Product Introduction
Ceramic Fiber Filter

- **Replace Traditional Filter Bag**: Compatible with standard bag filter design concepts.
- **High Temperature & Corrosion Resistance**: Better performance than traditional filter bag.
- **Long Lifetime**: Longer lifetime than Traditional filter bag.
- **Three-in-One low emission design**: Integration design system meets requirement of low emission and operation cost.
- **Thermal Recovery**: After removal of dust & acid, the clean exhaust can improve the value of thermal recovery.

(Without Catalyst)  
(With vanadium titanium Catalyst)  
(With Vanadium titanium tungsten Catalyst)
Clean Air Technology Ltd (FLKCAT) is an innovative manufacturer of ceramic fiber filter for monitoring and controlling air pollution (dust removal, acid gas removal, catalyst filter for NOx and dioxin removal etc.).

Based in Taiwan, FLKCAT is a wholly privately owned enterprise, employing the experienced ceramic filtration specialists who have been active in the business for many years.

FLKCAT manufacture three product lines: T-01-3000 (Bi-Functional Ceramic filter) and M-01/02-3000 (Multi-Functional ceramic catalyst filter).
<table>
<thead>
<tr>
<th>File No.</th>
<th>Effective date</th>
<th>Description of Certificate</th>
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<tr>
<td>I579480</td>
<td>2016/05/19</td>
<td>METHOD FOR STRENGTHENING CERAMIC FIBER FILTER TUBE AND STRENGTHENED CERAMIC FIBER FILTER TUBE</td>
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<tr>
<td>M531544</td>
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<td>M529558</td>
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<td>HIGH TEMPERATURE EXHAUST GAS TREATMENT EQUIPMENT</td>
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<td>M530924</td>
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<td>M534301</td>
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<td>M535785</td>
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<tr>
<td>M542029</td>
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<td>DEVICE HAVING FUNCTIONS OF HIGH TEMPERATURE WASTE GAS TREATMENT AND HEAT ENERGY RECYCLING FOR METALLURGY INDUSTRY</td>
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<td>M539026</td>
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<td>M542115</td>
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<td>WASTE GAS TREATMENT DEVICE FOR CEMENT, BRICK AND TILE KILN-USING INDUSTRIES</td>
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<td>CN206950991U</td>
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<td>BE USED FOR DECOMPOSING FINE CHIMNEY FILTER OF POTTERY OF GETTING RID OF DIOXIN</td>
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<td>CN207169295U</td>
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<td>I641693</td>
<td>2018/02/07</td>
<td>COKE OVEN FLUE GAS DE-DUSTING, DE-SULFURIZATION, DE-NITRIFICATION INTEGRATED EQUIPMENT</td>
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<td>M574209</td>
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<td>REMOVAL of PARTICULATE and NITROUS OXIDE INTEGRATED EQUIPMENT</td>
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Jointed announcement of MIIT and MOST of People’s Republic of China Catalogue of major environmental protection technology equipment encouraged by the state (2017 edition)

<table>
<thead>
<tr>
<th>Item</th>
<th>Name</th>
<th>Key Technology and Main technology indicators</th>
<th>Application range</th>
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<tr>
<td>1</td>
<td>High temperature composition filter for removing dust and decomposing NOx integration device</td>
<td>Key technology: Develop composition technology of catalyst and filtration media; Low temperature catalyst and filtration media integration technology; Technology of filtration film on composition filter surface; Technology of installing filter and reverse jet. Technology indicators: Application temperature range 250°C-450°C; Emission parameters: Dust ≤10mg/Nm³; Lowest limit: 5mg/Nm³; NOx≤50mg/Nm³; Meet the environment requirement of state’s standard.</td>
<td>Coking、Glass furnace、Biomass furnace、Refuse incinerator、Non ferrous metal melting、Industrial furnace、High temperature industrial furnace</td>
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</table>
The ceramic fiber filters are directly installed on the plate of dust collector and can be operated under high temperature. The solid structure provides high filtration efficiency and stability under long-run use.

