# TABLE OF CONTENTS

Fives Group Introduction ........................................................................................................ 5

Fives Solios, Air Pollution Control .......................................................................................... 7

Dedusting Solutions ................................................................................................................. 9
  Sonair™ Solution .................................................................................................................... 10
  TGT® Fabric filters Solution .................................................................................................. 10
  Bag Cleaning .......................................................................................................................... 11
  Efficiency ................................................................................................................................ 12
  Safety Features ....................................................................................................................... 12

Dry-Scrubbing Solutions ......................................................................................................... 13
  TGT-RI® Solution .................................................................................................................... 13
  OZEOS™ Solution .................................................................................................................... 14
  Aluminium Solutions | PFTS .................................................................................................... 15
  Aluminium Solutions | GTC ....................................................................................................... 15
  Aluminium Solutions | FTC ....................................................................................................... 16
  VENTURI Reactor ..................................................................................................................... 16
  All-Dry Scrubbing System ....................................................................................................... 17
  Enhanced All-Dry Scrubbing System ....................................................................................... 18
  Conditioning Drum ................................................................................................................... 19
  AD-NOx Solution ..................................................................................................................... 20
  EAD-NOx Solution ................................................................................................................... 20
  Catalytic Bags & Candle Filters ............................................................................................. 21
  Efficiency and Safety Features ............................................................................................... 21
  Hybrid Solution ....................................................................................................................... 22

Other Equipment .................................................................................................................. 23

Services .................................................................................................................................... 24

Turnkey Project Management ................................................................................................. 24

References ............................................................................................................................... 25

Technologies ........................................................................................................................... 26

# CONTACTS

**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**
Parc Les Erables - Bâtiment 4
66, route de Sartrouville
78230 Le Pecq (France)
Tel: +33 (0) 1 30 87 45 50
Fax: +33 (0) 1 30 87 45 55

**Fives Solios Corp.**
6860 S. Yosemite Ct.
Suite 2204
Centennial, CO 80112 (USA)
Tel.: +1 303-713-0222
www.apc.fivesgroup.com
FIVES, A TRUSTED PARTNER TO MANY LEADING INDUSTRIAL SEGMENTS

Fives develops proprietary technologies with high added value, high energy and environmental performance in 18 business lines.

- Aluminium Automation
- Cryogenics | Energy
- Combustion
- Tube and Pipe
- Sugar | Bio energy
- Piping Solutions
- Metal Cutting | Composites
- Induction
- Grinding | Ultras Precision
- Intralogistics
- Steel
- Glass

$2,119 million of sales
$138 million of EBITDA
$1,745 million of order intake

BREAKDOWN OF SALE BY END MARKET

- Automotive: 16%
- Logistics: 22%
- Energy: 32%
- Cement: 21%
- Aerospace and industry: 16%
- Energy Management: 13%

BREAKDOWN OF SALE BY GEOGRAPHICAL AREA

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

$43.7 million spent on R&D in 2015
2,032 patents in force
22% of patents application relating to energy and environmental performance

FIVES, AN INTERNATIONAL ORGANIZATION

A WORLDWIDE NETWORK OF SUBSIDIARIES

- 8,400 employees
- More than 100 subsidiaries and commercial offices in about 30 countries

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

SAFETY, A DRIVER FOR OPERATIONAL EXCELLENCE

- 79% Subsidiaries audited
- 58 HSE Professionals
- 13 million hours worked by Fives employees

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

Copyright © 2017 - Fives - All rights reserved.
FIVES SOLIOS
EXTENSIVE EXPERTISE IN AIR POLLUTION CONTROL TECHNOLOGIES

OFFICES IN THE WORLD

$1M to $200M
Around 150
More than 500
Project Range
Employees
Installed Systems

45+
Countries
14+
Target Industries

FRANCE
CANADA
USA

1949
1982
1996

PARIS
MONTREAL
DENVER

OUR 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
Gas Treatment Center on Electrolysis Pots
Fume Treatment Center on Anode Baking Furnace
Pitch Fume Treatment System in Anode Paste Plant

OTHER INDUSTRIES
Coal
Boilers
Brick
Propriants
Steel
Iron Ore
Pet Coke
Glass
Secondary metals

FIVES SOLIOS
PRODUCTS AND SERVICES

OUR SOLUTIONS

Gas Treatment Process

Dedusting
Dry Scrubbing
Hybrid Scrubbing

SONAR™
TGT®
CZEOS™
TGT-8™
AD™
AD-NOx™
AD-NOx™
Hybrid Systems

Pollutants

Particulates, ash
SO₂, SO₃
HCl
HF
Tars
Mercury (Hg) and other heavy metals
Dioxin / Furans
NOx
HCN, H₂S, COS, NH₃

+ Fabric Filter
Reagents injection
(hydrated lime, sodium bicarbonate, alumina...)
+ Activated carbon
Catalytic bags
+ Wet scrubber + cyclone

+ Fabric Filter
Reagents injection
(hydrated lime, sodium bicarbonate, alumina...)
+ Activated carbon
Catalytic bags or SCR

DEDUSTING SOLUTIONS

Five’s 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™ SOLUTION

- 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

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.

