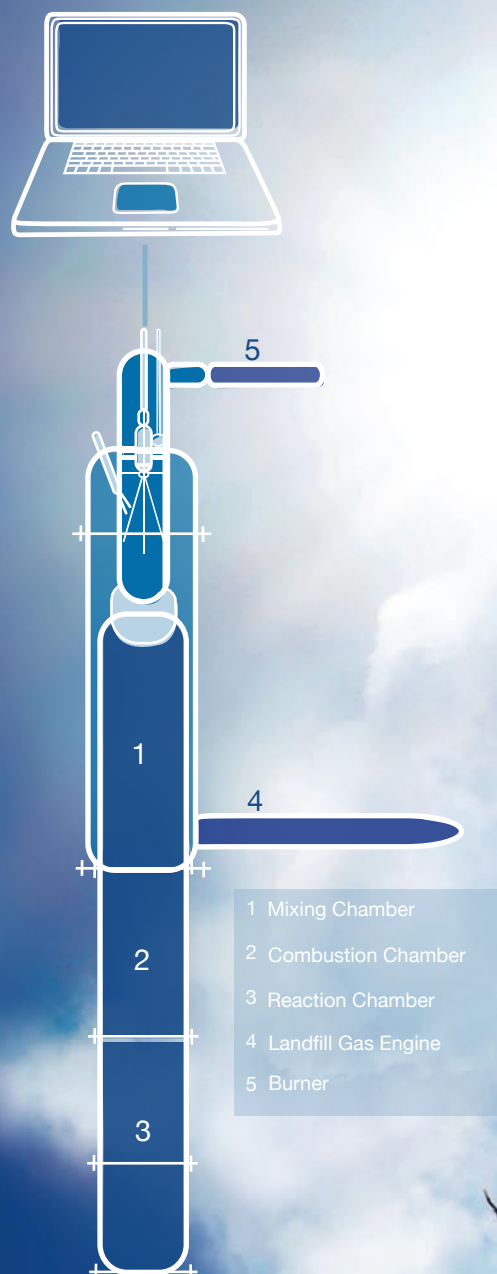
As the combusting gases enter this chamber there is sufficient oxygen for continual and intense combustion. This is the chamber where the majority of the heat is produced.

As the gases reach the exit end of the combustion chamber the oxygen content in the chamber has been significantly reduced.

### 3. Reaction Chamber

The gases are now starved for oxygen because most of the available oxygen has been used up combusting all carbon and hydrocarbons in the previous chamber.

Heat and water are the main by-products. The gases exhausted out of this chamber contain incredibly low levels of NO<sub>x</sub> and CO. NO<sub>x</sub> levels can be reduced by a further 50% with the addition of a urea/ammonia dosing module. Virtually no particulate matter is produced.



# Selective/ Reduction

Selective Non-catalytic Reduction

The inside of the Crystal-Air™ combustion chamber burns between 815°C and 1204°C, depending on fuel and air settings. The operation of this type of chamber is such that in the hottest zone is in the middle of the chamber. It is hot enough to break down all compounds that flow into this super heated zone. The super-heated zone is caused by two or more (patented) helical stators on the inside of the combustion chamber tube.

The helical stators cause the gases to slow down and rotate while passing through the combustion chamber and are therefore delayed in what is known as "dwell time." The dwell time, at the operating temperature inside the chamber, is long enough to cause total combustion of all organic compounds. Time and temperature both play a significant part in how much of the pollution will be reduced. On the other side of the super heated zone the gases are cooled sufficiently to reform again into compounds. Water is one of the components that reforms from the combustion gases.

The system is dynamic and can function between approximately 34% to 100% fuel input to the chambers – this is a true variable fuel system and not an "On-Off" operation.

Crystal-Air™ is highly energy efficient in that the majority of all of the fuel injected into the combustion chamber is consumed; with heat and water some of the main by-products. The conversion of fuel to heat produces the required temperatures for re-burning the engine exhausts. Furthermore, Crystal-Air™ chambers have no moving parts and require no maintenance.

Crystal-Air™ will be mated to the engine exhaust port and the exhaust will be directed into the combustion chamber.

There is over 50% less NOx and CO in the exhaust stream compared to the amounts that enter the Crystal-Air™ chamber from the engine. A further 50% reduction can be achieved using the additional urea/ammonia dosing module.

Crystal-Air™ requires some fuel for operation which can be the same as the fuel used by the engine. In proportion to the amount of fuel being used by the engine, the Crystal-Air™ fuel requirements are very small.

Perhaps Crystal-Air™ seems too good to be true. This is a real Selective Non-catalytic reduction system that has already been built, "proof of concept" tested and measured, and found to exceed expectations.



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**No Filters  
No Moving Parts  
No Operator Intervention**

**Long Life  
Retro-Fittable  
Cost-Effective Solution**