GENERAL PRESENTATION

AIR POLLUTION CONTROL SOLUTIONS
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Fives, a trusted partner to many leading industrial segments

Fives, an industrial engineering Group, designs and supplies machines, process equipment and production lines for the world’s largest industrial players. Its multisector offer is presented through 18 business lines.

Breakdown of sales by geographical area:

- Asia / Oceania: 22%
- The Americas: 32%
- Europe / Africa / Middle-East: 14%

Breakdown of sales by end market:

- Automotive: 16%
- Logistics: 32%
- Metals: 13%
- Aerospace and industry: 16%

A worldwide network of subsidiaries

- Expert teams located worldwide
- Renowned expertise in international project management

Services, to ensure performance during the life time of your installation

We believe that understanding our clients’ operations is the best way to offer them customized service solutions that will increase their return on investment.

Denis Bouteille
Group Service Director

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Fives, an extensive experience in Air Pollution Control Technologies

AIR POLLUTION CONTROL ACTIVITY

$1 to 200 million project range  Around 150 employees  14+ target industries

FRANCE  CANADA  USA

1949  1982  1996
PARIS  MONTREAL  DENVER

PROVEN TECHNOLOGIES, WELL POSITIONED OVER THE AIR POLLUTION CONTROL MARKET

OUR SOLUTIONS

<table>
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<th>Dry Scrubbing</th>
<th>Hybrid Scrubbing</th>
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</thead>
<tbody>
<tr>
<td>Particulates, Ash</td>
<td>+ Fabric Filter</td>
<td>+ Fabric Filter</td>
<td>+ Fabric Filter</td>
</tr>
<tr>
<td>SO₂, SO₃, HCl, HF</td>
<td>Reagents injection</td>
<td>Reagents injection</td>
<td>Reagents injection</td>
</tr>
<tr>
<td>Tars, Mercury (Hg)</td>
<td>+ Activated Carbon</td>
<td>+ Activated Carbon</td>
<td>+ Activated Carbon</td>
</tr>
<tr>
<td>Dioxins, Furans</td>
<td>+ Wet Scrubber + Cyclone</td>
<td>Catalytic bags or SCR</td>
<td>Catalytic bags</td>
</tr>
<tr>
<td>NOₓ</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCN, H₂S, COS, NH₃</td>
<td></td>
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</tr>
</tbody>
</table>

OUR MARKETS

WASTE & BIOMASS
- Gasification / Syngas
- Incineration

LIME
- Horizontal Kilns
- Vertical Kilns

CEMENT
- Kilns
- Alkali by-pass
- Raw mill
- Finish mill
- ESP conversions
- Clinker cooler

ALUMINIUM
- Electrolysis Pots
- Anode Baking Furnace
- Green Anode Plant
- Secondary casthouse

OTHER MINERALS
- Calciners
- Process Kilns
- Furnaces

OTHER INDUSTRIES
- Coal
- Boilers
- Brick
- Proprieters
- Steel
- Iron Ore
- Pet Coke
- Glass

500+ Installed Systems  45+ Countries

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Dedusting Solutions

Fives’ dust control solutions consist in proprietary baghouse filters, designed by our engineers to remove particulates out of air or gas generated by from industrial or combustion processes. We have more than 60 years of experience designing and manufacturing bag filters, for the renowned players of the industry. This extensive expertise allows us to provide the most reliable and efficient systems on the market.

SONAIR™
- Bag filter system equipped with bags up to 5 meters length
- High pressure pulse cleaning technology
- High efficiency at an economical cost
- Uniform leading of the whole filter surface
- Lateral gas flow distribution onto bags

TGT® FABRIC FILTER
- Bag filter system using long bags (6, 8, 10 + meters)
- Low pressure pulse cleaning technology
- Very high efficiency
- Compact footprint
- Process stability using adaptive “online” cleaning sequence

Fives was the first to develop this long bag technology to the cement market more than 20 years ago and has become the industry benchmark for high efficiency particulate removal equipment.

The Sonair™ Filter has been used for the last decades in many applications and remain a very reliable and proven baghouse technology for specific applications.
ESP CONVERSION

ESP or Electrostatic Precipitators are considered obsolete by most Air Pollution Control experts. Their lower efficiency and high CAPEX made them disappear from the dust control companies’ catalogs. As the particulates emission regulation are becoming more and more stringent, many industrials that already have ESPs installed need to add a second filtration system (ESP, baghouse filter…) to comply with the emission requirements.

Fives offers a complete service of ESP conversion into a baghouse filter with many relevant advantages:
- Considerable increase in particulate and dust removal efficiency
- Reduce the upgrade costs
- Footprint optimization
- Access to Fives’ large range of after sales services
Fives’ Dry Scrubbing solutions consist in combining reagent injection systems with a proprietary bag filter to control a wide range of pollutants. The main pollutant removal takes place in our Venturi reactors. Formed around the bags, the filter cakes provide a secondary stage of scrubbing to achieve very high efficiencies.