Assist to DeSOx: Use dry & semi-dry FGD and variety of Alkali sorbent, such as Sodium Hydroxide (NaOH) or Calcium Hydroxide (Ca(OH)$_2$) to remove acid gas (SO$_2$, HCl, HF...). Ceramic filter can be regarded as a DeSOx reactor. The surface of filter is full of Lime cake to increase the reaction efficiency.

Operating Temp.: 750°C
Instant Peak Temp.: Below 900°C
### Specification

<table>
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<th>Code</th>
<th>Description</th>
<th>Unit</th>
<th>Measurement</th>
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<tr>
<td>A</td>
<td>Element outer diameter</td>
<td>mm</td>
<td>150</td>
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<tr>
<td>B</td>
<td>Element inner diameter</td>
<td>mm</td>
<td>110</td>
</tr>
<tr>
<td>C</td>
<td>Flange outer diameter</td>
<td>mm</td>
<td>195</td>
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<tr>
<td>D</td>
<td>Flange height/thickness</td>
<td>mm</td>
<td>30</td>
</tr>
<tr>
<td>E</td>
<td>Element length</td>
<td>mm</td>
<td>3000</td>
</tr>
<tr>
<td>F</td>
<td>Element filtration area</td>
<td>m²</td>
<td>1.4</td>
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</table>

(1) The length of element can be customized.
Material properties

- High porosity
  - Porosity ratio: 65 ~ 85%
  - Low density of 0.4 g/cm³
  - Heat & shock resistance
    (Not impact of thermal expansion and contraction)
- High removal efficiency comes from very fine ceramic fiber (about 2-3 microns in diameter)
- Chemically almost inert
- High temperature resistance
- Rigid Structure

- One-piece Construction
  - Self-supporting / No need of frame
  - Cylinder
  - The basic material consists of aluminum silicate fiber and inorganic adhesive
Filtration mechanism of ceramic filter tube

1. Pre-Coating – Calcium Hydroxide Ca(OH)₂
2. Residual layer- Penetrate into the wall of 1~2 mm. Prevent particle from penetrating into the wall of tube to improve filtration efficiency.
3. Formed particle layer (Particle cake)- Reverse jet washes down particle layer.
4. High filtration efficiency – Wide processing range of particle size. The filtration level is HEPA class.

图(1) 图(2)
Traditional bag filter is flexible material. Reverse jet will inflate the bag to fall the particle layer. This inflation could allow the particle to penetrate the bag filter.

Because of the rigidity of ceramic tube and keeping residual layer in the wall, the filtration efficiency will be improved.

Compare to traditional bag filter, the service life is much longer.
### Operating Drop Pressure Control

- **In room temperature**, the drop pressure value of new ceramic filter element will be approx. 500Pa at filtration velocity 1.2m/min.
- **Between temp. 300-350°C**, the drop pressure of cleaning target will be approx. 2000Pa at filtration velocity 1.2m/min.
- The drop pressure in use depends on cleaning parameters, gas composition, gas temperature and filtration property of the particle.
- As for the efficiency of particulate filtration, the typical emission condition is lower than the standard working condition 5mg/Nm³, usually less than 2mg/Nm³.
M-01/02-3000–With catalyst

**M-01/02-3000**

**Removal of:**
- Particulate
- Acid Gas
- Nitrogen Oxides
- Dioxin

1. Not only dust, but also the acid gas (SO$_2$, HCl, HF...) can be removed by injection of alkali sorbent, Ammonia /urea added to gas stream to remove nitrogen oxides (Nox).

2. Catalyst distributed throughout filter element structure to accelerate removal of nitrogen oxides reaction.

3. The optimal operating temperature for M-01 (V-Ti-W type catalyst): 250-400°C · Maximum: 420 °C.

   The optimal operating temperature for M-02 (V-Ti type catalyst): 250-330°C · Maximum: 350 °C.

   $4\text{NO} + 4\text{NH}_3 (\text{Ammonia}) + \text{O}_2 \rightarrow 4\text{N}_2 + 6\text{H}_2\text{O}$

   $4\text{NO} + 2(\text{NH}_2)_2\text{CO} (\text{Urea}) + \text{O}_2 \rightarrow 4\text{N}_2 + 4\text{H}_2\text{O} + 2\text{CO}_2$
The distribution of catalyst on the ceramic fiber filter

- Catalyst distributed evenly throughout element wall and the contact area is wide, so the reaction time and removal efficiency are maximized.

