Technical and Cost Evaluation for the Management of Sulfur Dioxide Emissions

Globe Metallurgical, Beverly, Ohio

January 30, 2020
Project No.: 0444556
January 30, 2020

Technical and Cost Evaluation for the Management of Sulfur Dioxide Emissions

Globe Metallurgical, Beverly, Ohio

Joe Carvitti
Principal Consultant and Air Quality Engineer

Gary M. Keating
Partner

ERM, Inc.
9825 Kenwood Rd. Suite 100
Cincinnati, Ohio 45242

© Copyright 2020 by ERM Worldwide Group Ltd and / or its affiliates (“ERM”).
All rights reserved. No part of this work may be reproduced or transmitted in any form,
or by any means, without the prior written permission of ERM
CONTENTS

1. INTRODUCTION................................................................................................................................ 1

2. BACKGROUND.................................................................................................................................... 1

3. BACT EVALUATION FOR EAF NO. 5.............................................................................................. 2
   3.1 Technical feasibility of SO\textsubscript{2} add-on controls at EAF No. 5............................................. 2
   3.2 Consideration of innovative control technologies.............................................................................. 2
   3.3 Consideration of cost effectiveness .................................................................................................. 3
   3.4 Significant economic burden of SO\textsubscript{2} add-on controls........................................................... 3

4. THIRD-PARTY VENDOR OUTREACH FOR SO\textsubscript{2} ADD-ON CONTROLS ......................... 3
   4.1 Overview........................................................................................................................................... 4
   4.2 CEECO Equipment, Inc. .................................................................................................................... 4
   4.3 Redecam ........................................................................................................................................... 4

5. EXTRAPOLATING SO\textsubscript{2} ADD-ON CONTROL COSTS PROVIDED BY THIRD-PARTY
   VENDORS TO ESTIMATE COST TO CONTROL ALL FURNACES ................................................ 9

6. DSI / BAGHOUSE COST AND CONFIGURATION........................................................................... 20
   6.1 Cost of installing DSI pre-baghouse .................................................................................................... 21
   6.2 Ability to install DSI at the Facility to function with the existing baghouses........................................... 21
     6.2.1 Configuration #1: Furnace $\rightarrow$ DSI $\rightarrow$ existing baghouse.................................................. 22
     6.2.2 Configuration #2: Furnace $\rightarrow$ DSI $\rightarrow$ new baghouse ....................................................... 24
     6.2.3 Configuration #3: Furnace $\rightarrow$ existing baghouse $\rightarrow$ DSI $\rightarrow$ new baghouse ................. 24
     6.2.4 Configuration #4: Furnace $\rightarrow$ new baghouse $\rightarrow$ DSI $\rightarrow$ existing baghouse....................... 26
     6.2.5 Configuration #5: Furnace $\rightarrow$ new baghouse $\rightarrow$ DSI $\rightarrow$ new baghouse ......................... 26

7. IMPACT FROM LOSS OF SALE OF FUME IF ADD-ON SO\textsubscript{2} CONTROLS ARE INSTALLED..... 28
   7.1 Tons per year of baghouse dust collected and sold from No. 2 shop baghouse for 2014 – 2018 ...... 28
   7.2 Annual profits from selling No. 2 shop fume for 2014 – 2018 ......................................................... 29
   7.3 Cost of landfilling fume ....................................................................................................................... 30

8. IMPEDIMENTS TO ADDING A STACK TO THE EXISTING SHOP 1 AND SHOP 2
   BAGHOUSES................................................................................................................................... 30
   8.1 Issues with configuration option #1 (positive pressure baghouse) ................................................... 31
   8.2 Issues with configuration option #2 (negative pressure baghouse) .................................................. 31
   8.3 Issues associated with either configuration....................................................................................... 31

9. COST OF INSTALLING STACKS ON THE EXISTING BAGHOUSES ............................................. 31

ATTACHMENT A  BACT EVALUATION FOR EAF NO. 5
ATTACHMENT B  CEECO/AMERAIIR PROPOSALS FOR WET FGD AT EAF NO. 5 AND EAF
   NOS. 5 + 7
ATTACHMENT C  REDECAM PROPOSALS FOR DSI AT EAF NO. 5 AND EAF NOS. 5 + 7
ATTACHMENT D  QSEM STRUCTURAL INSPECTION REPORTS FOR NO. 1 SHOP AND NO. 2
   SHOP BAGHOUSES
LIST OF TABLES
Table 1 Cost Analysis: Wet Scrubber on EAF 5 ..........................................................................................5
Table 2 Cost Analysis: Dry Sorbent Injection on EAF 5 .................................................................7
Table 3 Summary of Various Cost Effectiveness Calculations ..........................................................11
Table 4 Estimated Cost: Wet FGD Shop 2 (EAFs Nos. 5 + 7) ..........................................................12
Table 5 Estimated Cost: Wet FGD Shop 1 (EAFs Nos. 1 + 2 + 3) ....................................................14
Table 6 Estimated Cost: DSI Shop 2 (EAFs Nos. 5 + 7) .................................................................16
Table 7 Estimated Cost: DSI Shop 1 (EAFs Nos. 1 + 2 + 3) .............................................................18
Table 8 Summary of Fume Collected and Sold ..................................................................................29
Table 9 Estimated Profit from Fume Sales ..........................................................................................29
Table 10 Cost Items Related to Stack Purchase/Installation (2019 dollars) ..............................................32
1. INTRODUCTION

In 2013, the U.S. Environmental Protection Agency (“U.S. EPA”) designated a portion of Washington County (Muskingum River area) as non-attainment of the 2010 1-hour National Ambient Air Quality Standard for sulfur dioxide (“2010 SO$_2$ NAAQS”). The Ohio Environmental Protection Agency (“Ohio EPA”) is preparing a plan to demonstrate attainment of the 2010 SO$_2$ NAAQS for the Muskingum River nonattainment area. Ohio EPA requested that Globe Metallurgical Inc. (“Globe”) evaluate the technical and economic feasibility of managing SO$_2$ emissions at Globe’s ferroalloy production facility located in Beverly, Ohio, Washington County (the “Facility”) through:

(1) The installation and operation of add-on SO$_2$ pollution controls at the Facility; and

(2) The addition of emission stacks to the two existing baghouses at the Facility.

In response, ERM worked with Globe to evaluate the technical and economic feasibility of managing SO$_2$ emissions through the addition of add-on SO$_2$ controls and/or stacks at Globe’s Facility. The results of this evaluation are presented in this technical and cost document (the “TCE”). The TCE demonstrates that neither the installation of add-on SO$_2$ controls nor the installation of stacks is technically or economically feasible at Globe’s Facility.

2. BACKGROUND

Globe operates two melt shops at the Facility containing five (5) electric arc furnaces (“EAFs”) to produce silicon (“Si”) metal and 50% and 75% ferrosilicon (“FeSi”) alloys. Shop 1 houses three (3) EAFs: EAF Nos. 1, 2, and 3, with the combined exhaust from those furnaces controlled by the No. 1 Shop Baghouse. Shop 2 houses two (2) EAFs: EAF Nos. 5 and 7, with the combined exhaust from those furnaces controlled by the No. 2 Shop Baghouse. Both the No. 1 Shop Baghouse and the No. 2 Shop Baghouse vent to roof monitors, not to stacks.

Each of the EAFs has a dedicated canopy hood. Exhaust gases from canopy hoods over EAF Nos. 1, 2, and 3 combine for transport to the Shop 1 multi-clone followed in series by a positive pressure baghouse. Similarly, exhaust gases from canopy hoods over EAF Nos. 5 and 7 combine for transport to the Shop 2 positive pressure baghouse. Each furnace has separate hoods designed to capture emissions from tapping operations. Shop 1 tapping hoods for EAF Nos. 1, 2, and 3 are exhausted by the Shop 1 main ventilation fan. Shop 2 tapping hoods for EAF Nos. 5 and 7 have separate dedicated fans that discharge into each furnace’s respective canopy hood. Carbon monoxide rising through the furnace charge burns in the area between the charge surface and the canopy hood. The combustion air produced at this point substantially increases the volume of gas the fabric filters must handle. Dilution air is added to the combined flows prior to entering the fabric filters to reduce the temperature in the fabric filters.

In March 2017, on behalf of Globe, ERM completed and provided to Ohio EPA a Reasonably Available Control Measures (“RACM”) evaluation for SO$_2$ at the Facility (“RACM Report”). In response to requests from U.S. EPA and the U.S. Department of Justice that Globe evaluate additional information related to its furnace operations and control equipment options, Globe undertook a supplemental RACM evaluation. ERM provided that evaluation on behalf of Globe to Ohio EPA in August 2017 (“Supplemental RACM Report”). Those evaluations concluded that SO$_2$ add-on controls were not a feasible control option and that RACM for control of SO$_2$ emissions from the Facility’s furnaces was the use of low sulfur coal and low sulfur coke.

Globe is currently involved in an ongoing U.S. EPA Clean Air Act enforcement action involving operations at its Facility. As part of ongoing discussions in this enforcement action (and separate and apart from
Globe’s RACM evaluations), Globe evaluated the feasibility of installing and operating add-on SO₂ pollution controls at its Facility. These evaluations conclude that there exist technical and economic hurdles that prohibit and/or make it infeasible for Globe to install and operate SO₂ add-on controls at its Facility. As part of these evaluations, in August 2018, ERM, again on behalf of Globe, provided U.S. EPA with a Top-Down Best Available Control Technology ("BACT") evaluation on the Facility’s EAF No. 5 (the “BACT Evaluation”).

3. BACT EVALUATION FOR EAF NO. 5

A copy of the BACT Evaluation for the control of SO₂ at EAF No. 5 is enclosed. (Attachment A). The BACT Evaluation was previously provided to U.S. EPA. Globe engaged ERM to conduct a thorough and objective Top-Down BACT analysis in accordance with the recognized methodology described in the U.S. EPA draft New Source Review Workshop Manual ("NSR Workshop Manual"). The resulting BACT Evaluation is objectively sound and comports with the accepted methodology for BACT assessments.

The BACT Evaluation determined that add-on control options were not technically feasible (and, even if they had been, were otherwise economically prohibitive) and, therefore, not BACT for EAF No. 5. Instead, the BACT Evaluation determined that the management of sulfur in raw materials was BACT for SO₂ control at EAF No. 5.

The following elaborates and provides additional clarity on certain items addressed in the BACT Evaluation:

3.1 Technical feasibility of SO₂ add-on controls at EAF No. 5

The BACT Evaluation presents a detailed list of conditions associated with Globe’s EAF No. 5 operation in comparison to the conditions experienced by other types of sources that currently employ various types of add-on controls. The BACT Evaluation reviewed the factors identified when designing SO₂ scrubber systems and identifies large differences between conditions under which an FGD has been successfully employed, and those at EAF No. 5. This comparison must be made to other types of sources because ERM’s extensive research identified no EAF (in any ferrous or silicon metallurgical process) that currently employs add-on controls for SO₂. When determining if other sources are similar to a source under evaluation, U.S. EPA guidance states that the primary factors considered are the characteristics of the gas stream to be controlled, the comparability of the production processes (e.g., batch versus continuous operation, frequency of process interruptions, special product quality concerns, etc.), and the potential impacts on other emission points within the source. Numerous process conditions exist at EAF No. 5 that would render the use of add-on SO₂ control systems infeasible, including wide variations in the characteristics of the process gas and process conditions as well as stringent quality control conditions.

The BACT Evaluation also discusses a determination from the State of Georgia in the context of a Prevention of Significant Deterioration ("PSD") permit evaluation that found that a wet scrubber was technically infeasible for an EAF due to the existence of variable process conditions (the same can be said for a dry FGD). That permitting authority’s determination is the only BACT conclusion identified that was issued for SO₂ control using add-on controls for EAF operations.

3.2 Consideration of innovative control technologies

While not required, sources may consider innovative control technologies as BACT. In performing the BACT Evaluation, ERM concluded that there were no SO₂ controls that ERM evaluated that qualified as
“innovative control technologies” as defined in the Ohio State Implementation Plan, including the Gore Mercury Control System technology for SO$_2$ control.

Gore was unable to provide any guarantee of a level of SO$_2$ removal from the EAF No. 5 emission stream. Instead, Gore has offered to conduct research, at great cost to Globe, to determine what is possible. While Gore has conducted pilot tests at combustion facilities, Gore has not yet been contracted to design or construct an SO$_2$ removal system using their technology. Following U.S. EPA’s BACT evaluation process, Globe ruled out the use of Gore’s technology as BACT based on lack of demonstrated performance for SO$_2$ removal.

### 3.3 Consideration of cost effectiveness

Consistent with U.S. EPA practice, cost effectiveness is considered only late in the BACT assessment (in Step 4 of the Top-Down assessment) for those technologies that have been determined to be technically feasible in early steps. Step 4 is intended to evaluate the most effective options (using economic, environmental, and energy criteria) to support the selection of BACT in Step 5. The BACT Evaluation concluded that no add-on control options were technically feasible within the confines of earlier BACT steps. Therefore, only those options pertaining to raw material management were deemed technically feasible and were evaluated economically. 

### 3.4 Significant economic burden of SO$_2$ add-on controls

The Top-Down BACT process ranks the technologies based on performance and then considers economic, energy, or environmental factors to determine which option should be selected. To eliminate an option based on economic, energy, or environmental factors, the Top-Down BACT must make a compelling case that one or some combination of these considerations illustrates significant differences and burden compared with what has previously been determined to be BACT for a given type of source and pollutant. The RACM and the BACT assessments indicate that no other sources of this type have been required to use add-on control for SO$_2$ to meet BACT. In light of this, spending millions of dollars for add-on controls would be disproportionately high and unusual compared to prior determinations. Therefore, given the technical infeasibility considerations of the add-on technologies, and – if it were considered – the disproportionately high and unusual significant economic burden of the technologies when compared with previous BACT determinations, BACT in this case is the management of sulfur in raw materials as presented in the evaluation.

### 4. THIRD-PARTY VENDOR OUTREACH FOR SO$_2$ ADD-ON CONTROLS

No other facility has been identified that is engaged in the same or similar metallurgical process as Beverly and that has installed add-on controls for the control of SO$_2$. As noted in the BACT Evaluation, other BACT determinations that have considered add-on SO$_2$ controls for EAFs have determined that such equipment is technically infeasible.

Notwithstanding the determination that BACT for the Facility is the management of sulfur in raw materials, Globe and ERM expended significant time and resources with third-party pollution control vendors to more fulsomely evaluate whether a control (more stringent than BACT) could be installed, and the corresponding costs. Globe solicited bids from eleven (11) vendors. The outreach did not identify any SO$_2$ control technology that Globe determined is feasible to implement at the Facility.

---

¹ Initial add-on control cost assessment information was provided in Globe’s RACM Report and Supplemental RACM Report. The expected economic impact is extraordinarily high.
4.1 Overview

- Only 2 of 11 vendors (CEECO Equipment, Inc. and Redecam) submitted bids in response to bid solicitations.
- Neither CEECO nor Redecam have demonstrated that their technology has been successfully implemented on a similar source.
- Redecam’s proposal would require installation of a pulse jet baghouse, which Globe has concluded is incompatible with the Facility’s EAFs.
- As further detailed in the tables below, both bid responses are economically prohibitive.
- As noted above, a third vendor, Gore, did not provide a substantive bid, instead informed Globe that it would need to undertake a lengthy and costly engineering study to evaluate whether its innovative control technology would be feasible at the Facility.

4.2 CEECO Equipment, Inc.

CEECO (in partnership with Amerair Industries, LLC) submitted a formal proposal\(^2\) to Globe in December 2018 for the installation of a wet FGD servicing EAF No. 5.\(^3\) The implementation cost at EAF No. 5 is disproportionately high and, therefore, infeasible from an economic perspective. Table 1 presents a cost analysis of the CEECO quote. Globe estimates that the capital cost (both direct and indirect capital costs) alone to implement CEECO’s proposed technology would exceed $21 million. On the basis of cost-per-ton of SO\(_2\) removed, the cost would exceed $21,000/ton (well in excess of any cost U.S. EPA itself has considered reasonable when evaluating control costs in a BACT determination).

4.3 Redecam

Redecam submitted a proposal to Globe in March 2019 for the installation of a dry FGD (specifically, dry sorbent injection (“DSI”)).\(^4\) Globe received incomplete technical and cost information from Redecam. Based on the preliminary cost figures (which ERM notes would only increase) provided by Redecam, ERM believes that the cost to implement Redecam’s controls would be similar to the cost for the CEECO controls, including on a cost-per-ton of SO\(_2\) removed basis. Table 2 presents a cost analysis of the DSI system for EAF No. 5.

---

\(^2\) CEECO did not provide Globe with a line-item cost estimate for the wet FGD. Rather, CEECO provided only a total system price for equipment with an option price for installation.

\(^3\) A copy of this proposal is enclosed as Attachment B. (Note that this proposal was prepared for and transmitted to Globe by Amerair working in conjunction with CEECO; references in this TCE, however, will be to CEECO.) ERM is also enclosing in Attachment B a copy of CEECO’s December 2018 proposal for EAF Nos. 5 + 7 (as discussions between Globe and CEECO progressed, the focus turned to addressing the exhaust of only EAF No. 5).

\(^4\) A copy of this proposal (which contains a separate technical and commercial offer) is enclosed as Attachment C. ERM is also enclosing a copy of Redecam’s February 2019 proposal in Attachment C, which was superseded by the March 2019 proposal (see Section 6.1, below, for further discussion of these proposals).
Table 1 Cost Analysis: Wet Scrubber on EAF 5

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Capital Costs&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Equipment (purchase, auxiliary, instruments, controls, and freight)</td>
<td>$10,779,000</td>
</tr>
<tr>
<td></td>
<td>CEMS&lt;sup&gt;b&lt;/sup&gt;</td>
<td>$150,000 (estimate)</td>
</tr>
<tr>
<td></td>
<td>Taxes (7% on Equipment (except freight) and CEMS)</td>
<td>$754,530</td>
</tr>
<tr>
<td></td>
<td>Installation</td>
<td>$7,500,000</td>
</tr>
<tr>
<td>Indirect Capital Costs&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Engineering (Globe)</td>
<td>$58,418</td>
</tr>
<tr>
<td></td>
<td>Performance test and dispersion modeling</td>
<td>$233,671</td>
</tr>
<tr>
<td></td>
<td>Contingencies&lt;sup&gt;d&lt;/sup&gt;</td>
<td>$584,177</td>
</tr>
<tr>
<td></td>
<td>Permits&lt;sup&gt;e&lt;/sup&gt;</td>
<td>$233,671</td>
</tr>
<tr>
<td></td>
<td>Furnace down time&lt;sup&gt;f&lt;/sup&gt;</td>
<td>No estimate included</td>
</tr>
<tr>
<td>Net Capital Costs</td>
<td>$20,293,465</td>
<td></td>
</tr>
</tbody>
</table>

| Direct Annual Costs | Material consumed (caustic, water, power, maintenance materials (MM), chemical shipping) | $1,564,616 | $1,799,791 |
|                     | CEMS maintenance and calibration | $30,000 (estimate) | |
|                     | Labor hours (supervisor, maintenance, operating) | $186,238 | |
|                     | Wet scrubber blowdown | $18,937 | |
| Indirect Annual Costs | Overhead on operating, supervisor, and maintenance labor, and MM | $146,721 | $614,062 |
|                     | Insurance on Base Price<sup>g</sup> (BP) (1%) | $116,835 | |
|                     | Property tax on BP (1%) | $116,835 | |
|                     | Administrative charges on BP (2%) | $233,671 | |
| Capital Recovery | 10 yr amortization, 5% interest CR factor (0.12950 x CC) | $2,628,004 | $2,628,004 |

<table>
<thead>
<tr>
<th>Direct Annual Costs</th>
<th>Indirect Annual Costs</th>
<th>Capital Recovery</th>
<th>Total Annualized Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1,799,791</td>
<td>$614,062</td>
<td>$2,628,004</td>
<td>$5,041,857</td>
</tr>
</tbody>
</table>

SO<sub>2</sub> Emissions 300 tons/yr

SO<sub>2</sub> Removal Efficiency 80%<sup>h</sup>

SO<sub>2</sub> Removed 240 tons/yr

SO<sub>2</sub> Removal Cost Effectiveness (total annualized cost/ tons SO<sub>2</sub> removed) $21,008
Notes for Table 1

a. Excludes site re-orientation (e.g., moving rail spurs).

b. The CEECO proposal did not include a Continuous Emissions Monitoring System (CEMS) or similar monitoring system for the reagent injection system. Globe included an estimated cost of a CEMS because the CEMS represents an important feed-back control for an SO\textsubscript{2} control system. The control cost evaluation includes the cost of a single CEMS for SO\textsubscript{2} measurement (cost conservatively estimated at $150,000 per CEMS). Depending on the actual control equipment configuration, however, more than one CEMS may be required.

c. The costs associated with the demolition and disposal of the existing baghouses is estimated at $750,000 per shop. This cost, however, was not included in the CEECO quote for a wet FGD system on EAF No. 5. If both EAF No. 5 and EAF No. 7 were controlled by a wet FGD system, the existing baghouse would need to be removed (with Globe incurring the above-estimated demolition and disposal costs) because inadequate space exists at the Facility to install the additional equipment necessary to accommodate the wet FGD system.

d. U.S. EPA directs sources to account for “retrofit costs,” which include both “retrofit factors” (unanticipated problems directly related to demolition, fabrication and installation, including issues associated with dismantled existing equipment to allow space for new equipment), and “contingency factors” (“reasonable but unanticipated increase[s] [that] are not directly related to the demolition, fabrication, and installation of the system”). See U.S. EPA Air Pollution Control Cost Manual, Chapter 2 (Cost Estimation: Concepts and Methodology), Seventh Edition, at section 2.6.4.2 (Nov. 2017), available at www.epa.gov/sites/production/files/2017-12/documents/epacmcostestimationmethodchapter_7thedition_2017.pdf, (“EPA Cost Manual”). Additional time that may be needed to accommodate the installation of SO\textsubscript{2} controls at the Facility are captured in this contingency estimate (however, this estimate does not account for the replacement and demolition of the existing baghouse, as may be necessary to accommodate wet FGD at the Facility).

e. U.S. EPA directs sources to consider permitting costs as a component of indirect costs associated with the installation of pollution control equipment. See EPA Cost Manual, at section 2.6.5.8 (explaining that permitting costs are a “site-specific cost” that “because of potentials for delays, re-design and other considerations ... should be included in the overall cost assessment”). For the control equipment installation cost evaluations, permitting costs are included as an Indirect Capital Cost, which was reasonably estimated at 2% of the Base Price (the EPA Cost Manual does not provide a method to estimate permit costs). Permitting costs include items such as building permits, power connections to the electrical grid, and environmental permits.

f. U.S. EPA directs sources to consider lost production time as a component of indirect costs associated with the installation of pollution control equipment. See EPA Cost Manual, Chapter 2, at 29 (“Lost Production. The shut-down for installation of a control device into the system should be a well-planned and anticipated event, and typically occurs during routine, scheduled outages. As such, its cost should be considered a part of the indirect installation cost (start-up).”). Furnace downtime will be required for installation of a wet FGD system, but an estimate of the financial impact of that downtime was not included in this analysis.

g. Base Price is Total Direct Capital Cost minus Installation. Base Price = $11,683,530.

h. The SO\textsubscript{2} removal efficiency of 80% is a conservative estimate. If removal efficiency decreases, cost per ton of SO\textsubscript{2} removal will increase.
### Table 2 Cost Analysis: Dry Sorbent Injection on EAF 5

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct Capital Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment (purchase, auxiliary, instruments, controls, and freight)</td>
<td>$7,510,770</td>
<td>$13,021,954</td>
</tr>
<tr>
<td>CEMS(b)</td>
<td>$150,000 (estimate)</td>
<td></td>
</tr>
<tr>
<td>Taxes (7% on Equipment (except freight) and CEMS)</td>
<td>$525,754</td>
<td></td>
</tr>
<tr>
<td>Installation</td>
<td>$4,835,430</td>
<td></td>
</tr>
<tr>
<td><strong>Indirect Capital Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering (Globe)</td>
<td>$40,933</td>
<td>$777,720</td>
</tr>
<tr>
<td>Performance test and dispersion modeling</td>
<td>$163,730</td>
<td></td>
</tr>
<tr>
<td>Contingencies(d)</td>
<td>$409,326</td>
<td></td>
</tr>
<tr>
<td>Permits(e)</td>
<td>$163,730</td>
<td></td>
</tr>
<tr>
<td>Furnace down time(f)</td>
<td>No estimate included</td>
<td></td>
</tr>
<tr>
<td><strong>Net Capital Costs</strong></td>
<td>$13,799,674</td>
<td></td>
</tr>
<tr>
<td><strong>Direct Annual Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material consumed (hydrated lime, water, power, maintenance materials (MM), chemical shipping)</td>
<td>$2,547,729</td>
<td>$2,959,095</td>
</tr>
<tr>
<td>CEMS maintenance and calibration</td>
<td>$30,000 (estimate)</td>
<td></td>
</tr>
<tr>
<td>Labor hours (supervisor, maintenance, operating)</td>
<td>$186,238</td>
<td></td>
</tr>
<tr>
<td>Lime Dust Disposal</td>
<td>$195,129</td>
<td></td>
</tr>
<tr>
<td><strong>Indirect Annual Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overhead on operating, supervisor, and maintenance labor, and MM</td>
<td>$146,721</td>
<td>$474,181</td>
</tr>
<tr>
<td>Insurance on Base Price(g) (BP) (1%)</td>
<td>$81,865</td>
<td></td>
</tr>
<tr>
<td>Property tax on BP (1%)</td>
<td>$81,865</td>
<td></td>
</tr>
<tr>
<td>Administrative charges on BP (2%)</td>
<td>$163,730</td>
<td></td>
</tr>
<tr>
<td><strong>Capital Recovery</strong></td>
<td>$1,787,058</td>
<td>$1,787,058</td>
</tr>
<tr>
<td>10 yr amortization, 5% interest CR factor (0.12950 x CC)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Direct Annual Costs</th>
<th>Indirect Annual Costs</th>
<th>Capital Recovery</th>
<th>Total Annualized Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2,959,095</td>
<td>$474,182</td>
<td>$1,787,058</td>
<td>$5,220,335</td>
</tr>
</tbody>
</table>

**SO₂ Emissions**: 300 tons/yr

**SO₂ Removal Efficiency**: 80%\(^{(h)}\)

**SO₂ Removed**: 240 tons/yr

**SO₂ Removal Cost Effectiveness (total annualized cost/ tons SO₂ removed)**: $21,751
Notes for Table 2

a. Excludes foundations, civil works, building work, site re-orientation (such as rail spurs), customs, duties, grounding systems, HV/MV transformer.

b. See Note b for Table 1 for an explanation for the basis for including CEMS costs. The Redecam technical offer similarly did not include a CEMS or similar monitoring system for the reagent injection system, nor does the commercial offer include an instrument cost for a CEMS. Depending on the actual control equipment configuration, more than one CEMS may be required.

c. The costs associated with the demolition and disposal of the existing baghouses is estimated at $750,000 per shop. This cost, however, was not included in the Redecam quote for a DSI system on EAF No. 5 because Redecam’s proposal did not propose the demolition of the existing baghouse servicing EAF No. 5. Instead, under Redecam’s proposal, the furnace gas off-take would occur prior to the existing baghouse, with the furnace gas instead ducted to an entirely independent, new, baghouse system. The existing baghouse would continue to operate to serve EAF No. 7. Note, however, that if both EAF No. 5 and EAF No. 7 were controlled by a DSI system, the existing baghouse would need to be removed (with Globe incurring the above-estimated demolition and disposal costs) because inadequate space exists at the Facility to install the additional equipment necessary to accommodate the DSI system.

d. See Note d for Table 1.

e. See Note e for Table 1.

f. See Note f for Table 1. Globe notes that furnace downtime will be required for installation of a DSI system, but Globe has not included an estimate of the financial impact of that downtime in this analysis.

g. Base Price is Total Direct Capital Cost minus Installation. Base Price = $8,186,524.

h. The SO$_2$ removal efficiency of 80% is a conservative estimate. If removal efficiency decreases, cost per ton of SO$_2$ removal will increase.
5. EXTRAPOLATING SO$_2$ ADD-ON CONTROL COSTS PROVIDED BY THIRD-PARTY VENDORS TO ESTIMATE COST TO CONTROL ALL FURNACES

Section 4, above, provided an estimated cost-breakdown for the installation of two vendor-proposed SO$_2$ control systems at EAF No. 5. The scope of work and associated cost estimates were specific to controlling SO$_2$ emissions from EAF No. 5 alone because this information was requested in connection with U.S. EPA’s enforcement action (which alleges SO$_2$ violations at EAF No. 5). Ohio EPA requested that Globe extrapolate the cost information provided by CEECO (wet FGD) and Redecam (DSI) to estimate the cost of controlling SO$_2$ emissions at all five furnaces at the Facility with either wet FGD or DSI. On behalf of Globe, ERM used the vendor cost information identified in Section 4 in conjunction with additional information provided by the two vendors to estimate the costs associated with the following control scenarios at the Facility:

- Wet FGD system for EAF No. 5 and EAF No. 7 (Shop 2)
- DSI system for EAF No. 5 and EAF No. 7 (Shop 2)
- Wet FGD system for EAF No. 1, EAF No. 2, and EAF No. 3 (Shop 1)
- DSI system for EAF No. 1, EAF No. 2, and EAF No. 3 (Shop 1)

ERM believes that the cost information provided below reflects a good-faith estimate of the cost to control SO$_2$ emissions for the entire Facility. However, ERM emphasizes that the actual cost to control the entire Facility could be significantly higher. These cost figures were prepared without additional outreach to either vendor and are based upon numerous assumptions and extrapolations that were not specifically studied or evaluated by the vendors or Globe.

ERM utilized the following methodology and assumptions to extrapolate the cost information from CEECO and Redecam to estimate costs at the entire Facility:

- Vendor information supplied for Shop 2 was used to develop a cost estimate for Shop 1. The cost estimates were then coupled with the SO$_2$ emission estimates presented in the RACM Report to derive an SO$_2$ control cost effectiveness using the same methodology utilized for EAF No. 5, above. This methodology follows the procedures set forth in Ohio EPA Engineering Guide 46\(^5\) and the EPA Cost Manual.

- Because the reported annual SO$_2$ emission rates for Shop 1 and Shop 2 are nearly identical in the study base year (i.e., 661 tons SO$_2$ per year from Shop 1 and 663 tons of SO$_2$ per year from Shop 2), the Shop 2 control cost effectiveness estimates were also used for Shop 1 with minor adjustments as appropriate to account for differences between the two shops.

- Equipment costs to control both furnaces in Shop 2 were obtained directly from the vendor quotes (i.e., CEECO proposal for EAF Nos. 5 + 7, and Redecam proposal for EAF Nos. 5 + 7) and used without adjustment. Some minor increases in equipment costs exist when controlling EAF No. 5 and EAF No. 7, as opposed to EAF No. 5 alone.

- The main differences in control costs for controlling the entire shop versus EAF No. 5 alone relate to operating costs and retrofit costs. As previously discussed in Note d for Table 1, retrofit costs include both retrofit factors (i.e., dismantling and disposal of the existing baghouse), and contingency factors (which can account for “inadequacies in cost estimating methods and for expected unknowns that

may arise during project execution\(^6\)). The new equipment needed to control EAF No. 5 and No. 7 in Shop 2 would occupy the same footprint as existing equipment (including the existing baghouse). Thus, the cost to control Shop 2 includes the cost to dismantle and remove the existing Shop 2 baghouse, as well as construction time and foundation preparation to complete the work. U.S. EPA advises that such retrofit costs could represent an additional 50% of the direct capital costs\(^7\). A conservative estimate of 30% was used in this cost analysis.

- Costs that Globe expects are likely to occur, but that were not specifically included in the Redecam quote or were missing from the CEECO quote are accounted for in the contingency factor that was applied to these cost estimates. As noted above (see Note d for Table 1), U.S. EPA allows for consideration of such costs.

- In addition, the CEECO proposal specifically excluded the following items and services, some of which are included in the cost estimate tables for the wet FGD scenarios: 13.6 kVA power; CEMS; performance testing; all State, Federal, and local sales and use taxes; and building, construction, environmental, occupancy, operating and all other permits. The Redecam proposal, on the other hand, specifically excluded the following items and services, and ERM has made no attempt to estimate these costs: instrumentation in general except the one mentioned; high voltage to medium voltage ("HV/MV") transformer; electrical power network upstream supplied boards; plant distributed control system ("DCS") and control panels; grounding system; lightning rods; lighting; foundations, civil and building works; and customs, duties, value added taxes ("VAT") and local taxes.

- ERM reasonably assumed that the equipment costs for Shop 1 would be the same as the costs developed for Shop 2.

Table 3 summarizes the estimated control costs the four control scenarios listed above to control the entire Facility. The estimated costs discussed in Section 4, above, for EAF No. 5 alone are included for reference purposes. Table 4 through Table 7 present breakdowns of estimated control costs for each of the four scenarios.

---


\(^7\) See EPA Cost Manual, Chap 2, section 2.6.4.2, at 27. U.S. EPA advises that in “complicated systems requiring many pieces of auxiliary equipment, it is not uncommon to see retrofit factors of much greater magnitude [than 50%] being used.” Id.
Table 3 Summary of Various Cost Effectiveness Calculations

<table>
<thead>
<tr>
<th>Scenario(a)</th>
<th>Direct Annual Costs</th>
<th>Indirect Annual Costs</th>
<th>Capital Recovery</th>
<th>Total Annualized Cost</th>
<th>SO(_2) Removal Rate, tons/yr</th>
<th>SO(_2) Removal Cost Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Scrubber</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EAF 5</td>
<td>$1,799,791</td>
<td>$614,062</td>
<td>$2,628,004</td>
<td>$5,041,857</td>
<td>240</td>
<td>$21,008/ton</td>
</tr>
<tr>
<td>Shop 2 (EAFs 5+7)</td>
<td>$2,907,339</td>
<td>$691,616</td>
<td>$3,570,585</td>
<td>$7,169,601</td>
<td>530</td>
<td>$13,517/ton</td>
</tr>
<tr>
<td>Shop 1 (EAFs 1+2+3)</td>
<td>$2,907,399</td>
<td>$691,616</td>
<td>$3,700,085</td>
<td>$7,299,101</td>
<td>529</td>
<td>$13,803/ton</td>
</tr>
<tr>
<td>Dry Sorbent Injection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EAF 5</td>
<td>$2,959,095</td>
<td>$474,182</td>
<td>$1,787,058</td>
<td>$5,220,335</td>
<td>240</td>
<td>$21,751/ton</td>
</tr>
<tr>
<td>Shop 2 (EAFs 5+7)</td>
<td>$4,086,334</td>
<td>$619,095</td>
<td>$3,138,120</td>
<td>$7,843,549</td>
<td>530</td>
<td>$14,788/ton</td>
</tr>
<tr>
<td>Shop 1 (EAFs 1+2+3)</td>
<td>$4,086,334</td>
<td>$619,095</td>
<td>$3,267,620</td>
<td>$7,973,049</td>
<td>529</td>
<td>$15,078/ton</td>
</tr>
</tbody>
</table>

a. Excludes site re-orientation (e.g. moving rail spurs). See Tables 1, 2 and 4 through 7 for other bases.
## Table 4 Estimated Cost: Wet FGD Shop 2 (EAFs Nos. 5 + 7)

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Direct Capital Costs&lt;sup&gt;(a)&lt;/sup&gt;</th>
<th>Indirect Capital Costs</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Capital Costs&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>Equipment (purchase, auxiliary, instruments, controls, and freight)</td>
<td>$12,591,000</td>
<td>$22,122,370</td>
</tr>
<tr>
<td></td>
<td>CEMS&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>$150,000 (estimate)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Taxes (7% on Equipment (except freight) and CEMS)</td>
<td>$881,370</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Installation</td>
<td>$8,500,000</td>
<td></td>
</tr>
<tr>
<td>Indirect Capital Costs</td>
<td>Engineering (Globe)</td>
<td>$68,112</td>
<td>$5,449,718</td>
</tr>
<tr>
<td></td>
<td>Performance test and dispersion modeling</td>
<td>$272,447</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contingencies&lt;sup&gt;(c)&lt;/sup&gt;</td>
<td>$4,086,711</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Permits&lt;sup&gt;(d)&lt;/sup&gt;</td>
<td>$272,447</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Furnace down time&lt;sup&gt;(e)&lt;/sup&gt;</td>
<td>No estimate included</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Demo/disposal of existing BH</td>
<td>$750,000</td>
<td></td>
</tr>
<tr>
<td>Net Capital Costs= $ 27,572,088</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct Annual Costs</td>
<td>Material consumed (caustic, water, power, maintenance materials, chemical shipping)</td>
<td>$2,653,288</td>
<td>$2,907,399</td>
</tr>
<tr>
<td></td>
<td>CEMS maintenance and calibration</td>
<td>$30,000 (estimate)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Labor hours (supervisor, maintenance, operating)</td>
<td>$186,238</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wet scrubber blowdown</td>
<td>$37,873</td>
<td></td>
</tr>
<tr>
<td>Indirect Annual Costs</td>
<td>Overhead on operating, supervisor, and maintenance labor, and maintenance materials</td>
<td>$146,721</td>
<td>$691,616</td>
</tr>
<tr>
<td></td>
<td>Insurance on Base Price&lt;sup&gt;(f)&lt;/sup&gt; (BP) (1%)</td>
<td>$136,224</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Property Tax on BP (1%)</td>
<td>$136,224</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Administrative charges on BP (2%)</td>
<td>$272,447</td>
<td></td>
</tr>
<tr>
<td>Capital Recovery</td>
<td>10 yr amortization, 5% interest CR factor (0.12950 x CC)</td>
<td>$3,570,585</td>
<td>$3,570,585</td>
</tr>
</tbody>
</table>
Table 4 Estimated Cost: Wet FGD Shop 2 (EAFs Nos. 5 + 7) (continued)

<table>
<thead>
<tr>
<th>Direct Annual Costs</th>
<th>Indirect Annual Costs</th>
<th>Capital Recovery</th>
<th>Total Annualized Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2,907,399</td>
<td>$691,616</td>
<td>$3,570,585</td>
<td>$7,169,601</td>
</tr>
</tbody>
</table>

**SO₂ Emissions**
- 663 tons/yr

**SO₂ Removal Efficiency**
- 80% (g)

**SO₂ Removed**
- 530 tons/yr

**SO₂ Removal Cost Effectiveness (total annualized cost/ tons SO₂ removed)**
- $13,517

Notes for Table 4

a. Excludes site re-orientation (e.g., moving rail spurs).

b. See Note b for Table 1 for an explanation for the basis for including CEMS costs.

c. See Note d for Table 1 for basis for including contingency costs. Contingency is conservatively set at 30% of Base Price to account for the costs and issues associated with retrofitting the Facility (i.e., removing certain existing equipment) to accommodate the footprint of the new equipment. The EPA Cost Manual lists a range of 1 to 50% based on the site.

d. See Note e for Table 1 for basis for permitting costs.

e. See Note f for Table 1 for basis for including furnace downtime.


g. The SO₂ removal efficiency of 80% is a conservative estimate. If removal efficiency decreases, cost per ton of SO₂ removal will increase.
### Table 5 Estimated Cost: Wet FGD Shop 1 (EAFs Nos. 1 + 2 + 3)

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct Capital Costs</strong>&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment (purchase, auxiliary, instruments, controls, and freight)</td>
<td>$12,591,000</td>
<td>$23,122,370</td>
</tr>
<tr>
<td>CEMS&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>$150,000 (estimate)</td>
<td></td>
</tr>
<tr>
<td>Taxes (7% on Equipment (except freight) and CEMS)</td>
<td>$881,370</td>
<td></td>
</tr>
<tr>
<td>Installation</td>
<td>$9,500,000</td>
<td></td>
</tr>
<tr>
<td><strong>Indirect Capital Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering (Globe)</td>
<td>$68,112</td>
<td>$5,449,718</td>
</tr>
<tr>
<td>Performance test and dispersion modeling</td>
<td>$272,447</td>
<td></td>
</tr>
<tr>
<td>Contingencies&lt;sup&gt;(c)&lt;/sup&gt;</td>
<td>$4,086,711</td>
<td></td>
</tr>
<tr>
<td>Permits&lt;sup&gt;(d)&lt;/sup&gt;</td>
<td>$272,447</td>
<td></td>
</tr>
<tr>
<td>Furnace down time&lt;sup&gt;(e)&lt;/sup&gt;</td>
<td>No estimate included</td>
<td></td>
</tr>
<tr>
<td>Demo/disposal of existing BH</td>
<td>$750,000</td>
<td></td>
</tr>
<tr>
<td><strong>Net Capital Costs</strong>= $ 28,572,088</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Direct Annual Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material consumed (caustic, water, power, maintenance materials, chemical shipping)</td>
<td>$2,653,288</td>
<td>$2,907,399</td>
</tr>
<tr>
<td>CEMS maintenance and calibration</td>
<td>$30,000 (estimate)</td>
<td></td>
</tr>
<tr>
<td>Labor hours (supervisor, maintenance, operating)</td>
<td>$186,238</td>
<td></td>
</tr>
<tr>
<td>Wet scrubber blowdown</td>
<td>$37,873</td>
<td></td>
</tr>
<tr>
<td><strong>Indirect Annual Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overhead on operating, supervisor, and maintenance labor, and maintenance materials</td>
<td>$146,721</td>
<td>$691,616</td>
</tr>
<tr>
<td>Insurance on Base Price&lt;sup&gt;(f)&lt;/sup&gt; (BP) (1%)</td>
<td>$136,224</td>
<td></td>
</tr>
<tr>
<td>Property Tax on BP (1%)</td>
<td>$136,224</td>
<td></td>
</tr>
<tr>
<td>Administrative charges on BP (2%)</td>
<td>$272,447</td>
<td></td>
</tr>
<tr>
<td><strong>Capital Recovery</strong></td>
<td>10 yr amortization, 5% interest CR factor (0.12950 x CC)</td>
<td>$3,700,085</td>
</tr>
</tbody>
</table>
Table 5 Estimated Cost: Wet FGD Shop 1 (EAFs Nos. 1 + 2 + 3) (continued)

<table>
<thead>
<tr>
<th>Direct Annual Costs</th>
<th>Indirect Annual Costs</th>
<th>Capital Recovery</th>
<th>Total Annualized Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2,907,399</td>
<td>$691,616</td>
<td>$3,700,085</td>
<td>$7,299,101</td>
</tr>
</tbody>
</table>

SO₂ Emissions: 661 tons/yr
SO₂ Removal Efficiency: 80% (g)
SO₂ Removed: 529 tons/yr
SO₂ Removal Cost Effectiveness (total annualized cost/ tons SO₂ removed): $13,803

Notes for Table 5
a. Excludes site re-orientation (e.g., moving rail spurs).
b. See Note b for Table 1 for an explanation for the basis for including CEMS costs.
c. See Note d for Table 1 for basis for including contingency costs. Contingency is conservatively set at 30% of Base Price to account for the costs and issues associated with retrofitting the Facility (i.e., removing certain existing equipment) to accommodate the footprint of the new equipment. The EPA Cost Manual lists a range of 1 to 50% based on the site.
d. See Note e for Table 1 for basis for permitting costs.
e. See Note f for Table 1 for basis for including furnace downtime.
g. The SO₂ removal efficiency of 80% is a conservative estimate. If removal efficiency decreases, cost per ton of SO₂ removal will increase.
### Table 6 Estimated Cost: DSI Shop 2 (EAFs Nos. 5 + 7)

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct Capital Costs</strong>&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment (purchase, auxiliary, instruments, controls, and freight)</td>
<td>$10,896,590</td>
<td>$19,408,361</td>
</tr>
<tr>
<td>CEMS&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>$150,000 (estimate)</td>
<td></td>
</tr>
<tr>
<td>Taxes (7% on Equipment (except freight) and CEMS)</td>
<td>$762,761</td>
<td></td>
</tr>
<tr>
<td>Installation</td>
<td>$7,599,010</td>
<td></td>
</tr>
<tr>
<td><strong>Indirect Capital Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering (Globe)</td>
<td>$59,047</td>
<td>$4,824,226</td>
</tr>
<tr>
<td>Performance test and dispersion modeling</td>
<td>$236,187</td>
<td></td>
</tr>
<tr>
<td>Contingencies&lt;sup&gt;(c)&lt;/sup&gt;</td>
<td>$3,542,805</td>
<td></td>
</tr>
<tr>
<td>Permits&lt;sup&gt;(d)&lt;/sup&gt;</td>
<td>$236,187</td>
<td></td>
</tr>
<tr>
<td>Furnace down time&lt;sup&gt;(e)&lt;/sup&gt;</td>
<td>No estimate included</td>
<td></td>
</tr>
<tr>
<td>Demo/disposal of existing BH</td>
<td>$750,000</td>
<td></td>
</tr>
<tr>
<td><strong>Net Capital Costs</strong>= $24,232,587</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Direct Annual Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material consumed (hydrated lime, water, power, maintenance materials, chemical shipping)</td>
<td>$3,514,528</td>
<td>$4,086,334</td>
</tr>
<tr>
<td>CEMS maintenance and calibration</td>
<td>$30,000 (estimate)</td>
<td></td>
</tr>
<tr>
<td>Labor hours (supervisor, maintenance, operating)</td>
<td>$186,238</td>
<td></td>
</tr>
<tr>
<td>Lime dust disposal</td>
<td>$355,568</td>
<td></td>
</tr>
<tr>
<td><strong>Indirect Annual Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overhead on operating, supervisor, and maintenance labor, and maintenance materials</td>
<td>$146,721</td>
<td>$619,095</td>
</tr>
<tr>
<td>Insurance on Base Price&lt;sup&gt;(f)&lt;/sup&gt; (BP) (1%)</td>
<td>$118,094</td>
<td></td>
</tr>
<tr>
<td>Property Tax on BP (1%)</td>
<td>$118,094</td>
<td></td>
</tr>
<tr>
<td>Administrative charges on BP (2%)</td>
<td>$236,187</td>
<td></td>
</tr>
<tr>
<td><strong>Capital Recovery</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 yr amortization, 5% interest CR factor (0.12950 x CC)</td>
<td>$3,138,120</td>
<td>$3,138,120</td>
</tr>
</tbody>
</table>
Table 6 Estimated Cost: DSI Shop 2 (EAFs Nos. 5 + 7)

<table>
<thead>
<tr>
<th></th>
<th>Direct Annual Costs</th>
<th>Indirect Annual Costs</th>
<th>Capital Recovery</th>
<th>Total Annualized Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO₂ Emissions</td>
<td>$4,086,334</td>
<td>$619,095</td>
<td>$3,138,120</td>
<td>$7,843,549</td>
</tr>
<tr>
<td>SO₂ Removal Efficiency</td>
<td>663 tons/yr</td>
<td>80%&lt;sup&gt;(g)&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO₂ Removed</td>
<td>530 tons/yr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO₂ Removal Cost Effectiveness (total annualized cost/ tons SO₂ removed)</td>
<td></td>
<td></td>
<td></td>
<td>$14,788</td>
</tr>
</tbody>
</table>

Notes for Table 6

a. Excludes site re-orientation (e.g., moving rail spurs).
b. See Note b for Table 1 for an explanation for the basis for including CEMS costs.
c. See Note d for Table 1 for basis for including contingency costs. Contingency is conservatively set at 30% of Base Price to account for the costs and issues associated with retrofitting the Facility (i.e., removing certain existing equipment) to accommodate the footprint of the new equipment. The EPA Cost Manual lists a range of 1 to 50% based on the site.
d. See Note e for Table 1 for basis for permitting costs.
e. See Note f for Table 1 for basis for including furnace downtime.
g. The SO₂ removal efficiency of 80% is a conservative estimate. If removal efficiency decreases, cost per ton of SO₂ removal will increase.
### Table 7 Estimated Cost: DSI Shop 1 (EAFs Nos. 1 + 2 + 3)

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct Capital Costs</strong>&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment (purchase, auxiliary, instruments, controls, and freight)</td>
<td>$10,896,590</td>
<td>$20,408,361</td>
</tr>
<tr>
<td>CEMS&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>$150,000 (estimate)</td>
<td></td>
</tr>
<tr>
<td>Taxes (7% on Equipment (except freight) and CEMS)</td>
<td>$762,761</td>
<td></td>
</tr>
<tr>
<td>Installation</td>
<td>$8,599,010</td>
<td></td>
</tr>
<tr>
<td><strong>Indirect Capital Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering (Globe)</td>
<td>$59,047</td>
<td>$4,824,226</td>
</tr>
<tr>
<td>Performance test and dispersion modeling</td>
<td>$236,187</td>
<td></td>
</tr>
<tr>
<td>Contingencies&lt;sup&gt;(c)&lt;/sup&gt;</td>
<td>$3,542,805</td>
<td></td>
</tr>
<tr>
<td>Permits&lt;sup&gt;(d)&lt;/sup&gt;</td>
<td>$236,187</td>
<td></td>
</tr>
<tr>
<td>Furnace down time&lt;sup&gt;(e)&lt;/sup&gt;</td>
<td>No estimate included</td>
<td></td>
</tr>
<tr>
<td>Demo/disposal of existing BH</td>
<td>$750,000</td>
<td></td>
</tr>
<tr>
<td><strong>Net Capital Costs</strong></td>
<td>$25,232,587</td>
<td></td>
</tr>
<tr>
<td><strong>Direct Annual Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material consumed (hydrated lime, water, power, maintenance materials, chemical shipping)</td>
<td>$3,514,528</td>
<td>$4,086,334</td>
</tr>
<tr>
<td>CEMS maintenance and calibration</td>
<td>$30,000 (estimate)</td>
<td></td>
</tr>
<tr>
<td>Labor hours (supervisor, maintenance, operating)</td>
<td>$186,238</td>
<td></td>
</tr>
<tr>
<td>Lime dust disposal</td>
<td>$355,568</td>
<td></td>
</tr>
<tr>
<td><strong>Indirect Annual Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overhead on operating, supervisor, and maintenance labor, and maintenance materials</td>
<td>$146,721</td>
<td>$619,095</td>
</tr>
<tr>
<td>Insurance on Base price&lt;sup&gt;(f)&lt;/sup&gt; (BP) (1%)</td>
<td>$118,094</td>
<td></td>
</tr>
<tr>
<td>Property Tax on BP (1%)</td>
<td>$118,094</td>
<td></td>
</tr>
<tr>
<td>Administrative charges on BP (2%)</td>
<td>$236,187</td>
<td></td>
</tr>
<tr>
<td><strong>Capital Recovery</strong></td>
<td>$3,267,620</td>
<td>$3,267,620</td>
</tr>
</tbody>
</table>

<sup>(a)</sup> Direct Capital Costs include all costs directly related to the installation of the DSI system.