**TGT-RI® FABRIC FILTER**
- Reactor integrated inside the filter module
- Optimal distribution of the reagent (only alumina) and the gases
- Highly efficient
- Only used in the aluminium industry
- Perfectly adapted for GTCs with high requirements (gas flowrates up to 2,500,000 Nm³)
- Suitable in all climate conditions

**OZEOS**
- Very large capacity filter
- Baghouse filter with improved integrated low velocity reactor
- Integrated reactor for compact footprint
- Enhanced alumina handling with external recirculation
- Dramatically reduced gas velocity inside the filter
- Longer bag life
- Fives Engineered Sustainability brand

**Comparison with benchmark technologies**
Optimum balance between compact design and performance
- +30% Enhanced bag life
- -5% electrical consumption in GTC
- -20% HF emissions

**Venturi Reactors | Reagent injection**
- Dry powder reagent injection
- Reaction device for intimate contact between acid gas and reagent
- Operates with low pressure drop
- Recycled material handles peaks in acid gas

1. Humidified recycled reagent
2. Hot, dry flue gas
3. Cooled, humidified flue gas
Dry-Scrubbing Solutions

ALL-DRY SCRUBBING SYSTEM (AD™)

- This Dry Scrubbing system combines a reagent injection system and a proprietary venturi reactor with a TGT® or Sonair™ filter to collect particulates and reacted reagent
- All-Dry scrubber: bag filter + reagent injection system + Venturi Reactor
- Pollutant neutralization in the Venturi Reactor
- Cost effective solution
- The filter cake on the bags provides a secondary stage of scrubbing

Pollutants removed:
Particulates, ash, SO₂, SO₃, HCl, HF, mercury, dioxins/ furans, heavy metals, VOCs

ENHANCED ALL-DRY SCRUBBING SYSTEM (EAD™)

- The Enhanced All-Dry (EAD™) scrubbing system combines an All-Dry with a reagent recirculation loop that includes our proprietary Conditioning Drum for increased SO₂ scrubbing efficiency
- Enhanced All-Dry Scrubber: bag filter + reagent injection system + Venturi reactor + reagent recirculation loop + Conditioning Drum
- Pollutants neutralization in the Venturi Reactor
- The Conditioning Drum is the key feature of the EAD™ scrubbing process
- Higher scrubbing efficiency and optimized reagent consumption
- The filter cake on the bags provides a secondary stage of scrubbing

Pollutants removed:
Particulates, ash, SO₂, SO₃, HCl, HF, mercury, dioxins/ furans, heavy metals, VOCs
SOLIOS CONDITIONING DRUM

The Conditioning Drum is an essential feature of the EAD™ Scrubbing Process. This proven equipment, developed from extensive testing, enhances the acid gas removal efficiency of the conventional All-Dry Scrubbing Process.

Operating principle of Enhanced All-Dry Scrubbing

- Use a high rate of reagent recirculation
- Recycled reagent is humidified in a Conditioning Drum by water fog nozzles
- Humidified recycled reagent mixture is injected in the reactor
- Water is quickly evaporated cooling the inlet gas by 20°C to 50°C for optimized neutralization temperature
- Flash cooling of reagent due to evaporation favors the reaction of SO₂ with lime.

AD-NOx™ SYSTEM

- AD™ + Catalytic bag filter + ammonia/urea injection system
- NOx control within the All-Dry Scrubber
- No SCR needed to achieve the DeNOx
- Important CAPEX reduction
- The catalytic filter elements neutralize the NOx and capture the particulates and the reagent
- Efficient for control of multiple pollutants

EAD-NOx™ SYSTEM

- EAD™ + catalytic bag filter + ammonia/urea injection system + heat exchanger
- NOx control within the Enhanced All-Dry Scrubber
- No SCR needed to achieve the DeNOx
- Higher scrubbing efficiency and optimized reagent consumption
- The catalytic filter elements neutralize the NOx and capture the particulates and the reagent
- Efficient for control of multiple pollutants
Dry-Scrubbing Solutions

<table>
<thead>
<tr>
<th>Efficiency</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO₂ removal efficiency</td>
<td>&gt;99%</td>
</tr>
<tr>
<td>HCl/HF removal efficiency</td>
<td>&gt;99%</td>
</tr>
<tr>
<td>NOₓ removal efficiency</td>
<td>&gt;99%</td>
</tr>
<tr>
<td>Water discharge</td>
<td>0</td>
</tr>
<tr>
<td>Treated air flow</td>
<td>10K to 2M Nm³/h</td>
</tr>
<tr>
<td>Particulate emissions</td>
<td>as low as 2 mg/Nm³</td>
</tr>
</tbody>
</table>

**HYBRID SYSTEM**

- Fives’ Hybrid System combines one of our dry scrubbing solutions to other technologies (cyclones, SCR, SNCR, wet scrubbers...) in the same process.
- A technology adapted to very demanding and stringent industries such as Waste-to-Energy and Syngas.
- The highest efficiency.
- Multi-pollutant control:
  - Particulates, ash, tar, SO₂, SO₃, HCl, HF, NOₓ, mercury, dioxin/furans, heavy metals, VOCs (Removed with zero water discharge).
  - HCN, H₂S, COS and NH₃.