TGT® FABRIC FILTER SOLUTION

- 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.
DEDUSTING SOLUTIONS

FILTRATION PROCESS

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

BAG CLEANING

• 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.

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

EFFICIENCY

- 10K to 2M Nm³/h
- Treated gas flow
- 0
- Water discharge
- Max 850°C
- Filtration Temperature
- as low as 2 mg/Nm³
- Particulate guarantee

OPTIONS & SAFETY FEATURES

• ATEX (Explosion proof) Certification
• Completely airtight filter
• Nitrogen pulse cleaning
• Walk-in plenum or penthouse
• NFPA Compliance
Our 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 SOLUTION**

- 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 flow rates up to 2,500,000 Nm³)
- Suitable in all climate conditions

**OZEOS™ SOLUTION**

- 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** label

**PITCH FUME TREATMENT SYSTEM (PFTS) | Aluminium Solutions**

**Pitch Fume Treatment System** to capture the pitch fumes produced during the anode preparation

Fives’ conventional Pitch Fume Treatment System consists of a Dry Scrubbing unit using the coke fines readily available in the carbon plant to adsorb the pitch fumes. The system is derived from the potline alumina dry injection scrubbing technology.

The fines are injected at counter flow to the charged fumes inside a venturi reactor. Pitch fume loaded fines are then collected in the bag filter and are reintroduced into the anode paste recipe. The process does not cause any product loss.
**FUME TREATMENT CENTER SOLUTION (FTC) | Aluminium Solutions**

Fume Treatment Center to adsorb hydrogen fluoride and capture tars from the anode baking process

Fives provides Fume Treatment Centers (FTC) dedicated to anode baking furnace fume treatment. Following recent improvements, Fives now offers optimized next-generation FTCs.

Fives’ Fume Treatment Centers rely on a solid knowledge of the filtering process and technologies to preserve physical properties of alumina and reduce as much as possible fresh alumina feed rate.

Fives’ Fume Treatment Centers adapts to any operating specificities such as huge variations in terms of flowrate or temperature.

**GAS TREATMENT CENTER SOLUTION (GTC) | Aluminium Solutions**

Gas Treatment Center to treat fluorinated gas and dust emissions produced during the reduction process and to recycle fluorinated alumina in the electrolysis pots

As there is little process difference between treating fumes from anode baking furnace and gases from electrolysis pots, the F&GTC is quite similar to a traditional GTC. It is fitted with an additional filter for the additional flow, as well as with a few additional pieces of equipment to convey fumes from the anode baking furnace towards the treatment plant.

**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

**EXAMPLE WITH LIME REAGENT**

- Surface evaporation
- Gas temperature drop
- Increased humidity
- Recycled material handles peaks in acid gas
DRY-SCRUBBING SOLUTIONS

ALL-DRY SCRUBBING SYSTEM SOLUTION (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 SOLUTION (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
DRY-SCRUBBING SOLUTIONS

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.

DRY-SCRUBBING (DeNOx) SOLUTIONS

AD-NOx™ SYSTEM SOLUTION

- 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

CATALYTIC BAGS | CANDLE FILTERS

- 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 SOLUTION

- 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

Fives ©

Copyright © 2017 - Fives - Allrights reserved.

19

20
**DRY-SCRUBBING SOLUTIONS**

**DRY SCRUBBING SOLUTIONS EFFICIENCIES**

- **SO2 removal efficiency**: >99%
- **HCl/HF removal efficiency**: >99%
- **NOx removal efficiency**: >99%
- **Water discharge**: 0
- **Treated air flow**: 10K to 2M Nm³/h
- **Particulate emissions**: as low as 2 mg/Nm³

**HYBRID SYSTEM SOLUTION**

- Our 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
OTHER EQUIPMENT

• 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
  • Regenerative Thermal Oxidizers (RTO)
  • Thermal Oxidizers

SERVICES

OPERATIONS

• 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

TURNKEY PROJECTS MANAGEMENT

• Detailed engineering
• Supply of key process equipment
• Project monitoring

• Installation supervision
• System commissioning
REFERENCES

OUR LATEST PROJECTS

WASTE-TO-ENERGY AND GASIFICATION PROJECTS
- 2017. Besançon, FRANCE, Hybrid ALL-DRY
- 2016. Rossy, UNITED-KINGDOM, Octime RDP Garden 1 Q01
- 2016. Bury, UNITED-KINGDOM, Octime RDP Garden 2 AD
- 2016. Boston, UNITED-KINGDOM, Octime RDP Garden 2AD