<sup>(b)</sup> CEMS costs are estimated.

<sup>(c)</sup> Contingencies include unexpected costs and are calculated as 5% of direct capital costs.

<sup>(d)</sup> Permits are estimated costs.

<sup>(e)</sup> Furnace down time is not included as an estimated cost.

<sup>(f)</sup> Insurance on Base Price is estimated as 1% of the base price.
Table 7 Estimated Cost: DSI Shop 1 (EAFs Nos. 1 + 2 + 3)

<table>
<thead>
<tr>
<th></th>
<th>Direct Annual Costs</th>
<th>Indirect Annual Costs</th>
<th>Capital Recovery</th>
<th>Total Annualized Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>$SO_2$ Emissions</strong></td>
<td>$4,086,334</td>
<td>$619,095</td>
<td>$3,267,620</td>
<td>$7,973,049</td>
</tr>
<tr>
<td><strong>$SO_2$ Removal Efficiency</strong></td>
<td>661 tons/yr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>$SO_2$ Removed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>$SO_2$ Removal Cost Effectiveness (total annualized cost/ tons $SO_2$ removed)</strong></td>
<td>$15,078</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes for Table 7

a. Excludes site re-orientation (e.g., moving rail spurs).

b. See Note b for Table 1 for an explanation for the basis for including CEMS costs.

c. See Note d for Table 1 for basis for including contingency costs. Contingency is conservatively set at 30% of Base Price to account for the costs and issues associated with retrofitting the Facility (i.e., removing certain existing equipment) to accommodate the footprint of the new equipment. The EPA Cost Manual lists a range of 1 to 50% based on the site.

d. See Note e for Table 1 for basis for permitting costs.

e. See Note f for Table 1 for basis for including furnace downtime.


g. The $SO_2$ removal efficiency of 80% is a conservative estimate. If removal efficiency decreases, cost per ton of $SO_2$ removal will increase.
6. **DSI / BAGHOUSE COST AND CONFIGURATION**

As presented in Section 4, the DSI technology proposed by Redecam is economically prohibitive and would present significant technical impediments at EAF No. 5. Ohio EPA requested that Globe provide additional analysis regarding the economic and technical feasibility of installing DSI at the Facility. Specifically, Ohio EPA requested that Globe provide:

1. The cost of installing DSI systems prior to the existing No. 1 Shop Baghouse and prior to the existing No. 2 Shop Baghouse; and
2. The feasibility/technical challenges to installing and operating DSI systems with the Facility’s existing No. 1 Shop and No. 2 Shop Baghouses.

Before turning to these specific topics, two background points provide important context. First, as earlier noted, Globe operates five (5) EAFs in two shops at the Facility: Shop 1 houses EAF Nos. 1, 2, and 3, with the combined exhaust from those furnaces controlled by the No. 1 Shop Baghouse; Shop 2 houses EAF Nos. 5 and 7, with the combined exhaust from those furnaces controlled by the No. 2 Shop Baghouse. The No. 1 and No. 2 Shop Baghouses are designed and functioning appropriately for their intended use—that is, the control of particulate matter (“PM”) from the EAFs exhaust streams, venting to the atmosphere through roof monitors. The baghouses were not designed to work in line with DSI, nor were they designed to exhaust to a stack.

Second, Globe and ERM expended significant time and resources researching and soliciting bids concerning potential SO$_2$ controls. Globe solicited the vendor bids in the context of the ongoing U.S. EPA enforcement action and so were focused on No. 2 Shop, and particularly on EAF No. 5. While the information provided in this section is limited by the available information, the information supports and forms the basis for the conclusions in this section.

Ohio EPA’s questions concerning the cost and configuration of DSI systems and baghouses turn on two fundamental questions. First, must the exhaust from the Facility’s furnaces be controlled by a baghouse upstream of DSI, in addition to a baghouse downstream of DSI? Second, can the existing baghouses be utilized in conjunction with DSI, either upstream or downstream of DSI?

As explained below, each DSI system must be coupled with at least two new baghouses—one controlling particulate upstream of DSI so that the DSI system can function as designed, and one controlling particulate (primarily particulate resulting from sorbent injection) downstream of DSI. The reasons for this are as follows:

- **First,** technical and cost issues prevent pairing the existing baghouse upstream or downstream of a DSI system with a second new baghouse.
- **Second,** modifications would be needed in order for the existing baghouses to operate either upstream or downstream of DSI. However, the modifications required for the existing baghouses to operate upstream of DSI are not structurally feasible. And the modifications known to be required for the existing baghouses to operate downstream of a new baghouse and DSI are significant and costly.
- **Third,** even with such modifications, Globe does not know whether the existing baghouses could function properly downstream of a DSI and new baghouse, including whether such a configuration could result in future reliability or operational issues.

The reasons supporting these conclusions are detailed below. In addition, it is an important point of emphasis that that DSI has never been implemented at a ferrosilicon facility. There are significant technical and cost impediments to the installation of DSI at the Facility even with two new baghouses.
6.1 Cost of installing DSI pre-baghouse

The cost and possible design/configurations of SO₂ control systems at the Facility are based upon vendor quotes submitted to Globe in response to a bid solicitation process to control SO₂ emissions from EAF Nos. 5 and 7. The solicitation provided bidders the option to instead, or in addition, design and supply an SO₂ control system to control emissions from EAF No. 5, alone. As noted above, Globe and ERM identified and solicited bids from 11 third-party vendors for SO₂ control systems. Only two vendors submitted bids. The bid solicitation did not specify the type of control technology or the design of the control system. Globe informed the vendors that the bid could involve the modification or replacement of the existing baghouse, if necessary.

Globe did not receive a quote from any vendor proposing a DSI system designed to operate without an upstream baghouse. As a result, ERM is unable to provide a specific cost estimate for the installation of DSI systems prior to the existing No. 1 and No. 2 Shop Baghouses, without the addition of new baghouses.

Only one of the two bids involved the installation of DSI. Redecam’s February 2019 proposal contemplated installation of a DSI system with two baghouses – one upstream and the other downstream of the DSI – serving both EAF Nos. 5 and 7. This proposal had incomplete technical and cost information. As discussions between Globe and Redecam progressed, the focus turned to addressing the exhaust of only EAF No. 5. Redecam submitted the final version of the bid for EAF No. 5 in March 2019. The March 2019 bid similarly contained incomplete technical and cost information.

The net capital cost from the March 2019 budget quote for EAF No. 5 was approximately $12.3 million, not including the cost of a CEMS or any indirect capital cost. Based on this estimate, as detailed above in Section 4, ERM estimated the total net capital cost (including a CEMS and indirect capital costs) at $13.8 million, with a total annualized cost of approximately $5.2 million.

6.2 Ability to install DSI at the Facility to function with the existing baghouses

Technical and financial impediments preclude the use of the existing baghouses with DSI. Globe considered five equipment configurations for DSI—three involving use of the existing baghouses, and two that do not, as follows:

Config. #1: Furnace → DSI → existing baghouse

---

8 A third vendor, Gore, who did not submit a substantive bid, instead informed Globe that it would need to undertake a lengthy and costly engineering study to evaluate the feasibility of installing and operating its technology at the Facility.

9 The original bid request directed vendors as follows: “The Bidder shall modify or replace, as necessary, the existing fabric filter used to collect particulate matter (PM) from both EAF 5 and EAF 7. The silica fume collected in the existing fabric filter is a salable product. The Bidder shall consider equipment orientation to maximize recovery of value from the collected silica fume when designing the SO₂ control unit.”

10 Redecam submitted an initial, incomplete, response to Globe’s bid request in December 2018. That draft was superseded by the February 2019 proposal, and then by the March 2019 proposal.

11 The costs for dismantling and disposing of the existing baghouses were also not included. For purposes of the below stack estimate, these costs were assumed to be $750,000 for each shop baghouse; however, they could be as high as $1,000,000 for each.

12 In addition, neither ERM nor Globe is aware of any demonstrated implementation of DSI in the metallurgical industry.
Config. #2: Furnace → DSI → new baghouse
Config. #3: Furnace → existing baghouse → DSI → new baghouse
Config. #4: Furnace → new baghouse → DSI → existing baghouse
Config. #5: Furnace → new baghouse → DSI → new baghouse

None of the five configurations was found to be suitable at the Facility. The reasons, including a further explanation of why the existing baghouses are not compatible with DSI, are discussed in turn below. Setting aside Globe’s fundamental concerns regarding whether DSI can effectively control SO\(_2\) in the Facility’s furnace exhaust streams, the only configuration potentially viable is Configuration #5 (but even here, again setting aside whether DSI can be effectively implemented for these furnaces, there are substantial technical and economic impediments to this configuration as proposed by Redecam).

### 6.2.1 Configuration #1: Furnace → DSI → existing baghouse

The simplest configuration places a new DSI system inline in the exhaust gas stream between the furnace off-takes and the existing baghouse fan inlets. Sorbent is injected into the gas streams and filtered out in the existing baghouses, along with particulate from the furnaces. The combined particulate (particulate from furnace exhaust + sorbent) is transported to existing silos where it is processed for shipment from the Facility. Substantial technical issues exist with this design, any one of which effectively precludes use of Configuration #1 as a technically viable option for SO\(_2\) control at the Facility.

#### 6.2.1.1 The DSI system would significantly increase fabric filter PM loading

The existing baghouses for No. 1 and 2 Shops were designed to control PM loadings from the combined furnace exhausts in each shop. The increase in PM loading associated with a DSI system (between 1,400 and 1,800 pounds per hour (“lb/hr”), without accounting for the effect of SiO\(_2\) in the gas stream) would increase the pressure across the filter bags, reduce the exhaust flow from the furnace exhaust hoods, increase fugitive emissions from the furnaces, and compromise filter life due to increased cleaning requirements. With an estimated current PM loading per Shop of 60,000 lb/day, the addition (at the upper end) of the estimated lime injection rate (1,800 lb/hr for No. 2 Shop, or 43,200 lb/day) represents 72% more PM that would enter No. 2 Shop Baghouse if a DSI system was installed and operated prior to the existing baghouse.

Modifications to the existing baghouses to accommodate the estimated 72% increase in PM loading would require, among other changes, increasing the number of filter bags and/or the size of the filter bags, increasing the size or number of baghouse compartments, increasing the compartment hopper sizes, redesigning the reverse-air cleaning system, and redesigning the PM conveying, storage, and load-out systems. In addition, the required modifications to the No. 1 Shop Baghouse and the No. 2 Shop Baghouse would require substantial structural enhancements that may not be possible with the existing baghouse structures. In all, the scope and cost of this re-work—presuming the modifications are structurally possible— is on par with complete baghouse replacement, identified as Configuration #2 below.

#### 6.2.1.2 PM in the furnace exhaust would interfere with the SO\(_2\)/sorbent reaction in DSI system

Exhaust from the Facility’s EAFs contains a variety of PM, including amorphous silicon dioxide (herein referred to as “SiO\(_2\)”). SiO\(_2\) particles are removed by the Facility’s existing baghouses. However, SiO\(_2\) would be present in the exhaust gas entering a DSI system installed prior to the baghouse. Entrained
SiO$_2$ particles are expected to physically block a portion of the DSI reagent (any reagent) from the SO$_2$ also present in the gas stream.

DSI efficiency is known to decrease when non-target PM is present in the gas stream. This technical limitation was noted by Redecam in their technical offer to Globe. Redecam explained that separating baghouse dust upstream of DSI would resolve the efficiency issue.

Globe has not determined the severity of the SiO$_2$ impedance on SO$_2$ removal from Globe’s EAF gas stream. ERM has also not identified any data evaluating the impact of SiO$_2$ on DSI performance on an EAF, and ERM is not aware of any commercially operating DSI system on an EAF or equivalent system.$^{13}$

### 6.2.1.3 SiO$_2$ Fume would react with the hydrated lime reagent

The only DSI system that was offered to Globe (by Redecam) proposed the use of high-grade hydrated lime as the sorbent.$^{14}$ The use of DSI with hydrated lime without first removing PM (and with it, SiO$_2$ particles) presents two significant concerns.

First, it is expected that the SiO$_2$ particles present in the pre-baghouse gas stream would compete with SO$_2$ for the hydrated lime reaction in the DSI system. This would have a direct, negative, impact on the stoichiometric ratio of hydrated lime required to react with the SO$_2$ present in the gas stream to effectively remove SO$_2$ from the exhaust stream. Globe estimates that approximately 60,000 lb/day of SiO$_2$ fume from Shop 2 would enter the DSI system (Globe expects a similar volume of SiO$_2$ fume from Shop 1),$^{15}$ compared with 4,000 lb/day of condensable SO$_2$ in a pre-cleaned gas stream. As stated above, the proposed Redecam DSI system for No. 2 Shop is estimated to require up to 43,200 lb/day of lime injection if injected into a clean gas. As a result of the lime reacting with SiO$_2$, the use of a DSI system with an uncleaned gas stream would require significantly more sorbent to potentially achieve the same removal efficiency. The injection of such high levels of lime would be expected to have a negative impact on baghouse performance due to the increased PM loading. The resulting PM loading could easily double the existing PM loading, which would overstress the existing baghouse structure and require the extensive modifications discussed earlier in topic 1.

Second, because the SiO$_2$ entrained in the furnace exhaust is highly pozzolanic, Globe anticipates that the amorphous SiO$_2$ fume and hydrated lime reagent would react to form cementitious product. The resultant cementitious product would cause catastrophic operational and maintenance problems downstream as it accumulates on fan surfaces, duct walls, damper blades, transport pipes, silo walls, etc.

### 6.2.1.4 Injection of reagent would prevent the sale of fume

The Facility’s EAF fume handling systems were designed to recover the Si content from the fume in the baghouses. Such designs are common in other metal production/recovery facilities as well (e.g., lead recovery, zinc recovery). Injecting sorbent into the EAF gas would contaminate the Si in the gas. Contamination of saleable silica fume with unreacted and spent sorbent, as well as reaction products

---

$^{13}$ Although fly ash from coal-fired boilers also contains SiO$_2$, exhaust streams and operational conditions are too different between coal-fired boilers and EAFs to draw any conclusions on the potential impact of SiO$_2$ on DSI performance on an EAF.

$^{14}$ Although no vendor proposed a sodium-based DSI system to Globe, a similar concern is expected to exist when using Trona or sodium bicarbonate as the sorbent because the presence of high levels of SiO$_2$ in the exhaust gas would reduce the available sorbent to react with and remove SO$_2$ from the gas stream.

$^{15}$ This estimate is based on the production of silicon metal.
entrained in the gas and ultimately removed in the baghouses, would render the combined product a waste that would need to be landfilled rather than sold for beneficial reuse. The contamination of the Facility's silica fume would, therefore, alter the fundamental design of the Globe fume recovery process, which, as designed, renders saleable silica fume.\(^\text{16}\)

\subsection*{6.2.1.5 Cost}

This equipment configuration was not costed due to the technical feasibility limitations described above. Tellingly, no vendor submitted a proposal or provided a cost estimate for Configuration #1.

As detailed in Section 4, above, Globe and ERM estimate that the installation of a DSI system upstream of the existing No. 2 Shop Baghouse would have significant financial implications. The same holds true for No. 1 Shop Baghouse.

In addition, as further detailed in Section 7, over the past five years, Globe sold an average of 15,489 tons of fume from the Facility (counting fume from both shops), generating average annual profits of $724,426. If Globe had to instead dispose of that fume, then (assuming the current transportation and disposal cost of $54.20 per ton), instead of generating $724,426 in average annual profits, Globe would have spent $839,519 in average annual transportation and disposal costs. The combined average annual impact of loss of profits plus the incurrence of transportation and disposal costs would have been $1,563,944.

\subsection*{6.2.2 Configuration #2: Furnace $\rightarrow$ DSI $\rightarrow$ new baghouse}

This configuration mirrors Configuration #1, but replaces the existing baghouses with new baghouses (downstream of DSI) and associated processing systems with sufficient capacity to handle the additional PM produced in the DSI system. The new baghouse would not resolve the technical issues associated with sorbent injection on uncleaned furnace gas.

\subsubsection*{6.2.2.1 A new baghouse would not address the majority of technical impediments.}

The installation of a new baghouse would, presumably, allow for a design that is able to accommodate the increased particulate loading resulting from the injection of sorbent upstream of the baghouse. However, the same technical issues associated with the interaction between SiO\(_2\) entrained in pre-baghouse exhaust and the DSI system that were identified in Configuration #1 remain. Globe maintains (as does Redecam, the only equipment vendor to propose any DSI system configuration for Globe) that exhaust from the EAF must pass through a baghouse prior to the DSI system regardless of whether a new baghouse is located downstream of the DSI system.

\subsubsection*{6.2.2.2 Cost}

For the same reasons identified in Configuration #1, this option was not costed due to technical feasibility limitations. In addition, no vendor provided a cost estimate for a DSI system with this configuration.

\subsection*{6.2.3 Configuration #3: Furnace $\rightarrow$ existing baghouse $\rightarrow$ DSI $\rightarrow$ new baghouse}

In this configuration, the furnace exhaust gases would be routed from the existing baghouses to the DSI systems, and then to new baghouses where the sorbent-produced PM can be removed. This configuration would solve certain feasibility concerns described in Configuration #1 and Configuration #2.

\(\text{16}\) Globe’s BACT Evaluation explained that the contamination of fume with reagent would “change the basic manufacturing process associated with FeSi and Si metal production.”
by using the existing baghouse filters to pre-clean the exhaust gas and provide the necessary residence time for the sorbent/\text{SO}_2\ reaction to occur. However, installing DSI systems downstream of the existing baghouses would require modifications to the existing baghouses that are not structurally feasible.\textsuperscript{17}

\textbf{6.2.3.1 The existing baghouses have structural limitations that prevent exhausting to a DSI system}

There are two primary modifications to the baghouses that would be required to exhaust to DSI systems. Both modifications exceed the structural limitations of the current baghouses, which are designed to operate with the current configuration of the Facility.

First, the existing baghouses were designed to operate at a neutral pressure on the clean side of the fabric filter bags. The baghouse “shell” is a light steel frame with corrugated sheet metal screwed to the outside of the frame. To induce flow from the existing baghouses into a downstream control device, clean-side exhaust gas would have to be pressurized by increased fan pressure on the supply side, or negatively pressurized by a new fan on the outlet side. Either option will impart substantial pressure on the baghouse walls, resulting in forces that the baghouse structures were not designed to accommodate.

Second, Globe would need to seal the existing baghouse roof exhausts (roof monitors) in order to exhaust to DSI systems. The additional material and load associated with sealing the roof monitors exceed the current structural limitations of either of the baghouses.\textsuperscript{18}

The structural limitations associated with the current baghouse design are further evidenced by the recommendation from another vendor that submitted a proposal in response to Globe’s bid request. Amerair/CEECO\textsuperscript{19} proposed installation of a different \text{SO}_2 control device – a wet FGD. Like Redecam, Amerair/CEECO’s proposal recommended against use of the existing baghouse with their \text{SO}_2 control. Amerair/CEECO explained, “[a] new fabric filter is proposed due to both [the] cost and complication in converting the existing fabric filter to a negative draft system as well as perceived structural inadequacies of the existing unit” (see CEECO proposal EAF Nos. 5 + 7, Attachment B).

To date, Globe has not identified an engineering solution that would solve these structural limitations and thus physically allow for the other necessary modifications.\textsuperscript{20} As noted in Section 8, below (discussing the installation of stacks) it may not be possible for Globe to address the structural issues presented by the baghouse modifications needed to vent to DSI. Even if those could be identified and addressed, the scope and cost of all of the modifications would be on par with complete baghouse replacement.

\textsuperscript{17} A number of other technical issues associated with operating DSI at the outlet of the existing baghouses exist, including issues associated with re-heating baghouse exhaust gas and overcoming an increase in pressure differential from installation of additional control equipment. See Supplemental RACM Report, pgs. 8-9.

\textsuperscript{18} The structural limitations associated with closing the existing baghouse roof monitors are also present if Globe tried to install a stack on the existing baghouses. These concerns are discussed in Section 8, below.

\textsuperscript{19} CEECO is familiar with the Facility due to the fact that they are a mechanical equipment supplier for the site.

\textsuperscript{20} Globe believes that it would need to address additional structural issues, including: stiffening housing internal and external walls; modifying internal and external roof monitor walls to construct a gas plenum; adding extra column support to handle extra weight; and/or evaluating/fortifying foundations in order to increase soil weight-bearing capabilities.
6.2.3.2 Cost

This configuration was not costed due to technical feasibility limitations. In addition, no vendor provided a cost estimate for a DSI system with this configuration.

6.2.4 Configuration #4: Furnace → new baghouse → DSI → existing baghouse

This configuration contemplates installing a new baghouse upstream of DSI to clean the furnace gas, while retaining the existing baghouses to operate downstream of the DSI system to remove sorbent. In essence, a new baghouse and new DSI system would need to be installed upstream of the existing baghouse. Globe did not receive a single vendor bid proposing to use the existing baghouse downstream of the SO\(_2\) control device (nor, for that matter, did Globe receive a vendor bid for any DSI configuration other than Configuration 5, below). Globe does not consider this Configuration #4 as a viable approach to SO\(_2\) control at the Facility. Further, as discussed below, there are a number of technical concerns that Globe would need to address that raise questions about the feasibility of this approach.

6.2.4.1 The existing baghouses are not designed to remove sorbent from the exhaust gas and the modifications to allow for such operation are not fully known

The existing baghouses are designed specifically to remove PM from furnace exhaust gas. Routing furnace exhaust gas first to a new baghouse and then through DSI would require that the existing baghouses undergo modifications to accommodate the removal of a different particulate with different properties, including a different exhaust stream. These modifications would likely include:

- Replacement of all of the existing filter bags with bags designed to accommodate the different particulate generated by DSI;
- Resizing of the baghouses as appropriate to handle a lower volume of particulate generated by the DSI system as compared to the furnaces;
- Replacement of the existing solids handling equipment to accommodate the different particulate; and
- Installation of additional duct work to allow for the routing of furnace exhaust gas to a new baghouse and DSI system, and then back to the existing baghouse for sorbent removal. Globe notes that there is limited space within the existing footprint of the No. 1 and No. 2 Shops. The installation of an additional baghouses and DSI systems within the existing Facility footprint may present engineering complications. For instance, the proximity of the existing No. 2 Shop Baghouse to the EAF Nos. 5 and 7, could require installation of a complex network of ducts that could cause plugging and other long-term operational issues.

6.2.4.2 Cost

This option was not costed because no vendor provided a cost estimate for a DSI system with this configuration. ERM estimates, however, that the modifications that may be required (which may be greater than the modifications listed above) to convert the existing baghouses to capture sorbent are expected to be significant. For example, the replacement alone of the baghouse filter bags in the existing baghouses would likely cost in the range of $1 million per baghouse. This calls into question the economic feasibility of utilizing the existing baghouses.

6.2.5 Configuration #5: Furnace → new baghouse → DSI → new baghouse

This configuration was proposed by Redecam for EAF No. 5. In the Redecam technical proposal, EAF No. 5 exhaust gas is routed from the furnace to a new primary baghouse where the SiO\(_2\) fume is
removed, then to a high-grade hydrated lime-based DSI system, and then to a new baghouse where the sorbent and reaction product can be removed (Redecam recommended that the DSI injection point be located after the replacement baghouse).

Configuration #5 represents the only potentially viable configuration to control SO₂ emissions at the Facility. Globe characterizes Configuration #5 as potentially viable because its potential viability is premised on the bid provided by Redecam to control emissions from EAF No. 5. However, Globe has concerns concerning the technical viability of Redecam’s design, as well as whether DSI can be effectively implemented for these furnaces. In addition, the estimated cost for installing – at a minimum – two new baghouses with two new DSI systems and associated equipment to control both Shop 1 and Shop 2 are not economically reasonable.

6.2.5.1 Vendor’s proposal requires the use of pulse jet baghouses that may not function properly at the Facility

Globe’s Facility is designed to function with reverse-air baghouses. Despite this, Redecam only proposed a DSI system coupled with installation of two (pre- and post-DSI) pulse jet baghouses. A pulse-jet cleaning system operates by completely breaking the dust cake from the filter membrane during a rapid cleaning process that cycles on/off roughly every 30 seconds. Globe is concerned that pulse jet baghouses may not operate properly with the lightweight silica exhaust fume generated by ferroalloy furnaces because the particulate is not heavy enough to clear the bags between cleaning cycles. This could result in baghouse plugging due to the inability to properly clean the bags, which can lead to reduced baghouse efficiency and increased particulate emissions, among other issues.

Because of the potential operational issues (and the fact that Globe is aware of at least one other ferroalloy facility that had operational difficulties with the use of pulsejet baghouses), Globe does not consider the installation of pulse jet baghouses (at least for the baghouse upstream of the DSI where silica fume is present from the furnaces) under Redecam’s proposal as a technically feasible design. This is particularly true here, where Globe already utilizes a reverse air baghouse system that has proven to be a reliable control technology to remove PM at its Facility. It is unreasonable to potentially jeopardize PM removal by switching to a pulse jet baghouse technology.

6.2.5.2 There is no demonstrated use of DSI on silicon metal or ferrosilicon furnaces

Although DSI systems have been operating on coal-fired boilers for the past 20 years, ERM is not aware (nor is Globe) of any demonstrated implementation of DSI in the metallurgical industry. The differences between coal-fired boilers and the metallurgical industry processes have not allowed transfer of DSI

---

21 Concerns regarding the use of pulsejet baghouses with silica fume have been studied. A June 2013 report, for example, noted that “[c]onsidering the low density and low settling velocity of the silica fume generated by FeSi and Si melting furnaces the filter velocity...has to be kept low, and bags longer than 4.2 meters must be avoided [, and] [c]areful consideration must be given to the spacing between the bags, the spacing between the bags and the internal walls.” See Guidelines for Sizing Baghouse Filters Used for Ferroalloy and Silicon Metal Furnace Applications, at section 9, 13th International Ferroalloys Congress June 9-13, 2013, available at www.pyrometallurgy.co.za/InfaconXIII/1015-Fereday.pdf.

22 The same concerns with the technical feasibility of pulse jet baghouses exist with any configuration proposing the use of pulse jet baghouses by Redecam (see, e.g., Configuration #4, 6.2.4).
technology to any known metallurgical operation. In addition to previously identified differences, the lack of a stable process gas temperature prior to a suitable sorbent inject point complicates DSI application at the Facility. Additionally, as previously mentioned in the RACM Report and the BACT Evaluation, the Beverly site is very congested with equipment, gas duct work, and support items such as rail lines that would impede construction of new facilities needed to implement DSI systems.

The effectiveness of DSI systems even on coal-fired boilers continues to vary widely depending on the specific application of the technology. This raises concerns for Globe that a DSI system installed at its Facility could achieve a specified SO$_2$ removal efficiency. For example, in Alaska, a DSI system was in use at a low-sulfur coal-fired power plant and achieved less than 30% removal of the SO$_2$. Several modifications were made to the DSI system to improve performance, but the system continues to operate with a removal efficiency near 30%. As noted in the Supplemental RACM Report (page 8 of that report), low SO$_2$ concentrations inherent in the Facility’s furnace exhaust would reduce the removal efficiency of DSI (because there is less SO$_2$ for secondary reactions in the baghouse following sorbent injection).

In short, there is significant uncertainty regarding the feasibility of operating DSI at the Facility. This uncertainty is only compounded by the complete lack of data from any operation of a DSI system at a metallurgical facility.

6.2.5.3 Cost

As provided in Section 4 of this TCE, Redecam provided a cost estimate for Configuration #5 to address the exhaust of EAF No. 5. And as provided in Section 5 of this TCE, ERM extrapolated costs from the Redecam proposal to develop a good-faith estimate of the cost to install Configuration #5 in Shop 1 and Shop 2 of the Facility.

7. IMPACT FROM LOSS OF SALE OF FUME IF ADD-ON SO$_2$ CONTROLS ARE INSTALLED

As part of the Facility’s regular business operations, Globe sells baghouse dust (which Globe refers to as “fume”) collected from the Facility’s two existing baghouses (No. 1 Shop baghouse and No. 2 Shop baghouse). Residuals in the gas stream from the use of add-on SO$_2$ controls would make the fume unavailable for sale to third-parties. As a consequence, the use of add-on SO$_2$ controls would require that Globe dispose of, rather than sell, its fume from the Facility. This has significant economic consequences for the Facility. These costs were not factored into any of the above-presented costs for the installation of add-on SO$_2$ controls.

Globe estimated the economic impact from installation of add-on SO$_2$ controls on EAF No. 5 (located in the Facility’s No. 2 Shop) resulting from the loss of fume sale, as follows:

7.1 Tons per year of baghouse dust collected and sold from No. 2 shop baghouse for 2014 – 2018

Globe tracks the tons-per-year of fume collected from No. 2 Shop baghouse. All of the fume collected from No. 2 Shop baghouse (and No. 1 Shop baghouse) is sold, not disposed in a landfill. Most but not all of the fume produced in a given year is sold during that same year. Globe maintains records of the total fume sold from the Facility in a given year. However, those records do not indicate what portion of that

---

23 See Globe’s BACT Evaluation, Section 3.1, for a discussion of the similarities and differences between coal-fired oiler facilities and Globe’s facility as they impact feasibility of DSI technology at Globe.
fume originated from No. 2 Shop baghouse, and what portion originated from No. 1 Shop baghouse. To estimate the total fume sold in a year that originated from No. 2 Shop baghouse, Globe applied the ratio of fume collected from No. 2 Shop baghouse during that year to the total fume collected from the plant during that year. Table 8 summarizes these data.

Table 8 Summary of Fume Collected and Sold

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 2 Shop BH fume collected (metric tons)</td>
<td>8,071</td>
<td>10,451</td>
<td>10,251</td>
<td>12,933</td>
<td>8,799</td>
</tr>
<tr>
<td>Total fume collected from No. 1 &amp; 2 Shops (metric tons)</td>
<td>15,737</td>
<td>15,681</td>
<td>12,248</td>
<td>20,030</td>
<td>15,139</td>
</tr>
<tr>
<td>Ratio of No. 2 BH fume to total fume collected</td>
<td>51%</td>
<td>67%</td>
<td>84%</td>
<td>65%</td>
<td>58%</td>
</tr>
<tr>
<td>Total fume sold from No. 1 &amp; 2 Shops (metric tons)</td>
<td>16,071</td>
<td>15,630</td>
<td>12,104</td>
<td>18,568</td>
<td>15,073</td>
</tr>
<tr>
<td>Estimated fume sold from No. 2 BH (metric tons)</td>
<td>8,242</td>
<td>10,417</td>
<td>10,130</td>
<td>11,989</td>
<td>8,761</td>
</tr>
</tbody>
</table>

7.2 Annual profits from selling No. 2 shop fume for 2014 – 2018

Globe does not directly track the annual profits from selling fume from the No. 2 Shop baghouse. Globe does maintain records of the total revenue from the sale of fume. It also maintains records of associated costs, consisting primarily of costs associated with processing and packaging fume for sale. The predominant component of those costs is the cost of labor.

To estimate the annual profits from selling No. 2 Shop baghouse fume, Globe multiplied the total plant revenue and costs associated with fume sales by the ratio of fume collected during that calendar year from No. 2 Shop baghouse to the total fume collected that year from the Facility. This results in an estimation of allocated revenue and costs. Globe then subtracted the allocated costs from the allocated revenue to generate an estimate of profits from the sale of fume that calendar year that was originally collected from No. 2 Shop baghouse.

Table 9 Estimated Profit from Fume Sales

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated profit from No. 2 BH fume sales</td>
<td>$393,520</td>
<td>$545,636</td>
<td>$471,857</td>
<td>$529,856</td>
<td>$378,747</td>
</tr>
</tbody>
</table>

This methodology provides an understated estimate of the share of profits resulting from the No. 2 Shop baghouse, including because it ignores the difference in fume quality that could be produced from No. 2 Shop baghouse than No. 1 Shop baghouse. Fume prices depend on a variety of factors, including the quality of the fume and the quantity of an order. Fume is classified into different types of products, in part, based on its silica dioxide content. And, generally, fume products with higher silica dioxide content (for example, meeting the ASTM-1240 standard) command a higher price than fume with lower silica dioxide content. Smaller volume orders tend to be for fume with higher silica content. This further increases the
difference in average value of fume that meets or exceeds the ASTM-1240 standard, compared with fume that does not. Fume from silicon metal production contains the highest percentage of silica dioxide, fume from 75% ferrosilicon has the next highest, and fume from 50% ferrosilicon production has the lowest. Critically, No. 1 Shop produces only ferrousilicon, not silicon metal. Consequently, losing fume from No. 2 Shop can have a disproportionate effect on the average price per ton of fume sold. That disproportionate effect was not accounted for in the above-estimation.

7.3 Cost of landfilling fume

Globe estimates that disposal of fume at a landfill, together with associated transportation to the landfill, would cost $54.20 per metric ton of fume. Globe has not estimated the associated cost of necessary labor, which would drive this price higher.

8. IMPEDIMENTS TO ADDING A STACK TO THE EXISTING SHOP 1 AND SHOP 2 BAGHOUSES

Globe evaluated the feasibility of adding stacks to the existing two fabric filter baghouses servicing Shop 1 and Shop 2. The technical obstacles to retrofit the existing No. 1 and No. 2 Shop baghouses with stacks are too significant and, as a consequence, would require that Globe undertake a full-scale replacement of each baghouse in order to exhaust Facility emissions through a stack.

Globe’s evaluation was based upon a review of structural inspection reports on the No. 1 Shop and No. 2 Shop baghouses conducted by QSEM Solutions, Inc. (“QSEM”) in September 2015 on behalf of Globe, and discussions with Facility personnel. QSEM determined that significant structural modifications would be required at the No. 1 Shop baghouse to exhaust to a stack. QSEM also determined that the No. 2 Shop baghouse could not accept the necessary structural modifications to exhaust to a stack. Based on Globe’s review of QSEM’s assessment and discussions with Facility personnel regarding the feasibility of retrofitting stacks on the No. 1 and No. 2 Shop baghouses, Globe has concluded that the technical obstacles to retrofit the existing No. 1 and No. 2 Shop baghouses with stacks are too significant.

Copies of the 2015 structural inspection reports for the No. 1 Shop baghouse and the No. 2 Shop baghouse are enclosed. (Attachment D).

The baghouse designs for the No. 1 and No. 2 Shops are roughly identical. Furnace fume from Shop 1 and Shop 2 is sent to independent PM control systems, which include positive-pressure reverse-air cleaning fabric filters (i.e., “baghouse”) for PM removal. Fans located on the dirty side of the baghouse produce the positive pressure. Clean air exits the baghouse through a continuous vent (known as a “monovent” or “roof monitor”) along the top ridge of each baghouse housing.

Converting the existing baghouses to exhaust through a stack could occur either by: (1) using the existing baghouse fans (positive pressure) to direct the furnace gas to newly-constructed stacks; or (2) installing

---

24 This evaluation was done independent of Globe’s evaluation of the feasibility of installing SO₂ add-on controls at the Facility.

25 QSEM’s assessment suggests that the No. 1 Shop baghouse could accommodate a stack with significant structural modifications. However, as further discussed below, issues associated with the necessary structural modifications and other technical issues associated with retrofitting the existing baghouse do not allow for the installation of a stack on the No. 1 Shop baghouse.
new induced draft fans (negative pressure) for the baghouse to deliver the furnace gas to newly-constructed stacks. Neither configuration presents a viable solution:

8.1 Issues with configuration option #1 (positive pressure baghouse)

- Internal housing steel plating is required to redirect gas to a stack. The plating would cause over-pressurization of the existing filter housing. The existing housing is not designed to withstand this additional internal positive pressure. The structural integrity of the filter housings could be compromised, thus producing unstable supports for the filters.
- The existing fan horsepower may be inadequate to overcome the additional back pressure produced by the single point stack discharge.
- The required internal housing steel plating would eliminate safe entry to the filter housing while the furnaces are operating. This would interfere with routine inspection and maintenance activities that are necessary for safe and proper operation of the baghouses.

8.2 Issues with configuration option #2 (negative pressure baghouse)

- The existing filter housings cannot be subjected to negative internal operating pressures without substantial reinforcement of the existing sidewalls.
- The reinforcement of existing sidewalls will overload the structural support columns for the filter housings. As a result, Globe would need to replace the existing filter housings.

8.3 Issues associated with either configuration

- New foundations and supports are necessary to install stacks on the existing baghouses. The foundations would need to be constructed in a congested area of the Facility and it is uncertain if the necessary space is available.
- Monovent modifications will overstress the existing structural support columns for the filter housings.
- The conversion from a monovent to stack exhaust system would require a complete re-engineering of the current air flow/pressure profiles and replacement of the existing fabric filters at each of the baghouses.
- Although a detailed engineering evaluation and review of such a conversion project would be needed, the conversion would be expected to entail furnace downtime for construction and result in significant construction and operating costs. Globe expects both capital costs and increased operating costs due to greater power consumption under the stack configuration.

9. COST OF INSTALLING STACKS ON THE EXISTING BAGHOUSES

As noted above, the installation of stacks on either of the existing baghouses is not technically feasible. As a result, ERM does not have a cost estimate for installation of stacks on No. 1 Shop and No. 2 Shop baghouses.

Stacks could be installed only if Globe first installed new baghouses. The total estimated capital cost of installing two new baghouses with stacks (one for each shop) is $22 million. The basis for this cost estimate is detailed in Table 10. Some adjustments were necessary to the line-item pricing to account for flow rates and other differences between No. 1 Shop and No. 2 Shop conditions; however, the cost for each shop are essentially the same. This estimate should be considered a “study” or “order-of-magnitude”
estimate with an accuracy of +/- 30% for those items included in the estimate. Table 10 presents a breakdown of the costs associated with the installation of stacks.