- The left image is the nanol-catalyst particles, increasing the active surface area and reaction efficiency.

Electron microscopic (SEM) amplification
Avoid Catalyst Failure / Dry DeSOx

- Due to the formation of dust cake on the surface of the filter element, catalyst is protected against the poisons such as arsenic (As), selenium (Se) and mercury (Hg).
- Catalyst distributed throughout filter element avoid dust clogging.
- As the catalyst distributed throughout ceramic filter element, the lifetime of catalyst can be longer. The residence time will be long and maintain high efficiency of performance.
- The even distribution of catalyst helps to improve the efficiency of reaction.
- In order to reduce ABS, the Pre-spray can use dry DeSOx.
Catalyst – Removal Efficiency of Dioxin

Cheng-Shiu University
Dioxin Removal Efficiency
Test datum

Overall Removal Efficiencies

Overall Removal Efficiencies

- F0
- F1
- Removal Effi.

The total temperature of PCDD/F Toxicity equivalent concentration (I-TEQ Nm⁻³) and its removal efficiency graph

Note: TEQ (Toxic Equivalents Quantity): Toxic Equivalent Quantity is used to calculate the total toxicities of dioxin compounds in media such as soil, air, water, organisms and food. The sum of the concentrations of the dioxins homologues multiplied by the sum of the toxicity equivalents represents the total toxic equivalent of 2,3,7,8-TeCDD. I-TEQ: including 7 kinds of dioxin and 10 kinds of furan, used for environmental pollution equivalent calculation.
Catalyst are not only used to remove NOx, but also can remove the dioxin. Under the reaction of vanadium-based catalyst, the reaction of dioxin and oxygen will be decomposed into CO₂, H₂O, HCl and other non-toxic substances.

The formula of removal of dioxin's reaction:

\[
C_{12}H_nCl_{8-n}O_2 + (9+0.5n)O_2 \rightarrow (n-4)H_2O + 12CO_2 + (8-n)HCl
\]

The disadvantage of activated carbon are as follows,

1. Activated carbon requires expensive spray device. The removal efficiency is affected by fluctuation of feeding work.
2. Activated carbon will absorb dioxin and just transfer to the fly ash. The total emission of dioxin do not decrease.
3. The adsorption efficiency and specific surface area of activated carbon are closely related to the degree of mixing flue gas. It's difficult to control the process and stability.
4. Fly ash contain dioxin and need to be sent to the waste plant for secondary treatment
5. It's possible that the existing carbon will cause spontaneous combustion inside the dust collector
6. Basically dioxin are just absorbed by activated carbon and they are unable to decompose, so the workers are in dangerous working environment.
Pollutant Removal Efficiency

Performance of Catalyst Ceramic Filter

Pollutants to treat in one stage:
- Particulates
- HCl
- SOx
- NOx
- Dioxins

Injection of alkali sorbent (lime or sodium bicarbonate)
Injection of ammonia/urea and support air

Less than 5 mg/Nm³ outlet particulates
- Up to 97% HCl removal
- Up to 95% SOx removal
- Up to 95% NOx removal

Multi-Pollutant Control

Note: The removal efficiency depends on graininess, purity, quantity and reaction time of additive.
System Design and Engineering
(1) A lot of ash is produced
(2) ABS blockage and blinding
(3) Slip-NH$_3$ increased
(4) Catalyst life is shortened
(5) DeNOx efficiency is reduced

(1) Not easy to maintain
(2) Open Channel
(3) High energy consumption
(4) Easy to corrode

(1) Wastewater treatment & sludge (CaSO$_4 \cdot 2$H$_2$O)
(2) Corrode (tower, equipment, pipe)
(3) Energy consumption (water, heat, electric power (mixer, pump, fan etc.))
Ammonium sulfates are formed when the NH$_3$ content of the flue gas exceeds that of the sulfur (SO$_3$).
Simple System
ALL IN ONE