ALUMINIUM PROJECTS
- 2017. Xinyuan, CHINA, XINFA. PFTS
- 2017. Volograd, RUSSIA, RUSAL. PFTS
- 2017. Volograd, RUSSIA, RUSAL. FTC
- 2014. Kitimat, CANADA, RTA. PFTS
- 2013. Chedde, FRANCE, SGL. PFTS
- 2013. Jonquière, Québec, CANADA, RTA. GTC
- 2013. Ras Al Khair, SAUDI-ARABIA, MAADEN ALUMINIUM. GTC
- 2012. East Coast, SAUDI-ARABIA, MAADEN ALCOA ALUMINIUM. PFTS
- 2012. Pavlodar, KAZAKHSTAN, KAZAKHSTAN ALUMINIUM. FTC
- 2011. Aditya 2, INDIA, HINDALCO. PFTS
- 2011. Krasnoyarsk Region, RUSSIA, BOGUCHANY. GTC
- 2011. Chhattisgarh State, INDIA, VEDANTA BALCO. GTC
- 2011. Aditya 1, INDIA, HINDALCO. PFTS
- 2011. Mahan, INDIA, HINDALCO. PFTS
- 2010. Messaied, QATAR. QATALUM. PFTS
- 2010. Messaied, QATAR, QATALUM ALUMINIUM. GTC
- 2009. Messaied, QATAR ALUMINIUM, FTC
- 2007. Point-Henry, AUSTRALIA, ALCOA ALUMINIUM. FTC
- 2007. Sohar, SULTANATE OF OMAN. SOHAR ALUMINIUM. FTC
- 2005. Manama, BAHRAIN, ALBA. FTC
- 2004. Sept-Iles, Québec, CANADA, ALLOUETTE. FTC

CELERITY PROJECTS
- 2016. Besançon, FRANCE, Hybrid ALL-DRY
- 2017. Barry, UNITED KINGDOM, Outotec RDF Gasifier. EAD
- 2017. Hull, UNITED KINGDOM, Outotec RDF Gasifier. EAD
- 2017. Boston, UNITED KINGDOM, Outotec RDF Gasifier. EAD

CEMENT PROJECTS
- 2015. Bryant, USA, ST-GOBAIN. TGT (EAD™)
- 2011. Fort Smith, USA, ST-GOBAIN. TGT (EAD™)
- 2009. Edmonton, CANADA, LEIGH EDMONTON. TGT
- 2009. Missisauga, CANADA, ST-LAWRENCE CEMENT. TGT
- 2008. Glenn Falls, CANADA, GLENS FALLS. CONDITIONING TOWER
- 2008. Paulding, USA, LAFARGE - PAULDING. TGT
- 2006. Virginia, USA, GRAYMONT PLEASANT GAP. EAD™
- 2003. Augusta, USA, BORAL BRICK. SONAIR (EAD™)
- 2002. Pittsburgh, USA, REDLAND BRICK. SONAIR (EAD™)
- 2001. Lévis, CANADA, RÉGIE RIVE-SUD QUEBEC. SONAIR
- 1998. Elgin, USA, TIFFANY BRICK. SONAIR (EAD™)

MINERAL AND OTHER PROJECTS
- 2015. Bryant, USA, ST-GOBAIN TGT (EAD™)
- 2014. Fort Smith, USA, ST-GOBAIN TGT (EAD™)
- 2013. Rockingham, USA, VIGRINIA TECH (EAD™)
- 2011. Blacksburg, USA, VIRGINIA TECH (EAD™)
- 2009. New Braunsell, USA, CEMEX BALCONES TGT
- 2009. Edgewater, CANADA, LEGH EDMONTON TGT
- 2009. Hirson, CANADA, ST-LAWRENCE CEMENT TGT
- 2008. Glen Falls, CANADA, GLENS FALLS. CONDITIONING TOWER
- 2008. Pulaski, USA, CEMENT-QUEBEC. TGT
- 2007. New-Braunfels, USA, CEMEX BALCONES TGT
- 2006. Fairdale, USA, GENERAL SHALE 2. SONAIR (EAD™)
- 2003. Augusta, USA, BORAL BRICK. SONAIR (AD™)
- 2002. Pittsburgh, USA, REDLAND BRICK. SONAIR (EAD™)
- 2001. Lévis, CANADA, RÉGIE RIVE-SUD QUEBEC. SONAIR
- 1998. Elgin, USA, TIFFANY BRICK. SONAIR (EAD™)
- 1997. Blacksburg, USA, VIRGINIA TECH (EAD™)

DRY SCRUBBING TECHNOLOGY

KEY CHARACTERISTICS AND BENEFITS

MULTI-INDUSTRY COMPLIANCE
- Cement and Minerals
- Aluminium
- Waste to Energy
- Syngas
- And 9 other industries

MULTI-POLLUTANT CONTROL
- Particulates (PM10, PM2.5, ash)
- Tars, slag and VOCs
- Acid gases: (HCl, HF, SO2, SO3)
- Mercury (Hg) and heavy metals
- Dioxin/furans
- NOx, NH3
- H2S, COS, HCN, NH3

CUSTOMER SERVICE
- Guaranteed High Efficiency
- On-line maintenance capabilities
- Complete turnkey projects

CUSTOMIZED AND OPTIMIZED DESIGN
- Site-specific system design
- Compact footprint
- Optimized reagent and power consumption for reduced OPEX

COMPANY’S REPUTATION
- Proven benefits in industrial applications since 1949
- Extensive scrubbing experience and references

PROVEN TECHNOLOGIES WELL POSITIONNED OVER THE AIR POLLUTION CONTROL MARKET

500+ Installed Systems
45+ Countries