Table 10 Cost Items Related to Stack Purchase/Installation (2019 dollars)

<table>
<thead>
<tr>
<th>DESCRIPTION OF CAPITAL COSTS</th>
<th>CAPITAL COSTS</th>
<th>BASIS OF ESTIMATE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct Capital Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New filter housing and bags, Shop 1</td>
<td>$2,200,000</td>
<td>Same as Shop 2</td>
</tr>
<tr>
<td>New filter housing and bags, Shop 2</td>
<td>$2,200,000</td>
<td>Based on Redecam EAF 5 + 7 quote</td>
</tr>
<tr>
<td>New fan, Shop 1</td>
<td>$1,625,000</td>
<td>125% of Shop 2 estimate</td>
</tr>
<tr>
<td>New fan, Shop 2</td>
<td>$1,300,000</td>
<td>Estimate at 75% of Redecam EAF 5 + 7 quote</td>
</tr>
<tr>
<td>Motor controls, Shop 1</td>
<td>included in fan cost</td>
<td></td>
</tr>
<tr>
<td>Motor controls, Shop 2</td>
<td>included in fan cost</td>
<td></td>
</tr>
<tr>
<td>Stack, Shop 1</td>
<td>$675,000</td>
<td>Shop 2 price adjusted for 3 furnaces</td>
</tr>
<tr>
<td>Stack, Shop 2</td>
<td>$450,000</td>
<td>Estimate based on Redecam EAF 5 + 7 quote</td>
</tr>
<tr>
<td>Ductwork, Shop 1</td>
<td>$540,000</td>
<td>50% increase over Redecam EAF 5 quote</td>
</tr>
<tr>
<td>Ductwork, Shop 2</td>
<td>$540,000</td>
<td>50% increase over Redecam EAF 5 quote</td>
</tr>
<tr>
<td>CEMS, (a) Shop 1</td>
<td>$150,000</td>
<td>Estimate</td>
</tr>
<tr>
<td>CEMS, Shop 2</td>
<td>$150,000</td>
<td>Estimate</td>
</tr>
<tr>
<td>Foundations/site prep, Shop 1</td>
<td>$50,000</td>
<td>Estimate</td>
</tr>
<tr>
<td>Foundations/site prep, Shop 2</td>
<td>$50,000</td>
<td>Estimate</td>
</tr>
<tr>
<td>Supports</td>
<td>not estimated</td>
<td></td>
</tr>
<tr>
<td>Insulation, Shop 1</td>
<td>$100,000</td>
<td>Estimate</td>
</tr>
<tr>
<td>Insulation, Shop 2</td>
<td>$100,000</td>
<td>Estimate</td>
</tr>
<tr>
<td>Painting</td>
<td>not estimated</td>
<td></td>
</tr>
<tr>
<td>Taxes</td>
<td>not estimated</td>
<td></td>
</tr>
<tr>
<td>Freight</td>
<td>not estimated</td>
<td></td>
</tr>
<tr>
<td><strong>Total Base Price (BP)</strong></td>
<td>$10,130,000</td>
<td>2 baghouses + 2 stacks</td>
</tr>
<tr>
<td><strong>Mechanical erection, Shop 1 (ME1)</strong></td>
<td>$5,340,000</td>
<td></td>
</tr>
<tr>
<td><strong>Mechanical erection, Shop 2 (ME2)</strong></td>
<td>$4,790,000</td>
<td></td>
</tr>
<tr>
<td><strong>Total Direct Capital Costs (DCC)</strong></td>
<td>$20,260,000</td>
<td></td>
</tr>
<tr>
<td><strong>Indirect Capital Costs</strong>(b,c)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering</td>
<td>$253,250</td>
<td>0.025 x BP</td>
</tr>
<tr>
<td>Construction and field expenses</td>
<td>included in BP</td>
<td></td>
</tr>
<tr>
<td>Structural support of existing equipment</td>
<td>included in BP</td>
<td></td>
</tr>
<tr>
<td>Furnace down time, Shop 1</td>
<td>No estimate included</td>
<td></td>
</tr>
<tr>
<td>Furnace down time, Shop 2</td>
<td>No estimate included</td>
<td></td>
</tr>
<tr>
<td>Demolition/disposal of existing BH 1</td>
<td>$750,000</td>
<td>Estimate</td>
</tr>
<tr>
<td>Demolition/disposal of existing BH 2</td>
<td>$750,000</td>
<td>Estimate</td>
</tr>
<tr>
<td><strong>Total Indirect Capital Costs (ICC)</strong></td>
<td>$1,753,250</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL ESTIMATED CAPITAL COST (CC=DCC+ICC)</strong></td>
<td>$22,013,250</td>
<td></td>
</tr>
</tbody>
</table>
Notes for Table 10

a. A CEMS is not necessary for a stack addition. However, as explained above, stacks can only be added to the Beverly facility if the existing baghouses are replaced. In this event, ERM assumes that a CEMS for SO$_2$ and/or opacity could be a required component of the baghouse replacement and stack-addition project. The cost evaluation, therefore, includes the cost of a single stack monitor (cost conservatively estimated at $150,000 per CEMS) for each shop.

b. Permitting costs were not included as an indirect cost as compared to the cost estimation for the installation of SO$_2$ control equipment.

c. See Note f for Table 1. While furnace downtime will be required, ERM has not included an estimate of the financial impact of that downtime in this analysis.
ATTACHMENT A    BACT EVALUATION FOR EAF NO. 5
Best Available Control Technology (BACT) Evaluation

Globe Metallurgical, Beverly, Ohio

August 2018

www.erm.com

The business of sustainability
# TABLE OF CONTENTS

1. INTRODUCTION ........................................................................................................... 1
2. AFFECTED EMISSION UNIT ................................................................................... 1
   2.1 PROCESS DESCRIPTION ............................................................................. 1
   2.2 ESTIMATED SULFUR DIOXIDE EMISSIONS ............................................ 3
3. BACT EVALUATION PROCESS ............................................................................. 5
   3.1 STEP 1: IDENTIFY ALL CONTROL OPTIONS ........................................... 9
      3.1.1 Pollution Prevention ......................................................................... 15
      3.1.2 Wet Scrubbers .................................................................................. 17
      3.1.3 Dry and Semi-Dry Scrubbers ............................................................... 20
      3.1.4 GORE Mercury Control System ......................................................... 23
      3.1.5 European Commission Report on Best Available Techniques ... 25
   3.2 STEP 2: ELIMINATE TECHNICALLY INFEASIBLE OPTIONS ............ 27
      3.2.1 Pollution Prevention ......................................................................... 28
      3.2.2 Wet Scrubbers .................................................................................. 30
   3.3 STEP 3: RANK REMAINING CONTROL OPTIONS BY CONTROL EFFECTIVENESS .......................................................................................................................... 35
   3.4 STEP 4: EVALUATE THE MOST EFFECTIVE CONTROLS .............. 36
   3.5 STEP 5: SELECT BACT .............................................................................. 38
4. SUMMARY AND CONCLUSIONS .......................................................................... 38

## APPENDIX

A. EAF ENTRIES IN THE RACT/BACT/LAER CLEARINGHOUSE
LIST OF TABLES

Table 1. Summary of Globe EAF Operating Conditions per the RACM Report ... 4

Table 2. Flow and Temperature Measurement Results Observed in the EAF Ventilation Study ................................................................................................................................. 4

Table 3. Calculated Process Gas Conditions at the Fabric Filter Outlet (Inlet to an \( \text{SO}_2 \) Control System) ................................................................................................. 5

Table 4. Electrode Properties used in EAF Metallurgical Processes ...................... 17

Table 5. Emissions from Open Submerged Arc Furnaces (concentration) .......... 26

Table 6. Sulfur Content of Materials Used in EAF ..................................................... 28

Table 7. Summary of Technical Feasibility of Pollution Prevention Control Options .............................................................................................................................................. 29

Table 8. Summary of Factors Leading to Technical Infeasibility of Wet Scrubber Use at EAF 5 ........................................................................................................................................ 32

Table 9. Summary of Factors Leading to Technical Infeasibility of Dry Scrubber Use at EAF 5 ........................................................................................................................................ 34

Table 10. Rank of Technically Feasible \( \text{SO}_2 \) Control Options for EAF 5 ........ 34

Table 11. Cost-effectiveness of Technically Feasible \( \text{SO}_2 \) Control Options .... 37
INTRODUCTION

Globe Metallurgical Inc. (Globe) owns and operates a ferroalloy production facility in Beverly, OH, located in Washington County. On June 30, 2015, the US Environmental Protection Agency (EPA) issued Globe a Notice of Violation (NOV) alleging that an April 2013 rebuild of electric arc furnace (EAF) 5 resulted in a net emissions increase of sulfur dioxide (SO$_2$) above the significant threshold defined in the regulations for Prevention of Significant Deterioration (PSD) of air quality. The NOV alleges that this made the rebuild project a major modification under the PSD requirements. The NOV further alleges that Globe has not applied for or obtained any permits containing the necessary PSD requirements (including application of Best Available Control Technology, or BACT) for this major modification. This report presents an evaluation of BACT with respect to EAF 5.

For a separate purpose, the Ohio EPA requested that Globe assist in the State Implementation Plan (SIP) process by evaluating Reasonably Available Control Measures (RACM) and reporting the findings of the evaluation to Ohio EPA. Globe performed a RACM evaluation and submitted the results of the evaluation to Ohio EPA in March 2017, with a supplement submitted in August 2017. The current BACT evaluation relies on some of the information presented previously in the RACM evaluation performed for all SO$_2$ emitting units at the Globe facility. However, this BACT evaluation looks at potential SO$_2$ controls applied only to EAF 5.

AFFECTED EMISSION UNIT

Globe operates two melt shops at its facility to produce silicon (Si) metal and 50% and 75% ferrosilicon (FeSi) alloys. Shop 1 includes three (3) EAFs, and Shop 2 includes two (2) EAFs. The affected emission unit is EAF 5. EAF 5 is housed in Shop 2 and has the ability to produce both FeSi alloys and Si metal. Out of necessity, some of the following discussion also includes aspects of EAF 7, which also is housed in Shop 2.

2.1 PROCESS DESCRIPTION

The EAF process is a reduction smelting operation in which metal oxides contained in raw materials are reduced to base metal. The reactants consist of

---

1 A portion of the process description provided below was obtained from the US EPA’s Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Fifth Edition, Chapter 12: Metallurgical Industry (AP-42).
quartzite gravel (containing silicon oxides), ferrous sources, and a carbon-source reducing agent (in the form of coke, low-volatility coal, charcoal, or wood chips). The weights of furnace input materials vary depending on the desired product and may include the following:

- **Silicon Source**
  - Quartzite gravel

- **Ferrous Sources**
  - Steel turnings
  - Mill scale
  - Pig iron

- **Carbon Sources**
  - Coal
  - Wood chips
  - Coke
  - Charcoal

Coke is not typically used in EAF 5; however, it can be used in small quantities while making FeSi. The raw materials are crushed, sized, and then conveyed to a mix house for weighing and blending. Conveyors transport the processed materials to the furnaces. The mix is then gravity-fed into the furnaces as needed. At high temperatures in the reaction zone, the carbon sources react with metal oxides to form carbon monoxide (CO) and to reduce the ores to base metal. A typical reaction producing FeSi is shown below:

\[
\text{Fe + SiO}_2 + 2 \text{C} \rightarrow \text{FeSi} + 2 \text{CO}
\]

The reaction for producing Si metal is:

\[
\text{SiO}_2 + 2 \text{C} \rightarrow \text{Si} + 2 \text{CO}
\]

Smelting in an EAF is accomplished by conversion of electrical energy to heat. An alternating current applied to carbon electrodes causes current to flow through the charge between the electrode tips. This provides a reaction zone at temperatures up to 2,000°C (3,632°F). The lower parts of the EAF are composed of a steel shell with a flat bottom or hearth. The electrodes extend through the cover and into the furnace shell opening. The surface of each furnace charge contains raw material mix, and at times, could contain molten metal. The lower ends of the electrodes are submerged to about 1 to 2 meters (3 to 7 feet) below the charge surface to allow the three-phase electric current arcs from electrode to electrode to pass through the charge material. The charge material melts and reacts to form the desired product as the electric energy is converted into heat. The carbonaceous material in the furnace charge reacts with oxygen in quartzite...
gravel to reduce the Si to base metal. The reactions produce CO that passes upward through the furnace charge. The molten metal and slag that accumulate on the furnace hearth are removed (tapped) through the tap hole extending through the furnace shell at the hearth level. Tapping typically lasts 15 to 90 minutes.

Operation of the EAF generates SO$_2$ emissions as a result of sulfur contained in the furnace input materials. Sulfur introduced to the EAF in the raw materials is oxidized in the same way as the carbon in the charge. As the carbon in the charge reacts to reduce the metal in the charge, the majority of the sulfur contained in the coal is oxidized to form SO$_2$ and released from the furnace through the furnace top. A canopy hood over the furnace captures the majority of the hot gases (fume) released from the EAF and directs the captured fume through a heat exchanger and to the Shop 2 positive pressure fabric filter for particulate matter (PM) removal.

Shop 2 is equipped with a multiclone followed by a single fabric filter used to collect the combined fume from EAF 5 and EAF 7. A small portion of the SO$_2$ is released as a fugitive emission from the furnace top and during furnace tapping. Carbon monoxide rising through the furnace charge burns in the area between the charge surface and the canopy hood. The combustion air produced at this point substantially increases the volume of gas the fabric filter must handle.

Air from EAF 5 and EAF 7 is captured by individual canopy hoods and then combined for transport to the Shop 2 fabric filter. Dilution air introduced through the bottom of the fabric filter as the gas enters the filter bag compartments reduces the gas temperature and increases the gas flows through the fabric filter. The dust collected in the fabric filter is silica fume, which is a marketable product. Sale of silica fume is an important part of Globe’s business model.

### 2.2 ESTIMATED SULFUR DIOXIDE EMISSIONS

As reported in the RACM evaluation, a study was conducted on EAF 5 in 1996 to improve capture of fugitive emissions. The 1996 study estimated the air flow from EAF 5 to be 122,278 dry standard cubic feet per minute (dscfm). The SO$_2$ concentration was measured in this air at 31.3 parts per million by volume (ppmv). Subsequent addition of capture air will increase this flow by 15,000 dscfm, yielding a total estimated air flow of 137,278 dscfm. Because of similarities between EAF 5 and EAF 7, the same air flow was assumed to exist for EAF 7, yielding a total estimated air flow from Shop 2 of 274,556 dscfm, prior to dilution at the fabric filter, at 600° F.
Table 1 presents a summary of Globe EAF operating conditions as reported in the March 2017 RACM evaluation. Annual SO2 emissions presented in Table 1 are based on highest reported emission rate in any of the 2011 through 2013 Globe Fee Emission Reports; a 98.5 percent capture is used to calculate stack emissions.

**Table 1. Summary of Globe EAF Operating Conditions per the RACM Report**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Highest Reported SO2 Emission, tons/yr</th>
<th>Annual EAF Operating Hours</th>
<th>Air Flow Rate at Furnace Outlet, dscfm</th>
<th>Extra Capture Air, dscfm</th>
<th>Total Air Flow From Furnace, dscfm</th>
<th>Total Air Flow From Shop, dscfm</th>
<th>Average SO2 Stack Emissions (a)</th>
<th>Temp., °F</th>
<th>Total Stack SO2, tons/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAF 5</td>
<td>304.8</td>
<td>7,218</td>
<td>122,278</td>
<td>15,000</td>
<td>137,278</td>
<td>274,556</td>
<td>83.2</td>
<td>56.7</td>
<td>300.2</td>
</tr>
<tr>
<td>EAF 7</td>
<td>368.5</td>
<td>8,670</td>
<td>122,278</td>
<td>15,000</td>
<td>137,278</td>
<td>83.7</td>
<td>57.0</td>
<td>363.0</td>
<td></td>
</tr>
</tbody>
</table>

(a) Based on 98.5% capture. Note that these estimates do not include SO2 contributions from sulfur contained in the EAF electrode estimated to be in the range of an additional 3 to 27 tons per year depending on whether a pre-bake or self-bake type electrode is used.

In response to a February 2017 US EPA Section 114 request, Globe performed a study at its facility as a prelude to evaluating potential improvements in its ventilation system. This study measured individual EAF 5 and EAF 7 exhaust flow rates using standard gas sampling equipment and procedures in terms of standard cubic feet per minute (scfm) and temperature (in °F). Table 2 presents a summary of the measured parameter values during this 2017 EAF Ventilation Study.

**Table 2. Flow and Temperature Measurement Results Observed in the EAF Ventilation Study**

<table>
<thead>
<tr>
<th>Shop</th>
<th>Emission Unit</th>
<th>Measured Flow, scfm</th>
<th>Measured Temperature, °F</th>
<th>Actual Flow Rate, acfm</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>EAF 5</td>
<td>122,134</td>
<td>665</td>
<td>259,247</td>
</tr>
<tr>
<td></td>
<td>EAF 7</td>
<td>172,285</td>
<td>553</td>
<td>329,292</td>
</tr>
</tbody>
</table>

The flows and temperatures listed in Table 2 represent the values at the inlet to the fabric filter. To prevent damage to the filter bags during high temperature spikes, dilution air is brought in through the bottom of the filter housing to lower the temperatures. Radiant cooling also is performed. The dilution and cooling lowers the exhaust gas temperature to approximately 400° F prior to entering the fabric filter, which is above the acid dew point but below the temperature that might cause bag failure. Table 3 presents the typical gas flow rates and SO2 concentrations produced after considering the dilution air that could be needed.

---


to cool the gas stream. These flows, concentrations, and temperatures are reasonable approximations of the values that would need to be treated in an SO$_2$ add-on control system. There is uncertainty in these values, however, and at times actual flow rates, temperatures, and concentrations will be less or more than the amounts shown in Table 3.

Table 3. Calculated Process Gas Conditions at the Fabric Filter Outlet (Inlet to an SO$_2$ Control System)

<table>
<thead>
<tr>
<th>Shop</th>
<th>Representative Flow, acfm</th>
<th>Average Temperature, °F</th>
<th>Average Flow, scfm</th>
<th>Average SO$_2$ Concentration, ppmv</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>769,000</td>
<td>400</td>
<td>474,000</td>
<td>32.9</td>
</tr>
</tbody>
</table>

a. This flow is a representative approximate amount after addition of dilution air (here assumed to be 70°F) through the bottom of the filter housing to cool the inlet gas to a safe level, i.e., less than 500°F. The dilution air volume will vary by season depending on ambient air temperature.

The 2017 measured gas properties for EAF 5 are comparable to those reported in the March 2017 RACM report, but display about 20 percent greater flow than the values reported for EAF 7. The EAF Ventilation Study data provide two important findings related to potential SO$_2$ emissions and options to control SO$_2$:

1. The expected gas flow rates that need to be handled in an abatement unit could be as high as 770,000 acfm for Shop 2 (whereas the RACM evaluation assumed actual flows of approximately 578,000 acfm for Shop 2), and
2. The corresponding furnace exhaust gas to be treated from Shop 2 has an average SO$_2$ concentration less than 40 ppmv. This concentration is comparable to the value measured from EAF 5 in 1996. The concentration may actually be lower in summer months when the ambient air temperature is above 70°F and cooling will require larger volumes of dilution (cooling) air. These two findings (very high exhaust gas volumes and corresponding low SO$_2$ concentrations) raise the question as to whether add-on control equipment is a technically feasible SO$_2$ control option for EAF 5. Further discussion is provided below.

3 BACT EVALUATION PROCESS

BACT is part of a hierarchical approach to air pollution limitations based in part on the air quality in the area in which a stationary source is, or would be, located. The hierarchy specifies three differing degrees of air pollution limitations depending on whether an area was in attainment of the prescribed NAAQS and whether the source requiring control was existing or new. BACT is applicable only to new sources or major modifications in areas that are in attainment of the NAAQS. In comparison, new sources and major modifications in nonattainment areas are required to comply with the Lowest Achievable Emission Rate (LAER)
for the source, whereas existing sources in nonattainment areas are required to apply RACT. No parallel concept exists for existing sources in attainment areas.

In a very broad sense, the distinction between BACT, LAER, and RACT is a cost consideration. Economics play the greatest role when identifying RACT for a source. Although no hard-fast cost line exists, a source is required to apply RACT only if the cost is “reasonable.” An economic test also is required when defining BACT, but an underlying acceptance is that the economic threshold for BACT is higher than for RACT. One rationale for this acceptance is that, because BACT applies to new sources and major modifications, one can include pollution control considerations during the design stage. The BACT cost must still be reasonable when compared to the costs observed at other facilities of the same type. Contrary to RACT and BACT, no cost consideration is given to specification of LAER. All three levels of control rely on application of demonstrated control techniques, as opposed to innovative technologies or techniques that have not been fully developed or demonstrated in practice.

Since originally defined in the mid-1970s, the process of making a BACT determination has undergone numerous refinements. The most notable BACT requirement is related to the PSD regulations concerning preconstruction review for new or modified major air pollutant sources located in clean air areas (i.e., attainment areas). Although the specific procedures have varied over the decades, the PSD BACT evaluation entails a pre-construction review that demonstrates that BACT will be applied on a pollutant-by-pollutant basis for each air pollutant emitted at a rate that exceeds its pollutant-specific PSD significant emission rate. Selection of a BACT emission limit is a case-by-case process that must consider site-specific aspects of the project, including the economics of the selection as well as the environmental and energy impacts that could result from the use of the technique or technology.

BACT is defined in the Ohio PSD regulations at OAC 3745-31-01(S), as follows:

...an emissions limitation (including a visible emissions standard) based on the maximum degree of reduction for each a regulated NSR pollutant which would be emitted from any proposed major stationary source or major modification which the director, on a case-by-case basis, taking into account energy, environmental and economic impacts and other costs, determines is achievable for such major stationary source or major modification through application of production processes or available methods, systems and techniques, including fuel cleaning or treatment or innovative fuel combination techniques for control of such pollutant. In no event shall application of BACT result in emissions of any pollutant that would exceed the emissions allowed by any applicable standard
under 40 CFR Parts 60, 61, and 63. If the director determines that technological or economic limitations on the application of measurement methodology to a particular emissions unit would make the imposition of an emission standard infeasible, a design, equipment, work practice, operational standard, or combination thereof, may be approved by the director instead to satisfy the requirement for the application of BACT. Such standard shall, to the degree possible, set forth the emission reduction achievable by implementation of such design, equipment, work practice or operation and shall provide for compliance by means which achieve equivalent results.

On December 1, 1987, the US EPA Assistant Administrator for Air and Radiation issued a memorandum that introduced the concept of a "top-down" method for determining BACT. The memorandum instructed the US EPA’s Office of Air Quality Planning and Standards to develop specific guidance on using the top-down approach to defining BACT. In 1990, US EPA prepared its draft New Source Review (NSR) Workshop Manual (i.e., the 1990 US EPA NSR Workshop Manual), and in doing so presented the first detailed description of steps needed to be performed when completing the top-down BACT evaluation process. The 1990 US EPA NSR Workshop Manual, although never published as a “final” document, describes the process for performing a BACT assessment, among other topics.

As described in the 1990 US EPA NSR Workshop Manual, the top-down BACT assessment process includes the following steps:

1. Identify all control options
   a. Demonstrated and transferrable technologies
   b. Optional: Innovative control technologies as defined by the Ohio SIP (OAC 3745-31-01 (CCC))
   c. Inherently lower polluting processes
2. Eliminate technically infeasible options
3. Rank remaining control options by control effectiveness (highest to lowest)
4. Evaluate the most effective options (using economic, environmental, and energy criteria) and document results
5. Select BACT

---

Step 1 in this process requires that all available control options be identified. As described by the 1990 US EPA NSR Workshop Manual, available control options are “those air pollution control technologies or techniques with a practical potential for application to the emission unit and the regulated pollutant under evaluation.”\(^6\) (emphasis added) An available control option is one that has been demonstrated to function efficiently on identical or similar processes.\(^7\) Additionally, an owner or operator of a source may—but is not required to—consider innovative control technologies in Step 1.\(^8\) Pursuant to OAC3745-31-01(CCC), innovative control technology means “any system of air pollution control that has not been adequately demonstrated in practice, but would have a substantial likelihood of achieving greater continuous emission reduction than any control system in current practice or of achieving at least comparable reductions at lower cost in terms of energy, economics or non air quality environmental impacts.” While innovative control technologies are not required to be considered, we note that no air pollutant control technology was identified as part of this BACT evaluation that constitutes innovative control technology.

Step 2 requires a review of the technical feasibility of available control options applied to the specific source in question. An option is eliminated as being technically infeasible when some factor, such as a physical, chemical, or engineering principle, precludes its use on the specific source in question.

Step 3 in the top-down BACT process ranks remaining control options by control effectiveness and is the heart of the top-down approach. This step requires that, after technically infeasible control options have been eliminated, the remaining technology with the greatest degree of control should be considered BACT unless the subsequent economic, energy, or environmental evaluation indicates an adverse impact will result. Therefore, in Step 4, the control options listed in Step 3 are evaluated with respect to economic, energy, and environmental factors. A control option can be eliminated if the option is determined to present an adverse impact on any of the three above-listed additional factors.

The level at which a specific evaluation criterion would be considered “adverse” is determined on a case-by-case basis. However, as stated in the 1990 US EPA NSR Workshop Manual,

To justify elimination of an alternative on these [economic] grounds, the applicant should demonstrate to the satisfaction of the permitting agency that costs of pollutant removal (e.g., dollars per total ton removed) for the control alternative are disproportionately high when compared to the

---

\(^7\) See Section IV.A in the 1990 US EPA NSR Workshop Manual.
cost of control for the pollutant in recent BACT determinations. [emphasis added] Specifically, the applicant should document that the cost to the applicant of the control alternative is significantly beyond the range of recent costs normally associated with BACT for the type of facility (or BACT control costs in general) for the pollutant.

Finally, Step 5 selects the control option that represents BACT. Each of these five steps is discussed in more detail below.

3.1 STEP 1: IDENTIFY ALL CONTROL OPTIONS

The first step in a "top-down" analysis is to identify all "available" control options for the emissions unit in question.\(^9\) Available control options are those air pollution control technologies or techniques with a practical potential for application to the emissions unit and the regulated pollutant under evaluation. The focus is on control options that are “demonstrated and potentially applicable” alternatives to achieve control of the pollutant in question.\(^10\) As described in the 1990 US EPA NSR Workshop Manual, to satisfy the legislative requirements of BACT, US EPA believes Step 1 must focus on control options with a demonstrated potential to achieve the highest level of control. A potentially applicable control option is one that has been demonstrated for the pollutant in question, but not necessarily at a similar source. The control options are identified regardless of the source type in which the demonstration has occurred.\(^11\) Technical judgment must then be exercised to determine whether an available control alternative can actually be installed and operated on the specific source type under consideration. Technologies that have not yet been applied to full-scale operations need not be considered.\(^12\)

The 1990 US EPA NSR Workshop Manual categorizes potentially applicable control options as follows:

1. Inherently lower-emitting processes/practices/designs;
2. Add-on controls; and
3. Combinations of 1 and 2.

The top-down approach entails reviewing options in all three of these categories. Inherently lower-emitting processes/practices/designs should be evaluated based on demonstrations made while manufacturing identical or similar products from identical or similar raw materials or fuels. Globe currently uses inherently lower-emitting practices. Add-on controls should be evaluated based on the physical and chemical characteristics of the pollutant-bearing stream and

---

\(^12\) See Section IV.A.1 in the 1990 US EPA NSR Workshop Manual.
the comparability of the production processes being evaluated (see further discussion below). Following this guidance, this BACT evaluation considers inherently lower-emitting practices (i.e., pollution prevention), including and beyond those practices currently employed by Globe, as well as potentially applicable add-on controls employed at similar sources.

The characteristics of Globe’s EAF 5 that are important when identifying potentially applicable add-on controls are as follows:

- **Production processes**
  - The EAF employs heat to smelt a natural resource (quartzite gravel) into metal (Si or FeSi) by employing a reducing agent (carbon) in the form of coal.
  - An electric current passing between electrodes lowered into the EAF supplies the energy (heat) to the smelting process.
  - The EAF has an operating cycle consisting of charging, smelting, and tapping during which various process gas constituents are released from the EAF at varying concentrations and conditions.
  - Si-bearing product is “tapped” from the EAF in the form of liquid metal as well as collected in a fabric filter in the form of a dry particulate silica fume.
  - The EAF 5 has a small charge capacity consisting of gravel, carbon, other minor input materials, and a ferrous source when producing FeSi.

- **Off-gas properties**
  - The off-gas contains a saleable product, i.e., silica fume.
  - The process gas flow rate from the EAF fluctuates over a wide range depending on EAF operating phase within the smelt cycle.
  - The process gas temperature fluctuates over a range between near-ambient temperature and 600˚F depending on EAF load and phase within the smelt cycle.
  - SO₂ concentrations in the process gas are low and vary between 32 and 56 ppmv, and possibly lower, depending on the cycle phase of the furnace.

The characteristics of other industrial processes and the process off-gas they produce were evaluated to identify potentially applicable control options for Globe. The most similar other industrial processes are those for making steel, specifically those steel-producing facilities that use an EAF in the melting operations. The following points compare steel production EAF facilities with Globe’s EAF facility:
• Similarities between steel-producing EAFs and Globe’s EAF 5 are:
  o Both processes use an electric current to smelt/melt charge material.
  o Both processes capture process off-gas to remove PM prior to discharge to the atmosphere.
  o Both processes undergo a charge/(s)melt/tap cycle to produce molten metal.
  o \( \text{SO}_2 \) is present in the process gas at very low concentrations, and neither process employs add-on \( \text{SO}_2 \) control equipment.

• Differences between steel-producing EAFs and Globe’s EAF 5 are:
  o Some steel-making EAFs are primary processes (i.e., they smelt ore), but many steel-producing EAFs are predominantly melting furnaces and do not use primary raw materials in the process (i.e., they use previously-produced iron or steel scrap as charge materials). EAF 5, on the other hand, charges only “raw” or virgin materials during Si metal production.
  o Steel-making EAFs have much greater melt capacities than EAF 5.
  o The fume generated by a steel-making EAF has no product value (and is actually a hazardous waste--K061) whereas the fume generated by EAF 5 is sold as Si product.

The production process in Globe’s EAF 5 requires coal as a carbon source, but the process is very different than other industrial facilities that use coal, such as a coal-fired boilers. The following points compare coal-fired boiler facilities with Globe’s facility:

• Similarities between coal-fired boilers and Globe’s EAF 5 are:
  o Both processes introduce coal as a critical aspect of the process/operation.
  o Both processes produce a high-temperature off-gas.
  o Both processes oxide the sulfur in the coal to \( \text{SO}_2 \).

• Differences between coal-fired boilers and Globe’s EAF 5 are:
  o A boiler combusts coal, whereas EAF 5 uses coal as a reactant to reduce the \( \text{SiO}_2 \) in the raw material.
  o A boiler typically operates under steady-state conditions and does not drastically vary heat inputs. Thus, boiler flue gas tends to remain at a constant condition with respect to temperature and flow rate. EAF 5 conditions fluctuate regularly throughout the smelt cycle, thereby producing wide variations in the gas flow rate and temperature.
  o Boiler fly ash contains metal impurities present in the coal, including arsenic, cadmium, chromium, lead, mercury, and selenium. These impurities limit the beneficial uses of collected
boiler fly ash. However, Globe’s ability to sell its collected Si fume is much more dependent on maintaining low concentrations of impurities in the fume. Coal used in EAF 5 has been “washed” to remove undesirable trace metal constituents, allowing Globe to collect and sell the fume in process off-gas as a product.

- Boilers that employ add-on SO$_2$ control equipment have SO$_2$ concentrations in the flue gas that typically range between 250 and 3,000 ppmv. The SO$_2$ concentration in EAF 5 off gas is 50 to 90 times lower than these concentrations.

When evaluating other industrial processes, steel EAFs are more similar to the Globe EAF 5 than any other industrial process. To assist in identifying potentially applicable control options for a source in question or a similar source, US EPA maintains a database of previous control determinations in its RACT, BACT, and LAER Clearinghouse (RBLC), as required by Section 108(h) of the Clean Air Act. The RBLC can assist in a BACT evaluation by identifying previous BACT determinations for similar sources. The RBLC was searched and found to include three facilities coded by the permit writer as Si-metal-producing EAFs. To expand the available data, the RBLC also was searched for steel-producing EAFs. As noted above, some primary steel-producing EAFs charge raw ore, a carbon source, and other materials into the furnace, thus operating in a somewhat similar fashion as Globe’s EAF 5, which accepts a charge of gravel and a carbon source as the primary raw materials. Other steel-producing entries, such as mini-mills, do not charge raw ore, and instead charge scrap metal/previously-produced steel. Thus, of all other industrial processes, only EAFs could be considered similar sources to Globe’s EAF 5 in that coal introduced into an EAF is a raw material as opposed to a coal fed to a boiler for use as fuel.

The steel-producing EAF search resulted in 58 additional entries at 47 additional facilities. No entries that clearly pertained to a mini-mill were included in the list of similar sources. (Even so, the only SO$_2$ control measure required at any mini-mill consisted of preparation and adherence to a scrap management plan.) Finally, we also considered one additional ferroalloy facility that was not included in the RBLC. Table A-1 presents a summary of the SO$_2$ control requirements presented in the RBLC for these ferroalloy and steel producing EAFs as well as the SO$_2$ control requirements listed in the PSD permit for the facility that was not included in the RBLC.

Several important features of the entries found in the RBLC search and presented in Table A-1 are presented below:
• The majority of the entries on Table A-1 refer to steel or steel alloy-producing facilities that have much larger melt capacities than silicon metal and ferrosilicon producing furnaces. As indicated in Table A-1, the capacity for each of the four EAFs at the Mississippi Silicon facility is only 2.75 tons/hr, which is comparable to the melt capacity of Globe’s EAF 5. In comparison, the melt capacities of the steel and steel-alloy facilities listed in Table A-1 range from 37 to 502 tons/hr.

• Despite the large size of the steel or steel alloy furnaces listed in Table A-1, none was required to use add-on control for SO$_2$ as a condition of BACT.

• None of the entries on Table A-1 pertain to an EAF producing FeSi, and only two pertain to an EAF producing (or that would produce) Si metal (Simcala/Dow Corning (RBLC Facility ID AL 0124), and Mississippi Silicon (which is not in the RBLC). The RBLC states that BACT for SO$_2$ for Simcala, for the production of Si metal, is a coal sulfur content limit of 0.8%. The Preliminary Determination issued to support the PSD permit for the Simcala plant specifically states that use of add-on SO$_2$ control equipment is technically infeasible.$^{13}$ The Mississippi Silicon PSD permit identifies BACT for SO$_2$, for the production of Si metal, as the requirement to limit SO$_2$ emissions to no more than 52.0 lb SO$_2$/ton of Si metal, as determined by a 3-hr rolling average period of Si metal produced, and utilize low sulfur content material where technically feasible. Note that both the proposed Simcala EAF and the constructed Mississippi Silicon EAFs produce (or were proposed to produce) exclusively Si metal and are similar to the Globe EAF 5, which produces both Si metal and FeSi (50 and 75%).

• The other two EAF results in Table A-1 that were listed in the RBLC as “ferroalloy” EAFs do not in fact pertain to EAFs operated to produce ferroalloys. The Bluewater Project (AR-0077) was coded by the permit writer as a ferroalloy facility; however, it does not actually produce ferroalloys. Rather, it includes an EAF capable of producing 350 tons of molten steel/hour and a ladle metallurgical furnace (LMF) that mixes ferroalloys with the molten steel to produce steel alloys. Similarly, the Nucor Steel ferroalloy entry (UT-0061) appears to be coded in error. Review of the referenced permit indicates that the Nucor Steel facility is a

$^{13}$ Preliminary Determination, Simcala, Inc. Electric Arc Silicon Furnace No 4 with Multiclope and Baghouse, prepared by Alabama Department of Environmental Management, Air Division, August 6, 1998. The subject emission unit, however, was never constructed.
steel alloy facility, not a ferroalloy facility; it is not regulated by the New Source Performance Standard for ferroalloy production. Nonetheless, the only SO2 control requirement for either of these facilities is use of low sulfur coke.

Additionally, US EPA identifies control measures when promulgating New Source Performance Standards (NSPS) and National Emission Standards for Hazardous Air Pollutants (NESHAP). The controls reflect the best system of continuous emissions reduction that has been demonstrated to work in a given industry, considering economic costs and other factors, such as energy use. Thus, an applicable NSPS or NESHAP could be considered the minimum control level representing BACT.

While no NSPS or NESHAP is applicable to EAF 5, we nonetheless reviewed whether controls are specified in NSPS and NESHAP regulations that apply to other ferroalloy EAFs or other similar sources. The US EPA has promulgated an NSPS for EAFs in operation at a metal ferroalloy production facility—40 CFR 60 Subpart Z, Standards of Performance for Ferroalloy Production Facilities. The provisions of this subpart are applicable to certain electric submerged arc furnaces which produce Si-metal, FeSi, and other ferroalloys. US EPA also has promulgated an NESHAP for EAFs—40 CFR Part 63, Subpart YYYY (NESHAP for Area Sources-EAF Steelmaking Furnaces).

The Subpart Z NSPS does not include a standard for control of SO2 from an EAF, indicating that US EPA has previously determined that no demonstrated economically available control technology was identified for the source type. The Subpart YYYY NESHAP prescribes a scrap management plan, but does not regulate SO2 and does not apply to Si metal or FeSi production. Therefore, the NESHAP standards do not provide a comparison for SO2 BACT. In an attempt to determine if any similar source was subject to an NSPS emission limit for SO2, this evaluation also considered whether control requirements included in any other NSPS or NESHAP for a similar operation could be used as a basis for SO2 control from a ferroalloy EAF. This evaluation concluded that no other NSPS or NESHAP includes an SO2 emission standard for a similar source.

The 1990 US EPA NSR Workshop Manual specifies that an applicant should evaluate whether SO2 control options might be transferrable from a similar process to the source under review. With respect to lower-polluting processes and materials, Globe already routinely evaluates the use of low sulfur content materials. With respect to add-on control options, as specified in the 1990 US EPA NSR Workshop Manual, add-on control should be considered based on the physical and chemical characteristics of the pollutant-bearing stream at a similar process. An add-on control option is not available if it can be shown that there
are significant differences from previous applications (temperature, pressure, concentration, volume flow, etc.) and the current potential application. A more recent statement of factors that should be considered when evaluating technology transfer for BACT was published by the Climate Change Work Group, which wrote:

On a case-by-case basis, the primary factors considered are the characteristics of the gas stream to be controlled, the comparability of the production processes (e.g., batch versus continuous operation, frequency of process interruptions, special product quality concerns, etc.), and the potential impacts on other emission points within the source.\textsuperscript{14}

Consistent with the above discussion, this BACT study has identified the following SO\textsubscript{2} control options and will ascertain in Step 1 whether or not each identified control option is available and applicable to Globe’s EAF 5:

- Pollution Prevention
  - Raw material quality (limiting sulfur in raw materials)
- Add-on Control Technology
  - Wet scrubbers
  - Dry scrubbers
  - Other (e.g., GORE Mercury Control System; note that this technology does not meet the “demonstrated in practice” criteria for SO\textsubscript{2} removal, and therefore should not actually be consider as an available control option per the 1990 US EPA NSR Workshop Manual. However, US EPA identified the technology as an option, and it is being discussed herein as a result.)

Finally, as discussed in the 1990 US EPA NSR Workshop Manual, technologies in application outside the United States should be considered to the extent they have been successfully demonstrated in practice. These considerations are addressed in Section 3.1.5 of this evaluation, which presents the results of a European Commission report regarding a review of control options practiced in the European non-ferrous metals production industry.

\textbf{3.1.1 Pollution Prevention}

As indicated above, the RBLC and permit review identified low sulfur coal or coke at two of the ferroalloy production facilities and nine of the steel production facilities. Likewise, Globe uses low sulfur coal and coke at its facility. Therefore,

\textsuperscript{14} Interim Phase I Report of the Climate Change Work Group or the Permits, New Source Review and Toxics Subcommittee, Clean Air Act Advisory Committee, February 3, 2010.
pollution prevention is a demonstrated control option in the ferroalloy and steel production industries.

Coal used in the metallurgical industry is processed at or near the mine to remove coal fines and other impurities. Specifically, coal utilized for making Si metal requires a low impurity content due to Si metal purity standards. Impurities that may adversely affect Si metal purity are present as trace metals in the coal. Therefore, coal destined for use in producing Si metal is subjected to an additional washing process to remove impurities. This washing process yields a specialty metallurgical coal that exhibits lower trace metals contents while providing the ancillary benefit of lower sulfur contents (generally less than 0.8%) than unwashed coal. FeSi products can tolerate coal with slightly higher impurities content. Coal used in the FeSi production process have not gone through the level of cleaning and processing that coal used for Si metal production has gone through, and, as a result, can have a slightly higher sulfur content (generally less than 1% sulfur). The trace metal content in these higher sulfur coals may actually help support FeSi production by introducing small amounts of iron that would otherwise need to be added to the EAF charge.

Three key factors dictate when low sulfur coal can be used in Si metal or FeSi production: 1) availability of reliable sources, 2) impact on product quality, and 3) impact of furnace production and performance. Based on data collected by Globe, the average sulfur content of coal used in EAF 5 for Si metal production does not exceed 0.8% and is consistent with the previous BACT determination for the Simcala plant. Note also that Globe EAF 5 Si metal SO$_2$ emissions are estimated to be no more than 43 lb SO$_2$ per ton Si metal, which is less than the 52.0 lb/ton BACT limit for Mississippi Silicon. The average sulfur content of coal used in EAF 5 for FeSi metal production at the Globe facility does not exceed 1% as reported in the RACM.

Carbon supply to an EAF can also consist of charcoal to replace the carbon introduced by the coal, although the ability to do so varies depending on the product being produced and the specific characteristics of a furnace. The same three key factors dictate when charcoal can be used in FeSi or Si metal production: 1) availability of reliable sources, 2) impact on product quality, and 3) impact on furnace production and performance. Charcoal contains less sulfur than coal, and some charcoal was used in EAF 5 prior to 2012. Globe has found that very little charcoal is currently available in the U.S. for metallurgical use. Coke is another raw material that can substitute for coal in certain EAFs. Coke contains a comparable amount of sulfur as the coal used at Globe, but coke contains too much ash for use during Si metal production. A small amount of coke can be used during FeSi production. As a result, coke use in EAF 5 is limited to small amounts during FeSi production only.
In addition to sulfur content in coal, sulfur contained in electrode raw materials contributes a small amount to SO$_2$ emissions. EAF 5 uses pre-bake electrodes for Si metal production, and either pre-bake or self-bake electrodes for FeSi production. Pre-bake electrodes are purchased in a solid, cylindrical form that has already been baked off-site, and, based on available data, typically contain a residual sulfur content of approximately 0.15% weight. Self-bake electrodes used for FeSi production consist of an electrode paste in a large metal cylinder can. The self-bake paste has an average sulfur content that can range from approximately 0.2% to 1.3% by weight. Table 4 presents estimated emissions from electrode options available to Globe. Production of Si metal requires use of pre-bake electrodes because the steel cans into which the self-bake paste is placed can introduce iron and other metal impurities into the Si metal. The Elkem TSR is the predominant self-bake electrode paste used for FeSi production at Globe’s facility.

Table 4. Electrode Properties used in EAF Metallurgical Processes

<table>
<thead>
<tr>
<th>Electrode Type</th>
<th>Paste Description</th>
<th>Product</th>
<th>Electrode or Paste Sulfur Content(a)</th>
<th>Estimated Annual EAF 5 SO$_2$ Emissions(b), tons/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-bake</td>
<td>N/A (solid electrode)</td>
<td>Si metal</td>
<td>0.15%</td>
<td>3.5</td>
</tr>
<tr>
<td>Self-bake</td>
<td>Elkem TSR</td>
<td>FeSi</td>
<td>0.2%</td>
<td>4.2</td>
</tr>
<tr>
<td>Self-bake</td>
<td>Rhienfelden</td>
<td>FeSi</td>
<td>0.6%</td>
<td>12.6</td>
</tr>
<tr>
<td>Self-bake</td>
<td>Alcoa Paste</td>
<td>FeSi</td>
<td>1.3%</td>
<td>27</td>
</tr>
</tbody>
</table>

a. The percentages provided are average approximate sulfur contents based on limited analytical test results or supplier specifications for maximum sulfur content.

b. These emissions are those attributed to the specific electrode when used as the exclusive electrode material in EAF 5.

Globe’s current electrode/paste supplies have average approximate sulfur contents of 0.15% based on limited analytical testing (pre-bake electrodes for Si metal products), and 0.2%, 0.6%, or 1.3% based on the maximum sulfur specification provided by the self-bake paste suppliers (Elkem TSR, Rhienfelden, or Alcoa Paste, respectively) used for FeSi products. Globe is capable of using any of the listed materials in EAF 5.

Based on the discussion in this subsection, limiting sulfur content in raw materials is an available control option for use in EAF 5.

3.1.2 Wet Scrubbers

Wet scrubbers may be in common use in the utility industry on coal-fired boilers but we do not know of any wet scrubbers in use on an EAF application. Because wet scrubbers are used to control SO$_2$ emissions from other sources, however, the US EPA NSR Workshop Manual specifies that wet scrubbers must be evaluated as a potential transferred control option. The ability to transfer the control...
option to the Globe EAF 5 depends on a comparison of the similarities between existing applications and the potential Globe application for EAF 5.