Flexible and compact customized design

Optimized reagent and electrical consumption

High efficiency multi-pollutant control
Fives can supply or design several other solutions according to the needs of our projects, to perfectly meet our clients’ requirements:

— Injection systems
— Conditioning towers
— Wet Scrubbers
— SCR and SNCR
— Fans
— Oxidizers: Catalytic Oxidizers (CO), Regenerative Thermal Oxidizers (RTO), Thermal Oxidizers (TO)

TURNKEY PROJECT MANAGEMENT

— Detailed engineering
— Supply of key process equipment
— Project monitoring
— Installation supervision
— System commissioning

Fives ©

Other equipment

Services

OPERATION

— Project monitoring
— Remote monitoring
— Technical audit of your air pollution control installation
— Spare parts supply

EVOLUTION

— Upsizing of your installation
— EAD™ and AD™ retrofitting to re-use an existing dust collector
— Improvement of the cleaning capacities

OPTIMIZATION

— Bag cleaning process optimization
— Reagent and power consumption optimization

WASTE-TO-ENERGY AND GASIFICATION PROJECTS

2017
EAD™ - OUTOTEC RDF Gasifier - Barry, UK
EAD™ - OUTOTEC RDF Gasifier - Hull, UK
EAD™ - OUTOTEC RDF Gasifier - Boston, UK
2016
Hybrid ALL-DRY scrubber - Beauçon, France

1999
AD™-SONAIR™ - Dundee, Keewatin, Great Britain
AD™ - Chambers County - Simonds, U.S.A.
AD™ - LIPSION - Binhai, China
1998
AD™-TGT® Filter - TPL - Ravenna, Italy
AD™ - Terra Manresa, Spain
AD™ - Izasa Granne, Spain

ALUMINIUM PROJECTS

2017
CITIZENS-SONAIR™ - Albania - Manama, Bahrain
SONAIR™ - XINFA - Xinyuan, China
VIBRAIR-OZEOS - RUSAL - Tula, Russia
SONAIR™ - RUSAL - Volgograd, Russia
2014
SONAIR™ - RUSAL - Klinets, Canada
2013
SONAIR™ - SGL - Cheddie, France
OZEOS - RUSAL - Ima, Belgium, Canada
TGT-N®-SONAIR™ - MAADEN

1999
AD™-SONAIR™ - Dundee, Keewatin, Great Britain

1998
AD™-TGT® Filter - TPL - Ravenna, Italy
AD™ - Terra Manresa, Spain
AD™ - Izasa Granne, Spain

CEMENT PROJECTS

2017
TGT® - CIMENT-QUEBEC - St-Basile de Port-Neuf, Canada
TGT® - LIME KILN - GRAYMONT - Cogent, USA
2016
TGT® - LIME KILN - GRAYMONT - Pêve, USA
2015
TGT® - ARMSTRONG CEMENT - Cabot, USA

2012
TGT-R - KAZAKHSTAN ALUMINIUM - Pavlodar, Kazakhstan
2011
Oxidiser (RCO) - HINDALCO - Aditya, India
VIBRAIR - BOGUCHAR - Krasnoyarsk Region, Russia
TGT-R - VEDANTA BALCO - Chhattisgarh State, India
Oxidiser (RCO) - HINDALCO - Mahan, India

2010
TGT® - CEMENT-QUEBEC - St-Basile de Port-Neuf, Canada
TGT® - LIME KILN - GRAYMONT - Cogent, USA

MINERAL AND OTHER PROJECTS

2015
EAD™-TGT® - ST-GOBIAN - Bryant, USA
2011
EAD™-TGT® - ST-GOBIAN - Fort Smith, USA
2007
EAD™-TGT® - MORRIN TECH - Bigfork, USA
2006
EAD™-SONAIR™ - GENERAL SHALE 2 - Fendale, USA
2003
AD™-SONAIR™ - BORAL BRICK - Augusta, USA
2002
EAD™-TGT® - REDLAND BRICK - Pittsburgh, USA
2001
SONAIR™ - JÉRÈME RIEU-SUD QUEBEC - Lévis, Canada

Latest references
A global service network

Fives Solios Inc
625, President Kennedy Avenue
14th floor
Montreal (Quebec) H3A 1K2 - CANADA
Tel.: +1 514 284 0341 - Fax: +1 514 284 1326

Fives Solios
66 route de Sartrouville
Parc les Erables - Bât 4
78230 Le Pecq - FRANCE
Tel.: +33 1 30 87 45 50 - Fax: +33 1 30 87 45 55

Fives Solios Corp
625, President Kennedy Avenue
6860 S. Yosemite Ct.
Suite 2204
Centennial, CO 80112 - UNITED STATE
Tel.: +1 303 713 0222

fsi.airpollutioncontrol@fivesgroup.com
airpollutioncontrol.fivesgroup.com