- Urea/Ammonia
- Lime
- 320~350℃
- Ceramic Filter
- Pollutants to treat in "ONE" stage:
  1. SOx
  2. NOx
  3. Particulates
- Advantage:
  1. Simple system
  2. Reduced running costs
  3. Excellent performance
- Heat Recovery:
  1. Energy saving
  2. Corrosion reduction
  3. Ash reduction

- WHB
- Stack

- Furnace Tail Gas or WHB
- Dry FGD
- Reactor
- Catalyst Ceramic Filter
- WHB Stack

- Benefits:
  - Reduce catalyst failure: ABS↓
  - Energy saving: Heat recovery
  - No wastewater: dry/semi DGD
The explanation of installing Catalyst Ceramic Filter

1. Sem-Dry scrubber and atomizer are no more needed. The temperature will be higher and the corrosion of post process can be improved.
2. Increasing a injector of dry NaHCO₃
3. Catalyst ceramic filter can help to remove acid gas and particle and decompose NOₓ and Dioxin.
4. A heat recovery device can be installed after filter.
## Applications – City Refuse Incineration Plant

<table>
<thead>
<tr>
<th></th>
<th>Catalyst Ceramic Filter</th>
<th>Bag Filter</th>
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<tbody>
<tr>
<td><strong>De-dioxin</strong></td>
<td>Catalyst direct decomposition</td>
<td>Activated carbon adsorption</td>
</tr>
<tr>
<td></td>
<td></td>
<td>toxic waste in fly ash</td>
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<tr>
<td><strong>Dust removal efficiency</strong></td>
<td>&lt; 5mg/Nm$^3$ (normal &lt;2mg/Nm$^3$)</td>
<td>10~20mg/Nm$^3$</td>
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<tr>
<td><strong>Operational pressure</strong></td>
<td>180~230$^\circ$C</td>
<td>130~140$^\circ$C near the dew point (corrosion)</td>
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<tr>
<td><strong>Heat resistance</strong></td>
<td>Max.350$^\circ$C</td>
<td>Max.260$^\circ$C</td>
</tr>
<tr>
<td><strong>Benefit</strong></td>
<td>X Activated carbon</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>X Dioxin fly ash</td>
<td></td>
</tr>
<tr>
<td></td>
<td>○ Heat recovery</td>
<td></td>
</tr>
<tr>
<td><strong>Life</strong></td>
<td>Potential for long life (&gt;5 years)</td>
<td>Only 1.5~3 years</td>
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</table>
Cleaning in Ceramic Filter Element

Filter can be cleaned using CDA reverse flow (backwash)

- CDA: eliminates the oil / water / dust
- Pulse pressure: 4~6 kg/cm²

Influence factors of backwash system:

- system pressure, operating pressure drop, position of pulse
- nozzle use of cleaning aids such as venturi, peak pulse pressure, period of pulse etc.
The injected NOx reducing agent, ammonia, reacts with the acid gases in the flue gas forming ammonia salts, i.e. \((\text{NH}_4)_2\text{SO}_4(\text{ABS}) \cdot \text{NH}_4\text{HSO}_4\)°.

Below the dew point ammonia and sulphuric acid condenses as liquid ammonium bisulphate(ABS), in the catalyst filter which inhibits the performance°.
Key Markets and Advantage
Key Markets, such as

- Glass Furnaces
- Cement Production
- Boiler
- Gasification Processes
- Soil Remediation
- Ship/Harbor APC

- Catalyst/HM Recovery
- Waste Incineration
- Metal smelting
- Power plants & WHB
- Product Collection

- Expired Ammunition Incinerator
- Waste Liquid Incinerator
- RDF Power Plant Melting Furnace
- Sludge Incinerator Lime Kiln
Applications and Case Studies
### Glass Furnaces Tail Gas -- CSYP, China, 2015/2016