In a wet scrubber system, SO\textsubscript{2}-containing gas is ducted to a spray tower where an aqueous slurry of sorbent is injected into the gas. The SO\textsubscript{2} dissolves into the slurry droplets where it reacts with the alkaline sorbent. The slurry is collected at the bottom of the spray tower, and treated flue gas is directed to a mist eliminator to remove any remaining slurry droplets. The spent slurry can either be recycled back to the absorber or dewatered and disposed. Typical sorbent materials are limestone (least expensive, least efficient), lime (more expensive, more efficient), or proprietary sorbents (most expensive, most efficient).

Some disadvantages of wet scrubbing techniques are 1) the cost of neutralizing chemicals, 2) disposal of the liquid stream containing soluble sulfur-containing salts, 3) scale build-up in the absorber, and 4) energy costs. Several wet scrubbing configurations exist, and all achieve similar SO\textsubscript{2} removals given an adequate inlet SO\textsubscript{2} concentration. Two common configurations are discussed as follows.

**Limestone Slurry with Forced Oxidation (LSFO)** - LSFO is a wet limestone scrubbing process that reduces the formation of gypsum scale in the absorber by oxidizing the spent slurry and removing the gypsum before it is recycled to the tower. The gypsum product can then potentially be sold, thereby eliminating the disposal costs. However, limited markets exist for this gypsum product, and no viable outlets may actually be available for the gypsum. Typical removal efficiencies for LSFO of 90% have been attained with high inlet SO\textsubscript{2} concentrations.

**Wet Limestone Scrubbing** - Wet limestone scrubbing is similar to LSFO, but uses hydrated or quick lime. This type generally has high capital and operating costs due to the need to handle both liquid reagent and waste. As reported in a 2007 journal article, virtually no wet lime systems are currently being requested by the utility industry. As a result, FGD vendors are generally not offering wet lime systems. In addition, moisture in the scrubber exhaust can result in a visible plume that complicates downstream fabric filtration. Typical removal efficiencies are comparable to the LSFO.

None of the EAF facilities identified in the RBLC or in our broader review requires the use of add-on controls as BACT for SO\textsubscript{2}. As noted earlier, the average SO\textsubscript{2} concentration in the EAF 5 off gas is estimated to be 56.7 ppm and may be as low as 32 ppm. This technical review indicates that the low SO\textsubscript{2} concentration (less than 100 ppmv) in the gas at Globe falls below the low range of common applications for this technology. In every US EPA air pollution control cost manual, including the most recent revision, wet scrubbers are
described as acid gas control systems that are used on gas streams with typical pollutant concentrations ranging from 250 to 10,000 ppmv.\textsuperscript{15} This published concentration range indicates that previous applications of wet scrubber technology do not meet the criterion of being used at a similar source. The lower end of the US EPA reported range is 10 times higher than the potential low end of the \textit{SO}_2 concentration range in gas leaving EAF 5.

As further verification of the lack of similarity, the coal boiler categories in the RBLC were reviewed, as these categories are where many scrubber requirements are listed. Five entries were found for wet scrubbers on coal boilers. The task of entering data into the RBLC is a voluntary action on the part of state permitting agencies. Thus, the RBLC is not a complete database. Nonetheless, we consider the information available within the RBLC to be representative of capabilities of and conditions under which technology is applied to the specific sources in question. The \textbf{controlled} \textit{SO}_2 emission from the wet scrubbers on coal boilers ranged from 491 lb/hr to 7,272 lb/hr, demonstrating quite clearly that the flue gas properties at these facilities are not at all similar to the EAF 5 gas average \textbf{uncontrolled} \textit{SO}_2 emission rate of 83 lb/hr, which is far below the after-control levels reported in the RBLC.

The large differences in pollutant loads between Globe and previous wet scrubber applications are not their only differences. As noted by the Climate Change Work Group of the Clean Air Act Advisory Committee, a BACT evaluation should consider comparability of production processes when considering the possible technology transfer from other sources. Factors such as batch versus continuous operation, frequency of process interruptions, and special product quality concerns should all be evaluated with respect to the specific source. All of these factors are relevant to EAF 5 operation. The charge/smelt/tap cycle of EAF 5 produces flow interruptions and wide fluctuations in temperature, flow rate, and \textit{SO}_2 loading over the cycle. These interruptions and fluctuations are vastly dissimilar to the operating modes of steady state sources, such as combustion sources, that typically employ add-on \textit{SO}_2 control devices. Additionally, the particulate (fume) generated in EAF 5 and captured in the fabric filter is a product. The typical wet scrubber application, in contrast, is on a process that has steady operating conditions with minimal variation; the treated off-gas is a waste gas, not a product.

Based on the dissimilarities between previous wet scrubber applications and the Globe process, a wet scrubber is not considered an available control option for

use on the Globe EAF 5. Nonetheless, Step 2 below presents some discussion of
the technical feasibility of wet scrubber technology use at Globe.

3.1.3 Dry and Semi-Dry Scrubbers

A trend exists in the use of dry scrubbers in the utility industry. In dry sorbent
injection (DSI) or spray drying absorber (SDA) operations, the SO$_2$ is reacted
with a sorbent (either dry or in a slurry) that is injected into the gas stream. The
sorbent forms a dried particle during the reaction. The majority of the dried
waste is collected at the bottom of the spray tower, and a downstream fabric
filter must be used to capture any suspended particles remaining in the gas
stream. This BACT evaluation found no dry or semi-dry scrubbers in use on an
EAF. The following paragraphs describe dry and semi-dry scrubbers.

Spray Dryer/Absorber - In SDA systems, a slurry of sorbent material and water is
fed to a spray dryer tower. In the tower, the slurry is atomized and injected into
the gas, where droplets react with SO$_2$ as the liquid evaporates. This action
produces a dry product that is collected in the bottom of the spray dryer and in
the downstream PM removal equipment (i.e., fabric filter or electrostatic
precipitator, ESP). The majority of the reaction takes place in the spray dryer.
When a fabric filter is used, the PM collects on the filter cloth developing a filter
cake that allows the gas a second chance to react with the reagent, thus
increasing utilization of the reagent and control efficiency. The fabric filter or
ESP, downstream of the spray dryer, removes the PM, ash, reaction products
(e.g., CaSO$_3$, CaSO$_4$, Na$_2$SO$_4$), and unreacted sorbent. Various calcium and
sodium-based reagents are utilized as sorbent. SDA systems typically inject lime
because it is more reactive than limestone and less expensive than sodium-based
reagents. SO$_2$ control efficiencies are somewhat comparable for wet limestone
scrubbers and spray dry systems; however, the capital and operating cost for
spray dryer systems are lower than for wet systems because equipment for
handling liquid reagent and wet waste products is not required. In addition,
carbon steel can be used to manufacture the absorber because the flue gas is less
humid.

It is reasonable to expect that SDA technology performance depends on the
facility-specific process characteristics. The properties most important for a SDA
application are an inlet gas temperature that allows the slurry to be evaporated
in the flue gas (a necessity for a spray dry scrubber); adequate mixing and
residence time that allow the sorbent to react with the SO$_2$ in the gas; and the use
of a PM control device to separate the reaction products from the gas stream.

A US EPA Air Pollution Control Technology Fact Sheet for FGD technologies
states that scrubbers are capable of reduction efficiencies in the range of 50 to
98%. The highest removal efficiencies are achieved by wet scrubbers, and the lowest by dry scrubbers (typically less than 80%). Low SO$_2$ loadings to a dry absorber, as are obtained when using low sulfur coal, tend to produce lower removal efficiencies, between 40% and 70%.

Dry Sorbent Injection (DSI) – Predominantly used in the utility industry, SO$_2$ may be removed by injecting a dry sorbent (limestone, Trona, or sodium bicarbonate are the common sorbents) into the combustion gases, typically above the burners or in the backpass before or after the air heater. This involves injection of the sorbent into the boiler system at a location downstream of the combustion zone through special injection ports. The sorbent contacts the hot gas, decomposes, and reacts in suspension with SO$_2$ to form reaction products, such as calcium sulfate (CaSO$_4$) when using lime or limestone, or sodium sulfate (Na$_2$SO$_4$) when using Trona (sodium sesquicarbonate) or sodium bicarbonate. The reaction products, unreacted sorbent, and fly ash are removed at the PM control device (either an ESP or fabric filter) downstream from the emission unit.

DSI has historically been used for reducing concentrations of hydrochloric acid (HCl), mercury, and sulfates (SO$_3$) from coal-fired boiler flue gas. Recently, DSI has seen greater use primarily as a system to comply with the Maximum Achievable Control Technology (MACT) requirements for boilers, aka, Boiler MACT. As operators began using DSI for HCl control in response to Boiler MACT, incidental removal of SO$_2$ was also being observed. SO$_2$ removal efficiencies of 30% to 70% have been reported for DSI in the utility industry when sorbent is injected and mixed at optimum conditions, and higher removals have been demonstrated in test/pilot operations. However, these performance levels have yet to be widely demonstrated on a long-term continuous basis at permanent installations. Additionally, some utility operators have reported difficulties in achieving the desired SO$_2$ removals with DSI systems. For example, the Golden Valley Electric Association, Inc. (GVEA) in Healy, AK has been attempting to stabilize its DSI system for several years. The history of DSI operation at the Healy facility of GVEA has been very unstable, producing a need to retrofit the system on two different occasions.

The observed erratic performance of the DSI technology draws into question its reliability as an SO$_2$ control option. As itemized below, successful DSI applications rely on operation within a stable, well-defined range of operating parameters. This stable operating range is much easier to achieve when operating a coal-fired boiler than when operating a cyclic process such as Globe’s EAF 5. In practice, because the reaction chemistry of a DSI system is straightforward, some level of SO$_2$ removal should be obtained when conditions exist that allow the reaction to take place. When process conditions are variable, however, the DSI system performance can suffer or fail completely.
The performance of a DSI system for SO$_2$ removal is a function of several factors:

- **Sorbent type**
  - Sodium-based sorbents (Trona and sodium bicarbonate) generally produce higher SO$_2$ removal rates than calcium-based sorbents (lime or limestone).
- **Flue gas temperature at the injection location**
  - A higher efficiency can be achieved when DSI is injected at a location where the gas temperature is approximately 500° F, and removal becomes less as the injection location is cooler or hotter.
- **Sorbent particle size**
- **Sorbent injection rate, or Normalized Stoichiometric Ratio**
  - Extent of sorbent-to-gas mixing
  - Reaction residence time prior to the PM collection device
- **PM control device type**
- **Flue gas properties**
  - Concentrations of other acid gases competing with SO$_2$ reaction chemistry
  - Flow distribution and moisture content

As stated in Section 3.1.2, none of the EAF facilities identified in the RBLC or in our broader review requires the use of add-on controls as BACT for SO$_2$. In every US EPA air pollution control cost manual, including the most recent revision, dry scrubbers are described as acid gas control systems that are used on gas streams with typical pollutant concentrations ranging from 250 to 10,000 ppmv. This published concentration range indicates that previous applications of dry scrubber technology do not meet the criterion of being used at a similar source. The lower end of the US EPA reported range is 10 times higher than the potential low end of the SO$_2$ concentration range in gas leaving EAF 5.

As further verification of the lack of similarity, the coal boiler categories in the RBLC were again reviewed. Ten (10) entries were found that reported a controlled SO$_2$ emission rate from a dry scrubber on a coal boiler. As indicated earlier in this BACT evaluation, we consider the information available within the RBLC to be representative of capabilities of and conditions under which technology is applied to the specific sources in question. Only one of the reported controlled emission rates (76.8 lb/hr) was less than the average uncontrolled EAF 5 average SO$_2$ emission rate (83.2 lb/hr). All other entries had a reported controlled SO$_2$ emission from the dry scrubbers ranging from 99.4 lb/hr to 480 lb/hr, demonstrating once again that the flue gas properties at these facilities are not similar to the EAF 5 gas average uncontrolled SO$_2$ emission rate of 83 lb/hr, which is below the after-control levels reported in the RBLC.
The large differences in pollutant loads between Globe and previous dry scrubber applications are not their only differences. As noted earlier in the section pertaining to wet scrubbers, the Climate Change Work Group of the Clean Air Act Advisory Committee has stated that a BACT evaluation should consider comparability of production processes when considering the possible technology transfer from other sources. Factors such as batch versus continuous operation, frequency of process interruptions, and special product quality concerns should all be evaluated with respect to the specific source. All of these factors are relevant to EAF 5 operation. The charge/smelt/tap cycle of EAF 5 produces flow interruptions and wide fluctuations in temperature, flow rate, and SO\textsubscript{2} loading over the cycle. These interruptions and fluctuations are vastly dissimilar to the operating modes of steady state sources, such as combustion sources, that typically employ add-on SO\textsubscript{2} control devices. Additionally, the particulate (fume) generated in EAF 5 and captured in the fabric filter is a product. The typical dry scrubber application, in contrast, is on a process that has steady operating conditions with minimal variation; the treated off-gas is a waste gas, not a product.

EAF 5 operation produces wide fluctuations in temperature and flow rate, depending on the operating mode of the furnace. In contrast, dry scrubbers must operate in a narrow temperature range, and the typical dry scrubber application is on a process that has steady operating conditions with minimal variation. EAF 5 exhaust gases display a large range of temperatures, flow rates, and gas composition that is influenced by the charge/smelt/tapping mode. These fluctuations in gas properties are very different than the near steady-stage conditions observed in processes that successfully employ dry scrubbers for SO\textsubscript{2} control.

Based on the dissimilarities between previous dry scrubber applications and the Globe process, a dry scrubber is not considered an available control option for use on the Globe EAF 5. Nonetheless, Step 2 below presents some discussion of the technical feasibility of dry scrubber technology use at Globe.

### 3.1.4 GORE Mercury Control System

No industrial facility currently uses the GORE Mercury Control System technology for SO\textsubscript{2} control (i.e., it has not been commercially demonstrated for SO\textsubscript{2} control), and facilities that employ the technology for mercury control do not measure or take credit for SO\textsubscript{2} reductions. Although this BACT evaluation found no GORE Mercury Control Systems in use on an EAF or demonstrated use for SO\textsubscript{2} control on any type of source, it is listed in Step 1 so as to acknowledge that US EPA has discussed potential application of the technology on Globe’s EAF 5.
GORE Mercury Control System is a mercury removal system with commercial applications exclusively limited to coal-fired utility boiler operations. About 2 years ago, Gore began asserting in literature that the technology could be used to reduce SO$_2$ emissions as well. Gore refers to this technology as the GORE Mercury Control System, even when discussing its potential use for SO$_2$ control. With respect to SO$_2$, therefore, this technology is not demonstrated and therefore not “available.”

The GORE Mercury Control System technology employs a Sorbent Polymer Catalyst (SPC) to perform chemisorption of gas-phase mercury and catalytic conversion of SO$_2$. The SPC is formed in sheets and packaged inside a 2-ft x 2-ft x 1-ft high module containing many corrugated sheets. Several hundred modules are then required for the engineered system.

Two Gore representatives visited Globe in June 2017 to discuss potential application of the GORE Mercury Control System on Shop 2. The Gore representatives indicated that application of the GORE Mercury Control System technology on the Globe EAFs would be “unique” compared to all other previous installations. Gore stated that the technology could reduce SO$_2$ by some unknown degree. This statement was based on various pilot-scale units (with gas flow rates approximately equal to 5,000 acfm, or less than 1 percent of the actual gas flow rate from EAF 5) and bench-scale test results. While the technology has been pilot tested on sources for SO$_2$ removal, no full-scale SO$_2$ removal system is in operation, nor has any pilot-scale system been tested on gas streams with SO$_2$ concentrations as low as those at Globe. Gore literature reports SO$_2$ test program results on gas streams containing between 150 and 1,900 ppm(v) SO$_2$ and on pilot-scale equipment treating approximately 5,000 acfm. Based on the EAF Ventilation Study, the estimated SO$_2$ concentrations at Globe are between 32.9 and 56 ppmv and could easily be much less, and the gas flow is over 500,000 acfm.$^{16}$ Gore verbally indicated that the technology could be applied to concentrations such as those observed at Globe; however, this performance capability is not reflected in the technology literature.

As of 30 May 2018, Gore confirmed that it still does not have even one commercial, full-scale operating SO$_2$ control project. Gore did indicate that it has several projects under development in support of new SO$_2$ regulations in Europe, but there has been no installation or demonstration.

Because the GORE Mercury Control System has not been demonstrated for SO$_2$ control, it does not meet the definition of an “available” control option for

---

evaluation under a top-down BACT review and is not discussed any further herein.

3.1.5 European Commission Report on Best Available Techniques

The original RACM evaluation included a brief narrative on the findings presented in the European Commission Draft “Reference Document on Best Available Techniques in the Non-Ferrous Metals Industries,” December 2001. This is an 800+ page report that provided extensive review of various operating and environmental aspects of metal production and included a chapter on ferroalloys, including FeSi and Si metal production. The RACM evaluation indicated that no add-on controls were identified in the Draft report for EAFs producing FeSi or Si metal.

As part of the Supplemental RACM Report, ERM obtained the final version of the European Commission report. This 1,200+ page Final Draft report also includes a chapter devoted to ferroalloys, including FeSi and Si metal. The Final Draft report identifies no FeSi or Si metal producing EAF in the European community that uses add-on SO\textsubscript{2} controls. Table 5 presents an extract of the Final Draft report that summarizes emissions and controls from open submerged EAFs (the same type of furnace as used at Globe’s facility). The extracted table presents average SO\textsubscript{2} concentrations for various FeSi and Si metal EAFs ranging from 19.4 to 210 milligrams per cubic meter (mg/Nm\textsuperscript{3}), which is equivalent to a range of 6.7 to 74.5 ppm SO\textsubscript{2}. Those SO\textsubscript{2} concentrations are comparable to the average SO\textsubscript{2} concentration from Globe’s EAF 5, which is estimated at 32.9 ppmv (see Table 3 presented previously). A notable feature about the European Commission Final Draft report is that none of the ferroalloy EAFs identified in the report is equipped with add-on control for SO\textsubscript{2}. This same conclusion was derived when reviewing the 2001 Draft report. A similar finding for operations in the U.S. was presented in the RACM evaluation based on review of the US EPA RBLC. Thus, the 2001 Draft and 2014 Final Draft European Commission reports corroborate the finding presented herein that add-on controls for reduction of SO\textsubscript{2} emissions from EAFs is not practiced in the industry – neither in the United States nor in Europe.

\textsuperscript{17} European Commission, Best Available Techniques (BAT) Reference Document for the Non-Ferrous Metals Industries, October 2014.
Table 5. Emissions from Open Submerged Arc Furnaces (concentration)\(^{(a)}\)

<table>
<thead>
<tr>
<th>Plant</th>
<th>Ferroalloy Produced</th>
<th>Pollutant</th>
<th>Abatement Technique</th>
<th>Minimum ((\text{mg/Nm}^3))</th>
<th>Average ((\text{mg/Nm}^3))</th>
<th>Maximum ((\text{mg/Nm}^3))</th>
<th>Type of Measurement</th>
<th>Measurement Frequency (number/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>FeSi</td>
<td>SO(_2)</td>
<td>none</td>
<td>NA</td>
<td>36</td>
<td>NA</td>
<td>Periodic</td>
<td>1 (2 samples)</td>
</tr>
<tr>
<td></td>
<td>FeSi</td>
<td>SO(_2)</td>
<td>none</td>
<td>NA</td>
<td>50</td>
<td>NA</td>
<td>Periodic</td>
<td>1 (2 samples)</td>
</tr>
<tr>
<td></td>
<td>FeSi</td>
<td>SO(_2)</td>
<td>none</td>
<td>NA</td>
<td>65</td>
<td>NA</td>
<td>Periodic</td>
<td>1 (2 samples)</td>
</tr>
<tr>
<td>P</td>
<td>Si</td>
<td>SO(_2)</td>
<td>none</td>
<td>34</td>
<td>86</td>
<td>169</td>
<td>Periodic</td>
<td>2</td>
</tr>
<tr>
<td>Q</td>
<td>Si</td>
<td>SO(_2)</td>
<td>none</td>
<td>NA</td>
<td>41</td>
<td>NA</td>
<td>Periodic</td>
<td>3</td>
</tr>
<tr>
<td>R</td>
<td>Si</td>
<td>SO(_2)</td>
<td>none</td>
<td>NA</td>
<td>19</td>
<td>NA</td>
<td>Periodic</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>FeSi</td>
<td>SO(_2)</td>
<td>none</td>
<td>NA</td>
<td>82</td>
<td>NA</td>
<td>Periodic</td>
<td>3</td>
</tr>
<tr>
<td>S</td>
<td>Si</td>
<td>SO(_2)</td>
<td>none</td>
<td>NA</td>
<td>18</td>
<td>NA</td>
<td>Periodic</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Si</td>
<td>SO(_2)</td>
<td>none</td>
<td>NA</td>
<td>9.4</td>
<td>NA</td>
<td>Periodic</td>
<td>1</td>
</tr>
<tr>
<td>U</td>
<td>Si</td>
<td>SO(_2)</td>
<td>none</td>
<td>31</td>
<td>32</td>
<td>32</td>
<td>Periodic</td>
<td>1 (2 samples)</td>
</tr>
<tr>
<td></td>
<td>Si</td>
<td>SO(_2)</td>
<td>none</td>
<td>30.3</td>
<td>31.2</td>
<td>32</td>
<td>Periodic</td>
<td>1 (2 samples)</td>
</tr>
<tr>
<td></td>
<td>Si</td>
<td>SO(_2)</td>
<td>none</td>
<td>34.5</td>
<td>35.3</td>
<td>36</td>
<td>Periodic</td>
<td>1 (2 samples)</td>
</tr>
<tr>
<td>V</td>
<td>Si</td>
<td>SO(_2)</td>
<td>none</td>
<td>NA</td>
<td>210</td>
<td>NA</td>
<td>Periodic</td>
<td>1</td>
</tr>
</tbody>
</table>

a. SO\(_2\) concentration values were extracted for FeSi and Si EAFs from Table 8.34 of the October 2014 European Commission Final Draft Report entitled “Best Available Techniques (BAT) Reference Document for the Non-Ferrous Metals Industries.” Values for other pollutants or ferroalloys production furnaces were not extracted.

b. Convert \(\text{mg/Nm}^3\) to ppm as follows: ppm SO\(_2\) = \(\text{mg/Nm}^3\) \(\text{SO}_2\) \times 24.45/MW, where MW = molecular weight of SO\(_2\) = 64.
3.2 **STEP 2: ELIMINATE TECHNICALLY INFEASIBLE OPTIONS**

Step 2 entails a source-specific evaluation of the technical feasibility of the control options identified in Step 1. The intent is to determine if source-specific or site-specific factors would preclude the successful use of the control option on the specific emission unit under review.

US EPA considers a control option feasible if it is:

1. demonstrated—i.e., it has been installed and operated successfully on the same type of source; or
2. available and applicable to the source type.

Step 1 identified available control options that could be evaluated as BACT for the EAF 5. An available control option is “applicable” if it can reasonably be installed and operated on the specific emission unit under review. A control option is not applicable (and therefore, technically infeasible) if it can be shown that there are significant differences from previous applications (temperature, pressure, concentration, and volume flow, batch versus continuous operation, frequency of process interruptions, and special product quality). Ideally, the BACT evaluation should assess each available control option in terms of its characteristics including:

   - development stage;
   - commercial application;
   - scope of installations; and
   - performance data.

Unresolved technical difficulties that result in an infeasibility determination may include:

   - the size of the unit;
   - the location of the proposed site; or
   - operating problems related to specific circumstances of the source.

In order to be deemed technically infeasible, the assessment would need to show, “based on physical, chemical, or engineering principles, that technical difficulties would preclude the successful use of a particular control option.” If cost is the only difficulty, the option must be considered feasible. Cost considerations are deferred until the economic impact section (Step 4).

---

As concluded in Section 3.1 of this BACT evaluation, only pollution prevention control options are available for use on EAF 5. No add-on control options were found to be operated on sources or processes similar to EAF 5. However, in addition to the technical review of pollution prevention control options, the following subsections provide technical information related to wet and dry scrubber operations so as to elaborate on the differences between other industrial operations that have scrubber applications and EAF 5 operation at the Globe facility.

### 3.2.1 Pollution Prevention

Pollution prevention was determined to be technically feasible. Based on the results obtained from the RBLC database, limiting the sulfur content of the carbon source charged to a furnace (i.e., coal or coke) is typically an accepted control technique used for reducing $\text{SO}_2$ emissions from FeSi and Si metal EAFs. The findings of the RBLC search lists only two BACT limits for Si metal EAFs and none for FeSi EAFs. The Si metal prior BACT determinations are for Simcala, with 0.8% sulfur content in coal; and Mississippi Silicon, with a requirement to limit $\text{SO}_2$ emissions to no more than 52.0 lb/ton, as determined by a 3-hr rolling average period of Silicon produced, and utilize low sulfur content material where technically feasible. Therefore this BACT assessment must evaluate whether a carbon supply with a lower sulfur content could be used in EAF 5.

As stated earlier in this report, three key factors dictate when a low sulfur carbon source can be used in FeSi or Si metal production: 1) availability of reliable sources, 2) impact on product quality, and 3) impact on furnace production and performance. EAF 5 produces both Si metal and FeSi products. Table 6 presents current sulfur content in raw materials used by Globe in EAF 5.

#### Table 6. Sulfur Content of Materials Used in EAF 5

<table>
<thead>
<tr>
<th>Product</th>
<th>Annual Average Coal Sulfur Content (% wt)</th>
<th>Annual Average Coke Sulfur Content (% wt)</th>
<th>Electrode Type</th>
<th>Annual Average Electrode Sulfur Content (% wt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si metal</td>
<td>0.8% or less</td>
<td>See note a</td>
<td>Pre-bake</td>
<td>0.15%</td>
</tr>
<tr>
<td>FeSi (50 or 75%)</td>
<td>1% or less</td>
<td>0.8% or less</td>
<td>Self-bake</td>
<td>0.2% to 1.3%</td>
</tr>
</tbody>
</table>

a. Charcoal and coke are also carbon sources. Charcoal is currently not being used in EAF 5, and coke is not charged to EAF 5 during Si production due to its high ash content. A small amount of coke can be used during FeSi production.

As stated above, Globe EAF 5 already uses raw materials for Si metal production that are commensurate to or better performing than the prior Si metal BACT.
determinations for Simcala and Mississippi Silicon. There are no BACT
determinations for FeSi production. Table 7 presents a technical feasibility
assessment of whether other lower sulfur materials can be used for coal or
electrodes in EAF 5.

Table 7. Summary of Technical Feasibility of Pollution Prevention Control
Options

<table>
<thead>
<tr>
<th>Option No.</th>
<th>Description</th>
<th>Feasibility Discussion</th>
<th>Feasible or Infeasible</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carbon Source Sulfur Reduction Options</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Use lower sulfur content coal for Si metal production</td>
<td>Globe is currently using the lowest sulfur content coal that is domestically available. Some foreign coal sources have a lower sulfur content. For example, one foreign coal supply that Globe investigated had a typical sulfur content of 0.6 to 0.7% (versus the 0.8% used for Si metal in EAF 5), even the foreign supplier will only commit to a 0.8% in its specification. Furthermore, using a supplier located in a foreign country produces a supply chain risk due to political instability concerns.</td>
<td>Infeasible</td>
</tr>
<tr>
<td>2</td>
<td>Use lower (0.8%) sulfur coal for both Si metal and FeSi production. (FeSi production currently uses metallurgical coal with &lt;1% sulfur that has not been further processed or cleaned to further reduce impurities in the coal).</td>
<td>As stated above, the coal used in FeSi production supports the process. This option is potentially technically feasible and will be ranked and assessed in Steps 3 and 4.</td>
<td>Feasible</td>
</tr>
<tr>
<td>3</td>
<td>Supplement EAF 5 coal with charcoal</td>
<td>EAF 5 is physically capable of charging charcoal in place of some of the coal that is currently charged, but adequate supplies of charcoal do not exist. Current charcoal production in the U.S. is geared towards supplying backyard barbeques, and this grade of charcoal is not suitable for use in Globe’s EAFs. Globe has found that very little charcoal is currently available in the U.S. for metallurgical use.</td>
<td>Infeasible</td>
</tr>
<tr>
<td>4</td>
<td>Use lower sulfur coke during FeSi production</td>
<td>Globe uses low sulfur coke as a carbon source in EAF 5 during FeSi production. Lower sulfur coke is not available for use in EAF 5.</td>
<td>Infeasible</td>
</tr>
<tr>
<td><strong>Electrode Sulfur Reduction Options</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Use pre-bake electrodes for all EAF 5 production (extend use from Si metal to FeSi products)</td>
<td>During periods of scheduled FeSi production EAF 5 can use self-baked electrodes. As an option, Globe could consider using pre-bake electrodes at all times in EAF 5. This option is potentially feasible and will be ranked and assessed in Steps 3 and 4.</td>
<td>Feasible</td>
</tr>
<tr>
<td>6</td>
<td>Use lower sulfur paste for self-bake electrodes used in FeSi products</td>
<td>The maximum vendor-specified electrode paste sulfur content ranges from approximately 0.2% to 1.3%. At times, Globe already uses self-bake electrode paste with the lowest available sulfur content of 0.2% by weight on average.</td>
<td>Infeasible</td>
</tr>
</tbody>
</table>
3.2.2 Wet Scrubbers

In Step 1, wet scrubbers were determined to be not available for SO$_2$ control on EAF 5 due to the lack of similarity between EAF 5 and other sources using wet scrubbers for SO$_2$ control. We were not able to identify any examples of utilizing wet scrubbing techniques to control exhaust streams with SO$_2$ concentrations similar to or lower than those at the Globe facility. Furthermore, the widely varying process operating conditions of EAF 5 are very different from the steady-stage conditions of source typically equipped with wet scrubbers. Even if we had found that wet scrubbers represented an applicable control option, further technical review, as discussed below, would conclude that wet scrubbers are technically infeasible.

Technical literature and previously issued permits were reviewed for this assessment, and the following relevant information pertaining to the technical feasibility of flue gas desulfurization (FGD) systems for EAFs was found:

- In a PSD Preliminary Determination prepared by the State of Georgia when reviewing an application for a steel plant, the State compared inlet gas concentrations of utility boilers to those of a steel EAF and concluded that wet scrubbing is not applicable. SO$_2$ in the exhaust gases of the EAF are in the <100 ppm range as opposed to the 1,000 ppm range for coal-fired power plants;\textsuperscript{19} and

- The State of Georgia also cites various operating problems associated with the use of wet scrubbers to control SO$_2$ emissions from an EAF: 1) particulates can plug spray nozzles, packing plates, and trays, 2) the EAF exhaust would contain a relatively small SO$_2$ concentration, and 3) the SO$_2$ concentration in the EAF exhaust would vary widely over the EAF cycle. The State also noted that the applicant was unable to identify any wet scrubbing system used on an EAF due to the technical difficulties with this type of installation. The State concluded that add-on control technology was not technically feasible.\textsuperscript{20}

A significant aspect of scrubber use for EAF 5 is placement of the scrubber unit itself. As noted earlier, EAF 5 and EAF 7 are ducted to a common fabric filter for PM control and recovery of silica. Fume recovery in a fabric filter is a fundamental design consideration for numerous metal production furnaces. Unlike typical sources employing a wet scrubber (e.g., coal-fired boiler), the

\textsuperscript{19} State of Georgia, Department of Natural Resources in the PSD Preliminary Determination for Osceola Steel Company, November 2010.

\textsuperscript{20} ibid, State of Georgia.
exhaust gas from EAF 5 has material value represented by the fume. Insertion of a wet (or dry) scrubbing system into the EAF gas train would severely contaminate the fume to the point where it would no longer be a viable product. This situation would change the basis manufacturing process associated with FeSi and Si metal production, and produce a net operating cost of over $1,000,000 per year, which is the value of the fume marketed by Globe. (While not a factor in the technical feasibility of a control option, this cost alone far exceeds the cost borne by others in the industry for application of BACT, and therefore leads to a conclusion of adverse impacts on the Globe operation.)

Table 8 summarizes these findings in terms of the conditions of a BACT assessment of technical feasibility. This evaluation of source-specific factors leads Globe to conclude that wet scrubbers are not technically feasible.

3.2.3 Dry Scrubbers

In Step 1, dry scrubbers were determined to be not available for SO\textsubscript{2} control on EAF 5 due to the lack of similarity between EAF 5 and other sources using dry scrubbers for SO\textsubscript{2} control. As with wet scrubbers, we also were not able to identify any examples of utilizing dry/semi-dry scrubbing techniques to control exhaust streams with SO\textsubscript{2} concentrations similar to or lower than those at EAF 5. Even if we had found that dry scrubbers represented an available control option, further technical review, as discussed below, would conclude that dry scrubbers are technically infeasible.

The wet scrubber technical review results provided above also generally apply to dry scrubbers, as observed, for example, in US EPA’s Cost Manual, which puts both scrubber types in the same categorical discussion. As discussed above, contacts with a vendor and review of the European Commission report support these findings.

A primary fundamental difference exists between the properties of the Globe exhaust gas and gases normally treated with dry scrubbers. This difference is that the gas from the EAF has value, and the control strategy applied to the EAF 5 exhaust gas is designed to recover the material value contained in the gas. As discussed above, the Si fume currently collected in the fabric filters is sold as a product. The Si fume is marketed with specific density and pH specifications as well as a minimum silicon dioxide (SiO\textsubscript{2}) content. Inclusion of spray-dried particles in the fabric filter catch would alter important characteristics of this by-product and render the silica fume unsaleable. Application of spray drying at the Globe facility would eliminate this product stream, and the saleable product would then become a waste, thus causing the revenue stream to become a cost item. Additionally, as described in Section 2, the combined exhaust from the two
EAFs in Shop 2 is treated in a single fabric filter. Installation of a dry injection or spray drying operation would require that the two existing fabric filters be replaced with new PM control systems to accommodate the much greater PM loading produced by a dry injection or spray dry system. Finally, as with wet scrubbers, the low SO$_2$ concentration (less than 100 ppmv) falls below the low range of common applications for this technology, and below the concentration range of any project we could identify. As noted above, none of the facilities identified in the RBLC or in our broader review apply dry scrubbers to reduce SO$_2$ emissions from an EAF. Therefore, dry injection or spray drying operations are considered technically infeasible.

Another factor influencing the technical feasibility is the temperature profile of the EAF exhaust. Currently estimated to average 400˚ F, the temperature is below the optimum operating range for SO$_2$ removal in dry scrubbers. The true exhaust temperature could be much less than this at times, even close to ambient temperature, thus severely impacting the performance of any system installed at the Globe facility.

This technical review indicates that the low SO$_2$ concentration (less than 100 ppmv) in the gas at Globe falls below the low range of common applications for this technology. Additionally, the wide range of off-gas properties leads to uncertain success at reducing SO$_2$ concentrations in the EAF 5 gas stream. Finally, none of the facilities identified in the RBLC or in our broader review requires the use of add-on controls as BACT for SO$_2$. Table 9 summarizes these findings in terms of the conditions of a BACT assessment of technical feasibility. This evaluation of source-specific factors leads us to conclude that dry scrubbers are not technically feasible.
<table>
<thead>
<tr>
<th>Evaluation Factor for Wet Scrubbers</th>
<th>Source-Specific Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development Stage</td>
<td>Not demonstrated at any metal production facility in the U.S. or abroad; no development in process.</td>
</tr>
<tr>
<td>Commercial Application</td>
<td>Wet scrubber technology is available to reduce SO₂ emissions from utility flue gas and other higher SO₂ concentration gas streams. Existing commercial applications are applied to SO₂ concentrations between 50 to 3,000 ppmv. The low end of this range is applicable only to operations with much lower flow rates than observed at Globe. Notably, the US EPA’s Air Pollution Control Cost Manual indicates that wet scrubbers are used to control gas streams with SO₂ concentrations greater than 250 ppmv. Based on the low concentration of contaminants in the Globe exhaust gases and the large gas volumes, vendors generally recommend that a wet scrubber not be used.</td>
</tr>
<tr>
<td>Scope of Installations</td>
<td>Wet scrubbers are typically installed on sources with 250 to 3,000 ppmv SO₂, predominantly at coal-fired power plants. The operating conditions at such sources are far more stable than those at EAF 5.</td>
</tr>
<tr>
<td>Performance Data</td>
<td>No performance data were found for treatment of gas with the low concentrations as found at Globe.</td>
</tr>
<tr>
<td>Technical Difficulties</td>
<td>Required equipment items include: scrubber towers with minimum diameters between 13 feet and 30 feet; chemical receiving and transfer systems; chemical storage tanks; large horsepower water pumps; scrubber water pre-treatment systems; scrubber blowdown wastewater treatment system (physical/chemical units followed by a filter press); electrical transformers and service panels; fans; and gas discharge stacks. The limited amount of available space makes layout of these equipment items highly uncertain, dangerous to existing operations, and technically infeasible.</td>
</tr>
<tr>
<td>Proposed Site (location, size)</td>
<td>Limited space is available to support the number of wet scrubbers and wastewater treatment systems needed to control the large volume of air and relatively low concentrations.</td>
</tr>
<tr>
<td>Operating Problems</td>
<td>A wet scrubber placed in the EAF 5 gas train would contaminate the fume and cause the loss of a saleable by-product. Replacing the existing fans/fan motors with larger units is not feasible because the filter housings are unable to operate under additional positive or negative pressure. Pressurizing the existing fabric filter will not allow entry into the housing as is currently performed during bag replacement. This would present a safety hazard in that the system would need to be shut down to allow safe entry for bag replacement, and would thereby produce an increase in fugitive particulate emissions. Those operating problems noted by the State of Georgia would likely be experienced at EAF 5 as well.</td>
</tr>
</tbody>
</table>
### Table 9. Summary of Factors Leading to Technical Infeasibility of Dry Scrubber Use at EAF 5

<table>
<thead>
<tr>
<th>Evaluation Factor for Dry Scrubbers</th>
<th>Source-Specific Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development Stage</td>
<td>Not demonstrated at any metal production facility in the U.S. or abroad; no development in process.</td>
</tr>
<tr>
<td>Commercial Application</td>
<td>Dry scrubber technology is available to reduce SO$_2$ emissions from utility flue gases with higher SO$_2$ concentration gas streams.</td>
</tr>
<tr>
<td></td>
<td>Existing commercial applications are applied to SO$_2$ concentrations between 100 to 600 ppmv. The low end of this range is applicable only to operations with much lower flow rates than observed at Globe. Notably, the US EPA’s Air Pollution Control Cost Manual indicates that dry scrubbers are used to control gas streams with SO$_2$ concentrations greater than 250 ppmv.</td>
</tr>
<tr>
<td>Scope of Installations</td>
<td>Dry scrubbers are typically installed on sources with 100 to 600 ppmv SO$_2$, predominantly at coal-fired power plants. The operating conditions at such sources are far more stable than those at EAF 5.</td>
</tr>
<tr>
<td>Performance Data</td>
<td>No performance data were found for treatment of gas with the low concentrations as found at Globe. However, information was found that several dry scrubber operators are having difficulties with the systems, and several corrective retrofit actions are needed.</td>
</tr>
</tbody>
</table>

**Technical Difficulties**

| Unit Size                           | Required equipment items include: heat exchanger/cooling system; spray dryer towers (perhaps two @ 20 feet diameter each); dry chemical receiving systems; multiple dry chemical storage silos; dry chemical transfer conveyors; dry chemical mill; dry chemical transfer systems; chemical injection systems; additional fabric filters; particulate handling systems; electrical transformers and service panels; fans; and discharge stacks. The limited amount of available space makes layout of these equipment items highly uncertain, dangerous to existing operations, and technically infeasible. |
| Proposed Site (location, size)      | Extensive site review is required to determine if adequate space exists for the required equipment items. The extent of necessary equipment items lead to a preliminary determination that space is not available. |
| Operating Problems                  | A dry scrubber placed in the EAF 5 gas train would contaminate the fume and cause the loss of a saleable by-product. |
|                                     | Replacing the existing fans/fan motors with larger units is not feasible because the filter housings are unable to operate under additional positive or negative pressure. |
|                                     | Pressurizing the existing fabric filter will not allow entry into the housing as is currently performed during bag replacement. This would present a safety hazard in that the system would need to be shut down to allow safe entry for bag replacement, and would thereby produce an increase in fugitive particulate emissions. |
|                                     | An operating issue has been observed when DSI systems operate with a high Normalized Stoichiometric Ratio. As the Ratio increases, a brown nitrogen oxide (NOx) plume begins to be generated and emitted from the stack. This situation produces an undesirable environmental impact of using a DSI system. |
3.3 STEP 3: RANK REMAINING CONTROL OPTIONS BY CONTROL EFFECTIVENESS

Table 10 ranks the technically feasible control options by control effectiveness. Emission reductions in Table 10 are reductions from assumed baseline emissions. The 1990 US EPA NSR Workshop Manual describes baseline emissions as “essentially uncontrolled emissions, calculated using realistic upper boundary operating assumptions.” Steps 1 and 2 herein concluded pollution prevention (i.e., material substitution) is the only available and technically feasible control option for EAF 5, and, therefore, pollution prevention is the only control option discussed in this section. No add-on control options were deemed available and applicable, and therefore, add-on control options are not included in Table 10.

Table 10. Rank of Technically Feasible SO$_2$ Control Options for EAF 5

<table>
<thead>
<tr>
<th>Rank</th>
<th>Control Option</th>
<th>Product</th>
<th>Estimated SO$_2$ Emission Reduction, tons/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Carbon Source Selection</td>
<td>Use lower (0.8%) sulfur coal</td>
<td>Si metal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>FeSi (50% and 75%)</td>
</tr>
<tr>
<td>2</td>
<td>Electrode Selection in EAF 5$^{(b)}$</td>
<td>Use pre-bake electrodes</td>
<td>Si metal</td>
</tr>
<tr>
<td>2a</td>
<td>Use pre-bake electrodes in EAF 5 (0.15% sulfur) instead of Alcoa Paste</td>
<td>FeSi (50% and 75%)</td>
<td>23.5</td>
</tr>
<tr>
<td>2b</td>
<td>Use pre-bake electrodes in EAF 5 (0.15% sulfur) instead of Rhienfelden Paste</td>
<td>FeSi (50% and 75%)</td>
<td>9.1</td>
</tr>
<tr>
<td>2c</td>
<td>Use pre-bake electrodes in EAF 5 (0.15% sulfur) instead of Elkem TSR</td>
<td>FeSi (50% and 75%)</td>
<td>0.7</td>
</tr>
</tbody>
</table>

$^a$. The reduction achievable with coal switching is a conservative estimate based on the largest annual SO$_2$ emission over the past 5 years (no more than 400 tons). This annual SO$_2$ emission is larger than that reported earlier in Table 1 because data from additional emission reporting years were also considered. A 20% emission reduction is achieved when assuming that all of the coal used contained 1% sulfur and that a 0.8% sulfur coal would instead be used. The actual SO$_2$ emission reduction would be much less than this amount due to actual coal usage and product scheduling.

$^b$. Emission reductions due to use of pre-bake electrodes are based on expected annual usages of a single self-bake paste if that paste were to be only one used, assuming each paste contains the maximum sulfur content included in the suppliers specifications.
Globe currently employs the greatest degree of pollution prevention available when producing Si metal. The primary carbon source charged to EAF 5 is low sulfur (specialty) coal. This grade of coal, with a 0.8% annual average sulfur content, must be used to avoid contaminating the Si metal with trace metals found in the coal. Globe is already using the lowest sulfur content metallurgical coal produced within the U.S. To substitute lower sulfur metallurgical coal would require using a foreign coal source. Even if using a foreign coal source, however, we cannot guarantee the quality or availability of a lower sulfur foreign coal source going forward. Additionally, inadequate supplies of metallurgical grade charcoal exist to make increased charcoal use a feasible SO$_2$ control option. Sulfur also is present in the electrodes used in EAF 5, and to maintain product purity, Globe already uses the lowest sulfur-content electrodes during Si metal production (i.e., pre-bake electrodes that average 0.15% sulfur based on limited data). Therefore, no SO$_2$ control options are feasible when producing Si metal.

Some SO$_2$ control options may exist during FeSi production. Globe specifies and uses a coal with maximum 1% sulfur content when producing FeSi. Using the same 0.8% sulfur coal as is used during Si metal production is technically feasible when producing FeSi in EAF 5, and such use would yield a modest SO$_2$ emission reduction. Similarly, the self-bake electrode paste (which is estimated to contain an average sulfur content between 0.2% and 1.3% based on limited supplier specifications) makes up a large portion of the electrode use during FeSi production. As noted in Table 10, switching to the pre-bake electrodes (used when making Si metal) during FeSi production in EAF 5 would yield a modest SO$_2$ emission reduction, depending on the actual self-bake electrode used.

