AIR POLLUTION CONTROL SOLUTIONS

GENERAL PRESENTATION
# TABLE OF CONTENTS

- Fives Group Introduction ................................................................. 5
- Fives in Air Pollution Control ............................................................... 7
- Dedusting Solutions ........................................................................ 9
- Dry-Scrubbing Solutions ................................................................... 12
- Other Equipment ............................................................................ 20
- Services ........................................................................................... 20
- References ....................................................................................... 21
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**

- **$3,100** million of order intake
- **$197.7** million of EBITDA
- **$2,776** million of sales

**Breakdown of Sales by End Market**

- Automotive: 21%
- Logistics: 12%
- Metals: 20%
- Energy: 16%
- Aerospace and industry: 12%
- Cement: 3%

**Breakdown of Sales by Geographical Area**

- Europe: 37%
- Africa / Middle-East: 30%
- Asia / Oceania: 17%
- The Americas: 16%

**Additional Information**

- **$51.1** million spent on R&D
- **13%** of patents application relating to energy and environmental performance
- **2,169** patents in force

*Figures dated 2017*
Fives, an international organization

A WORLDWIDE NETWORK OF SUBSIDIARIES

8,700 employees
more than 100 operational subsidiaries and regional offices in about 30 countries

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

SAFETY, A DRIVER FOR OPERATIONAL EXCELLENCE

75% subsidiaries audited
67 HSE Professionals

SERVICES, TO ENSURE PERFORMANCE DURING THE LIFE TIME OF YOUR INSTALLATION

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

Figures dated 2017
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 POSITIONNED OVER THE AIR POLLUTION CONTROL MARKET

500+ Installed Systems
45+ Countries
MARKETS

WASTE & BIOMASS
- Gasification / Syngas
- Incineration

LIME
- Horizontal Kilns
- Vertical Kilns

OTHER MINERALS
- Calciners
- Process Kilns
- Furnaces

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 INDUSTRIES
- Coal
- Boilers
- Brick
- Proppants
- Steel
- Iron Ore
- Pet Coke
- Glass
The Solios Sonair™ Filter has been used for the last decades in many applications and remain a very reliable and proven baghouse technology for specific applications.
SOLIOS 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

The TGT® is a Fives Solios equipment

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.
Filtration Process

- Pulse jet cleaning valves
- Automatic filter bags cleaning according to filter’s differential pressure
- Automatic bag leakage detection system (row detection)
- High or low bag cleaning pressure
- Optimized for extended bag life
- Seam - sealed bags
- Fully welded tube sheets
- Very low can velocities by splitting inlet gas flow.

Bag Cleaning

- Compressed air pipe
- Gas with dust
- Wire cage
- Filter media
- Dust removal (Compressed air pulse)

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 particulate emission regulations 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
- Upgrade costs reduction
- Footprint optimization
- Access to Fives’ large range of after sales services
Dedusting Solutions Efficiency

10K to 2M Nm³/h

Treated gas flow

Max 850°C

Filtration Temperature

as low as 2 mg/Nm³

Particulate guarantee

0

Water discharge

Options & Safety Features

— ATEX (Explosion proof) Certification
— Completely airtight filter
— Nitrogen pulse cleaning
— Walk-in plenum or penthouse
— NFPA Compliance
Dry-Scrubbing Solutions

Solios 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.

**SOLIOS 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

The TGT-RI® is a Fives Solios equipment
SOLIOS OZEOS

- Very large capacity filter
- Baghouse filter with improved integrated low velocity reactor
- Integrated reactor for compact footprint
- Enhanced alumina handling with external recirculation
- Drastically 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

The OZEOS and Venturi Reactor are Fives Solios equipment
SOLIOS ALL-DRY SCRUBBING SYSTEM (AD™)

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

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

The AD™ is a Fives Solios dry-scrubbing system
SOLIOS ENHANCED ALL-DRY SCRUBBING SYSTEM (EAD™)

- The Solios Enhanced All-Dry (EAD™) scrubbing system combines an All-Dry with a reagent recirculation loop that includes our proprietary Conditioning Drum for increased SO\textsubscript{2} 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 Fives Solios 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, SO\textsubscript{x}, SO\textsubscript{3}, HCl, HF, mercury, dioxins/furans, heavy metals, VOCs.

The EAD™ is a Fives Solios dry-scrubbing system.
Dry-Scrubbing Solutions

SOLIOS CONDITIONING DRUM

The Solios Conditioning Drum is an essential feature of the Solios 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 Solios 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 $\text{SO}_2$ with lime.