#### Emissions and Performance Requirements

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<th>Plant #1 550t/d</th>
<th>Plant #2 600t/d</th>
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<td>NG 天然气</td>
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<td>70000</td>
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<td>Dust (inlet)</td>
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<tr>
<td>Dust (outlet)</td>
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<td>≤30</td>
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<tr>
<td>NOx (inlet)</td>
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<td>≤2500</td>
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<td>NOx (outlet)</td>
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<td>DeNOx Eff.</td>
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<td>Slip NH₃</td>
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<td>3</td>
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<tr>
<td>H₂O, vol%</td>
<td>10</td>
<td>10</td>
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<tr>
<td>O₂, vol% wet</td>
<td>8.3</td>
<td>8.3</td>
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<td>Temp.</td>
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<td>SOx (inlet)</td>
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<td>SOx (outlet)</td>
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<tr>
<td>DeSOx Eff.</td>
<td>≥92.5</td>
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</table>

**Note:** All values are in the context of standard temperature and pressure conditions. Vol% refers to volume percentage.
Applications - Glass Furnaces, TSYP China

Glass Furnaces Tail Gas -- TSYP, China, 2015

Plant #1
(catalyst ceramic filter applied, 2015)

Plant #2 (not applied)
Applications - Glass Furnaces, CSYP China

Glass Furnaces Tail Gas –
CSYP 3# Gas flow 68000 Nm³/h, China, 2016
CSPY 1# Gas flow 68000 Nm³/h, China, 2017

Ceramic Filter & Stack
Ceramic Filter Reactor
WHB

Ammonia Storage Tank
After improvement – 270 tubes/cell × 4 cells

Applications – Waste Incineration Plant
Super Max Engineering TAIWAN

Air pollution control system

Super Max Engineering TAIWAN

Lime Slurry
Cooling Water

<table>
<thead>
<tr>
<th>检测结果</th>
<th>建筑比例</th>
<th>检测方法</th>
<th>分析样品编号</th>
<th>检测值</th>
<th>标准值</th>
<th>合格率</th>
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<td>平均值</td>
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Yearly production 2.2 million tons coking dust removal, desulfurization and denitrification integration unit, CHINA, 2017 – Operation
Yearly production 2.2 million tons coking dust removal, desulfurization and denitrification integration unit, CHINA, 2019 – Under construction

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
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<td>Tail gas parameters</td>
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<td>Gas Temp.</td>
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<tr>
<td>Gas flow</td>
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<tr>
<td>SO₂</td>
<td>mg/Nm³</td>
<td>100</td>
</tr>
<tr>
<td>NOₓ</td>
<td>mg/Nm³</td>
<td>650</td>
</tr>
<tr>
<td>O₂</td>
<td>%</td>
<td>11</td>
</tr>
<tr>
<td>H₂O</td>
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<td>10</td>
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<tr>
<td>CO₂</td>
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<td>Chimney</td>
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<td>Out gas limits</td>
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<tr>
<td>SO₂</td>
<td>mg/Nm³</td>
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<td>NOₓ</td>
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### Tail gas parameters

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<tr>
<td>Gas Temp.</td>
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<tr>
<td>SO₂ content</td>
<td>mg/Nm³</td>
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<td>NOₓ content</td>
<td>mg/Nm³</td>
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<td>g/Nm³</td>
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### Out gas limit

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<tr>
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<tbody>
<tr>
<td>SO₂ content</td>
<td>mg/Nm³</td>
<td>35</td>
</tr>
<tr>
<td>NOₓ content</td>
<td>mg/Nm³</td>
<td>50</td>
</tr>
<tr>
<td>Particle content</td>
<td>mg/Nm³</td>
<td>10</td>
</tr>
</tbody>
</table>

**Applications – Biomass Power Plant in Shandong**

- 130 tons biomass dust removal, desulfurization and denitrification integration unit, CHINA, 2018
Applications - Sludge Incinerator (CFB), Japan

Turbocharged Fluidized Bed Incinerator (new generation system)
Conclusions

- Verified technology
- Has been applied for more than 10 years
- Excellent performance
- Reduced total costs of ownership
- Scalable technology to suit your needs
- Long life of product
- Technical back up from first class team
- Lower capex, opex & energy cost
~ THE END ~

THANK YOU!

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