3.4 **STEP 4: EVALUATE THE MOST EFFECTIVE CONTROLS**

Table 11 presents the results of additional evaluation performed on the two control options ranked in Table 10. No capital costs are associated with either control option. Only operating costs will be incurred. Cost effectiveness for the coal replacement option was determined by calculating the difference in SO$_2$ emission per ton of coal based on 100% conversion of sulfur in the coal to SO$_2$. Assuming 100% conversion of sulfur (a conservative assumption that maximizes the value of the control option), 1% sulfur coal yields 40 lb SO$_2$/ton of coal. The control option, using 0.8% sulfur coal, yields 32 lb SO$_2$/ton of coal. Thus, the difference between using 1% sulfur coal and 0.8% sulfur coal would yield a reduction of 8 lb SO$_2$/ton of coal. The delivered cost of the 0.8% sulfur coal (Alden Blue Gem Low Ash Coal) is $372/ton. The delivered cost of the 1% sulfur coal (Alden Blue Gem Medium Ash Coal) is $173/ton. These prices yield a cost differential of $199/ton. The calculated SO$_2$ reduction and coal cost differential produce a cost effectiveness equal to $49,750/ton SO$_2$ reduced per year.
Table 11. Cost-effectiveness of Technically Feasible SO$_2$ Control Options

<table>
<thead>
<tr>
<th>Control Option</th>
<th>Emission Reduction, tons/yr</th>
<th>Capital Cost</th>
<th>Annual Cost</th>
<th>Cost-Effectiveness, $/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use low sulfur coal for FeSi</td>
<td>80</td>
<td>$0</td>
<td>Not calculated</td>
<td>49,750$^{(a)}</td>
</tr>
<tr>
<td>Use pre-bake electrodes for FeSi$^{(b)}$</td>
<td>0.7</td>
<td>$0</td>
<td>$840,800</td>
<td>&gt;1.2 million</td>
</tr>
<tr>
<td>Elkem TSR</td>
<td>9.1</td>
<td>$0</td>
<td>$834,100</td>
<td>91,660</td>
</tr>
<tr>
<td>Rhienfelden</td>
<td>23.5</td>
<td>$0</td>
<td>$803,000</td>
<td>34,170</td>
</tr>
</tbody>
</table>

a. The cost-effectiveness of coal switch only includes the differential coal price and does not include the additional cost associated with alloy/metal additions to the mix to achieve desired FeSi properties.

b. Annual electrode substitution cost is based on the listed self-bake electrode paste that can currently be used and that might be replaced in EAF 5 with pre-baked electrodes.

The cost effectiveness of the control option using low sulfur electrodes is based on the expected reduction of annual SO$_2$ emissions presented in Table 10 (i.e., 0.7, 9.1, or 23.5 ton/yr) and the estimated annual cost to purchase additional pre-bake electrodes for use when producing FeSi. The estimated cost differential between using pre-bake electrodes (the more expensive option) and self-bake electrodes (the less expensive option) is between $583,000 and $753,000/yr, (based on current self-bake paste and current pre-bake electrode prices). When compared to the estimated annual SO$_2$ emission reduction, this information produces a calculated cost effectiveness that is much greater than other similar facilities.
3.5 **STEP 5: SELECT BACT**

BACT for the control of SO$_2$ emissions from EAF 5 at Globe’s facility is pollution prevention through the use of low sulfur coal. Globe currently uses low sulfur coal as a necessity for quality control purposes. The coal used when producing FeSi contains on average less than 1% sulfur, and that used when producing Si metal averages 0.8% sulfur on a coal-weighted annual basis. BACT is considered as continued use of this coal in EAF 5. Because the sulfur content of coal can vary significantly based on shipment and raw material source, Globe proposes to demonstrate compliance with coal sulfur content on a weighted annual average basis.

Specification of this BACT level is consistent with previous BACT determinations rendered by permitting agencies in Alabama, Arkansas, Indiana, Illinois, and South Carolina. These agencies are the only ones that have incorporated an SO$_2$ control measure on EAF operations. Furthermore, Ohio has made previous determinations that add-on SO$_2$ controls and charge substitution are not feasible SO$_2$ control options at an EAF facility. (RBLC Facility ID OH-0245).

4 **SUMMARY AND CONCLUSIONS**

In conclusion, the conditions of EAF 5 operation, and the resultant wide variations in the properties of the exhaust gas from EAF 5, preclude the use of add-on control devices for reduction of SO$_2$ emissions. The annual operating cost associated with loss of fume sale alone would greatly exceed a reasonable BACT cost effectiveness level, with annual fume sales in excess of $1 million, which greatly exceeds the costs borne by similar sources and therefore cannot represent BACT. Even if add-on SO$_2$ control technology was to be considered feasible, constraints at the Globe facility, including lack of available space for the required retrofit equipment installation and the lack of structural integrity in the existing fabric filter housings, would produce retrofit costs that are far greater than the control cost experienced at other Si metal and FeSi facilities. To fully address these constraints and devise a system that considers the site challenges would entail extensive preliminary engineering efforts. However, very much like all other EAF shops, the current conditions at the Globe facility combine to produce operating conditions and infrastructure challenges that cannot support installation and operation of add-on SO$_2$ control equipment. Furthermore, based on our review of metallurgical operations around the world, no EAF operation producing FeSi or Si metal has ever been equipped with an add-on control system to reduce SO$_2$ emissions, including EAFs constructed as recently as 2014.
APPENDIX A

EAF ENTRIES IN THE RACT/BACT/LAER CLEARINGHOUSE
### Table A-1. Summary of Identified Electric Arc Furnaces SO$_2$ Limits

<table>
<thead>
<tr>
<th>Search Criteria</th>
<th>Facility ID</th>
<th>Facility Name</th>
<th>Emission Unit</th>
<th>Permit Date</th>
<th>SO$_2$ Limit$^{(a)}$</th>
<th>Control Required</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AL-0124</td>
<td>Simcala Inc. Montgomery, AL (acquired by Dow Corning Corp. on June 17, 2003)</td>
<td>20 MW silicon EAF</td>
<td>09/18/1998</td>
<td>27.61 lb/hr 0.8% sulfur in coal</td>
<td>Limit coal sulfur content to 0.8%</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td>Permit Date = 1/1/1990 to 2/16/2017</td>
<td>AR-0077</td>
<td>Bluewater Project, Steelcorr, Inc. Mississippi, AR</td>
<td>300 ton/hr EAF for steel production (ferroalloys are not produced in the EAF; instead they are produced in the ladle metallurgical furnace (LMF))</td>
<td>07/22/2004</td>
<td>0.2 lb/ton</td>
<td>Low sulfur coke and scrap management</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td>Process = electric arc furnace, ferroalloy metal</td>
<td>UT-0061</td>
<td>NUCOR Steel Corp, Box Elder, UT</td>
<td>65 ton/hr EAF for recycled steel, each of two units (review of the referenced permit indicates that this facility produces steel alloys, not ferroalloys)</td>
<td>08/29/1997</td>
<td>19.95 lb/hr</td>
<td>none specified</td>
<td>Basis is Other case-by-case</td>
</tr>
<tr>
<td>Pollutant Name = SO$_2$</td>
<td>Not in RBLC</td>
<td>Mississippi Silicon LLC Burnsville, MS</td>
<td>2.75 ton/hr silicon metal in each of four EAFs</td>
<td>11/27/2013</td>
<td>52.0 lb/ton over a 3-hr period</td>
<td>Utilize low sulfur content material (where technically feasible)</td>
<td>Basis is BACT-PSD; facility-wide SO$_2$ emissions are limited to 2,170.1 tons/yr</td>
</tr>
</tbody>
</table>

---

$^{(a)}$ The RBLC reports all limits to four decimal places, irrespective of the number of significant digits in the actual limit. Trailing zeros reported in the RBLC have been eliminated from this summary table.
<table>
<thead>
<tr>
<th>Search Criteria</th>
<th>Facility ID</th>
<th>Facility Name</th>
<th>Emission Unit</th>
<th>Permit Date</th>
<th>SO₂ Limit(a)</th>
<th>Control Required</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permit Date = 1/1/1990 to 2/16/2017</td>
<td>AL-0087</td>
<td>Trico Steel Co., LLC Morgan, AL</td>
<td>440 ton/hr carbon steel EAF</td>
<td>09/22/1995</td>
<td>0.09 lb/ton</td>
<td>Scrap management</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>AL-0129</td>
<td>IPSCO Steel, Inc. Mobile, AL</td>
<td>220 ton/hr EAF</td>
<td>10/16/1998</td>
<td>0.7 lb/ton</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>AL-0197</td>
<td>NUCOR Steel Decatur, LLC Morgan, AL</td>
<td>2@ 440 ton/hr EAF</td>
<td>07/11/2002</td>
<td>220 lb/hr</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>AL-0202</td>
<td>Corus Tuscaloosa</td>
<td>160 ton/hr EAF</td>
<td>06/03/2003</td>
<td>99.2 ton/hr</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>AL-0218</td>
<td>NUCOR Steel Tuscaloosa, Inc. Tuscaloosa, AL:</td>
<td>300 ton/hr EAF</td>
<td>06/06/2006</td>
<td>0.46 lb/ton</td>
<td>Scrap management</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>AL-0230</td>
<td>Thyssenkrupp Steel and Stainless USA, LLC Mobile, AL</td>
<td>2@ 126 ton/hr EAF</td>
<td>08/17/2007</td>
<td>0.15 lb/ton</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>AL-0231</td>
<td>Nucor Decatur LLC Morgan, AL</td>
<td>2@ 440 ton/hr EAF</td>
<td>06/12/2007</td>
<td>0.62 lb/ton</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>AR-0021</td>
<td>Quanex Corporation - Macsteel Division Sebastian, AR</td>
<td>2@ 86 ton/hr EAF</td>
<td>02/18/1998</td>
<td>90.3 lb/hr</td>
<td>Scrap management</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>AR-0030</td>
<td>Arkansas Steel Associates, Jackson, AR</td>
<td>50 ton/hr scrap steel EAF</td>
<td>09/24/1998</td>
<td>0.71 lb/ton</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>AR-0033</td>
<td>Nucor Yamato Steel Company Mississippi, AR</td>
<td>450 ton/hr for two scrap steel EAFs</td>
<td>03/28/2000</td>
<td>67.5 lb/hr</td>
<td>Low sulfur coke and scrap management</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>AR-0055</td>
<td>Nucor Yamato Steel Company Mississippi, AR</td>
<td>225 ton/hr EAF for steel</td>
<td>10/10/2001</td>
<td>1.5 lb/ton</td>
<td>Low sulfur coke and scrap management</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td>Search Criteria</td>
<td>Facility ID</td>
<td>Facility Name</td>
<td>Emission Unit</td>
<td>Permit Date</td>
<td>SO$_2$ Limit$^{(a)}$</td>
<td>Control Required</td>
<td>Comment</td>
</tr>
<tr>
<td>-----------------</td>
<td>------------</td>
<td>---------------</td>
<td>---------------</td>
<td>-------------</td>
<td>---------------------</td>
<td>-----------------</td>
<td>---------</td>
</tr>
<tr>
<td></td>
<td>AR-0056</td>
<td>Macsteel Division, Quanex Corporation, Sebastian, AR</td>
<td>two EAFs at 37 ton/hr each for steel</td>
<td>10/28/1993</td>
<td>0.54 lb/ton</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>AR-0078</td>
<td>Nucor Steel, Arkansas, Mississippi, AR</td>
<td>425 ton/hr EAF for steel</td>
<td>06/09/2003</td>
<td>155 lb/hr</td>
<td>Scrap management</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>AR-0086</td>
<td>Nucor-Yamato Steel Company, Blytheville Mill, Mississippi, AR</td>
<td>250 ton/hr EAF for steel</td>
<td>06/11/2004</td>
<td>90 lb/hr</td>
<td>Low sulfur coke</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>AR-0096</td>
<td>Nucor Yamato Steel, Mississippi, AR</td>
<td>500 ton/hr EAF for steel</td>
<td>01/31/2008</td>
<td>100 lb/hr</td>
<td>Low sulfur coke and scrap management</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>AR-0130</td>
<td>Nucor-Yamato Steel Company, Blytheville Mill, Mississippi, AR</td>
<td>450 ton/hr EAF #1</td>
<td>06/11/2004</td>
<td>90 lb/hr</td>
<td>Low sulfur coke</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>CO-0054</td>
<td>CF&amp;I Steel L.P. Da Rocky Mountain Steel Mills, Pueblo, CO</td>
<td>156 ton/hr EAF</td>
<td>06/21/2004</td>
<td>0.25 lb/ton</td>
<td>Alternative raw materials and process controls</td>
<td>Basis is Other case-by-case</td>
</tr>
<tr>
<td></td>
<td>CO-0061</td>
<td>CF&amp;I Steel L.P. Da Rocky Mountain Steel Mills, Pueblo, CO</td>
<td>154 ton/hr EAF #5</td>
<td>06/21/2004</td>
<td>0.25 lb/ton</td>
<td>Alternative raw materials and process controls</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>*CO-0066</td>
<td>ERMS Pueblo, Pueblo, CO</td>
<td>185 ton/hr EAF #5</td>
<td>11/30/2011</td>
<td>0.15 lb/ton</td>
<td>Process controls</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>GA-0142</td>
<td>Osceola Steel Co. Cook, GA</td>
<td>430,000 ton/yr EAF</td>
<td>12/29/2010</td>
<td>0.18 lb/ton</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>IN-0054</td>
<td>NUCOR Steel, Montgomery, IN</td>
<td>2@ 130 ton/hr EAF</td>
<td>11/30/1993</td>
<td>0.2 lb/ton</td>
<td>Low sulfur coke (0.65%)</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td>Search Criteria</td>
<td>Facility ID</td>
<td>Facility Name, Location</td>
<td>Emission Unit</td>
<td>Permit Date</td>
<td>SO₂ Limit(^{(a)})</td>
<td>Control Required</td>
<td>Comment</td>
</tr>
<tr>
<td>-----------------</td>
<td>------------</td>
<td>------------------------</td>
<td>---------------</td>
<td>-------------</td>
<td>----------------</td>
<td>-----------------</td>
<td>---------</td>
</tr>
<tr>
<td>IN-0061</td>
<td>Steel Dynamics, Inc. DeKalb, IN</td>
<td>225 ton/hr EAF #1</td>
<td>10/07/1994</td>
<td>0.2 lb/ton</td>
<td>Scrap management</td>
<td>Basis is BACT-PSD</td>
<td></td>
</tr>
<tr>
<td>IN-0073</td>
<td>Qualitech Steel Corp. Hendricks, IN</td>
<td>135 ton/hr EAF</td>
<td>10/31/1996</td>
<td>149 lb/hr</td>
<td>Raw material input</td>
<td>Basis is BACT-PSD</td>
<td></td>
</tr>
<tr>
<td>IN-0108</td>
<td>Nucor Steel Montgomery, IN</td>
<td>502 ton/hr EAF (2)</td>
<td>11/21/2003</td>
<td>0.25 lb/ton</td>
<td>Scrap management</td>
<td>Basis is BACT-PSD</td>
<td></td>
</tr>
<tr>
<td>IN-0140</td>
<td>Nucor Steel, Montgomery, IN</td>
<td>502 ton/hr (2)</td>
<td>02/08/2010</td>
<td>0.33 lb/ton, 3- hr avg</td>
<td>none specified</td>
<td>Basis is Other case-by-case</td>
<td></td>
</tr>
<tr>
<td>IA-0055</td>
<td>IPSCO Steel, Inc. Muscatine, IA</td>
<td>EAF in melt shop EP #1</td>
<td>01/03/1995</td>
<td>1.22 ppm</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
<td></td>
</tr>
<tr>
<td>IL-0068</td>
<td>Keystone Steel &amp; Wire Company Peoria, IL</td>
<td>1.2 million ton/yr steel EAF</td>
<td>06/01/2000</td>
<td>2 lb/ton</td>
<td>Use of low sulfur injection coke (0.65% or less). Work practices</td>
<td>Basis is BACT-PSD</td>
<td></td>
</tr>
<tr>
<td>MI-0376</td>
<td>Macsteel Division Jackson, MI</td>
<td>560,000 ton/yr in 2 EAFs</td>
<td>12/08/2003</td>
<td>1 lb/ton</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
<td></td>
</tr>
<tr>
<td>MI-0404</td>
<td>Gerdau Macsteel, Inc. Monroe, MI</td>
<td>130 ton/hr EAF</td>
<td>01/04/2013</td>
<td>0.2 lb/ton</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
<td></td>
</tr>
<tr>
<td>MN-0070</td>
<td>Minnesota Steel Industries, LLC Itasca, MN</td>
<td>2@205 ton/hr EAFs</td>
<td>09/07/2007</td>
<td>0.15 lb/ton</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
<td></td>
</tr>
<tr>
<td>NC-0112</td>
<td>NUCOR Steel Hertford, NC</td>
<td>not listed</td>
<td>11/23/2004</td>
<td>0.35 lb/ton</td>
<td>Scrap management</td>
<td>Basis is BACT-PSD</td>
<td></td>
</tr>
<tr>
<td>NE-0055</td>
<td>Nucor Steel Stanton, NE</td>
<td>206 tons scrap steel melted per hour</td>
<td>10/09/2013</td>
<td>105 lb/ton, 30-day avg</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
<td></td>
</tr>
<tr>
<td>Search Criteria</td>
<td>Facility ID</td>
<td>Facility Name</td>
<td>Emission Unit</td>
<td>Permit Date</td>
<td>SO₂ Limit(^{(a)})</td>
<td>Control Required</td>
<td>Comment</td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------</td>
<td>---------------</td>
<td>---------------</td>
<td>-------------</td>
<td>----------------</td>
<td>----------------</td>
<td>---------</td>
</tr>
<tr>
<td>NJ-0040</td>
<td>Co-Steel Raritan Middlesex, NJ</td>
<td>1,160,320 ton/yr EAF</td>
<td>12/19/1996</td>
<td>2 lb/hr</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
<td></td>
</tr>
<tr>
<td>NY-0094</td>
<td>Nucor Auburn Steel Cayuga, NY</td>
<td>110 ton/hr EAF</td>
<td>06/22/2004</td>
<td>25.3 lb/hr</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
<td></td>
</tr>
<tr>
<td>OH-0245</td>
<td>Republic Technologies International Stark, OH</td>
<td>85 ton/hr EAF #7</td>
<td>01/27/1999</td>
<td>5.95 lb/hr</td>
<td>Looked at charge substitution (not feasible) and SO₂ controls (not feasible) none specified</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OH-0245</td>
<td>Republic Technologies International Stark, OH</td>
<td>165 ton/hr EAF #9</td>
<td>01/27/1999</td>
<td>11.55 lb/hr</td>
<td>Looked at charge substitution (not feasible) and SO₂ controls (not feasible) none specified</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OH-0246</td>
<td>The Timken Company/Faircrest Plant Stark, OH</td>
<td>200 ton/hr EAF</td>
<td>02/20/2003</td>
<td>0.15 lb/ton</td>
<td>none specified</td>
<td>Basis is Other case-by-case</td>
<td></td>
</tr>
<tr>
<td>OH-0276</td>
<td>Charter Steel Cuyahoga, OH</td>
<td>110 ton/hr scrap melting EAF</td>
<td>06/10/2004</td>
<td>22 lb/hr</td>
<td>none specified</td>
<td>Basis is BACT-PSD; SIP</td>
<td></td>
</tr>
<tr>
<td>OH-0302</td>
<td>Republic Engineered Products, Inc. Stark, OH</td>
<td>183.3 ton/hr EAF</td>
<td>08/30/2005</td>
<td>12.83 lb/hr</td>
<td>none specified</td>
<td>Basis is BACT-PSD; SIP</td>
<td></td>
</tr>
<tr>
<td>OH-0315</td>
<td>New Steel International, Inc., Haverhill Haverhill, OH</td>
<td>2 @ 331 ton/hr EAF</td>
<td>05/06/2008</td>
<td>33 lb/hr</td>
<td>none specified</td>
<td>Basis is BACT-PSD; SIP</td>
<td></td>
</tr>
<tr>
<td>OH-0316</td>
<td>V &amp; M Star Mahoning, OH</td>
<td>134 ton/hr EAF</td>
<td>09/23/2008</td>
<td>33.5 lb/hr</td>
<td>none specified</td>
<td>Basis is Other case-by-case</td>
<td></td>
</tr>
<tr>
<td>OH-0328</td>
<td>V &amp; M Star Mahoning, OH</td>
<td>1.4 million ton/yr steel tube</td>
<td>04/10/2009</td>
<td>43 lb/hr</td>
<td>none specified</td>
<td>Basis is BACT-PSD; SIP</td>
<td></td>
</tr>
<tr>
<td>Search Criteria</td>
<td>Facility ID</td>
<td>Facility Name</td>
<td>Emission Unit</td>
<td>Permit Date</td>
<td>SO₂ Limit(a)</td>
<td>Control Required</td>
<td>Comment</td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------</td>
<td>---------------</td>
<td>---------------</td>
<td>-------------</td>
<td>--------------</td>
<td>-----------------</td>
<td>---------</td>
</tr>
<tr>
<td>OH-0331</td>
<td>AK Steel Corporation Mansfield Works Richland, OH</td>
<td>2,610 ton/day for 2 EAFs in a steel melt shop</td>
<td>01/11/2010</td>
<td>0.073 lb/ton</td>
<td>none specified</td>
<td>Basis is Other case-by-case; SIP</td>
<td></td>
</tr>
<tr>
<td>OH-0339</td>
<td>Harrison Steel Plant Stark, OH</td>
<td>400,000 ton/yr increase each of 2 EAFs</td>
<td>12/29/2010</td>
<td>0.44 lb/ton</td>
<td>Partial coke replacement with scrap tires</td>
<td>Basis is Other case-by-case</td>
<td></td>
</tr>
<tr>
<td>OH-0341</td>
<td>Nucor Steel Marion, Inc. Marion, OH</td>
<td>1,800 ton/day finished steel; EAF</td>
<td>12/23/2010</td>
<td>0.5 lb/ton</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
<td></td>
</tr>
<tr>
<td>OH-0342</td>
<td>Faircrest Steel Stark, OH</td>
<td>1,300,000 ton/yr facility capacity; EAF</td>
<td>12/29/2010</td>
<td>0.52 lb/ton</td>
<td>none specified</td>
<td>Basis is Other case-by-case</td>
<td></td>
</tr>
<tr>
<td>OH-0350</td>
<td>Republic Steel Lorain, OH</td>
<td>150 ton/hr EAF</td>
<td>07/18/2012</td>
<td>0.39 lb/ton</td>
<td>none specified</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OK-0128</td>
<td>Mid American Steel Rolling Mill Marshall, OK</td>
<td>50 ton/hr per EAF</td>
<td>09/08/2008</td>
<td>0.3 lb/ton, 3-hr avg</td>
<td>Scrap management</td>
<td>Basis is BACT-PSD</td>
<td></td>
</tr>
<tr>
<td>PA-0235</td>
<td>Koppel Steel Corp. Beaver, PA</td>
<td>598,000 ton/yr melt shop</td>
<td>11/26/2003</td>
<td>50 lb/hr</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
<td></td>
</tr>
<tr>
<td>PA-0251</td>
<td>Ellwood National Steel Warren, PA</td>
<td>45 ton/hr EAF</td>
<td>08/18/2006</td>
<td>0.55 lb/ton</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
<td></td>
</tr>
<tr>
<td>PA-0284</td>
<td>AK Steel Corp/Butler Works Butler, PA</td>
<td>1.2 million tons steel per year in 3 EAFs</td>
<td>03/11/2005</td>
<td>500 ppmvd</td>
<td>none specified</td>
<td>Basis is BACT-PSD and Other case-by-case</td>
<td></td>
</tr>
<tr>
<td>SC-0039</td>
<td>Nucor Steel Berkeley, SC</td>
<td>165 ton/hr EAF</td>
<td>08/16/1995</td>
<td>0.2 lb/ton</td>
<td>Low sulfur coke (&lt;0.65%)</td>
<td>Basis is BACT-PSD</td>
<td></td>
</tr>
<tr>
<td>Search Criteria</td>
<td>Facility ID</td>
<td>Facility Name</td>
<td>Emission Unit</td>
<td>Permit Date</td>
<td>SO₂ Limit (a)</td>
<td>Control Required</td>
<td>Comment</td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------</td>
<td>--------------------------------</td>
<td>-------------------</td>
<td>-------------</td>
<td>---------------</td>
<td>-----------------------------------------------------------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td></td>
<td>SC-0127</td>
<td>Nucor Steel Corporation</td>
<td>1,314,000 ton/yr EAF</td>
<td>12/29/2006</td>
<td>0.67 lb/ton</td>
<td>Scrap management; limit on the total annual production of resulfurized steel to 105,200 billet tons</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>TN-0155</td>
<td>Nucor Steel Corporation</td>
<td>150 ton/hr EAF</td>
<td>11/06/2000</td>
<td>0.16 lb/ton</td>
<td>Scrap management; Limit high-sulfur steel production to 125,000 ton/yr; Maintain a log of iron pyrite usage during high-sulfur steel production</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>TX-0399</td>
<td>Nucor Jewett Plant</td>
<td>240 ton/hr EAF</td>
<td>01/05/2003</td>
<td>421.68 lb/hr</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>*TX-0651</td>
<td>Steel Mill</td>
<td>316 ton/hr EAF</td>
<td>10/02/2013</td>
<td>1.76 lb/ton</td>
<td>Good process operation and scrap management</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>VA-0226</td>
<td>Roanoke Electric Steel</td>
<td>500,000 tons steel per year EAF</td>
<td>12/08/1994</td>
<td>41.9 ton/yr</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
</tr>
<tr>
<td></td>
<td>VA-0241</td>
<td>Roanoke Electric Steel</td>
<td>100 ton/hr steel in #5 EAF</td>
<td>11/06/1998</td>
<td>16.8 ton/hr</td>
<td>none specified</td>
<td>Basis is BACT-PSD</td>
</tr>
</tbody>
</table>
December 4, 2018

Sulfur Dioxide Emission Control System
Globe Metallurgical, Inc.
County Road 32
Beverly, Ohio 45715

Attention: Mr. Matt Greene

Reference: Sulfur Dioxide Emission Control System
Furnace 5 Only
Amerair Industries Budget Proposal #180603-A, Rev. 1

[REDACTED]
REDACTED
December 4, 2018

Sulfur Dioxide Emission Control System
Globe Metallurgical, Inc.
County Road 32
Beverly, Ohio 45715

Attention: Mr. Matt Greene

Reference: Sulfur Dioxide Emission Control System
Furnace 5+7
Amerair Industries Budget Proposal #180603-B, Rev. 1

Confidential Business Information
ATTACHMENT C  REDECAM PROPOSALS FOR DSI AT EAF NO. 5 AND EAF NOS. 5 + 7
FLUE GAS TREATMENT LINE
EAF5-7

BEVERLY, OH
USA

BUDGET QUOTE
P18120477 – Rev. 1 Commercial
February 8th, 2019
## A. COMMERCIAL CONDITIONS

### A.1 Weights and Price sheet

<table>
<thead>
<tr>
<th>Description</th>
<th>Weight [Kg]</th>
<th>Weight [Kg]</th>
<th>Price [USD]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering of the New Flue Gas Treatment</td>
<td>-</td>
<td>-</td>
<td>$220,530.00</td>
</tr>
<tr>
<td>Supply of no. 1 new Pulse Jet Filter in place of existing RABH, for silica collection</td>
<td>565,050</td>
<td>-</td>
<td>$2,217,130.00</td>
</tr>
<tr>
<td>Supply of no. 1 new Pulse Jet Filter downstream the RT, for dust collection</td>
<td>534,490</td>
<td>-</td>
<td>$1,783,590.00</td>
</tr>
<tr>
<td>Supply of the #3 new ID fans with LV motors and LV frequency converters</td>
<td>67,500</td>
<td>-</td>
<td>$1,704,860.00</td>
</tr>
<tr>
<td>Supply of the new HG lime Reactor</td>
<td>3,600</td>
<td>-</td>
<td>$380,430.00</td>
</tr>
<tr>
<td>Supply of the HG Lime injection system</td>
<td>3,600</td>
<td>-</td>
<td>$306,210.00</td>
</tr>
<tr>
<td>Supply of the new ductworks</td>
<td>-</td>
<td>74,150</td>
<td>$329,960.00</td>
</tr>
<tr>
<td>Supply of the new stack</td>
<td>-</td>
<td>77,000</td>
<td>$424,250.00</td>
</tr>
<tr>
<td>Mechanical Erection</td>
<td>-</td>
<td>-</td>
<td>$7,599,010.00</td>
</tr>
<tr>
<td>Advisory service for commissioning</td>
<td>-</td>
<td>-</td>
<td>$66,510.00</td>
</tr>
<tr>
<td>Compressed air production and treatment station</td>
<td>-</td>
<td>-</td>
<td>$237,460.00</td>
</tr>
<tr>
<td>Description</td>
<td>Quantity</td>
<td>Unit</td>
<td>Total</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>----------</td>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>LV MCC and PLC system for the supplied equipment, cables and trays, wiring and installation into a new electrical room</td>
<td></td>
<td></td>
<td>$1,167,540.00</td>
</tr>
<tr>
<td>Execution of the thermal insulation (5,960 m2)</td>
<td></td>
<td></td>
<td>$938,240.00</td>
</tr>
<tr>
<td>Packing and transport DDP of the supplied equipment</td>
<td></td>
<td></td>
<td>$1,119,880.00</td>
</tr>
<tr>
<td>Total weight</td>
<td>1,174,240</td>
<td>151,150</td>
<td></td>
</tr>
<tr>
<td><strong>Total Net Budget Price</strong></td>
<td></td>
<td></td>
<td>$18,495,600.00</td>
</tr>
</tbody>
</table>
A.2 Consolidated Commercial Conditions:

Total Budget Price: $18,495,600

Total weight components and steelworks: 1,175 Tons Redecam supply

Schedule: T.B.D.

Delivery: DDP Beverly, OH

Payment: T.B.D.

Offer validity: 60 days

Best Regards,

Eng. Niccolo’ Griffini
Redecam Group SpA
Iron & Steel Specialist
Director, Business Development

Eng. Salvatore Gallo
Redecam USA, LLC.
VP & Sales Director
FLUE GAS TREATMENT LINE
EAF5-7
BEVERLY, OH
USA

P18120477 – Rev. 1
1st of February 2019
0. INDEX

A. FOREWORD.............................................................................................................3
B. MAIN DESIGN DATA................................................................................................6
C. DETAILED SCOPE OF SUPPLY ..............................................................................7
D. BATTERY LIMITS ...................................................................................................32
E. MATERIALS, PAINTING AND INSULATION ..........................................................33
F. PRELIMINARY PROJECT PLAN............................................................................34
G. GUARANTEES........................................................................................................35
H. EXCLUSIONS.........................................................................................................38
I. GENERAL CONDITIONS .........................................................................................39
J. SPARE PARTS & AFTER SALES SERVICES ..........................................................42
K. ANNEXES ...............................................................................................................43
A. FOREWORD

The current proposal is based on the design data that we have received by your tender email and following clarifications by email.

For meeting your needs in terms of dedusting and pollutants reduction, Redecam is proposing a flue gas treatment plant, equipped with dry injection of hydrated lime High Grade for SOx removal and bag filter for dust emission reduction.

We have considered the following split equipment supply:

Dry Reactor, mainly including
- Reactor Tower (RT)
- RT dust extraction system

Reagent Storage and Injection System, mainly including
- Hydrated Lime HG storage silo
- Hydrated Lime HG extraction and injection system

Bag Filters (one in place of existing RABH and one downstream the RT), mainly including
- Bag Filter (BF) equipped with internals and key components
- Bags cleaning control panel (PLC) and bag filter instrumentation as described
- Bag filter supporting structure and service platforms
- Bag Filter mechanical dust transport system for secondary dedusting new unit only

Dust Storage System
- bucket elevator
- storage system
- truck loading

Exhaust Fan System
- ID fan
- ID fan motor
- ID fan frequency converter

Set of Ductworks and Dampers, mainly including:
- Process gas ductworks
- Fresh air emergency valve
- By-pass system
- New Stack
NOTES on selected DeSOx solution:

The efficiency of the powdered hydrated lime for SO2 removal is depending on several factors, among which the most important are fineness of the lime, gas temperature where the injection takes place in relation with gas moisture, contact time between lime and SO2, presence of inert dust, SO2 concentration baseline.

Generally speaking, a good efficiency is favorized by high fineness, low inert dust, long contact time, high SO2 baseline.

With reference to temperature, the leading parameter is the distance between the actual gas temperature and the dewpoint temperature. The shorter it is, the higher is the efficiency.

The hydrated lime we are proposing to use is specifically produced for DeSOx purpose and has a BET surface around 35-40 m2/g, thus responding to the first requirement.

Dust coming from the process is separated in the baghouse upstream the lime injection, thus solving the second requirement.

Contact time is increased by installing a dry reactor able to guarantee at least 4 seconds, so responding to the third requirement.

With reference to SO2 baseline and temperature, both of them are probably changing along with the process phase. In order to have a good process efficiency, the lowest is the temperature of the gas flow coming to the FGT treatment, the better it is in terms of hydrated lime consumption.

In principle we deem it’s possible to achieve 80% SO2 reduction with a temperature <200°C, with a sorbent consumption slightly decreasing the more we go below 200°C, but a measurement campaign targeted to verify the SO2 and temperature trends would be advisable.

In this way, we could verify is it’s worth to add further equipment for temperature control, like a gas conditioning tower or a water foggy system in order to be safer in terms of the max efficiency achievable and to minimize the sorbent consumption.

Since the emission is probably periodically changing, the hydrated lime injection too will be intermittent. Injection regulation can be done in several ways, following the emission at the stack through a simple PID or introducing an injection program based on the process phases.
Reagent (Hydrated Lime with High Grade) consumption in the worst (maximum load) operating case is estimated in the range of 640 kg/h (few excess from stoichiometric consumption, according to reagent producer) and 820 kg/h (considering the possible reagent pollutants and the ‘real’ operating conditions).

The proposed FGT here described is based on same operating condition that may be too “conservative”: we expect that SOx are not generated continuously ion all process phases, so we suggest a first technical review with process specialist of both sides (Globe and Redecam) to better discuss how to optimize the solution.
B. MAIN DESIGN DATA

B.1 General plant information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>Beverly, OH</td>
</tr>
<tr>
<td>country</td>
<td>USA</td>
</tr>
<tr>
<td>altitude above sea</td>
<td>8 m</td>
</tr>
<tr>
<td>ambient temperature (min/max)</td>
<td>-20/38 °C</td>
</tr>
<tr>
<td>humidity (min/avg/max)</td>
<td>10/74/100 %</td>
</tr>
<tr>
<td>rainfall (max)</td>
<td>852 mm/h</td>
</tr>
<tr>
<td>wind speed (max)</td>
<td>125 km/h (*)</td>
</tr>
<tr>
<td>snow load</td>
<td>250 kN/m² (*)</td>
</tr>
<tr>
<td>earthquake factor</td>
<td>- (*)</td>
</tr>
<tr>
<td>low voltage</td>
<td>13.8 kV</td>
</tr>
<tr>
<td>medium voltage</td>
<td>480 V</td>
</tr>
<tr>
<td>frequency</td>
<td>60 Hz</td>
</tr>
<tr>
<td>auxiliary tension</td>
<td>230 V</td>
</tr>
<tr>
<td>control voltage</td>
<td>24 VDC</td>
</tr>
<tr>
<td>protection</td>
<td>IP 55</td>
</tr>
<tr>
<td>insulating class</td>
<td>F to B</td>
</tr>
</tbody>
</table>

(*) Customer to confirm, it might have impact on weights and costs.

B.2 Operating conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum load</td>
<td></td>
</tr>
<tr>
<td>gas flow rate</td>
<td>653,000 Nm³/h wet</td>
</tr>
<tr>
<td></td>
<td>1,192,000 Am³/h wet</td>
</tr>
<tr>
<td>temperature</td>
<td>200 °C</td>
</tr>
<tr>
<td>pressure @ inlet</td>
<td>-350 daPa</td>
</tr>
<tr>
<td>type of dust</td>
<td>silica dust</td>
</tr>
<tr>
<td>gas composition (wet)</td>
<td></td>
</tr>
<tr>
<td>CO₂</td>
<td>1.20 %</td>
</tr>
<tr>
<td>SO₂</td>
<td>0.004 %</td>
</tr>
<tr>
<td>N₂</td>
<td>75.90 %</td>
</tr>
<tr>
<td>H₂O</td>
<td>3.60 %</td>
</tr>
<tr>
<td>O₂</td>
<td>19.30 %</td>
</tr>
</tbody>
</table>
C. DETAILED SCOPE OF SUPPLY

Group 01 N. 1 New Pulse Jet Filter in place of existing RABH

Consisting of:

1 N.1 Bag Filter type 8 DPZ 14x18/10-X

The resulting proposed bag filter is with on line pulse jet cleaning system divided in 10 excludable chambers for online maintenance. Here following the main characteristics and process data in the operating conditions:

Bag filter main mechanical data:

- width (internal): 11,800 mm
- length (internal): 33,680 mm
- number of bags: 4,032
- bags diameter: 152 mm
- bags length: 10.0 m
- cloth area: 19,254 m²
- casing design pressure @ 250 °C: -800 daPa
- compressed air consumption: 558 Nm³/h
- compressed air pressure for cleaning: 3.5 bar

Design conditions

- gas flow rate: 653,000 Nm³/h
- temperature: 200 °C
- inlet pressure: -350 daPa
- inlet dust content: 100 mg/Nm³
- type of dust: silica with unreacted lime
- outlet dust content: ≤ 5 mg/Nm³
- air to cloth ratio: 1.03 m³/m² min
- can velocity: 1.16 m/s
- expected pressure drop: < 130 daPa

Normal conditions

- gas flow rate: 600,000 Nm³/h
- temperature: 150 °C
- pressure @ inlet: -320 daPa
inlet dust content : 100 mg/Nm³

type of dust : silica with unreacted lime

outlet dust content : ≤ 5 mg/Nm³

air to cloth ratio : 0.85 m³/m² min

can velocity : 0.95 m/s

expected pressure drop : < 120 daPa

1.1 Special Components – Redecam supply

N 16 compressed air tank 12" receivers, each one complete of:
  ▪ 14 piston 3" pulse air valve
  ▪ 14 union between air valve and jet tube

N 8 air-proof boxes of die-cast light alloy (IP65 protection), holding the 24 VDC pilot solenoid valves which control the air valves

N 4.032 filtering sets, each composed of:
  - Bags in fiberglass with PTFE membrane, ø 152 x 10,.000 mm and nominal 740 g/m²
  - Bag cages realized in painted carbon steel, 20 wires, 2 pieces

N 1 set of air compressed accessories, composed of:
  - pressure regulator
  - air filter regulator
  - service unit

N 10 outlet (plenum) dampers, for online maintenance, on/off mode, pneumatically operated

1.1.1 First Urgency Spare Parts – Redecam supply

N 80 bags, as described above
N 50 cages, as described above
N 2 piston 3" pulse air valve

1.2 Instrumentation, Electrical and Control Devices – Redecam supply

N 1 PLC (Siemens S7-300 or eq.) to control of the bags’ cleaning sequence based on deltaP, granting a compressed air consumption reduction, through automatic optimization of the pause time between the consecutive shots

N 8 pressure switches on compressed air pipes
N 2 bags pressure drop transmitters
N 8 hopper level sensors (one each hopper)
N 2 temperature transmitters (at bag filter inlet and outlet)
N 1 pressure transmitter (at bag filter outlet)
N 8 set of electrical heat tracing, to be applied on 1/3 of the hopper height
N 8 hopper vibrators
N 1 tribo sensor (broken bag detector)
N 1 electric service hoist, capacity 1 t, height approx. 30 m
N 2 manual hoists 0,4 t for plenum doors opening
N 8 set of pneumatic actuators and 2 limit switches for the compartment’s outlet dampers

1.3 Steelworks – Redecam supply
N 64 jet tubes feeding the compressed air to the nozzles in carbon steel
N 8 modules of bag filter plenum in carbon steel S235JR, thickness 4 mm, complete of:
  - tube sheets set in carbon steel, thickness 5 mm
  - pre-insulated plenum doors
N 1 casing, realized in carbon steel S235JR, thickness 4 mm
N 8 hoppers, realized in carbon steel S235JR, thickness 4 mm
N 1 penthouse structure made of carbon steel profiles
N 1 penthouse pre-painted trapezoidal sheet metal
N 1 set of service platforms for the dust transport system
N 1 set of service platforms for the hopper compartment dampers system
N 1 set of stairs from ground level to the bag filter plenum
N 1 supporting structure with free height underneath the hopper flanges of 2.5 m

1.4 Thermal Insulation – Redecam supply
For the bag filter hoppers, with the following main characteristics:

material : rockwool
thickness : 100 mm
sheet metal material : galvanized CS
sheet metal thickness : 1,2 mm
surface (hoppers) : 750 m²

1.5 Dust Transport System – Existing to be reused
The existing dust transport system will be reutilized to collect the silica dust from the BFs hoppers and it will convey them into the existing storage silo.
Group 02 N. 1 Dry Reactor

Consisting of:

2 N. 1 Redecam Reactor Tower—Redecam supply

The reaction tower is a self-standing type tower and is connected to the filter inlet flange. It will be installed downstream the new PJBF that replaces the existing positive pressure Bag House.

The reaction tower is fitted with internal “venturi” to produce turbulence in the raw gas so to ease the perfect mixing of the reagents with the gas itself.

The tower is constituted of an internal vertical duct exiting in an expansion chamber over and around the internal duct itself; the combination of the two volumes given by the internal duct and by the expansion chamber is proper to grant the necessary contact time.

Reactors main mechanical data:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactor type</td>
<td>double pass</td>
</tr>
<tr>
<td>Diameter of venturi</td>
<td>4,000 mm</td>
</tr>
<tr>
<td>Diameter internal duct</td>
<td>4,800 mm</td>
</tr>
<tr>
<td>Diameter outer duct</td>
<td>7,500 mm</td>
</tr>
<tr>
<td>Total height</td>
<td>35,000 mm</td>
</tr>
<tr>
<td>Inlet flange quantity</td>
<td>1</td>
</tr>
<tr>
<td>Outlet flange quantity</td>
<td>1</td>
</tr>
<tr>
<td>Residence time</td>
<td>2.6 sec</td>
</tr>
<tr>
<td>Material</td>
<td>S235JR</td>
</tr>
<tr>
<td>Wall thickness</td>
<td>6 mm</td>
</tr>
<tr>
<td>Type of reagent</td>
<td>hydrated lime HG</td>
</tr>
</tbody>
</table>

2.1 Instrumentation, Electrical and Control Devices – Redecam supply

N 2 temperature transmitters (at reactor outlet)
N 1 level transmitter (on hopper)
N 2 pressure transmitters (at reactor inlet and outlet)
N 1 set of electrical heat tracing to be applied on 1/3 of the hopper height

2.2 Steelworks – Redecam supply

N 1 casing, realized in painted carbon steel
N 1 hopper, realized in painted carbon steel
N 1 set of inspection doors in painted carbon steel
N 1 set of service platforms for injection points access, realized in hot deep galvanized carbon steel

N 1 supporting structure with a free height underneath the hopper flange, realized in hot deep galvanized carbon steel

2.3 RT extraction System – Redecam supply

Nominal capacity : 300 kg/h
Dust density : 0.30 t/m³

Consisting of:

2.3.1 N. 1 manual cut-off gate - Redecam supply

installed at hopper outlet, for maintenance reason, with the following main characteristics:

size : 300x300 mm

complete of limit switches, gaskets and connection bolts.