The Conditioning Drum is a Fives Solios equipment
Dry-Scrubbing (DeNOx) Solutions

**SOLIOS AD-NOx™ SYSTEM**

- Solios 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

**SOLIOS EAD-NOx™ SYSTEM**

- Solios 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

The AD-NOx™ & EAD-NOx™ are Fives Solios dry scrubbing systems.
Dry-Scrubbing Solutions Efficiency

- >99% SO₂ removal efficiency
- >99% HCl/HF removal efficiency
- >99% NOx removal efficiency

- 0 Water discharge
- 10K to 2M Nm³/h Treated air flow
- as low as 2 mg/Nm³ Particulate emissions
SOLIOS HYBRID SYSTEM

— Solios’ 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

The Hybrid System is a Fives Solios dry-scrubbing system

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)

## Services

### OPERATION
- Project monitoring
- Remote monitoring
- Technical audit of your air pollution control installation
- Spare parts supply

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

### OPTIMIZATION
- Bag cleaning process optimization
- Reagent and power consumption optimization

### TURNKEY PROJECT MANAGEMENT
- Detailed engineering
- Supply of key process equipment
- Project monitoring
- Installation supervision
- System commissioning
**WASTE-TO-ENERGY AND GASIFICATION PROJECTS**

- **2017**
  - **EAD™** - OUTOTEC RDF Gasifier - Barry - U.K.
  - **EAD™** - OUTOTEC RDF Gasifier - Hull - U.K.
  - **EAD™** - OUTOTEC RDF Gasifier - Boston - U.K.

- **2016**
  - Hybrid ALL-DRY scrubber - Besançon, FRANCE.

**2016**

- **EAD™ - OUTOTEC RDF Gasifier - Hull** - U.K.
- **EAD™ - OUTOTEC RDF Gasifier - Boston** - U.K.

**2015**

- **Hybrid ALL-DRY scrubber - Besançon, FRANCE.**

**ALUMINIUM PROJECTS**

- **2017**
  - **OZEOS-SONAIR™** - ALBA - Manama, BAHRAIN.
  - **SONAIR™** - XINF - Xingyuan, CHINA.
  - **VIBRAIR-OZEOS** - RUSAL - Taishet, RUSSIA.
  - **SONAIR™** - RUSAL - Volgograd, RUSSIA.

- **2014**
  - **SONAIR™** - RTA - Kitimat, CANADA.

- **2013**
  - **SONAIR™** - SGL - Cheddé, FRANCE.
  - **OZEOS** - RTA - Jonquière, Quebec, CANADA.
  - **TGT®-RI®-SONAIR™** - MAADEN.

**2011**

- **Oxidiser (RCO)** - HINDALCO - Aditya, INDIA.
- **VIBRAIR** - BOGUCHANY - Krasnoyarsk Region, RUSSIA.

**2010**

- **Oxidiser (RCO)** - HINDALCO - Mahan, INDIA.

**CEMENT PROJECTS**

- **2017**
  - **TGT®** - CIMENT-QUEBEC - St-Basile de Port-Neuf, CANADA.
  - **TGT®** - LIME KILN - GRAYMONT - Cricket Mountain, USA.

- **2016**
  - **TGT®** - LIME KILN - GRAYMONT - Pilot Peek, USA.

- **2015**
  - **TGT®** - ARMSTRONG CEMENT - Cabot, USA.

**2012**

- **SONAIR™** - ROANOKE CEMENT - Roanoke, USA.
- **Conditioning Tower** - ASH GROVE CEMENT - Leamington, USA.

**2009**

- **TGT®** - CEMEX BALCONE - New-Braunfels, USA.
- **TGT®** - LEIGH EDMONTON - Edmonton, CANADA.

**MINERAL AND OTHER PROJECTS**

- **2015**
  - **EAD™-TGT®** - ST-GOBAIN - Bryant, USA.

- **2011**
  - **EAD™-TGT®** - ST-GOBAIN - Fort Smith, USA.

- **2007**
  - **EAD™-TGT®** - VIGINIA TECH - Blacksburg, USA.

- **2006**
  - **EAD™-SONAIR™** - GENERAL SHALE 2 - Fairdale, USA.

**2003**

- **AD™-TGT®** - BORAL BRICK - Augusta, USA.

**2002**

- **EAD™-TGT®** - REDLAND BRICK - Pittsburgh, USA.

**2001**

- **SONAIR™** - RÉGIE RIVE-SUD QUEBEC - Lévis, CANADA.
A worldwide presence