2.3.2 N. 1 Chain Conveyor – Redecam supply

Installed under RT hopper, to transport the collected dust to the bag filter collecting conveyor, with the following main characteristics:

design capacity : 300 kg/h
conveyor nominal size : 1.0 m³/h
length : 9 m
slope : 0 °
intermediate bearings : none
discharge position : one end
estimated transport speed : 0.2 m/min
max capacity at 100% filling : 2 m³/h
filling degree in design condition : < 35 %
installed motor power : 0.90 kW
gearred motor by : SEW, NORD or eq
with rotation detector by : Telemecanique / IFM
heat tracing : included
thermal insulation : yes by others
2.3.3 N. 1 Rotary Valve - Redecam supply

Installed at the conveyor outlet flange, motorized, with the following main characteristics:

- design capacity: 300 kg/h
- nominal size: 300 mm
- filling degree in design condition: < 30 %
- installed motor power: 0.90 kW
- geared motor by: SEW, NORD or eq
- with rotation detector by: Telemecanique /IFM

2.4 Thermal Insulation – Redecam supply

For the Reactor, with the following main characteristics:

- material: rockwool
- thickness: 100 mm
- sheet metal material: galvanized CS
- sheet metal thickness: 1.2 mm
- surface: 980 m²
Group 03 N. 1 Reagent Dosing System

Consisting of:

3  
**N.1 Hydrated Lime Injection System**

The injection system has been sized according to the following results in the worst case:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total reagent consumption</td>
<td>820 kg/h</td>
</tr>
<tr>
<td>Reagent max rate (for dosing system design)</td>
<td>1,000 kg/h</td>
</tr>
</tbody>
</table>

3.1  
**N. 1 Hydrated Lime HG Storage Silo**

Redecam is proposing a dust storage system sized for one-week operation at max load reference.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total reagent flow rate with excess</td>
<td>820 kg/h</td>
</tr>
<tr>
<td>Reagent density</td>
<td>0.55 t/m³</td>
</tr>
<tr>
<td>Quantity of silos</td>
<td>1</td>
</tr>
<tr>
<td>Storage volume each silo</td>
<td>250 m³</td>
</tr>
<tr>
<td>Silo body preliminary diameter</td>
<td>4.5 m</td>
</tr>
<tr>
<td>Silo body preliminary height</td>
<td>18 m</td>
</tr>
<tr>
<td>Days of storage</td>
<td>168 hours</td>
</tr>
<tr>
<td></td>
<td>7 days</td>
</tr>
</tbody>
</table>

3.1.1  
**N. 1 set of Silo Special Components – Redecam Supply**

- N 1 safety valve on silo roof
- N 1 self-cleaning silo roof filter
- N 1 manhole

3.1.2  
**N. 1 set of Instruments for Hydrated Lime Silo – Redecam supply**

- N 3 level indicators switches
- N 1 pressure indicator (on filling line)
- N 1 pressure indicator (on silo)
- N 1 fluidification system
- N 1 set of weighting cells

3.1.3  
**N. 1 Silo Steelworks – Redecam supply**

- N 1 silo cone and body in painted carbon steel S235JR
- N 1 supporting structure in painted carbon steel S235JR
- N 1 set of service platforms in galvanized steel S235JR
3.1.4 N. 1 Hydrated Lime Dosing System – Redecam supply
N 1 hydrated lime silo extracting screw conveyor
N 1 buffer hopper
N 1 overpressure vent line with valve and limit switches
N 1 scrapper with electrical motor (0.45kW) and rotation detection
N 1 dosing screw conveyor with electrical motor (0.75kW) and rotation detection
N 1 set load cells on hydrated lime weighing bin
N 2 level indicators on bicarbonate weighing bin
N 3 pressure transmitter on conveying line

3.2 N.1 Reagent Injection System
This system will inject the Hydrated Lime directly on the reactor system.

Consisting of:

3.2.1 N.1 Rotary Feeder – Redecam supply

Inlet/outlet : 250 mm
Conveying capacity : 1,000 kg/h
Material Density : 0.55 t/m³
Motor : 0.95 kW

rotary feeder housing and bearing plates in sturdy steel construction, bearings located outside and are free of maintenance, shaft sleeve sealed with adjustable stuffing box, rotor with pockets and exchangeable sealing strips, drive via directly flanged SEW or NORD gearbox motor.

3.2.2 N.1 Blow Shoe – Redecam Supply
made in steel construction, for conveying line DN 80 with connection flange to rotary feeder.

3.2.3 N.1 Conveying line including pipe and bend – Redecam Supply
Including pipes and bends, made out of steel pipe DN 80 (88.9 x 3.2 mm), in standard length, incl. loose flanges, gaskets, galvanized connection bolts, pipe clamps, round steel bracket, pipe fasteners, pipe suspensions, loose supplied.
3.2.4 **N. 2 Rotary Piston Blowers – Redecam Supply**
One in operation and one in stand-by.

- **motor**
  - power: 11 kW
  - speed: 3,000 min⁻¹

Blower with free shaft extension, base-frame for blower and motor, motor slide rails, anti-vibration pads and mounting material, intake silencer with weather hood, air outlet silencer, safety valve, non-return valve, flanged pipe with rubber sleeve and clips, with v-belt drive and guard.

3.2.5 **N. 2 Sound Protection Covers – Redecam Supply**
For rotary piston blower complete for blower and motor, with detachable side-panel, sound pressure level: <75 dB(A).

3.2.6 **N. 1 Sets of Air-supply Piping – Redecam Supply**
Between conveying air blower, cooler, humidifier and blow shoe, consisting of steel pipe, delivered in standard length, including the required loose elbows, pipe reduction, saddle adapter, washer throttle valves, pipe clips, steel rod bracket, pipe support and pipe suspensions delivered as loose parts.

3.2.7 **N. 2 Butterfly Valves – Redecam Supply**
Hand operated, to be mounted in the air pipe, valve to be placed between flanges, supplied without counter-flanges, casing made out of cast steel, flap-disc in stainless steel, sealing sleeve for a max. temperature of 120 °C, with control box for end position detection with 2 mechanical micro switches (OPEN-CLOSE).

3.3 **Thermal Insulation – Redecam supply**
For the Silo, with the following main characteristics:

- **material**: rockwool
- **thickness**: 100 mm
- **sheet metal material**: galvanized CS
- **sheet metal thickness**: 1.2 mm
- **surface (only cone)**: 90 m²
**Group 04 N. 1 New Bag Filter**

Consisting of:

4 **N.1 Bag Filter type 8 DPZ 14x18/10-X**

The resulting proposed bag filter is with on line pulse jet cleaning system divided in 10 excludable chambers for online maintenance. Here following the main characteristics and process data in the operating conditions:

**Bag filter main mechanical data:**

- **width (internal)** : 11,800 mm
- **length (internal)** : 33,680 mm
- **number of bags** : 4,032
- **bags diameter** : 152 mm
- **bags length** : 10.0 m
- **cloth area** : 19,254 m²
- **casing design pressure @ 250 °C** : -800 daPa
- **compressed air consumption** : 558 Nm³/h
- **compressed air pressure for cleaning** : 3.5 bar

**Design conditions**

- **gas flow rate** : 653,000 Nm³/h
  
  1,192,000 m³/h
- **temperature** : 200 °C
- **inlet pressure** : -350 daPa
- **inlet dust content** : 100 mg/Nm³
- **type of dust** : silica with unreacted lime
- **outlet dust content** : \( \leq 5 \) mg/Nm³
- **air to cloth ratio** : 1.03 m³/m² min
- **can velocity** : 1.16 m/s
- **expected pressure drop** : < 130 daPa

**Normal conditions**

- **gas flow rate** : 600,000 Nm³/h
  
  977,230 m³/h
- **temperature** : 150 °C
- **pressure @ inlet** : -320 daPa
- **inlet dust content** : 100 mg/Nm³
- **type of dust** : silica with unreacted lime
outlet dust content : \( \leq 5 \text{ mg/Nm}^3 \)
air to cloth ratio : 0.85 \( \text{m}^3/\text{m}^2 \text{ min} \)
can velocity : 0.95 m/s
expected pressure drop : < 120 daPa

4.1 Special Components – Redecam supply

N 16 compressed air tank 12" receivers, each one complete of:
  - 14 piston 3” pulse air valve
  - 14 union between air valve and jet tube
N 8 air-proof boxes of die-cast light alloy (IP65 protection), holding the 24 VDC pilot solenoid valves which control the air valves
N 4.032 filtering sets, each composed of:
  - Bags in fiberglass with PTFE membrane, \( \varnothing 152 \times 10000 \text{ mm} \) and nominal 740 g/m²
  - Bag cages realized in painted carbon steel, 20 wires, 2 pieces
N 1 set of air compressed accessories, composed of:
  - pressure regulator
  - air filter regulator
  - service unit
N 10 outlet (plenum) dampers, for online maintenance, on/off mode, pneumatically operated

4.1.1 First Urgency Spare Parts – Redecam supply

N 80 bags, as described above
N 50 cages, as described above
N 2 piston 3” pulse air valve

4.2 Instrumentation, Electrical and Control Devices – Redecam supply

N 1 PLC (Siemens S7-300 or eq.) to control of the bags' cleaning sequence based on deltaP, granting a compressed air consumption reduction, through automatic optimization of the pause time between the consecutives shots
N 8 pressure switches on compressed air pipes
N 2 bags pressure drop transmitters
N 8 hopper level sensors (one each hopper)
N 2 temperature transmitters (at bag filter inlet and outlet)
N 1 pressure transmitter (at bag filter outlet)
N 8 set of electrical heat tracing, to be applied on 1/3 of the hopper height
N 8 hopper vibrators
N 1 tribo sensor (broken bag detector)
N 1 electric service hoist, capacity 1 t, height approx. 30 m
N 2 manual hoists 0.4 t for plenum doors opening
N 8 set of pneumatic actuators and 2 limit switches for the compartment’s outlet dampers

4.3 Steelworks – Redecam supply

N 64 jet tubes feeding the compressed air to the nozzles in carbon steel
N 8 modules of bag filter plenum in carbon steel S235JR, thickness 4 mm, complete of:
   tube sheets set in carbon steel, thickness 5 mm
   pre insulated plenum doors
N 1 casing, realized in carbon steel S235JR, thickness 4 mm
N 8 hoppers, realized in carbon steel S235JR, thickness 4 mm
N 1 penthouse structure made of carbon steel profiles
N 1 penthouse pre painted trapezoidal sheet metal
N 1 set of service platforms for the dust transport system
N 1 set of service platforms for the hopper compartment dampers system
N 1 set of stairs from ground level to the bag filter plenum
N 1 supporting structure with free height underneath the hopper flanges of 2.5 m

4.4 Thermal Insulation – Redecam supply

For the bag filter hoppers, with the following main characteristics:

<table>
<thead>
<tr>
<th>Material</th>
<th>rockwool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>100 mm</td>
</tr>
<tr>
<td>Sheet metal material</td>
<td>galvanized CS</td>
</tr>
<tr>
<td>Sheet metal thickness</td>
<td>1.2 mm</td>
</tr>
<tr>
<td>Surface (hoppers)</td>
<td>750 m²</td>
</tr>
</tbody>
</table>
4.5 Dust Transport System – Redecam supply

Nominal capacity : 3.2 t/h
Dust density : 0.3 ÷ 0.6 t/m³

A complete mechanical transport system will collect the dust from the BF discharge point, and it will convey them into the storage silo. The silo is fitted with the extraction system with telescopic device, for truck discharge.

4.5.1 N. 2 Longitudinal Chain Conveyors – Redecam supply

Installed under the bag filter hoppers, to transport the collected dust to one side of the bag filter, with the following main characteristics:

nominal capacity : 1.6 t/h
maximum capacity : 5 t/h
conveyor size : 340 mm
length : 35 m
slope : 0 °
transport speed : 0.15 m/s
thermal insulation : yes
absorbed power : 1.6 kW
motor gearbox installed power : 2.4 kW
rotation detector by : Telemecanique/IFM
geared motor by : Nord/Sew/Flender/Bonfiglioli

4.5.2 N. 2 Rotary Valves – Redecam supply

motorized, with the following main characteristics:

model : DCM14
size : 350 mm
nominal capacity : 1.6 t/h
maximum capacity : 10 t/h
filling degree : 16 %
electrical heat tracing power : no
thermal insulation : no
motor : 1.1 kW
rotation detector by : Telemecanique/IFM
geared motor by : Nord/Sew Flender/Bonfiglioli

complete of limit switches, gaskets and connection bolts.
4.5.3 **N. 1 Transversal Chain Conveyor – Redecam supply**

Installed at one side of the bag filter to transport the collected dust to the chain elevator, with the following main characteristics:

- **nominal capacity**: 3.2 t/h
- **maximum capacity**: 15 t/h
- **conveyor size**: 390 mm
- **slope**: 0°
- **transport speed**: 0.2 m/s
- **thermal insulation**: yes
- **absorbed power**: 2.7 kW
- **motor gearbox installed power**: 3.6 kW

- rotation detector by: Telemecanique/IFM
- geared motor by: Nord/Sew/Flender/Bonfiglioli

4.5.4 **N. 1 Chain Elevator – Redecam supply**

To transport the dust to the storage silo, with the following main characteristics:

- **nominal capacity**: 3.2 t/h
- **maximum capacity**: 10 t/h
- **conveyor size**: 390 mm
- **slope**: 40°
- **transport speed**: 0.2 m/s
- **thermal insulation**: yes
- **absorbed power**: 3.2 kW
- **motor gearbox installed power**: 4.8 kW

- rotation detector by: Telemecanique/IFM
- geared motor by: Nord/Sew/Flender/Bonfiglioli

4.5.5 **N. 1 Dust storage silo**

Installed in proximity of the bag filter to store the dust collected in the bag filter hoppers, is realized with cylindrical shell and conic hopper; it is complete of supporting structure with sufficient height to allow the positioning of a lorry truck for dust discharging, access ladder, walkways and handrail, with the following main characteristics:

- **diameter**: 3,600 mm
- **shell thickness**: 6 mm
- **capacity**: 120 m³
- **material of shell and hopper**: carbon steel
4.5.5.1 N. 1 Silo Steelworks – Redecam supply
N 1 body and hopper made of painted carbon steel
N 1 supporting structure, made of carbon steel profiles
N 1 set of stairs and platforms, made of carbon steel profiles
N 1 set of cladding enclosure for silo structure

4.5.5.2 N. 1 set of special components for silo – Redecam supply
N 1 vibrating bottom cone
N 4 air shock devices for the end zone of the silo hopper
N 1 manual gate valve at the hopper discharge mouth, with limit switches
N 1 loading spout for truck charging complete with suction point
N 3 rotating level switches
5 Nr.3 Exhaust Fans– Redecam supply

double inlet fans, to be installed on ground on concrete foundation, between bearings, with the following main characteristics:

Technical data – each fan

| Arrangement | 8 |
| Impeller arrangement | between bearings |
| Flowrate max | 430,000 Am³/h |
| Gas Temperature | 150-200 °C |
| Static pressure at inlet | -500 / -600 daPa |
| Static efficiency (preliminary) | 82 % |
| Shaft adsorbed power (max) | 910 kW |
| Speed | 1,180 rpm |
| Drive | electric motor |
| Drive rating | 1,100 kW |
| | 6 poles |
| | 60 Hz |
| Control type | frequency converter |
| mechanical design temperature | 250 °C |

Each fan will be designed in order to have:

- Split casing for rotor extraction in S235 JR
- Complete rotor (impeller wheel, shaft and hub) statically and dynamically balanced
- Machined wheel hub and forged steel shaft, in C35 construction with floating rings sealing
- Elastic coupling motor-fan with protection guard
- Two shaft supports with antifriction roller bearings, grease lubricated
- N°2 cooling wheels with protection guard
- N°2 Pt100 for bearings and N°1 vibration monitoring system
- Inlet and outlet flexible joints (2 at inlet + 1 at outlet)
- 100 mm thickness acoustic insulation
5.1 Nr.2 Exhaust Fan Drives

Consisting of:

5.1.1 Nr.3 Frequency Converters – Redecam supply

designed for continuous operating of one Squirrel-Cage induction motor, with following main characteristics:

| Configuration | 6 pulses |
| Protection | IP21 |
| Type rating | 1,200 kW |
| No overload use | 1,250 A |
| Frequency | 48 – 66 Hz |
| Total harmonic distortion | THDI>30% |
| Voltage | 690 V |

- IOEC-Boards 3 & 4 and PT100 transmitters for motor measurements
- Profinet (DP/FMS)
- Coated Printed Circuit Boards
- Converter space heater
- Redundant cooling pump
- Starter for motor fan
- Chopper and breaking resistor
- Common mode choke
- Factory witness test
- Communication test with Customer PLC connected via Profinet-DP

5.1.2 Nr.3 LV Motors – Redecam supply

Preliminary Data

| type | Squirrel-Cage Induction |
| installed power | 1,100 kW |
| voltage | 480 V |
| poles | 6 |
| cooling | IC411 |
| speed | 1,180 rpm |
| minimum ambient temperature | -20 °C |
| protection | IP55 |
| Insulation class | F/B |
| Standards electric | IEC |
| Start | Soft start via FC |
Accessories:
• one temperature sensor and two PT100 for rolling contact bearings;
• six PT100 on stator windings, 2 wires connection;
• Witnessed Routine test according to vendor standard procedure.

Painting: special color shade and surface treatment C3 - Standard industrial environment.
Group 06 Raw and clean gas ducts, valves and exhaust stack

Consisting of:

6.1 N.2 sets of Raw Gas Ducts – Redecam supply
From : existing hairpin cooler
To : reactor inlet

with the following main characteristics:

- section : square/round
- section : 13-15 m²
- thickness : 6 mm
- material : EN S275JR
- insulation : yes (*)
- insulation thickness : 100 mm
- average gas speed : 22-26 m/s

(*) the duct will be insulated only in the parts where can be touched from the personnel, for safety reason. The ducts are complete of expansion joints and supports, where needed and accesses for instruments sockets as well as for process dampers.

6.2 N.1 Fresh air valve – Redecam supply
located at : Bag filter inlet duct

with the following main characteristics:

- type : butterfly
- quantity : 1
- actuator : on-off pneumatic
- diameter : 2,500 mm
- design ambient air temperature : 40 °C
- material : EN S275JR
- alarm temperature for opening : 240 °C

6.3 N.1 set of Clean Gas Ducts – Redecam engineering, Customer supply
From : filter outlet
To : stack inlet

with the following main characteristics:

- section : square
thickness : 5 mm
material : EN S275JR
insulation : yes (*)
insulation thickness : 100 mm
average gas speed : 18-20 m/s

(*) the duct will be insulated only in the parts where can be touched from the personnel, for safety reason.

The duct is complete of supports, where needed and accesses for instruments sockets.

6.4 N.1 Exhaust Stack – Redecam supply

Realized with concrete basement and internal baffle plates, with the following main characteristics:

diameter : 5,000 mm
thickness : 8/10/12 mm
material : EN S275JR
height : 48 m

The stack is complete of stairs and platforms with accesses for instruments sockets.
7 Electrical and Automation System

The new fume treatment plant will be completed by a modern control system which performs all the basic automation functions required to run the facilities in safety condition while achieving better control.

7.1 PLC Control System

For the process control and command of the new Redecam dedusting system is foreseen the supply of a PLC Siemens S7-1200 board realized in steel panels with IP54 protection degree; the leaf will be blind type with an operator panel MP277 on the front side access leaf (cable entry from the bottom).

The PLC will be realized with a suitable number of input/outputs foreseen for the field connection and for internal diagnosis, besides a 15% spare.

The main function carried out by the PLC are:

- setting of all working parameters of the equipment;
- setting of all alarm thresholds of the equipment;
- input signal collection from the field;
- sending of signals to the HMI station;
- control transfer to the field;
- logic sequences for the operations of the various parts of the dedusting system and the interlocks;
- collection of the alarm signals;
- control and command of the dampers and motors for fans;
- control and command of the dust discharge system

7.2 HMI Arrangement

The apparatus dedicated to the dedusting plant, according to the previous component list, will be installed in an electrical room; the hardware of the HMI client PC will be composed fully according to last commercial standard, including nr.1 LCD monitor and ink-jet printer.

All video pages (English language) of the automation system shall be agreed upon by the Buyer at the basic Engineering stage.

The HMI unit is dedicated to the supervision of the dedusting plants, carried on through mimics displayed on the color monitor, in particular:

- plant general mimic;
- bag filter mimic;
- fan motor mimic;
- process dampers mimic;
- reagent injection system mimic;
- alarms and events jogging;
- trends

7.3 Basic system and application software

The operative systems of the HMI unit will be Microsoft Windows 10 professional or later version.
The application software of the HMI unit will be WinCC supplied in open type Runtime.
The application software of the PLC will be developed with Siemens supplied in open type.
The basic software with the relevant developing licenses will be given to the Buyer at system commissioning.

7.4 LV Motor Control Center

The LV Motor Control Center is composed of low-voltage cubicles, modular design (no drawers, form B2) for the power supply, protection and control of three-phases asynchronous motors, resistances, and, in general, all other users usually used in the dedusting plant.

Each panel is made mounting bending pressed steel sheets with modular holes which allow the composition of different type of cubicles.

The protection degree is IP54 and the cable entrance is from the bottom. There is one incoming line at 480 V.
8 Other Services

Consisting of:

8.1 Compressed air – Redecam supply

Required compressed air quality classes (ref. to ISO 8573-1:2010: Compressed air - Part 1: Contaminants and purity classes) for filter bag cleaning, instruments and control devices, are the following:

<table>
<thead>
<tr>
<th>Filter CLASS</th>
<th>Particle content</th>
<th>Water content</th>
<th>Oil content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

min. overdesign capacity
based on max. consumption : +20% Nm³/h
pressure at our mains : 5,5 bar

For the definition of the classes, please refer to the table here below:

<table>
<thead>
<tr>
<th>Class</th>
<th>Solid Particles</th>
<th>Water</th>
<th>Oil (Aerosol, liquid and vapor)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum number of particles per m³ (d = particle size in μm)</td>
<td>Pressure dew point in °C</td>
<td>mg/m³</td>
</tr>
<tr>
<td></td>
<td>0.1&lt;d≤0.5</td>
<td>0.5&lt;d≤1.0</td>
<td>1.0&lt;d≤5.0</td>
</tr>
<tr>
<td>0</td>
<td>≤20,000</td>
<td>≤400</td>
<td>≤10</td>
</tr>
<tr>
<td>1</td>
<td>≤400,000</td>
<td>≤6,000</td>
<td>≤100</td>
</tr>
<tr>
<td>2</td>
<td>≤90,000</td>
<td>≤1,000</td>
<td>≤1,000</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>≤10,000</td>
<td>≤ +3</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>-</td>
<td>≤100,000</td>
</tr>
</tbody>
</table>

In order to reduce the number of start and stop for the compressor it is advisable to install a separate air receiver between the compressor and the fabric filter.
8.2 Packing – Redecam supply

Redecam standard packing is included in the scope of supply. All the equipment will be delivered suited for container transport, packed according our standard as follows:

- Compressed Air manifold with pneumatic valves in boxes
- Blowing pipes grouped in bundles
- Bag Cages in crates
- Bags in boxes
- Control Cleaning panel in wooden cages
- Instrumentation in boxes
  - Filter Plenum in preassembled modules suited for transport
  - Other steelwork: in panels with max length suited for transport

LEGEND: To be locally stored (by others), up to its installation, as follow:
- Indoor
  - Covered, in ventilated area

8.3 Transportation to site – Customer supply

DAP Beverly plant according to INCOTERMS 2010.

8.4 Equipment storage

Customer will organize a proper storage place for the equipment that must be kept indoor (instrumentation, filter bags, etc.) and a proper area where to storage steel structures and bag cages.

In case the Customer will delay the delivery of the equipment for any reason beyond the control of Redecam, and in case the goods are still in the workshops, a free of charge period of 1 month is granted as storage in the workshops. Beyond that period, we reserve the right to invoice on the date stipulated in the original contract and the equipment will be stored and handled by a third part or supplier at the expense and risks of the Customer, without our liability for any reason whatsoever, on the base of a monthly fee to be agreed.
8.5 Meetings, Assistance and Supervision

A multiple mission of our technicians during the project execution and the site activities is included in our scope of works as described hereafter. If, for any reason beyond Redecam responsibility, the supervision, the startup or the commissioning as well as the training period should be prolonged, the daily rate will be applied, as defined at chapter 1.3.

8.5.1 Project meetings - Redecam supply

Two missions of three of our technicians for measurements and kick-off meetings are included in Redecam scope of supply for a duration of 2 (+2 for travelling) days each.

Two missions for additional meetings of three of our technicians are included in Redecam scope of supply for a duration of 1 (+2 for travelling) days.

8.5.2 Supervision during erection - Excluded

Excluded, we remain at Customer disposal for defining any mission package.

8.5.3 Start up and commissioning supervision - Redecam supply

One mission for Start-up and Commissioning of two of our technicians (full project process and PLC), are included for a duration of 12 (+2 for travelling) days.

A grace / extra period of 4 days of our technician is also granted, if needed for the correct operation of the new system, free of charge.

One mission for Start-up and Commissioning of two of our technicians (fan and motor, catalyst), are included for a duration of 5 (+2 for travelling) days.

8.5.4 Training - Redecam supply

One mission for Training of the Plant engineers of two of our technicians is included for a duration of 3 (+2 for travelling) days. It can also be held during the cold-test and/or commissioning phases.

A grace / extra period of 2 days of our technician is also granted, if needed for the correct operation of the new system, free of charge.
D. BATTERY LIMITS

At the present stage, the battery limits of engineering of Redecam scope of works are the following:

D.1 Equipment:

Mechanical
- *Flue gas*: from BF inlet flange up to Stack outlet flange.
- *Dust*: at first PJBF outlet hoppers flanges
- *Dust*: from second PJBF Bag filter hoppers outlet flanges up to Bag filter dust silo storage system
- *Reagent*: from truck loading flange at silo up to injection point.

Electrical
- *LV MCC inlet terminals*
- *Instrumentation: instrument connection.*

D.2 Cleaning control panel and electrical users:

At their terminal blocks.

D.3 Compressed Air:

From the compressed air station.
E. MATERIALS, PAINTING AND INSULATION

E.1 Definition

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Material</th>
<th>Thick.</th>
<th>Painting Internal</th>
<th>Painting External</th>
<th>Thermal insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bag Filter Plenum</td>
<td>S235JR</td>
<td>4</td>
<td>A</td>
<td>C</td>
<td>By client</td>
</tr>
<tr>
<td>Tube Sheets</td>
<td>S235JR</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td>N.A.</td>
</tr>
<tr>
<td>Bag Filter Casing</td>
<td>S235JR</td>
<td>4</td>
<td>A</td>
<td>C</td>
<td>By client</td>
</tr>
<tr>
<td>Bag filter Hoppers</td>
<td>S235JR</td>
<td>4</td>
<td>A</td>
<td>C</td>
<td>By client</td>
</tr>
<tr>
<td>Reactor Casing and hopper</td>
<td>S235JR</td>
<td>8</td>
<td>A</td>
<td>C</td>
<td>By client</td>
</tr>
<tr>
<td>Ductworks</td>
<td>S235JR</td>
<td>5/6</td>
<td>A</td>
<td>C</td>
<td>By Client</td>
</tr>
<tr>
<td>Stairs, Ladders and Walkways</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N.A. G or E</td>
</tr>
<tr>
<td>Handrails</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N.A. G or E</td>
</tr>
<tr>
<td>Supporting and Penthouse Structures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N.A. G or E</td>
</tr>
<tr>
<td>Third Parts Equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Standard of manufacturer</td>
</tr>
</tbody>
</table>

E.2 Painting cycles

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Surface preparation</th>
<th>Primer</th>
<th>Intermediate</th>
<th>Final</th>
<th>RAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Brushing</td>
<td>zinc phosphate thk 60 μm</td>
<td>none</td>
<td>none</td>
<td>t.b.d.</td>
</tr>
<tr>
<td>B</td>
<td>Sandblasting SA 2 1/2</td>
<td>zinc phosphate thk 60 μm</td>
<td>none</td>
<td>none</td>
<td>t.b.d.</td>
</tr>
<tr>
<td>C</td>
<td>Sandblasting SA 2 1/2</td>
<td>inorganic zinc th. 75 μm</td>
<td>none</td>
<td>none</td>
<td>t.b.d.</td>
</tr>
<tr>
<td>D</td>
<td>Sandblasting SA 2 1/2</td>
<td>inorganic zinc th. 75 μm</td>
<td>none</td>
<td>alkyd enamel th. 40 μm</td>
<td>t.b.d.</td>
</tr>
<tr>
<td>E</td>
<td>Sandblasting SA 2 1/2</td>
<td>epoxy zinc phosphate th. 40 μm</td>
<td>none</td>
<td>epoxy resin th. 40 μm</td>
<td>t.b.d.</td>
</tr>
<tr>
<td>F</td>
<td>Sandblasting SA 2 1/2</td>
<td>inorganic zinc th. 75 μm</td>
<td>none</td>
<td>silicon paint th. 30 μm</td>
<td>t.b.d.</td>
</tr>
<tr>
<td>G</td>
<td>Galvanized</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>Sandblasting SA 2 1/2</td>
<td>inorganic zinc th. 75 μm</td>
<td>epoxy paint th. 40 μm</td>
<td>epoxy resin th. 40 μm</td>
<td>t.b.d.</td>
</tr>
</tbody>
</table>
F. PRELIMINARY PROJECT PLAN

The project plan is based on the assumption that all necessary information are available before starting the engineering phase. The Customer approvals, if any and if not differently agreed, is estimated to occur within one week from the document issuing date. The project plan does not include, nor are we responsible for, possible delays during customs clearance or during plant acceptance nor unloading.

F.1 Engineering

The following has been considered (to be mutually agreed):

- General arrangement drawings (preliminary): 4 weeks after contract / LOI
- Drawings with loads: 4 weeks after G.A. approval
- P&ID (preliminary): 4 weeks after contract / LOI
- Flowsheet (preliminary): 4 weeks after contract / LOI
- Electrical consumer list (preliminary): 8 weeks after contract / LOI
- Process description (preliminary): 10 weeks after G.A. approval
- Electrical description (preliminary): 12 weeks after G.A. approval
- Logic diagram (preliminary): 2 w. after approval of above doc
- Detailed engineering for fabrication: 16-20 weeks after G.A. approval

F.2 Equipment Supply

Delivery of the supplied Equipment: to be agreed

F.3 Site activity

A preliminary project time schedule will be commonly discussed before project start.
G. GUARANTEES

G.1 Pre-conditions
Any mechanical, functional or bag guarantee as laid out in the following paragraph will be valid only if below preconditions will be respected:
- The equipment supplied by Redecam shall be operated and maintained according to the Redecam guidelines included in the Operating and Maintenance Manual.
- All the spare parts used shall be in conformity with Redecam guidelines and recommended spare part list included in the Operating and Maintenance Manual.
- If the supplied equipment is operated by the Customer without Redecam supervision before the performance test, Redecam reserve the right to check and test the equipment. Upon Redecam request the Customer shall restore the equipment to proper operating condition before the test.
- All the existing or new equipment connected to the Redecam supplied equipment are working according to the nominal operating condition.
- Redecam supplied equipment are working according to the nominal operating condition as per enclosed datasheet (i.e. gas flow, quantity of dust, cooling water quality, etc.) and record of the following measurements (where applicable) will be made available to Redecam on a periodical basis:
  - Gas volume rate at the fans, or fans speed and dampers position.
  - Bag filter inlet and outlet temperature
  - Compressed Air quality

G.2 Mechanical Guarantees
All the supplied equipment and components are new, of good quality and well-constructed, free of any defect resulting from faulty design, imperfect material or defective workmanship.
If, within 24 months after the first plant start-up (or cold test) or within 36 months from the material delivery (whichever comes first), the equipment or any part thereof is or becomes defective for reason due to events preceding the pass of risk to the customer (i.e. defect resulting from faulty design, imperfect material or defective workmanship) or any other reason attributable to Redecam, Redecam at his own choice, upon request of customer, will replace or repair within a reasonable time from the customer notification. The customer should written notify any damages or defective malfunction within max. two weeks from its appearance.
Redecam guarantee doesn’t cover wear or tear part, like gasket, packing, joints, bearings, mineral wool, fuses, lights, screen etc. or damages due to improper use or negligence in following operating and maintenance instruction.
G.3 Functional Guarantees

G.3.1 LIMITS

The following process guarantees are given:

<table>
<thead>
<tr>
<th>Pos.</th>
<th>Parameters</th>
<th>Units</th>
<th>Guaranteed values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Dust</td>
<td>mg/Nm³, dry, 6%O₂</td>
<td>≤ 5</td>
</tr>
<tr>
<td>2.0</td>
<td>SO₂</td>
<td>mg/Nm³, dry, 6%O₂</td>
<td>≤ 280</td>
</tr>
</tbody>
</table>

The measurement procedure of dust emission shall be as defined by European VDI 2066 standards.

This standard fulfills the normative requirements of DIN EN 13284-1, and specifies a manual gravimetric reference measurement method for the determination of the dust load (dust content) and the dust mass flow of a dust/gas mixture flowing through defined cross-sections like stacks, pipelines or ducts. It allows the determination dust emissions in case of for instance check of compliance with limit or guarantee values, calibration of automated dust emission measuring systems, performance measurements at dust precipitators, and during check or optimization of process parameters.

The performance test shall be carried out by the Customer at the presence of Redecam advisory personnel.

The test period for clean gas dust content measurement will be one shift, 8 hours.

G.4 Bags life Guarantees

The following bag’s life guarantees are given:

<table>
<thead>
<tr>
<th>Pos.</th>
<th>Description</th>
<th>Units</th>
<th>Guaranteed values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Fiberglass with PTFE membrane</td>
<td>Years</td>
<td>2 full</td>
</tr>
</tbody>
</table>

Damages to the filtering bags or failure to meet the specified guarantees due to issues out of Redecam control are specifically excluded from this guarantee:

- Abrasion caused by gas/dust flows higher than what specified in the design conditions
- Fire or high temperature due to non-correct maneuvers performed by site personnel
- Moisture or oil which might be contained in the compressed air cleaning systems (due to improper use or negligence during the operation or maintenance)
- Bag blinding caused by unburnt hydrocarbons, CaCl$_2$ or ZnCl$_2$
- Faulty operations of any equipment connected to the filter not supplied by us.
- Gas temperature peaks for max 5 minutes and max 1 time per month
- Gas operating temperature always above the (acid) dew point plus 25°C
- Transient conditions according to the given procedure (e.g. pre-coating, warm-up curves, etc.)

Redecam is responsible for the supply of the eventual new bags, the Customer is responsible for the substitution activities.

The Customer will be responsible to keep documentation of any occurrences where the filter’s inlet temperature should exceed the maximum allowable temperature and shall keep Redecam informed in writing. Should the bags fail to perform as specified, the Customer shall notify Redecam immediately.

The Customer must give Redecam written indication of the reasons of any/all bags which might be removed during the guarantee period; positions of the bags (i.e. row, positioning in the row, and chambers’ numbering, if any) and any relevant data shall be indicated in the said written communication.

The failure in terms of bags’ lifetime is intended to be whenever any bags might result affected with wear holes, rips or tears due to strength losses, prior the minimum guaranteed bags lifetime is achieved.
H. EXCLUSIONS

The following items and services are not included in our basic Scope of Supply:

- Project for submission to the authorities
- Instrumentation in general except the one mentioned
- HV/MV transformer
- MCC, transformers and power supply
- Plant DCS, control panels
- Inertization systems
- Grounding system
- Lightning rods
- Lighting
- Spare parts (except the ones mentioned)
- Foundations, civil and building works
- Customs, duties, VAT and Local Taxes
- Anything not mentioned in the present offer
I. GENERAL CONDITIONS

I.1 Engineering
All project drawings supplied by Redecam will be done in the English language. All training manuals, preventive maintenance schedules and sub-supplier literature will be done in English language. Services and engineering provided by Redecam will be, where applicable, in accordance to the following definitions:

I.1.1 Basic Data (BD)
Main process data and related equipment, comprising:
- Estimated Load Data.
- Preliminary Arrangement Drawings.
- Characteristics of main equipment.
- Main dimensions of main equipment.
- Specification of tubes, fittings and fixations with tube installation schematics.
- All drawings will be supplied in dwg format.

I.1.2 Basic Engineering (BE)
To enable qualified engineers to work out the detail engineering, comprising:
- Preliminary General Lay-out (for customer approval).
- Final General Lay-out.
- Preliminary and Final Load data
- Equipment List with main data.
- Preliminary P&I Diagram.
- Preliminary Motor and consumer List.
- Preliminary Instrument List.
- Preliminary I/O PLC signals.
- Logical diagrams for process control.

I.1.3 Detailed Engineering (DE)
Specific drawings and documents, comprising:
- Final P&I diagrams.
- Equipment List.
- Final Motor and consumer List.
- Final Instrument List.
- Final I/O PLC signals.
- Detailed Drawings for fabrication complete of material list.
- General assembly equipment drawings.
- Erection procedures.
- Operating and Maintenance Manual (French language).
I.2 Supervision during erection

Unless stated otherwise in Chapter C, supervision during erection is not included in our scope of supply.

The cost for Redecam supervisor during erection is €950 per any day of absence from the office, based on 8h/days / 6 days by week.

Extra hours from 8 to 10 hours will be invoiced at 150 € / hour.
Extra hours during week-ends and bank holidays will be invoiced at 170 € / hour.

Travel, accommodations and allowance expenses will be invoiced at cost. Living fees for the duration of the mission such as hotel, restaurant, car rental... are at Customer charge, the fees will be directly paid by the Customer or back charged.

I.3 Supervision during start up, training and commissioning

Unless stated otherwise in Chapter C, supervision during commissioning and start up is not included in our scope of supply.

The cost for Redecam supervisor during start up and commissioning is €950 per any day of absence from the office, based on 8h/days / 6 days by week.

Extra hours from 8 to 10 hours will be invoiced at 150 € / hour.
Extra hours during week-ends and bank holidays will be invoiced at 170 € / hour.

Travel, accommodations and allowance expenses will be invoiced at cost. Living fees for the duration of the mission such as hotel, restaurant, car rental... are at Customer charge, the fees will be directly paid by the Customer or back charged.

I.4 Liability

Our liability is limited to the Scope of Supply. As a consequence Redecam cannot provide compensation for any special, indirect or consequential damages or losses such as, but not limited to, loss of profit, loss of revenue, loss of production, loss of contracts, loss of use, loss of data, loss of image, costs of capital and other indirect losses that remain excluded from the liability of the Parties.

It is also understood that time is one of the important aspect of the contract, but it cannot be considered as being of the essence or the main aspect of the contract.

I.5 Jurisdiction and applicable law

This contract is subject to the Italian law. The contracting parties are obliged in the case of disputes over interpretation and fulfillment of the contract to strive for an amicable settlement first.

If such an agreement doesn't take place, all disputes arising will have to be decided by a responsible proper court. Place of jurisdiction is Milan (Italy).
I.6 **Property transfer**

The ownership of the equipment will remain at Redecam until the full payment of the contract price, including any additional agreement.

I.7 **General**

Redecam’s quotation is exclusively based on the Technical Specification and commercial conditions stated in this document and its Annexes. All condition not provided herein are ruled by Orgalime S2000. Unless stated otherwise, all taxes and other duties that should arise outside Italy, should be paid by the Customer. Unless stated otherwise, the prices are firm and not subject to escalation for the duration of the contract, if the order is placed within the validity of offer as specified in the Commercial Conditions. The prices included in the present offer are only valid if the offer is accepted as a whole. In case only part of the offered equipment and/or services should be ordered, we reserve the right to adjust such prices.
J. SPARE PARTS & AFTER SALES SERVICES

J.1 Spare parts
The internal Spare Parts Department will be at your disposal for any needs in terms of spare parts quotations or supplies; quotations for both emergency and two years spare parts will be issued within 6 months from the contract signature.

NOTE: we are including in our basic scope of supply a set of first urgency spare parts as described in the Chapter C.

J.2 After sales services
Redecam After Sales Service will be at your disposal in order to ensure the correct operation and maintenance of the plants. Highly qualified engineers will be available to operate both in Italy and abroad. Should you require assistance for any troubles on site, Redecam will generally ensure very fast responses times.
The following list of preliminary annexes forms an integral part of this quotation:

1. Bag Filter data sheet
2. Preliminary Division of Scope of Work
3. Process Flow Diagram (preliminary)
4. Layout drawings
FLUE GAS TREATMENT LINE
EAF5

BEVERLY, OH
USA

BUDGET QUOTE
P18120477 – Rev. 2 Commercial
March 7th, 2019
## A. COMMERCIAL CONDITIONS

### A.1 Weights and Price sheet

<table>
<thead>
<tr>
<th>Description</th>
<th>Weight [Kg]</th>
<th>Price [USD]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering of the New Flue Gas Treatment</td>
<td>-</td>
<td>$234,440.00</td>
</tr>
<tr>
<td>Supply of no. 1 new Pulse Jet Filter for silica collection</td>
<td>23.360</td>
<td>$954,960.00</td>
</tr>
<tr>
<td>Supply of no. 1 new Pulse Jet Filter downstream the RT, for dust collection</td>
<td>24.360</td>
<td>$956,350.00</td>
</tr>
<tr>
<td>Supply of the #3 new ID fans with LV motors and LV frequency converters</td>
<td>-</td>
<td>$1,120,390.00</td>
</tr>
<tr>
<td>Supply of the new HG lime Reactor</td>
<td>3.600</td>
<td>$344,320.00</td>
</tr>
<tr>
<td>Supply of the HG Lime injection system</td>
<td>10.800</td>
<td>$605,960.00</td>
</tr>
<tr>
<td>Supply of the new ductworks</td>
<td>-</td>
<td>$361,840.00</td>
</tr>
<tr>
<td>Supply of the new stack</td>
<td>-</td>
<td>$374,140.00</td>
</tr>
<tr>
<td>Mechanical Erection</td>
<td>150</td>
<td>$4,835,430.00</td>
</tr>
<tr>
<td>Advisory service for commissioning</td>
<td>-</td>
<td>$68,720.00</td>
</tr>
<tr>
<td>Description</td>
<td>Quantity</td>
<td>Unit</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>----------</td>
<td>------</td>
</tr>
<tr>
<td>Compressed air production and treatment station</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LV MCC and PLC system for the supplied equipment, cables and trays, wiring and installation into a new electrical room</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Execution of the thermal insulation (m²)</td>
<td></td>
<td>3.040</td>
</tr>
<tr>
<td>Packing and transport DDP of the supplied equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total weight</strong></td>
<td>62,270</td>
<td></td>
</tr>
<tr>
<td><strong>Total Net Budget Price</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A.2 Consolidated Commercial Conditions:

Total Budget Price: $12,345,590

Total weight components and steelworks: 783 Tons Redecam supply

Schedule: T.B.D.

Delivery: DDP Beverly, OH

Payment: T.B.D.

Offer validity: 60 days

Best Regards,

Eng. Niccolo’ Griffini
Redecam Group SpA
Iron & Steel Specialist
Director, Business Development

Eng. Salvatore Gallo
Redecam USA, LLC.
VP & Sales Director
0. INDEX

A. FOREWORD.............................................................................................................3
B. MAIN DESIGN DATA.................................................................................................6
C. DETAILED SCOPE OF SUPPLY ..............................................................................7
D. BATTERY LIMITS .....................................................................................................36
E. MATERIALS, PAINTING AND INSULATION .........................................................37
F. PRELIMINARY PROJECT PLAN ...........................................................................38
G. GUARANTEES..........................................................................................................39
H. EXCLUSIONS..........................................................................................................42
I. GENERAL CONDITIONS.........................................................................................43
J. SPARE PARTS & AFTER SALES SERVICES .......................................................46
K. ANNEXES ............................................................................................................47
A. FOREWORD

The current proposal is based on the design data that we have received by your tender email and following clarifications by email.

For meeting your needs in terms of dedusting and pollutants reduction, Redecam is proposing a flue gas treatment plant, equipped with dry injection of hydrated lime High Grade for SOx removal and bag filter for dust emission reduction.

We have considered the following split equipment supply:

Dry Reactor, mainly including
- Reactor Tower (RT)
- RT dust extraction system

Reagent Storage and Injection System, mainly including
- Hydrated Lime HG storage silo
- Hydrated Lime HG extraction and injection system

Bag Filters (one upstream and one downstream the RT), mainly including
- Bag Filter (BF) equipped with internals and key components
- Bags cleaning control panel (PLC) and bag filter instrumentation as described
- Bag filter supporting structure and service platforms
- Bag Filter Penthouse
- Bag Filter mechanical dust transport system for silica and for dust

Silica Storage System
- bucket elevator
- storage system

Dust Storage System
- bucket elevator
- storage system
- truck loading

Booster Fan System
- Booster fan
- Booster fan motor
- Booster fan frequency converter

Exhaust Fan System
- ID fan
- ID fan motor
- ID fan frequency converter

Set of Ductworks and Dampers, mainly including:
- Process gas ductworks
- Fresh air emergency valve
- By-pass system
- New Stack

NOTES on selected DeSOx solution:

The efficiency of the powdered hydrated lime for SO2 removal is depending on several factors, among which the most important are fineness of the lime, gas temperature where the injection takes place in relation with gas moisture, contact time between lime and SO2, presence of inert dust, SO2 concentration baseline.

Generally speaking, a good efficiency is favorized by high fineness, low inert dust, long contact time, high SO2 baseline.

With reference to temperature, the leading parameter is the distance between the actual gas temperature and the dewpoint temperature. The shorter it is, the higher is the efficiency.

The hydrated lime we are proposing to use is specifically produced for DeSOx purpose and has a BET surface around 35-40 m2/g, thus responding to the first requirement.

Dust coming from the process is separated in the baghouse upstream the lime injection, thus solving the second requirement.

Contact time is increased by installing a dry reactor able to guarantee at least 4 seconds, so responding to the third requirement.

With reference to SO2 baseline and temperature, both of them are probably changing along with the process phase. In order to have a good process efficiency, the lowest is the temperature of the gas flow coming to the FGT treatment, the better it is in terms of hydrated lime consumption.

In principle we deem it's possible to achieve 80% SO2 reduction with a temperature <200°C, with a sorbent consumption slightly decreasing the more we go below 200°C, but a measurement campaign targeted to verify the SO2 and temperature trends would be advisable.
In this way, we could verify is it’s worth to add further equipment for temperature control, like a gas conditioning tower or a water foggy system in order to be safer in terms of the max efficiency achievable and to minimize the sorbent consumption.

Since the emission is probably periodically changing, the hydrated lime injection too will be intermittent. Injection regulation can be done in several ways, following the emission at the stack through a simple PID or introducing an injection program based on the process phases.

Reagent (Hydrated Lime with High Grade) consumption in the worst (maximum load) operating case is estimated in the range of 500 kg/h (few excesses from stoichiometric consumption, according to reagent producer) and 750 kg/h (considering the possible reagent pollutants and the ‘real’ operating conditions).

The proposed FGT here described is based on same operating condition that may be too “conservative”: we expect that SOx are not generated continuously ion all process phases, so we suggest a first technical review with process specialist of both sides (Globe and Redecam) to better discuss how to optimize the solution.
### B. MAIN DESIGN DATA

#### B.1 General plant information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>location</strong></td>
<td>Beverly, OH</td>
</tr>
<tr>
<td><strong>country</strong></td>
<td>USA</td>
</tr>
<tr>
<td><strong>altitude above sea</strong></td>
<td>8 m</td>
</tr>
<tr>
<td><strong>ambient temperature (min/max)</strong></td>
<td>-20/38 °C</td>
</tr>
<tr>
<td><strong>humidity (min/avg/max)</strong></td>
<td>10/74/100 %</td>
</tr>
<tr>
<td><strong>rainfall (max)</strong></td>
<td>852 mm/h</td>
</tr>
<tr>
<td><strong>wind speed (max)</strong></td>
<td>125 km/h (*)</td>
</tr>
<tr>
<td><strong>snow load</strong></td>
<td>250 kN/m² (*)</td>
</tr>
<tr>
<td><strong>earthquake factor</strong></td>
<td>- (*)</td>
</tr>
<tr>
<td><strong>low voltage</strong></td>
<td>13.8 kV</td>
</tr>
<tr>
<td><strong>medium voltage</strong></td>
<td>480 V</td>
</tr>
<tr>
<td><strong>frequency</strong></td>
<td>60 Hz</td>
</tr>
<tr>
<td><strong>auxiliary tension</strong></td>
<td>230 V</td>
</tr>
<tr>
<td><strong>control voltage</strong></td>
<td>24 VDC</td>
</tr>
<tr>
<td><strong>protection</strong></td>
<td>IP 55</td>
</tr>
<tr>
<td><strong>insulating class</strong></td>
<td>F to B</td>
</tr>
</tbody>
</table>

(*) *Customer to confirm, it might have impact on weights and costs.*

#### B.2 Operating conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum load</strong></td>
<td></td>
</tr>
<tr>
<td><strong>gas flow rate</strong></td>
<td>200,000 Nm³/h wet</td>
</tr>
<tr>
<td></td>
<td>358,000 Am³/h wet</td>
</tr>
<tr>
<td><strong>temperature</strong></td>
<td>200 °C</td>
</tr>
<tr>
<td><strong>pressure @ inlet</strong></td>
<td>-150 daPa</td>
</tr>
<tr>
<td><strong>type of dust</strong></td>
<td>silica dust</td>
</tr>
<tr>
<td><strong>gas composition (wet)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>CO₂</strong></td>
<td>1.20 %</td>
</tr>
<tr>
<td><strong>SO₂</strong></td>
<td>0.004 %</td>
</tr>
<tr>
<td><strong>N₂</strong></td>
<td>75.90 %</td>
</tr>
<tr>
<td><strong>H₂O</strong></td>
<td>3.60 %</td>
</tr>
<tr>
<td><strong>O₂</strong></td>
<td>19.30 %</td>
</tr>
</tbody>
</table>
C. DETAILED SCOPE OF SUPPLY

Group 01 N. 1 New Pulse Jet Filter after existing cooler

Consisting of:

1  N.1 Bag Filter type 6 DPZ 18x16/8-W

The resulting proposed bag filter is with on line pulse jet cleaning system divided in 6 excludable chambers for online maintenance. Here following the main characteristics and process data in the operating conditions:

Bag filter main mechanical data:
width (internal) : 10,200 mm
length (internal) : 12,360 mm
number of bags : 1,728
bags diameter : 152 mm
bags length : 8.0 m
cloth area : 6,601 m²
casing design pressure @ 250 °C : -600 daPa
compressed air consumption max : 160 Nm³/h
compressed air pressure for cleaning : 3.5 bar

Design conditions
gas flow rate : 200,000 Nm³/h
358,000 Am³/h
temperature : 200 °C
inlet pressure : -150 daPa
inlet dust content : 100 mg/Nm³
type of dust : silica

outlet dust content : ≤ 5 mg/Nm³
air to cloth ratio : 0.90 m³/m² min
can velocity : 1.04 m/s
expected pressure drop : < 120 daPa

1.1 Special Components – Redecam supply
N 6 compressed air tank 12" receivers, each one complete of:
N 16 full immersion 2" pulse air valve
N 16 union between air valve and jet tube
12 air-proof boxes of die-cast light alloy (IP65 protection), holding the 24 VDC pilot solenoid valves which control the air valves

1,728 filtering sets, each composed of:
- Bags in fiberglass with PTFE membrane, ø 152 x 8,000 mm and nominal 740 g/m²
- Bag cages realized in painted carbon steel, 20 wires, 2 pieces

1 set of air compressed accessories, composed of:
- pressure regulator
- air filter regulator
- service unit

6 outlet (plenum) dampers, for online maintenance, on/off mode, pneumatically operated

1.1.1 First Urgency Spare Parts – Redecam supply

80 bags, as described above
50 cages, as described above
2 full immersion 2” pulse air valve

1.2 Instrumentation, Electrical and Control Devices – Redecam supply

1 PLC (Siemens S7-300 or eq.) to control of the bags’ cleaning sequence based on deltaP, granting a compressed air consumption reduction, through automatic optimization of the pause time between the consecutive shots

6 pressure switches on compressed air pipes
2 bags pressure drop transmitters
6 hopper level sensors (one each hopper)
2 temperature transmitters (at bag filter inlet and outlet)
1 pressure transmitter (at bag filter outlet)
6 set of electrical heat tracing, to be applied on 1/3 of the hopper height
6 hopper vibrators
1 tribo sensor (broken bag detector)
1 electric service hoist, capacity 1 t, height approx. 30 m
2 manual hoists 0.4 t for plenum doors opening
6 set of pneumatic actuators and 2 limit switches for the compartment’s outlet dampers

1.3 Steelworks – Redecam supply

108 jet tubes feeding the compressed air to the nozzles in carbon steel
6 modules of bag filter plenum in carbon steel S235JR, thickness 4 mm, complete of:
- tube sheets set in carbon steel, thickness 5 mm
- pre-insulated plenum doors
1 casing, realized in carbon steel S235JR, thickness 4 mm
N 6 hoppers, realized in carbon steel S235JR, thickness 4 mm
N 1 penthouse structure made of carbon steel profiles
N 1 penthouse pre-painted trapezoidal sheet metal
N 1 set of service platforms for the silica transport system
N 1 set of service platforms for the hopper compartment dampers system
N 1 set of stairs from ground level to the bag filter plenum
N 1 supporting structure with free height underneath the hopper flanges of 2.5 m

1.4 Thermal Insulation – Redecam supply

For the bag filter hoppers, with the following main characteristics:

<table>
<thead>
<tr>
<th>Material</th>
<th>Rockwool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>100 mm</td>
</tr>
<tr>
<td>Sheet metal material</td>
<td>Galvanized CS</td>
</tr>
<tr>
<td>Sheet metal thickness</td>
<td>1.2 mm</td>
</tr>
<tr>
<td>Surface (hoppers)</td>
<td>310 m²</td>
</tr>
</tbody>
</table>

1.5 Silica Transport System – Redecam supply

Nominal capacity : 3,2 t/h
Dust density : 0.3 ÷ 0.6 t/m³

A complete mechanical transport system will collect the silica dust dust from the BFs discharge point, and it will convey them into the storage silo.

1.5.1 N. 2 Longitudinal Chain Conveyors – Redecam supply

Installed under the bag filter hoppers, to transport the collected silica to one side of the bag filter, with the following main characteristics:

<table>
<thead>
<tr>
<th>Nominal capacity</th>
<th>1,6 t/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum capacity</td>
<td>5 t/h</td>
</tr>
<tr>
<td>Conveyor size</td>
<td>340 mm</td>
</tr>
<tr>
<td>Length</td>
<td>15 m</td>
</tr>
<tr>
<td>Slope</td>
<td>0 °</td>
</tr>
<tr>
<td>Transport speed</td>
<td>0,15 m/s</td>
</tr>
<tr>
<td>Thermal insulation</td>
<td>Yes</td>
</tr>
<tr>
<td>Absorbed power</td>
<td>1,6 kW</td>
</tr>
<tr>
<td>Motor gearbox installed power</td>
<td>2,4 kW</td>
</tr>
<tr>
<td>Rotation detector by</td>
<td>Telemecanique/IFM</td>
</tr>
<tr>
<td>Geared motor by</td>
<td>Nord/Sew/Flender/Bonfiglioli</td>
</tr>
</tbody>
</table>
1.5.2 **N. 2 Rotary Valves – Redecam supply**

Motorized, with the following main characteristics:

- **Model**: DCM14
- **Size**: 350 mm
- **Nominal capacity**: 1.6 t/h
- **Maximum capacity**: 10 t/h
- **Filling degree**: 16%
- **Electrical heat tracing power**: No
- **Thermal insulation**: No
- **Motor**: 1.1 kW
- **Rotation detector by**: Telemecanique/IFM
- **Geared motor by**: Nord/Sew Flender/Bonfiglioli

Complete of limit switches, gaskets and connection bolts.

1.5.3 **N. 1 Transversal Chain Conveyor – Redecam supply**

Installed at one side of the bag filter to transport the collected dust to the chain elevator, with the following main characteristics:

- **Nominal capacity**: 3.2 t/h
- **Maximum capacity**: 15 t/h
- **Conveyor size**: 390 mm
- **Slope**: 0°
- **Transport speed**: 0.2 m/s
- **Thermal insulation**: Yes
- **Absorbed power**: 2.7 kW
- **Motor gearbox installed power**: 3.6 kW

**Rotation detector by**: Telemecanique/IFM

**Geared motor by**: Nord/Sew Flender/Bonfiglioli

1.5.4 **N. 1 Chain Elevator – Redecam supply**

To transport the dust to the storage silo, with the following main characteristics:

- **Nominal capacity**: 3.2 t/h
- **Maximum capacity**: 10 t/h
- **Conveyor size**: 390 mm
- **Slope**: 40°
- **Transport speed**: 0.2 m/s
- **Thermal insulation**: Yes
- **Absorbed power**: 3.2 kW
motor gearbox installed power : 4.8 kW
rotation detector by : Telemecanique/IFM
geread motor by : Nord/Sew/Flender/Bonfiglioli

1.5.5 N. 1 Dust storage silo

Installed in proximity of the bag filter to store the dust collected in the bag filter hoppers, is realized with cylindrical shell and conic hopper; it is complete of supporting structure with sufficient height to allow the positioning of big bags for silica discharging, access ladder, walkways and handrail, with the following main characteristics:

diameter : 3,600 mm
shell thickness : 6 mm
capacity : 120 m³
material of shell and hopper : carbon steel

1.5.5.1 N. 1 Silo Steelworks – Redecam supply

N 1 body and hopper made of painted carbon steel
N 1 supporting structure, made of carbon steel profiles
N 1 set of stairs and platforms, made of carbon steel profiles
N 1 set of cladding enclosure for silo structure

1.5.5.2 N. 1 set of special components for silo – Redecam supply

N 1 vibrating bottom cone
N 4 air shock devices for the end zone of the silo hopper
N 1 manual gate valve at the hopper discharge mouth, with limit switches
N 3 rotating level switches
Group 02 N. 1 Dry Reactor

Consisting of:

2 N.1 Redecam Reactor Tower– Redecam supply

The reaction tower is a self-standing type tower and is connected to the filter inlet flange. It will be installed downstream the new PJBF that replaces the existing positive pressure Bag House.

The reaction tower is fitted with internal “venturi” to produce turbulence in the raw gas so to ease the perfect mixing of the reagents with the gas itself.

The tower is constituted of an internal vertical duct exiting in an expansion chamber over and around the internal duct itself; the combination of the two volumes given by the internal duct and by the expansion chamber is proper to grant the necessary contact time.

Reactor main mechanical data:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactor type</td>
<td>Double pass</td>
</tr>
<tr>
<td>Diameter of venturi</td>
<td>1,900 mm</td>
</tr>
<tr>
<td>Diameter internal duct</td>
<td>3,100 mm</td>
</tr>
<tr>
<td>Diameter outer duct</td>
<td>4,500 mm</td>
</tr>
<tr>
<td>Total height</td>
<td>26,000 mm</td>
</tr>
<tr>
<td>Inlet flange quantity</td>
<td>1</td>
</tr>
<tr>
<td>Outlet flange quantity</td>
<td>1</td>
</tr>
<tr>
<td>Residence time</td>
<td>2.6 sec</td>
</tr>
<tr>
<td>Material</td>
<td>S235JR</td>
</tr>
<tr>
<td>Wall thickness</td>
<td>6 mm</td>
</tr>
<tr>
<td>Type of reagent</td>
<td>Hydrated lime HG</td>
</tr>
</tbody>
</table>

2.1 Instrumentation, Electrical and Control Devices – Redecam supply

<table>
<thead>
<tr>
<th>N</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Temperature transmitters (at reactor outlet)</td>
</tr>
<tr>
<td>1</td>
<td>Level transmitter (on hopper)</td>
</tr>
<tr>
<td>2</td>
<td>Pressure transmitters (at reactor inlet and outlet)</td>
</tr>
<tr>
<td>1</td>
<td>Set of electrical heat tracing to be applied on 1/3 of the hopper height</td>
</tr>
</tbody>
</table>

2.2 Steelworks – Redecam supply

<table>
<thead>
<tr>
<th>N</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Casing, realized in painted carbon steel</td>
</tr>
<tr>
<td>1</td>
<td>Hopper, realized in painted carbon steel</td>
</tr>
<tr>
<td>1</td>
<td>Set of inspection doors in painted carbon steel</td>
</tr>
</tbody>
</table>
N 1 set of service platforms for injection points access, realized in hot deep galvanized carbon steel
N 1 supporting structure with a free height underneath the hopper flange, realized in hot deep galvanized carbon steel

2.3 RT extraction System – Redecam supply

<table>
<thead>
<tr>
<th>Nominal capacity</th>
<th>300 kg/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust density</td>
<td>0.30 t/m³</td>
</tr>
</tbody>
</table>

Consisting of:

2.3.1 N. 1 manual cut-off gate - Redecam supply

installed at hopper outlet, for maintenance reason, with the following main characteristics:

- size: 300x300 mm
- complete of limit switches, gaskets and connection bolts.

2.3.2 N. 1 Chain Conveyor – Redecam supply

Installed under RT hopper, to transport the collected dust to the bag filter collecting conveyor, with the following main characteristics:

- design capacity: 300 kg/h
- conveyor nominal size: 1.0 m³/h
- length: 290 (9) mm (")
- slope: 9 m
- intermediate bearings: none
- discharge position: one end
- estimated transport speed: 0.2 m/min
- max capacity at 100% filling: 2 m³/h
- filling degree in design condition: < 35 %
- installed motor power: 0.90 kW
- geared motor by: SEW, NORD or eq
- with rotation detector by: Telemecanique /IFM
- heat tracing: included
- thermal insulation: yes by others
2.3.3 **N. 1 Rotary Valve - Redecam supply**

Installed at the conveyor outlet flange, motorized, with the following main characteristics:

- **design capacity**: 300 kg/h
- **nominal size**: 300 mm
- **filling degree in design condition**: < 30 %
- **installed motor power**: 0.90 kW
- **geared motor by**: SEW, NORD or eq
- **with rotation detector by**: Telemecanique /IFM

2.4 **Thermal Insulation – Redecam supply**

For the Reactor, with the following main characteristics:

- **material**: rockwool
- **thickness**: 100 mm
- **sheet metal material**: galvanized CS
- **sheet metal thickness**: 1.2 mm
- **surface**: 465 m²
Group 03 N. 1 Reagent Dosing System

Consisting of:

3  N.1 Hydrated Lime Injection System

The injection System has been sized according to the following results in the worst case:

- total reagent expected average consumption : 500 kg/h
- reagent max rate (for dosing system design) : 1,000 kg/h

3.1  N. 1 Hydrated Lime HG Storage Silo

Redecam is proposing a dust storage system sized for **one-week** operation at max load reference.

- Total reagent flow rate with excess : 750 kg/h
- Reagent density : 0.55 t/m³
- Quantity of silos : 1
- Storage volume each silo : 150 m³
- Silo body preliminary diameter : 4.0 m
- Silo body preliminary height : 15 m
- Days of storage : 168 hours : 7 days

3.1.1  N. 1 set of Silo Special Components – Redecam Supply

- N 1 safety valve on silo roof
- N 1 self-cleaning silo roof filter
- N 1 manhole

3.1.2  N. 1 set of Instruments for Hydrated Lime Silo – Redecam supply

- N 3 level indicators-switches
- N 1 pressure indicator (on filling line)
- N 1 pressure indicator (on silo)
- N 1 fluidification system
- N 1 set of weighting cells

3.1.3  N. 1 Silo Steelworks – Redecam supply

- N 1 silo cone and body in painted carbon steel S235JR
- N 1 supporting structure in painted carbon steel S235JR
- N 1 set of service platforms in galvanized steel S235JR
3.1.4 N.1 Hydrated Lime Dosing System – Redecam supply

N 1 hydrated lime silo extracting screw conveyor
N 1 buffer hopper
N 1 overpressure vent line with valve and limit switches
N 1 scrapper with electrical motor (0.45kW) and rotation detection
N 1 dosing screw conveyor with electrical motor (0.75kW) and rotation detection
N 1 set load cells on hydrated lime weighing bin
N 2 level indicators on bicarbonate weighing bin
N 3 pressure transmitter on conveying line

3.2 N.1 Reagent Injection System

This system will inject the Hydrated Lime directly on the reactor system.

Consisting of:

3.2.1 N.1 Rotary Feeder – Redecam supply

Inlet/outlet : 250 mm
Conveying capacity : 1,000 kg/h
Material Density : 0.55 t/m³
Motor : 0.95 kW

rotary feeder housing and bearing plates in sturdy steel construction, bearings located outside and are free of maintenance, shaft sleeve sealed with adjustable stuffing box, rotor with pockets and exchangeable sealing strips, drive via directly flanged SEW or NORD gearbox motor.

3.2.2 N.1 Blow Shoe – Redecam Supply

made in steel construction, for conveying line DN 80 with connection flange to rotary feeder.

3.2.3 N.1 Conveying line including pipe and bend – Redecam Supply

Including pipes and bends, made out of steel pipe DN 80 (88.9 x 3.2 mm), in standard length, incl. loose flanges, gaskets, galvanized connection bolts, pipe clamps, round steel bracket, pipe fasteners, pipe suspensions, loose supplied.
3.2.4 **N. 2 Rotary Piston Blowers – Redecam Supply**

One in operation and one in stand-by.

- **Motor:**
  - Power: 11 kW
  - Rotation: 3,000 min⁻¹

Blower with free shaft extension, base-frame for blower and motor, motor slide rails, anti-vibration pads and mounting material, intake silencer with weather hood, air outlet silencer, safety valve, non-return valve, flanged pipe with rubber sleeve and clips, with v-belt drive and guard.

3.2.5 **N. 2 Sound Protection Covers – Redecam Supply**

For rotary piston blower complete for blower and motor, with detachable side-panel, sound pressure level: <75 dB(A).

3.2.6 **N. 1 Sets of Air-supply Piping – Redecam Supply**

Between conveying air blower, cooler, humidifier and blow shoe, consisting of steel pipe, delivered in standard length, including the required loose elbows, pipe reduction, saddle adapter, washer throttle valves, pipe clips, steel rod bracket, pipe support and pipe suspensions delivered as loose parts.

3.2.7 **N. 2 Butterfly Valves – Redecam Supply**

Hand operated, to be mounted in the air pipe, valve to be placed between flanges, supplied without counter-flanges, casing made out of cast steel, flap-disc in stainless steel, sealing sleeve for a max. temperature of 120 °C, with control box for end position detection with 2 mechanical micro switches (OPEN-CLOSE).

3.3 **Thermal Insulation – Redecam supply**

For the Silo, with the following main characteristics:

- **Material:** rockwool
- **Thickness:** 100 mm
- **Sheet metal material:** galvanized CS
- **Sheet metal thickness:** 1.2 mm
- **Surface (only cone):** 25 m²
Group 04 N. 1 New Bag Filter for dust collection

Consisting of:

4 N.1 Bag Filter type 6 DPZ 18x16/8-W

The resulting proposed bag filter is with on line pulse jet cleaning system divided in 6 excludable chambers for online maintenance. Here following the main characteristics and process data in the operating conditions:

Bag filter main mechanical data:
width (internal) : 10,200 mm
length (internal) : 12,360 mm
number of bags : 1,728
bags diameter : 152 mm
bags length : 8.0 m
cloth area : 6,601 m²

casing design pressure @ 250 °C : -600 daPa
compressed air consumption max : 160 Nm³/h
compressed air pressure for cleaning : 3.5 bar

Design conditions

gas flow rate : 200,000 Nm³/h
          : 358,000 m³/h
temperature : 200 °C
inlet pressure : -150 daPa
inlet dust content : 100 mg/Nm³
type of dust : silica

outlet dust content : ≤ 5 mg/Nm³
air to cloth ratio : 0.90 m³/m² min
can velocity : 1.04 m/s
expected pressure drop : < 120 daPa

4.1 Special Components – Redecam supply

N 6 compressed air tank 12” receivers, each one complete of:
N 16 full immersion 2” pulse air valve
N 16 union between air valve and jet tube
N 12 air-proof boxes of die-cast light alloy (IP65 protection), holding the 24 VDC pilot solenoid valves which control the air valves
N 1,728 filtering sets, each composed of:
- Bags in fiberglass with PTFE membrane, ø 152 x 8,000 mm and nominal 740 g/m²
- Bag cages realized in painted carbon steel, 20 wires, 2 pieces

N 1  set of air compressed accessories, composed of:
- pressure regulator
- air filter regulator
- service unit

N 6  outlet (plenum) dampers, for online maintenance, on/off mode, pneumatically operated

4.1.1 First Urgency Spare Parts – Redecam supply
N 80  bags, as described above
N 50  cages, as described above
N 2  full immersion 2 " pulse air valve

4.2 Instrumentation, Electrical and Control Devices – Redecam supply
N 1  PLC (Siemens S7-300 or eq.) to control of the bags’ cleaning sequence based on deltaP, granting a compressed air consumption reduction, through automatic optimization of the pause time between the consecutive shots
N 6  pressure switches on compressed air pipes
N 2  bags pressure drop transmitters
N 6  hopper level sensors (one each hopper)
N 2  temperature transmitters (at bag filter inlet and outlet)
N 1  pressure transmitter (at bag filter outlet)
N 6  set of electrical heat tracing, to be applied on 1/3 of the hopper height
N 6  hopper vibrators
N 1  tribo sensor (broken bag detector)
N 1  electric service hoist, capacity 1 t, height approx. 30 m
N 2  manual hoists 0.4 t for plenum doors opening
N 6  set of pneumatic actuators and 2 limit switches for the compartment’s outlet dampers

4.3 Steelworks – Redecam supply
N 108 jet tubes feeding the compressed air to the nozzles in carbon steel
N 6  modules of bag filter plenum in carbon steel S235JR, thickness 4 mm, complete of:
  tube sheets set in carbon steel, thickness 5 mm
  pre-insulated plenum doors
N 1  casing, realized in carbon steel S235JR, thickness 4 mm
N 6  hoppers, realized in carbon steel S235JR, thickness 4 mm
N 1  penthouse structure made of carbon steel profiles
N 1  penthouse pre-painted trapezoidal sheet metal
N 1  set of service platforms for the silica transport system
N 1  set of service platforms for the hopper compartment dampers system
N 1  set of stairs from ground level to the bag filter plenum
N 1  supporting structure with free height underneath the hopper flanges of 2.5 m

4.4  Thermal Insulation – Redecam supply

For the bag filter hoppers, with the following main characteristics:

- material : rockwool
- thickness : 100 mm
- sheet metal material : galvanized CS
- sheet metal thickness : 1.2 mm
- surface (hoppers) : 310 m²
4.5 Dust Transport System – Redecam supply

Nominal capacity : 3.2 t/h
Dust density : 0.3 – 0.6 t/m³

A complete mechanical transport system will collect the dust from the BF discharge point, and it will convey them into the storage silo. The silo is fitted with the extraction system with telescopic device, for truck discharge.

4.5.1 N. 2 Longitudinal Chain Conveyors – Redecam supply

Installed under the bag filter hoppers, to transport the collected dust to one side of the bag filter, with the following main characteristics:

nominal capacity : 1.6 t/h
maximum capacity : 5 t/h
conveyor size : 340 mm
length : 15 m
slope : 0°
transport speed : 0.15 m/s
thermal insulation : yes
absorbed power : 1.6 kW
motor gearbox installed power : 2.4 kW
rotation detector by : Telemecanique/IFM
geared motor by : Nord/Sew/Flender/Bonfiglioli

4.5.2 N. 2 Rotary Valves – Redecam supply

motorized, with the following main characteristics:

model : DCM14
size : 350 mm
nominal capacity : 1.6 t/h
maximum capacity : 10 t/h
filling degree : 16%
electrical heat tracing power : no
thermal insulation : no
motor : 1.1 kW
rotation detector by : Telemecanique/IFM
geared motor by : Nord/Sew Flender/Bonfiglioli

complete of limit switches, gaskets and connection bolts.
4.5.3 N. 1 Transversal Chain Conveyor – Redecam supply

Installed at one side of the bag filter to transport the collected dust to the chain elevator, with the following main characteristics:

nominal capacity : 3.2 t/h
maximum capacity : 15 t/h
conveyor size : 390 mm
slope : 0 °
transport speed : 0.2 m/s
thermal insulation : yes
absorbed power : 2.7 kW
motor gearbox installed power : 3.6 kW

rotation detector by : Telemecanique/IFM
geared motor by : Nord/Sew/Flender/Bonfiglioli

4.5.4 N. 1 Chain Elevator – Redecam supply

To transport the dust to the storage silo, with the following main characteristics:

nominal capacity : 3.2 t/h
maximum capacity : 10 t/h
conveyor size : 390 mm
slope : 40 °
transport speed : 0.2 m/s
thermal insulation : yes
absorbed power : 3.2 kW
motor gearbox installed power : 4.8 kW

rotation detector by : Telemecanique/IFM
geared motor by : Nord/Sew/Flender/Bonfiglioli

4.5.5 N. 1 Dust storage silo

Installed in proximity of the bag filter to store the dust collected in the bag filter hoppers, is realized with cylindrical shell and conic hopper; it is complete of supporting structure with sufficient height to allow the positioning of a lorry truck for dust discharging, access ladder, walkways and handrail, with the following main characteristics:

diameter : 3,600 mm
shell thickness : 6 mm
capacity : 120 m³
material of shell and hopper : carbon steel
4.5.5.1 N. 1 Silo Steelworks – Redecam supply
- N 1 body and hopper made of painted carbon steel
- N 1 supporting structure, made of carbon steel profiles
- N 1 set of stairs and platforms, made of carbon steel profiles
- N 1 set of cladding enclosure for silo structure

4.5.5.2 N. 1 set of special components for silo – Redecam supply
- N 1 vibrating bottom cone
- N 4 air shock devices for the end zone of the silo hopper
- N 1 manual gate valve at the hopper discharge mouth, with limit switches
- N 1 loading spout for truck charging complete with suction point
- N 3 rotating level switches
Group 05 Fans System

Consisting of:

5.1 Nr.1 Booster Fan – Redecam supply

single inlet fan, to be installed on ground on concrete foundation, between bearings, with the following main characteristics:

Technical data – each fan

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrangement</td>
<td>tbd</td>
</tr>
<tr>
<td>Impeller arrangement</td>
<td>between bearings</td>
</tr>
<tr>
<td>Flowrate max</td>
<td>360,000 Am³/h</td>
</tr>
<tr>
<td>Gas Temperature</td>
<td>150-200 °C</td>
</tr>
<tr>
<td>Static pressure at inlet</td>
<td>-150 / -200 daPa</td>
</tr>
<tr>
<td>Static efficiency (preliminary)</td>
<td>72 %</td>
</tr>
<tr>
<td>Shaft adsorbed power (max)</td>
<td>285 kW</td>
</tr>
<tr>
<td>Speed</td>
<td>1,180 rpm</td>
</tr>
<tr>
<td>Drive</td>
<td>electric motor</td>
</tr>
<tr>
<td>Drive rating</td>
<td>350 kW</td>
</tr>
<tr>
<td></td>
<td>6 poles</td>
</tr>
<tr>
<td></td>
<td>60 Hz</td>
</tr>
<tr>
<td>Control type</td>
<td>frequency converter</td>
</tr>
<tr>
<td>mechanical design temperature</td>
<td>250 °C</td>
</tr>
</tbody>
</table>

Each fan will be designed in order to have:

- Split casing for rotor extraction in S235 JR
- Complete rotor (impeller wheel, shaft and hub) statically and dynamically balanced
- Machined wheel hub and forged steel shaft, in C35 construction with floating rings sealing
- Elastic coupling motor-fan with protection guard
- Two shaft supports with antifriction roller bearings, grease lubricated
- N°2 cooling wheels with protection guard
- N°2 Pt100 for bearings and N°1 vibration monitoring system
- Inlet and outlet flexible joints
- 100 mm thickness acoustic insulation
5.2 Nr.1 Booster Fan Drive

Consisting of:

5.2.1 Nr.1 Frequency Converter – Redecam supply

designed for continuous operating of one Squirrel-Cage induction motor, with following main characteristics:

- Configuration : 6 pulses
- Protection : IP21
- Type rating : 400 kW
- No overload use : 390 A
- Frequency : 48 – 66 Hz
- Total harmonic distortion : THDI<30%
- Voltage : 480 V

- IOEC-Boards 3 & 4 and PT100 transmitters for motor measurements
- Profibus (DP/FMS)
- Coated Printed Circuit Boards
- Converter space heater
- Redundant cooling pump
- Starter for motor fan
- Chopper and breaking resistor
- Common mode choke
- Factory witness test
- Communication test with Customer PLC connected via Profibus-DP

5.2.2 Nr.1 LV Motor – Redecam supply

Preliminary Data

<table>
<thead>
<tr>
<th>type</th>
<th>Squirrel-Cage Induction</th>
</tr>
</thead>
<tbody>
<tr>
<td>installed power</td>
<td>378 kW</td>
</tr>
<tr>
<td>voltage</td>
<td>480 V</td>
</tr>
<tr>
<td>poles</td>
<td>6</td>
</tr>
<tr>
<td>cooling</td>
<td>IC411</td>
</tr>
<tr>
<td>speed</td>
<td>1,180 rpm</td>
</tr>
<tr>
<td>minimum ambient temperature</td>
<td>-20 °C</td>
</tr>
<tr>
<td>protection</td>
<td>IP55</td>
</tr>
<tr>
<td>Insulation class</td>
<td>F/B</td>
</tr>
<tr>
<td>Standards electric</td>
<td>IEC</td>
</tr>
<tr>
<td>Start</td>
<td>Soft start via FC</td>
</tr>
</tbody>
</table>
Accessories:
• one temperature sensor and two PT100 for rolling contact bearings;
• six PT100 on stator windings, 2 wires connection;
• Witnessed Routine test according to vendor standard procedure.

Painting: special color shade and surface treatment C3 - Standard industrial environment.
5.3 Nr.2 Exhaust Fans – Redecam supply

single inlet fans, to be installed on ground on concrete foundation, between bearings, with the following main characteristics:

Technical data – each fan

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrangement</td>
<td>tbd</td>
</tr>
<tr>
<td>Impeller arrangement</td>
<td>between bearings</td>
</tr>
<tr>
<td>Flowrate max</td>
<td>200,000 Am³/h</td>
</tr>
<tr>
<td>Gas Temperature</td>
<td>150-200 °C</td>
</tr>
<tr>
<td>Static pressure at inlet</td>
<td>-350 / -400 daPa</td>
</tr>
<tr>
<td>Static efficiency (preliminary)</td>
<td>81 %</td>
</tr>
<tr>
<td>Shaft adsorbed power (max)</td>
<td>280 kW</td>
</tr>
<tr>
<td>Speed</td>
<td>1,180 rpm</td>
</tr>
<tr>
<td>Drive</td>
<td>electric motor</td>
</tr>
<tr>
<td>Drive rating</td>
<td>320 kW</td>
</tr>
<tr>
<td></td>
<td>6 poles</td>
</tr>
<tr>
<td></td>
<td>60 Hz</td>
</tr>
<tr>
<td>Control type</td>
<td>frequency converter</td>
</tr>
<tr>
<td>mechanical design temperature</td>
<td>250 °C</td>
</tr>
</tbody>
</table>

Each fan will be designed in order to have:

- Split casing for rotor extraction in S235 JR
- Complete rotor (impeller wheel, shaft and hub) statically and dynamically balanced
- Machined wheel hub and forged steel shaft, in C35 construction with floating rings sealing
- Elastic coupling motor-fan with protection guard
- Two shaft supports with antifriction roller bearings, grease lubricated
- N°2 cooling wheels with protection guard
- N°2 Pt100 for bearings and N°1 vibration monitoring system
- Inlet and outlet flexible joints
- 100 mm thickness acoustic insulation

5.4 Nr.2 Exhaust Fan Drives

Consisting of:

5.4.1 Nr.2 Frequency Converters – Redecam supply

designed for continuous operating of one Squirrel-Cage induction motor, with following main characteristics:
Configuration: 6 pulses
Protection: IP21
Type rating: 360 kW
No overload use: 365 A
Frequency: 48 – 66 Hz
Total harmonic distortion: THDI<30%
Voltage: 480 V

- IOEC-Boards 3 & 4 and PT100 transmitters for motor measurements
- Profibus (DP/FMS)
- Coated Printed Circuit Boards
- Converter space heater
- Redundant cooling pump
- Starter for motor fan
- Chopper and breaking resistor
- Common mode choke
- Factory witness test
- Communication test with Customer PLC connected via Profibus-DP

5.4.2 Nr.2 LV Motors – Redecam supply

Preliminary Data

type: Squirrel-Cage Induction
installed power: 320 kW
voltage: 480 V
poles: 6
cooling: IC411
speed: 1,180 rpm
minimum ambient temperature: -20 °C
protection: IP55
Insulation class: F/B
Standards electric: IEC
Start: Soft start via FC

Accessories:
- one temperature sensor and two PT100 for rolling contact bearings;
- six PT100 on stator windings, 2 wires connection;
- Witnessed Routine test according to vendor standard procedure.

Painting: special color shade and surface treatment C3 - Standard industrial environment.
Group 06 Raw and clean gas ducts, valves and exhaust stack

Consisting of:

6.1 N.2 sets of Raw Gas Ducts – Redecam supply

From: existing hairpin cooler
To: reactor inlet

with the following main characteristics:

- section: square/round
- section: 6-8 m²
- thickness: 5 mm
- material: EN S275JR
- insulation: yes (*)
- insulation thickness: 100 mm
- average gas speed: 22-26 m/s

(*) the duct will be insulated only in the parts where can be touched from the personnel, for safety reason. The ducts are complete of expansion joints and supports, where needed and accesses for instruments sockets as well as for process dampers.

6.2 N.1 Fresh air valve – Redecam supply

located at: Bag filter inlet duct

with the following main characteristics:

- type: butterfly
- quantity: 1
- actuator: on-off pneumatic
- diameter: 2,000 mm
- design ambient air temperature: 40 °C
- material: EN S275JR
- alarm temperature for opening: 240 °C

6.3 N.1 set of Clean Gas Ducts – Redecam engineering, Customer supply

From: filter outlet
To: stack inlet

with the following main characteristics:

- section: square
thickness : 5 mm
material : EN S275JR
insulation : yes (*)
insulation thickness : 100 mm
average gas speed : 18-20 m/s

(*) the duct will be insulated only in the parts where can be touched from the personnel, for safety reason.

The duct is complete of supports, where needed and accesses for instruments sockets.

6.4 N.1 Exhaust Stack – Redecam supply

Realized with concrete basement and internal baffle plates, with the following main characteristics:

diameter : 2,800 mm
thickness : 8/10/12 mm
material : EN S275JR
height : 48 m

The stack is complete of stairs and platforms with accesses for instruments sockets.
7 Electrical and Automation System

The new fume treatment plant will be completed by a modern control system which performs all the basic automation functions required to run the facilities in safety condition while achieving better control.

7.1 PLC Control System

For the process control and command of the new Redecam dedusting system is foreseen the supply of a PLC Siemens S7-1200 board realized in steel panels with IP54 protection degree; the leaf will be blind type with an operator panel MP277 on the front side access leaf (cable entry from the bottom).

The PLC will be realized with a suitable number of input/outputs foreseen for the field connection and for internal diagnosis, besides a 15% spare.

The main function carried out by the PLC are:

- setting of all working parameters of the equipment;
- setting of all alarm thresholds of the equipment;
- input signal collection from the field;
- sending of signals to the HMI station;
- control transfer to the field;
- logic sequences for the operations of the various parts of the dedusting system and the interlocks;
- collection of the alarm signals;
- control and command of the dampers and motors for fans;
- control and command of the dust discharge system

7.2 HMI Arrangement

The apparatus dedicated to the dedusting plant, according to the previous component list, will be installed in an electrical room; the hardware of the HMI client PC will be composed fully according to last commercial standard, including nr.1 LCD monitor and ink-jet printer.

All video pages (English language) of the automation system shall be agreed upon by the Buyer at the basic Engineering stage.

The HMI unit is dedicated to the supervision of the dedusting plants, carried on through mimics displayed on the color monitor, in particular:

- plant general mimic;
- bag filter mimic;
- fan motor mimic;
- process dampers mimic;
- reagent injection system mimic;
- alarms and events jogging;
- trends

7.3 Basic system and application software

The operative systems of the HMI unit will be Microsoft Windows 10 professional or later version.
The application software of the HMI unit will be WinCC supplied in open type Runtime.
The application software of the PLC will be developed with Siemens supplied in open type.
The basic software with the relevant developing licenses will be given to the Buyer at system commissioning.

7.4 LV Motor Control Center

The LV Motor Control Center is composed of low-voltage cubicles, modular design (no drawers, form B2) for the power supply, protection and control of three-phases asynchronous motors, resistances, and, in general, all other users usually used in the dedusting plant.

Each panel is made mounting bending pressed steel sheets with modular holes which allow the composition of different type of cubicles.

The protection degree is IP54 and the cable entrance is from the bottom. There is one incoming line at 480 V.
8 Other Services

Consisting of:

8.1 Compressed air – Redecam supply

Required compressed air quality classes (ref. to ISO 8573-1:2010: Compressed air - Part 1: Contaminants and purity classes) for filter bag cleaning, instruments and control devices, are the following:

<table>
<thead>
<tr>
<th>Filter CLASS</th>
<th>Particle content</th>
<th>Water content</th>
<th>Oil content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

min. overdesign capacity
based on max. consumption: +20% Nm³/h
pressure at our mains: 5,5 bar

For the definition of the classes, please refer to the table here below:

<table>
<thead>
<tr>
<th>Class</th>
<th>Solid Particles</th>
<th>Water</th>
<th>Oil (Aerosol, liquid and vapor)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum number of particles per m³ (d = particle size in μm)</td>
<td>Pressure dew point °C °F</td>
<td>mg/m³ ppm w/w</td>
</tr>
<tr>
<td>0</td>
<td>≤20,000</td>
<td>≤400</td>
<td>≤10</td>
</tr>
<tr>
<td>1</td>
<td>≤400,000</td>
<td>≤6,000</td>
<td>≤100</td>
</tr>
<tr>
<td>2</td>
<td>-</td>
<td>≤90,000</td>
<td>≤1,000</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>-</td>
<td>≤10,000</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>-</td>
<td>≤100,000</td>
</tr>
</tbody>
</table>

In order to reduce the number of start and stop for the compressor it is advisable to install a separate air receiver between the compressor and the fabric filter.
8.2 Packing – Redecam supply

Redecam standard packing is included in the scope of supply. All the equipment will be delivered suited for container transport, packed according our standard as follows:

- Compressed Air manifold with pneumatic valves in boxes
- Blowing pipes grouped in bundles
- Bag Cages in crates
- Bags in boxes
- Control Cleaning panel in wooden cages
- Instrumentation in boxes
  - Filter Plenum in preassembled modules suited for transport
  - Other steelwork: in panels with max length suited for transport

LEGEND: To be locally stored (by others), up to its installation, as follow:

- Indoor
  - Covered, in ventilated area

8.3 Transportation to site – Customer supply

DAP Beverly plant according to INCOTERMS 2010.

8.4 Equipment storage

Customer will organize a proper storage place for the equipment that must be kept indoor (instrumentation, filter bags, etc.) and a proper area where to storage steel structures and bag cages.

In case the Customer will delay the delivery of the equipment for any reason beyond the control of Redecam, and in case the goods are still in the workshops, a free of charge period of 1 month is granted as storage in the workshops.

Beyond that period, we reserve the right to invoice on the date stipulated in the original contract and the equipment will be stored and handled by a third part or supplier at the expense and risks of the Customer, without our liability for any reason whatsoever, on the base of a monthly fee to be agreed.
8.5 Meetings, Assistance and Supervision

A multiple mission of our technicians during the project execution and the site activities is included in our scope of works as described here after. If, for any reason beyond Redecam responsibility, the supervision, the startup or the commissioning as well as the training period should be prolonged, the daily rate will be applied, as defined at chapter I.3.

8.5.1 Project meetings - Redecam supply

Two missions of three of our technicians for measurements and kick-off meetings are included in Redecam scope of supply for a duration of 2 (+2 for travelling) days each.

Two missions for additional meetings of three of our technicians are included in Redecam scope of supply for a duration of 1 (+2 for travelling) days.

8.5.2 Supervision during erection - Excluded

Excluded, we remain at Customer disposal for defining any mission package.

8.5.3 Start up and commissioning supervision - Redecam supply

One mission for Start-up and Commissioning of two of our technicians (full project process and PLC), are included for a duration of 12 (+2 for travelling) days.

A grace / extra period of 4 days of our technician is also granted, if needed for the correct operation of the new system, free of charge.

One mission for Start-up and Commissioning of two of our technicians (fan and motor, catalyst), are included for a duration of 5 (+2 for travelling) days.

8.5.4 Training - Redecam supply

One mission for Training of the Plant engineers of two of our technicians is included for a duration of 3 (+2 for travelling) days. It can also be held during the cold-test and/or commissioning phases.

A grace / extra period of 2 days of our technician is also granted, if needed for the correct operation of the new system, free of charge.
D. **BATTERY LIMITS**

At the present stage, the battery limits of engineering of Redecam scope of works are the following:

D.1 **Equipment:**

Mechanical
- *Flue gas:* from cooler outlet flange up to Stack outlet flange.
- *Silica:* at silica storage silo outlet hopper flange
- *Dust:* from second PJBF Bag filter hoppers outlet flanges up to Bag filter dust silo storage system
- *Reagent:* from truck loading flange at silo up to injection point.

Electrical
- LV MCC inlet terminals
- Frequency Converters inlet terminals
- Instrumentation: instrument connection.

D.2 **Cleaning control panel and electrical users:**

At their terminal blocks.

D.3 **Compressed Air:**

From the compressed air station.
## E. MATERIALS, PAINTING AND INSULATION

### E.1 Definition

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Material</th>
<th>Thick.</th>
<th>Painting Internal</th>
<th>Painting External</th>
<th>Thermal insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bag Filter Plenum</td>
<td>S235JR</td>
<td>4</td>
<td>A</td>
<td>C</td>
<td>By client</td>
</tr>
<tr>
<td>Tube Sheets</td>
<td>S235JR</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td>N.A.</td>
</tr>
<tr>
<td>Bag Filter Casing</td>
<td>S235JR</td>
<td>4</td>
<td>A</td>
<td>C</td>
<td>By client</td>
</tr>
<tr>
<td>Bag filter Hoppers</td>
<td>S235JR</td>
<td>4</td>
<td>A</td>
<td>C</td>
<td>By client</td>
</tr>
<tr>
<td>Reactor Casing and hopper</td>
<td>S235JR</td>
<td>8</td>
<td>A</td>
<td>C</td>
<td>By client</td>
</tr>
<tr>
<td>Ductworks</td>
<td>S235JR</td>
<td>5/6</td>
<td>A</td>
<td>C</td>
<td>By Client</td>
</tr>
<tr>
<td>Stairs, Ladders and Walkways</td>
<td></td>
<td></td>
<td>N.A.</td>
<td>G or E</td>
<td></td>
</tr>
<tr>
<td>Handrails</td>
<td></td>
<td></td>
<td>N.A.</td>
<td>G or E</td>
<td></td>
</tr>
<tr>
<td>Supporting and Penthouse Structures</td>
<td></td>
<td></td>
<td>N.A.</td>
<td>G or E</td>
<td></td>
</tr>
<tr>
<td>Third Parts Equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Standard of manufacturer</td>
</tr>
</tbody>
</table>

### E.2 Painting cycles

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Surface preparation</th>
<th>Primer</th>
<th>Intermediate</th>
<th>Final</th>
<th>RAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Brushing</td>
<td>zinc phosphate thk 60 μm</td>
<td>none</td>
<td>none</td>
<td>t.b.d.</td>
</tr>
<tr>
<td>B</td>
<td>Sandblasting SA 2 1/2</td>
<td>zinc phosphate thk 60 μm</td>
<td>none</td>
<td>none</td>
<td>t.b.d.</td>
</tr>
<tr>
<td>C</td>
<td>Sandblasting SA 2 1/2</td>
<td>inorganic zinc th. 75 μm</td>
<td>none</td>
<td>none</td>
<td>t.b.d.</td>
</tr>
<tr>
<td>D</td>
<td>Sandblasting SA 2 1/2</td>
<td>inorganic zinc th. 75 μm</td>
<td>none</td>
<td>alkyd enamel th. 40 μm</td>
<td>t.b.d.</td>
</tr>
<tr>
<td>E</td>
<td>Sandblasting SA 2 1/2</td>
<td>epoxy zinc phosphate th. 40 μm</td>
<td>none</td>
<td>epoxy resin th. 40 μm</td>
<td>t.b.d.</td>
</tr>
<tr>
<td>F</td>
<td>Sandblasting SA 2 1/2</td>
<td>inorganic zinc th. 75 μm</td>
<td>none</td>
<td>silicon paint th. 30 μm</td>
<td>t.b.d.</td>
</tr>
<tr>
<td>G</td>
<td>Galvanized</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>Sandblasting SA 2 1/2</td>
<td>inorganic zinc th. 75 μm</td>
<td>epoxy paint th. 40 μm</td>
<td>epoxy resin th. 40 μm</td>
<td>t.b.d.</td>
</tr>
</tbody>
</table>
F. PRELIMINARY PROJECT PLAN

The project plan is based on the assumption that all necessary information are available before starting the engineering phase. The Customer approvals, if any and if not differently agreed, is estimated to occur within one week from the document issuing date. The project plan does not include, nor are we responsible for, possible delays during customs clearance or during plant acceptance nor unloading.

F.1 Engineering

The following has been considered (to be mutually agreed):

- General arrangement drawings (preliminary): 4 weeks after contract / LOI
- Drawings with loads: 4 weeks after G.A. approval
- P&ID (preliminary): 4 weeks after contract / LOI
- Flowsheet (preliminary): 4 weeks after contract / LOI
- Electrical consumer list (preliminary): 8 weeks after contract / LOI
- Process description (preliminary): 10 weeks after G.A. approval
- Electrical description (preliminary): 12 weeks after G.A. approval
- Logic diagram (preliminary): 2 w. after approval of above doc
- Detailed engineering for fabrication: 16-20 weeks after G.A. approval

F.2 Equipment Supply

Delivery of the supplied Equipment: to be agreed

F.3 Site activity

A preliminary project time schedule will be commonly discussed before project start.
G. GUARANTEES

G.1 Pre-conditions
Any mechanical, functional or bag guarantee as laid out in the following paragraph will be valid only if below preconditions will be respected:
- The equipment supplied by Redecam shall be operated and maintained according to the Redecam guidelines included in the Operating and Maintenance Manual.
- All the spare parts used shall be in conformity with Redecam guidelines and recommended spare part list included in the Operating and Maintenance Manual.
- If the supplied equipment is operated by the Customer without Redecam supervision before the performance test, Redecam reserve the right to check and test the equipment. Upon Redecam request the Customer shall restore the equipment to proper operating condition before the test.
- All the existing or new equipment connected to the Redecam supplied equipment are working according to the nominal operating condition.
- Redecam supplied equipment are working according to the nominal operating condition as per enclosed datasheet (i.e. gas flow, quantity of dust, cooling water quality, etc.) and record of the following measurements (where applicable) will be made available to Redecam on a periodical basis:
  - Gas volume rate at the fans, or fans speed and dampers position.
  - Bag filter inlet and outlet temperature
  - Compressed Air quality

G.2 Mechanical Guarantees
All the supplied equipment and components are new, of good quality and well-constructed, free of any defect resulting from faulty design, imperfect material or defective workmanship.
If, within 24 months after the first plant start-up (or cold test) or within 36 months from the material delivery (whichever comes first), the equipment or any part thereof is or becomes defective for reason due to events preceding the pass of risk to the customer (i.e. defect resulting from faulty design, imperfect material or defective workmanship) or any other reason attributable to Redecam, Redecam at his own choice, upon request of customer, will replace or repair within a reasonable time from the customer notification. The customer should written notify any damages or defective malfunction within max. two weeks from its appearance.
Redecam guarantee doesn’t cover wear or tear part, like gasket, packing, joints, bearings, mineral wool, fuses, lights, screen etc. or damages due to improper use or negligence in following operating and maintenance instruction.
G.3 Functional Guarantees

G.3.1 LIMITS

The following process guarantees are given:

<table>
<thead>
<tr>
<th>Pos.</th>
<th>Parameters</th>
<th>Units</th>
<th>Guaranteed values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Dust</td>
<td>mg/Nm³, dry, 6%O₂</td>
<td>≤ 5</td>
</tr>
<tr>
<td>2.0</td>
<td>SO₂</td>
<td>mg/Nm³, dry, 6%O₂</td>
<td>≤ 280</td>
</tr>
</tbody>
</table>

The measurement procedure of dust emission shall be as defined by European VDI 2066 standards.

This standard fulfils the normative requirements of DIN EN 13284-1, and specifies a manual gravimetric reference measurement method for the determination of the dust load (dust content) and the dust mass flow of a dust/gas mixture flowing through defined cross-sections like stacks, pipelines or ducts. It allows the determination dust emissions in case of for instance check of compliance with limit or guarantee values, calibration of automated dust emission measuring systems, performance measurements at dust precipitators, and during check or optimization of process parameters.

The performance test shall be carried out by the Customer at the presence of Redecam advisory personnel.

The test period for clean gas dust content measurement will be one shift, 8 hours.

G.4 Bags life Guarantees

The following bag’s life guarantees are given:

<table>
<thead>
<tr>
<th>Pos.</th>
<th>Description</th>
<th>Units</th>
<th>Guaranteed values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Fiberglass with PTFE membrane</td>
<td>Years</td>
<td>2 full</td>
</tr>
</tbody>
</table>

Damages to the filtering bags or failure to meet the specified guarantees due to issues out of Redecam control are specifically excluded from this guarantee:

- Abrasion caused by gas/dust flows higher than what specified in the design conditions
- Fire or high temperature due to non-correct maneuvers performed by site personnel
- Moisture or oil which might be contained in the compressed air cleaning systems (due to improper use or negligence during the operation or maintenance)
- Bag blinding caused by unburnt hydrocarbons, CaCl₂ or ZnCl₂
- Faulty operations of any equipment connected to the filter not supplied by us.
- Gas temperature peaks for max 5 minutes and max 1 time per month
- Gas operating temperature always above the (acid) dew point plus 25°C
- Transient conditions according to the given procedure (e.g. pre-coating, warm-up curves, etc.)

Redecam is responsible for the supply of the eventual new bags, the Customer is responsible for the substitution activities.

The Customer will be responsible to keep documentation of any occurrences where the filter’s inlet temperature should exceed the maximum allowable temperature and shall keep Redecam informed in writing. Should the bags fail to perform as specified, the Customer shall notify Redecam immediately. The Customer must give Redecam written indication of the reasons of any/all bags which might be removed during the guarantee period; positions of the bags (i.e. row, positioning in the row, and chambers’ numbering, if any) and any relevant data shall be indicated in the said written communication. The failure in terms of bags’ lifetime is intended to be whenever any bags might result affected with wear holes, rips or tears due to strength losses, prior the minimum guaranteed bags lifetime is achieved.
H. EXCLUSIONS

The following items and services are not included in our basic Scope of Supply:

- Project for submission to the authorities
- Instrumentation in general except the one mentioned
- HV/MV transformer
- Electrical power network upstream supplied boards
- Plant DCS, control panels
- Inertization systems
- Grounding system
- Lightning rods
- Lighting
- Spare parts (except the ones mentioned)
- Foundations, civil and building works
- Customs, duties, VAT and Local Taxes
- Anything not mentioned in the present offer
I. GENERAL CONDITIONS

I.1 Engineering

All project drawings supplied by Redecam will be done in the English language. All training manuals, preventive maintenance schedules and sub-supplier literature will be done in English language. Services and engineering provided by Redecam will be, where applicable, in accordance to the following definitions:

I.1.1 Basic Data (BD)

Main process data and related equipment, comprising:
- Estimated Load Data.
- Preliminary Arrangement Drawings.
- Characteristics of main equipment.
- Main dimensions of main equipment.
- Specification of tubes, fittings and fixations with tube installation schematics.
- All drawings will be supplied in dwg format.

I.1.2 Basic Engineering (BE)

To enable qualified engineers to work out the detail engineering, comprising:
- Preliminary General Lay-out (for customer approval).
- Final General Lay-out.
- Preliminary and Final Load data.
- Equipment List with main data.
- Preliminary P&I Diagram.
- Preliminary Motor and consumer List.
- Preliminary Instrument List.
- Preliminary I/O PLC signals.
- Logical diagrams for process control.

I.1.3 Detailed Engineering (DE)

Specific drawings and documents, comprising:
- Final P&I diagrams.
- Equipment List.
- Final Motor and consumer List.
- Final Instrument List.
- Final I/O PLC signals.
- Detailed Drawings for fabrication complete of material list.
- General assembly equipment drawings.
- Erection procedures.
- Operating and Maintenance Manual (French language).
I.2 Supervision during erection

Unless stated otherwise in Chapter C, supervision during erection is not included in our scope of supply.

The cost for Redecam supervisor during erection is €950 per any day of absence from the office, based on 8h/days / 6 days by week.

Extra hours from 8 to 10 hours will be invoiced at 150 € / hour.

Extra hours during week-ends and bank holidays will be invoiced at 170 € / hour.

Travel, accommodations and allowance expenses will be invoiced at cost. Living fees for the duration of the mission such as hotel, restaurant, car rental... are at Customer charge, the fees will be directly paid by the Customer or back charged.

I.3 Supervision during start up, training and commissioning

Unless stated otherwise in Chapter C, supervision during commissioning and start up is not included in our scope of supply.

The cost for Redecam supervisor during start up and commissioning is €950 per any day of absence from the office, based on 8h/days / 6 days by week.

Extra hours from 8 to 10 hours will be invoiced at 150 € / hour.

Extra hours during week-ends and bank holidays will be invoiced at 170 € / hour.

Travel, accommodations and allowance expenses will be invoiced at cost. Living fees for the duration of the mission such as hotel, restaurant, car rental... are at Customer charge, the fees will be directly paid by the Customer or back charged.

I.4 Liability

Our liability is limited to the Scope of Supply. As a consequence Redecam cannot provide compensation for any special, indirect or consequential damages or losses such as, but not limited to, loss of profit, loss of revenue, loss of production, loss of contracts, loss of use, loss of data, loss of image, costs of capital and other indirect losses that remain excluded from the liability of the Parties.

It is also understood that time is one of the important aspect of the contract, but it cannot be considered as being of the essence or the main aspect of the contract.

I.5 Jurisdiction and applicable law

This contract is subject to the Italian law. The contracting parties are obliged in the case of disputes over interpretation and fulfillment of the contract to strive for an amicable settlement first.

If such an agreement doesn't take place, all disputes arising will have to be decided by a responsible proper court. Place of jurisdiction is Milan (Italy).
I.6 **Property transfer**

The ownership of the equipment will remain at Redecam until the full payment of the contract price, including any additional agreement.

I.7 **General**

Redecam’s quotation is exclusively based on the Technical Specification and commercial conditions stated in this document and its Annexes. All condition not provided herein are ruled by Orgalime S2000. Unless stated otherwise, all taxes and other duties that should arise outside Italy, should be paid by the Customer. Unless stated otherwise, the prices are firm and not subject to escalation for the duration of the contract, if the order is placed within the validity of offer as specified in the Commercial Conditions. The prices included in the present offer are only valid if the offer is accepted as a whole. In case only part of the offered equipment and/or services should be ordered, we reserve the right to adjust such prices.
J. SPARE PARTS & AFTER SALES SERVICES

J.1 Spare parts
The internal Spare Parts Department will be at your disposal for any needs in terms of spare parts quotations or supplies; quotations for both emergency and two years spare parts will be issued within 6 months from the contract signature.

NOTE: we are including in our basic scope of supply a set of first urgency spare parts as described in the Chapter C.

J.2 After sales services
Redecam After Sales Service will be at your disposal in order to ensure the correct operation and maintenance of the plants. Highly qualified engineers will be available to operate both in Italy and abroad. Should you require assistance for any troubles on site, Redecam will generally ensure very fast responses times.
K. ANNEXES

The following list of preliminary annexes forms an integral part of this quotation:

1. Bag Filter data sheet rev2
2. Preliminary Division of Scope of Work rev2
3. Process Flow Diagram (preliminary)
4. Layout drawings
## Division of Scope of Supply and Services

The following is the division of scope of supply between REDECAM and Customer.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>SERVICES OR EQUIPMENT</th>
<th>LEVEL OF SUPPLY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>BD</td>
</tr>
<tr>
<td>1.00</td>
<td>CIVILS AND FOUNDATION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anchor Bolts</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Concrete embedded plates</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Civil works for fume treatment plant</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Civil work for compressor and electrical room</td>
<td>R</td>
</tr>
<tr>
<td>2.00</td>
<td>TAC FILTER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expansion joints</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Internal key-components &amp; Cleaning System</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Bag cages</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Filter bags</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Plenum</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Casing</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Hoppers with inspection door</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Internal deflectors</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Penthouse structure and sheeting</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Supporting structures</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Walkways for filter inspection</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Stairs and ladders</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Hopper heating system</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Electrical hoist</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Manual hoist</td>
<td>R</td>
</tr>
<tr>
<td>3.00</td>
<td>REACTION TOWER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RT internal key-components</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>RT casing and hopper</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>RT internal deflectors</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>RT supporting structure</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>RT dust extraction system as described</td>
<td>R</td>
</tr>
<tr>
<td>4.00</td>
<td>HYDRATED LIME STORAGE AND INJECTION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Silo/dischargers</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Supporting structures</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Dosing conveyor and blowers</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Injection line and lances</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Stairs and ladders</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Instrumentation as described</td>
<td>R</td>
</tr>
<tr>
<td>5.00</td>
<td>COMPRESSED AIR STATION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Compressors</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Dryers</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Compressed air storage tank</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Compressed air treatment station (dryers, valves, fittings)</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Compressed air station cabinet</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Compressed air piping (within battery limits)</td>
<td>R</td>
</tr>
<tr>
<td>6.00</td>
<td>SILICA &amp; DUST TRANSPORT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Slide Gate valves</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Rotary valves</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Chain conveyors</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Dust silo steelworks</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Dust silo instruments/accessories</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Dust silo extraction system</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Stairs and ladders</td>
<td>R</td>
</tr>
</tbody>
</table>

### Legend

- **BD**: Basic Data
- **ERE**: Erection
- **BE**: Basic Engineering
- **DE**: Detail Engineering
- **SUP**: Supply
- **TIN**: Thermal Insulation
- **ERE**: Redecam
- **SUP**: Option
- **TIN**: Excluded / N.A.
### Division of Works (Preliminary)

#### 7.00 DUCTWORKS AND DAMPERS
- Instrumentation as described: R R R R - R
- Expansion joints: R R R R - R
- Process Dampers: - - - - - -
- Fresh air damper: R R R R - R
- Silencer: - - - - - -
- Raw Gas Ducts: R R R R - R
- Clean Gas Ducts: R R R R - R
- Supporting structure for ducts: R R R R - R

#### 8.00 ID FAN
- ID Fan - Impeller: R R R R - R
- ID Fan - Static parts: R R R R - R
- Main electrical motor: R R R R - R
- Inlet damper: R R R R - R
- Frequency converter: R R R R - R
- Supporting base-frame: R R R R - R
- Thermal-aphonic insulation: R R R R - R
- Accessories and instruments: R R R R - R

#### 9.00 BOOSTER FAN
- Booster Fan - Impeller: R R R R - C
- Booster Fan - Static parts: R R R R - C
- Main electrical motor: R R R R - C
- Inlet damper: - - - - - -
- Frequency converter: R R R R - C
- Supporting base-frame: R R R R - C
- Thermal-aphonic insulation: R R R R - C
- Accessories and instruments: R R R R - C

#### 10.00 ELECTRICAL DISTRIBUTION
- Low voltage switchgear: R R R R - R
- Medium voltage switchgear: C C C C - C
- Step-down transformer: C C C C - C
- LV MCC for BF: R R R R - R
- LV MCC for dust transport: R R R R - R
- Cabling of the boxes of the solenoid valves: R R R R - R
- Electrical Motors: R R R R - R
- Power cables: R R R R - R
- Control cables: R R R R - R
- Cable trays: R R R R - R
- Cable tunnels, civil works, embedded conduits, etc.: R R C C - C
- Lighting system: R R R R - R
- Local control cabinet for lighting and socket system: R R R R - R
- Lightning grounding system: R R R C - R
- Ventilation and air conditionion system for electrical room: R R R R - R

#### 11.00 AUTOMATION AND CONTROL SYSTEM
- Flue Gas Treatment Plant PLC: R R R R - R
- Local control boxes: R R R R - R
- Junction Boxes: R R R R - R
- Gas analyzing system: R R R R - R
- Opacimeter: R R R R - R
- Human-machine interface (HMI): R R R R - R
- Automation level 1 - hardware: R R R R - R
- Automation level 1 - software licenses: R R R R - R
- Automation level 1 - application programs: R R R R - R
- UPS: R C C C - C
ATTACHMENT D

QSEM STRUCTURAL INSPECTION REPORTS
FOR NO. 1 SHOP AND NO. 2 SHOP
BAGHOUSES
September 1, 2015

Mr. Matt Greene
Globe Metallurgical, Inc.
P.O. Box 157
Beverly, OH 45715

Re: Fabric Filter Inspection Reports
PN 2059.006.01

Dear Mr. Greene:

I have enclosed two copies of the fabric filter inspection reports for Shop Nos. 1 and 2. These reports document the structural deficiencies found during the inspections during the week of February 16, 2015. The structural deficiencies found are judged to be reparable and would not impact future operation of the units.

We have completed the feasibility study analysis of Shop No. 1 filter for operation under negative pressure and have determined that with structural modifications, the unit can be modified to exhaust to a stack. We have also concluded that Shop No. 2 filter cannot accept additional structural loading and can only be operated at negative pressure by using the existing gull exhaust structure as a plenum. Final analysis of this unit is pending additional process operating data.

I am transmitting a draft report by email detailing the feasibility of modification of the filters and will finalize the report when process data is received.

Sincerely,

QSEM SOLUTIONS, INC.

Ronald Hawks
Process Engineering Manager

JPC

www.qsesolutions.com
2015 STRUCTURAL INSPECTION

No.2 Baghouse

Prepared for

QSEM Solutions
and
Globe Metallurgical, Inc.

QSEM Solutions Reference No.: 2059-006-1

EQ Engineers, LLC Reference No.: 02-1751-00

Inspection Date: February 16 through February 19, 2015
March 18, 2015

QSEM Solutions, Inc.
6120 S. Gilmore Rd.
Suite 204
Fairfield, OH 45014
USA

Attention: Mr. Ron Hawks
Process Engineering Manager

Subject: Globe Metallurgical, Beverly, OH
No. 2 Baghouse Structural Framing
2015 Structural Inspection
QSEM Solutions Ref. No.: 2059-006-1
EQ Engineers, LLC Ref. No.: 02-1751-00

Dear Mr. Ron Hawks:

In reference to the above subject, we are issuing this report summarizing the results of the cursory inspection along with corresponding repair recommendations where applicable.

The following is a list of items inspected on February 16 through February 19, 2015 by EQ Engineers, LLC:

- No. 2 Baghouse Structural Framing
- Concrete Pedestals
- Internal Sheeting
- External Sheeting
- Bag Compartment Doors and Framing

The results of the inspection along with the repair recommendations are contained within the body of this report. Refer to American Air Filter Drawings for use by Globe Metallurgical Inc. personnel.

EQ is submitting (3) three copies of the report, plus an electronic copy for your use. The submission of this report completes EQE's Scope of Services.

As always, it has been a pleasure working with you and your staff on this project. Should you have any questions concerning any aspect of this report, please contact our office.

Sincerely,

EQ Engineers, LLC

[Signature]

John A. Gill
Inspection Services
Senior Lead Inspector
TABLE OF CONTENTS

SECTION

I. EXECUTIVE SUMMARY

II. INTRODUCTION

III. REPAIR RECOMMENDATIONS AND INSPECTION FINDINGS AND PHOTOS

IV. INSPECTION DRAWINGS
I. EXECUTIVE SUMMARY

A detailed visual inspection on February 16 through February 19, 2015 of the Globe Metallurgical Inc. – No.2 Baghouse Structural Framing, Concrete Pedestals, Sheeting and Bag Compartment Doors, was conducted to determine the condition of the present structures, which are deemed to be in “Fair” condition. The deficiencies encountered during the course of this inspection are in brief description as follows:

1. The bottom 1'-0” of the framing support W8 columns web and flanges are rusted thin and through at ground level.

2. The framing support W8 column base plates, anchor bolts and nuts have 20% to 70% deterioration.

3. The framing support W8 column concrete pedestals are cracked and spalled with missing sections and exposed rebar.

4. The framing support W8 column gusset plates and X-bracing are rusted thin and through and rust packed at ground level.

5. The framing support W8 columns, are rusted and pitted throughout with deterioration at ground level.

6. The framing support W8 column flanges are rusted thin and through at hopper level.

7. The sheeting support C6 girt is rusted thin and through at hopper level.

8. The ends of framing support W8 x 17 beams web and flanges are rusted thin and through with deterioration, at hopper level.

9. The ends of the framing support L5" x 5" x 5/16" diagonals are rusted thin and through and rust packed, at hopper level.

10. The framing support diagonal gusset plates are rusted thin and through and rust packed at hopper level.

11. The W8 x 28’s are rusted and pitted throughout at hopper level.

12. The framing support diagonal section was cut and removed between elevation 687'-0" and elevation 704'-0”

13. The external doors for the bag compartments have broken door handle, and door hinge. Also, bent up, missing, not connected, rusted thin and through or will not close properly along column row (“A” & “C”) at elevation 704'-0".
14. The external doors for the bag compartments are bent, bent and mangled, missing and rusted thin and through along column row “C” at elevation 738’-0”.

15. The internal divider sheeting for bag compartment is bent and wavy along column row “C” at elevation 738’-0”

Individual repair recommendations for these deficiencies are provided within the body of this report.

In conclusion, it is recommended that Globe Metallurgical Inc. - Maintenance Department review the contents of this report and develop/implement a comprehensive repair program to address all deficiencies contained herein to prevent their propagation to a more serious condition.
II. INTRODUCTION

A. FORMAT AND PRIORITY SCHEDULE

The following report is formatted by dividing the structure into its basic functional components. The inspection findings (Section III) are numbered sequentially and are in descriptive form. These findings are then followed by repair recommendations which are referenced to their corresponding finding numbers and are based on the following priority schedule:

P1. Emergency Condition – Immediate repairs are required. Operations of the equipment involved should cease until repairs are made.

NOTE: This rating is used when component failure is imminent or has already occurred or if there exists a potential hazard to the safety of personnel or the potential for serious damage to the equipment or machinery.

P2. Critical Condition – Repairs should be made as soon as possible, but in no event should they go unrepaired for more than thirty (30) days.

NOTE: This rating is less serious than a "P1"; however, it is a deficiency that may develop into an emergency condition if it is not repaired within the thirty (30) days.

P3. Primary Deficiency – Repairs should be made within six (6) months or less.

NOTE: This condition does not represent failure or instability at the present time, but may produce additional damage if not repaired.

P4. Secondary Deficiency – Repairs should be made during routine maintenance and in no more than one (1) year.

NOTE: This condition, if neglected for any great length of time, may cause or contribute to future damage.

P5. For Reference Only – No repairs are required at the present time.

NOTE: This deficient condition is minor in nature and is noted only because the condition is less than new.
**Safety Related Condition (SR)** – Plant Operations should be notified and be made aware that there may be a potential safety hazard to personnel.

Globe Metallurgical Inc. shall review the identified potential safety hazard and prioritize it in accordance with their decision and procedures.

Included in this report, when applicable, are repair standards and repair guidelines, which explains and illustrates the recommended repair for each inspection finding. The inspection location drawings (Section IV) provide the approximate locations of the specific inspection findings referenced in the report. Also, please refer to American Air Filter Drawings.
III. INSPECTION FINDINGS AND REPAIR RECOMMENDATIONS

This inspection report is not intended to serve as a repair document or contractor bid document. This report is also not intended to take the place of detailed engineering. The suggested repair recommendations described in this report are most often common generic repairs, which are currently used throughout the industry. Specific repairs to address particular deficiencies are recommended and described in further detail as required, again utilizing accepted industry practices. Therefore, the recommendations are meant to provide a preliminary scope of work and aid in identifying the magnitude of the required repairs.

The recommended repairs can be performed as maintenance type activities, providing procedures are in place to follow and adhere to current construction standards and practices. The repairs should also be based on the original design of the structure.

Where any repairs are suggested as temporary, they are specifically directed toward deficiencies, which require additional attention to restore the complete integrity of the structure. The anticipated life of the temporary repairs is unknown due to the many possible underlying causes of the observed deficiencies. However, these repairs should be performed as soon as possible until permanent long-term solutions can be developed and implemented. Consideration for all long-term solutions should be primarily, but not solely, based on client operating, maintenance, and/or budgetary constraints.

Where the report indicates that detailed engineering is required, a condition has been identified that, if not promptly addressed and repaired or replaced, has the potential to damage the integrity of the structure. Therefore, engineering analysis should be performed to develop corrective action(s) where appropriate. Activities that define the engineering analysis include, but are not limited to: detailed engineering, shop drawings, bills of material, welding specifications, material specifications, and construction procedures. These items are not included in this report.
III. INSPECTION FINDINGS AND REPAIR RECOMMENDATIONS (cont.)

The following list of current inspection findings (F) represents the structural deficiencies encountered during this inspection. Included with the findings are corresponding repair recommendations (R) and repair priorities (P) for each repair recommendation. For specific locations of the inspection findings, refer to the inspection location drawing(s) located in (Section IV) of this report.

NO. 2 BAGHOUSE

COLUMNS @ GRADE LEVEL

Column Line “A”
(Refer to dwg. BH2-SK1)
(Reference American Air Filter dwgs. B-1175, B-1179, B-1180 & B-1163)

F1. Along column line “A”, at column row “1”, the W8 x 24 web has 40% deterioration and the flange is rusted thin and through at the bottom 1'-0". (Photo 1)

F2. Along column line “A”, at column row “1”, the base plate and anchor bolts have 40% deterioration. (Photo 1)

R1. & R2. P2. Replace the bottom 4'-0" of the W8 x 24, base plate and anchor bolts “In-Kind” as required.
(Refer American Air Filter dwgs. B-1175 & B-1180)
Column Line "A" (cont.)

F3. Along column line "A", at column row "4", the W8 x 28 web has 40% deterioration and the flange is rusted thin and through at the bottom 1'-0". (Photo 2)

F4. Along column line "A", at column row "4", the base plate and anchor bolts have 40% deterioration. (Photo 2)

R3. to R4. P2. Replace the bottom 4'-0" of the W8 x 24, base plate and anchor bolts "In-Kind" as required.
(Refer to American Air Filter dwgs.B-1175 & B-1180)
Column Line “A” (cont.)

F5. Along column line “A”, at column row “5”, the W8 x 28 flange is rusted thin and through, at the bottom 1'-0". (Photo 3)

F6. Along column line “A”, at column row “5”, the gusset plate has 20% deterioration at the bottom 6". (Photo 3)

F7. Along column line “A”, at column row “5”, the base plate and anchor bolts have 20% deterioration. (Photo 3)

R5. to R7. P2. Replace the bottom 4'-0" of the W8 x 28, base plate, anchor bolts and gusset plate “In-Kind” as required.
(Refer to American Air Filter dwgs.B-1175 & B-1180)
Column Line “A” (cont.)

F8. Along column line “A”, at column row “6”, the original W8 x 48 web is rusted thin and through with a patch plate installed for temporary stability. (Photo 4)

F9. Along column line “A”, at column row “6”, the anchor bolts have 20% deterioration and the anchor bolt nuts have 70% deterioration. (Photo 4)

R8. & R9. P2. Replace the bottom 4'-0" of the W8 x 48, base plate and anchor bolts “In-Kind” as required. (Refer to American Air Filter dwgs. B-1175 & B-1180)
Column Line "A" (cont.)

F10. Along column line "A", at column row "7", the W8 x 28 web is rusted thin and through at the bottom 1'-0". (Photo 5)

F11. Along column line "A" at column row "7", gusset plate is rusted thin and through at the bottom 6". (Photo 5)

R10. & R11. P2. Replace the bottom 4'-0" of the W8 x 28, and gusset plate "In-Kind" as required.
(Refer to American Air Filter dwgs. B-1175 & B-1180)
Column Line “A” (cont.)

F12. Along column line “A”, at column row “8”, the concrete pedestal has missing sections with exposed rebar. (Photo 6)

R12. P2. Clean the cracked and spalled areas to sound concrete, apply a concrete bonding agent, form and pour new concrete “In-Kind” as required.

F13. Along column line “A”, at column row “8”, the original W8 x 28 web is rusted thin and through with a patch plate installed for temporary stability. (Photo 6)

F14. Along column line “A”, at column row “8”, the anchor bolts have 20% deterioration and the anchor bolt nuts have 70% deterioration. (Photo 6)

R13. R14. P2. Replace the bottom 4'-0" of the W8 x 28, base plate and anchor bolts “In-Kind” as required.
(Refer to American Air Filter dwgs.B-1175 & B-1180)
Column Line “A” (cont.)

F15. Along column line “A”, at column row “9”, the concrete pedestal has missing sections with exposed rebar. (Photo 7)

R15. P3. Clean the cracked and spalled areas to sound concrete, apply a concrete bonding agent, form and pour new concrete "In-Kind" as required.
Column Line “A” (cont.)

F16. Along column line “A”, at column row “9”, the original W8 x 28 web has 40% deterioration at the bottom 1'-0" with a patch plate installed for temporary stability. (Photo 8)

F17. Along column line “A”, at column row “9”, the anchor bolts and base plate have 20% deterioration. (Photo 8)

R16. & R17. P2. Re-enforce the web or replace the bottom 4'-0" of the W8 x 28, base plate and anchor bolts “In-Kind” as required. (Refer to American Air Filter dwgs. B-1175 & B-1180)
Column Line "A" (cont.)

F18. Along column line "A", at column row "10", the concrete pedestal has missing sections with exposed rebar. (Photo 9)

R18. P3. Clean the cracked and spalled areas to sound concrete, apply a concrete bonding agent, form and pour new concrete "In-Kind" as required.
Column Line “A” (cont.)

F19. Along column line “A”, at column row “10”, the W8 x 28, has 20% deterioration in a 2'-0" area at about 2'-0" above base plate. (Photo 10)


F20. Along column line “A”, at column row “11”, the W8 x 24 has 20% deterioration and rusted and pitted throughout.

F21. Along column line “A”, at column row “12”, the W8 x 24 has 20% deterioration and rusted and pitted throughout.


Column Line “B”
(Refer to dwg. BH2-SK1)
(Reference American Air Filter dwgs. B-1175, B-1179, B-1180 & B-1183)

F22. Along column line “B”, at column row “3”, the concrete pedestal cracked and spalled with exposed rebar. (Photo 11)

R22. P3. Clean the cracked and spalled areas to sound concrete, apply a concrete bonding agent, form and pour new concrete “In-Kind” as required.

F23. Along column line “B”, at column row “11”, the concrete pedestal cracked and spalled in a 6” x 1’-0” area.

R23. P3. Clean the cracked and spalled areas to sound concrete, apply a concrete bonding agent, form and pour new concrete “In-Kind” as required.
Column Line "B" (cont.)

F24. Along column line "B", at column row "12", the W8 x 31 web is rusted thin and through at the bottom 1'-0" (Photo 12)

R24. P2. Re-enforce the web or replace the bottom 4'-0" of the W8 x 31, "In-Kind" as required.
(Refer to American Air Filter dwgs. B-1175 & B-1183)
Column Line "C"
(Refer to dwg. BH2-SK1)
(Reference American Air Filter dwgs. B-1175, B-1179, B-1180 & B-1183)

F25. Along column line "C", at column row "1", the W8 x 31 web and flange are rusted thin and through at the bottom 1'-0". (Photo 13)

F26. Along column line "C", at column row "1", the base plate and anchor bolts have 40% deterioration. (Photo 13)

F27. Along column line "C", at column row "1", the gusset plate and x-bracing are rusted thin and through at the bottom 1'-0". (Photo 13)

Replace the bottom 4'-0" of the W8 x 31, base plate, anchor bolts, gusset plate and x-bracing "In-Kind" as required.
(Refer to American Air Filter dwgs. B-1175 & B-1179)
Column Line “C” (cont.)

F28. Along column line “C”, at column row “5”, the W8 x 31 flange is rusted thin and through at the bottom 1'-0". (Photo 14)

F29. Along column line “C”, at column row “5”, the gusset plate is rusted thin and through at the bottom 6". (Photo 14)

F30. Along column line “C”, at column row “5”, the gusset plate is rust packed at the bottom connection. (Photo 14)

R28. to Replace the bottom 4'-0" of the W8 x 31, base plate, anchor bolts and gusset plates “In-Kind” as required.
R30. P2. (Refer to American Air Filter dwgs.B-1175 & B-1179)
Column Line "C" (cont.)

F31. Along column line "C", at column row "6", the W12 x 79 web and flange are rusted thin and through at the bottom 1'-0". (Photo 15)

F32. Along column line "C", at column row "6", the anchor bolts and nuts have 20% deterioration. (Photo 15)

R31. & R32. P2. Replace the bottom 4'-0" of the W12 x 79, base plate and anchor bolts "In-Kind" as required.
(Refer to American Air Filter dwgs.B-1175 & B-1179)
Column Line “C” (cont.)

F33. Along column line “C”, at column row “7”, the W8 x 31 flange is rusted thin and through at the bottom 1'-0". (Photo 16)

F34. Along column line “C”, at column row “7”, the gusset plate is rusted thin and through at the bottom 1'-0". (Photo 16)

F35. Along column line “C”, at column row “7”, the gusset plate is rust packed at the bottom connection. (Photo 16)

R33. to R35. P2. Replace the bottom 4'-0" of the W8 x 31 and gusset plates “In-Kind” as required. (Refer to American Air Filter dwgs.B-1175 & B-1179)

F36. Along column line “C”, at column row “8”, the anchor bolts are rusted thin and through.

R36. P2. Replace the base plate and anchor bolts “In-Kind” as required. (Refer to American Air Filter dwgs.B-1175 & B-1179)
Column Line “C” (cont.)

F37. Along column line “C”, at column row “9”, the W8 x 31 web is rusted thin and through and the flange has 40% deterioration at the bottom 1'-0". (Photo 17)

R37. P2. Replace the bottom 4'-0" of the W8 x 31, base plate, and anchor bolts "In-Kind" as required. (Refer to American Air Filter dwgs.B-1175 & B-1179)
Column Line "C" (cont.)

F38. Along column line "C", at column row "11", the W8 x 31 web is rusted thin and through and the flange has 50% deterioration, at the bottom 1'-0". (Photo 18)

F39. Along column line "C", at column row "11", the anchor bolts and nuts have 20% deterioration. (Photo 18)

R38. & R39. P2. Replace the bottom 4'-0" of the W8 x 31, base plate, and anchor bolts "In-Kind" as required. (Refer to American Air Filter dwgs.B-1175 & B-1179)
Column Line “C” (cont.)

F40. Along column line “C” at column row “12”, the W8 x 48 web is rusted thin and through and the flange has 30% deterioration at the bottom 1'-0". (See Photo 19)

F41. Along column line “C”, at column row “12”, the anchor bolts and nuts have 30% deterioration. (Photo 19)

R40. & R41. P2. Replace the bottom 4'-0" of the W8 x 48, base plate, and anchor bolts "In-Kind" as required.
(Refer to American Air Filter dwgs.B-1175 & B-1179)
HOPPER LEVEL @ EL. 687'-0"

Column Line "A"
(Refer to dwg. BH2-SK2)
(Reference American Air Filter dwgs.B-1180 & B-1184)

F42. Along column line "A"; at column row "1", the W8 x 24 flange is rusted thin and through at the bottom 3'-0". (Photo 20)

R42. P2. Reinforce or replace the 3'-0" of the W8 x 24, "In-Kind" as required.
(Refer to American Air Filter dwgs.B-1180 & B-1184)
Along column line “A”, between column rows “1 & 2”, the C6 sheeting girt is rusted thin and through. *(Photo 21)*

Replace the girt “In-Kind” as required.  
(Refer to American Air Filter dwgs. B-1180 & B-1184)

Along column line “A” at column row “2”, the W8 x 28 is rusted and pitted throughout.

Along column line “A” at column row “3”, the W8 x 28 is rusted and pitted throughout.

Along column line “A” at column row “4”, the W8 x 28 is rusted and pitted throughout.

Sandblast rusted areas to sound metal, prime and paint to Globe Metallurgical Inc. specifications.
Column Line "A" (cont.)

F47. Along column line "A", at column row "5", the W8 x 17 beam web and flange have 70% deterioration at the end 3'-0". (Photo 22)

R47. P2. Replace the W8 x 17 "In-Kind" as required.
(Refer to American Air Filter dwgs.B-1180 & B-1184)
Along column line “A”, at column row “5”, the L5” x 5” x 5/16” diagonal at the end 3'-0" and gusset plate are rusted thin and through. (Photo 22)

R48. P2. Replace the diagonal and gusset plate “In-Kind” as required. (Refer to American Air Filter dwgs.B-1180 & B-1184)
Column Line "A" (cont.)

F49. Along column line "A", at column row "6", the W8 x 17 beam web and flange are rusted thin and through at the end 3'-0". (*Photo 23*)

F50. Along column line "A", at column row "6", both L5" x 5" x 5/16" diagonals, at the end 3'-0" and gusset plates, are rusted thin and through. (*Photo 23*)

R49. to Replace the W8 x 17, diagonals and gusset plates "In-Kind" as required.
R50. P2. (Refer to American Air Filter dwgs.B-1180 & B-1184)
Column Line “A” (cont.)

F51. Along column line “A”, at column row “7”, the W8 x 17 beam web and flange are rusted thin and through at the end 3'-0". (Photo 24)

F52. Along column line “A”, at column row “7”, the L5" x 5" x 5/16" diagonal at the end 3'-0" and gusset plate are rusted thin and through. (Photo 24)

R51. to Replace the W8 x 17, diagonal and gusset plate “In-Kind” as required.
R52. P2. (Refer to American Air Filter dwgs.B-1180 & B-1184)
Column Line “A” (cont.)

F53. Along column line “A”, at column row “11”, the W8 x 17 beam web and flange are rusted thin and through at the end 3'-0". (Photo 25)

F54. Along column line “A” at column row “11”, the L5" x 5" x 5/16" diagonal, at the end 3'-0" and gusset plate, are rusted thin and through. (Photo 25)

R53. to Replace the W8 x 17, diagonal and gusset plate “In-Kind” as required.
R54. P2. (Refer to American Air Filter dwgs.B-1180 & B-1184)
Column Line “B”  
(Refer to dwg. BH2-SK2)

F55. Along column line “B”, at column row “12”, the W8 x 17 beam web and flange are rusted thin and through at the end 2'-0". (Photo 26)

R55. P2. Replace the end 4'-0" of the W8 x 17 “In-Kind” as required.  
(Refer to American Air Filter dwgs.B-1183 & B-1184)
Column Line "C"
(Refer to dwg. BH2-SK2)

F56. Along column line "C", between column row "11 & 12", the W8 x 17 beam web and flange are rusted thin and through at the end 3'-0". (Photo 27)

R56. P2. Replace the end 4'-0" of the W8 x 17 "In-Kind" as required. (Refer to American Air Filter dwgs.B-1179 & B-1184)
Column Line “C” (cont.)

F57. Along column line “C”, at column row “12”, the W8 x 17 beam web is rusted thin and through at the end 2'-0”. (Photo 28)

F58. Along column line “C” at column row “12”, the L5” x 5” x 5/16” diagonal at the end 3'-0” and gusset plate are rust packed. (Photo 28)

R57. to Replace the W8 x 17, diagonal and gusset plate “In-Kind as required.
R58. P2. (Refer to American Air Filter dwgs.B-1179 & B-1184)

FRAMING MEMBER BETWEEN EL. 687'-0 & EL. 704-0”

East Elevation
(Refer to dwg. BH2-SK3)
(Reference American Air Filter dwgs.B-1179)

F59. Along column line “A”, between column lines “6 & 7”, the L5” x 5” x 5/16” diagonal, at midspan, was cut and removed 3'-0”.

R59. P2. Replace the diagonal “In-Kind as required.
(Refer to American Air Filter dwgs.B-1179)
EXTERNAL SHEETING AND DOORS @ EL. 704'-0"

East Elevation
(Refer to dwg. BH2-SK3)
(Reference American Air Filter dwgs.B-1179 & B-1104)

NOTE:  Overall, external sheeting has light oxidation throughout.

F60.  Along column line “A”, between column lines “1 & 2”, at bag compartment “1”, the external door is missing.  (Photo 30)

F61.  Along column line “A”, between column lines “2 & 3”, at bag compartment “2”, the external door is rusted thin and through throughout.  (Photo 30)

F62.  Along column line “A”, between column lines “3 & 4”, at bag compartment “3”, the external door is not connected at the top and rusted thin and through throughout.  (Photo 30)

F63.  Along column line “A”, between column lines “4 & 5”, at bag compartment “4”, the external door is missing.  (Photo 30)

F64.  Along column line “A”, between column lines “5 & 6”, at bag compartment “5”, the external door plate is missing at the bottom.

F65.  Along column line “A”, between column lines “6 & 7”, at bag compartment “6”, the external door is rusted thin and through 6” at the bottom.
East Elevation (cont.)

F66. Along column line “A”, between column lines “7 & 8”, at bag compartment “7”, the external door is rusted thin and through 3” at the bottom.

F67. Along column line “A”, between column lines “8 & 9”, at bag compartment “8”, the outside door is rusted thin and through 6” at the bottom.

F68. Along column line “A”, between column lines “9 & 10”, at bag compartment “9”, the external door is bent up 6” at the bottom and will not close.

F69. Along column line “A”, between column lines “10 & 11”, at bag compartment “10”, the external door is not connected at the top and rusted thin and through throughout.

F70. Along column line “A”, between column lines “11 & 12”, at bag compartment “11”, the external door is rusted thin and through 3” at the bottom.

R60. to Replace the doors “In-Kind” as required.
R70. P3. (Refer to American Air Filter dwgs.B-1104 & B-1179)

West Elevation
(Refer to dwg. BH3-SK4)
(Reference American Air Filter dwgs.B-1179 & B-1104)

F71. Along column line “C”, between column lines “1 & 2”, at bag compartment “1”, the center and south external door are rusted thin and through 6” at the bottom and top door hinge is broken.

F72. Along column line “C”, between column lines “2 & 3”, at bag compartment “2”, the north external door will not close properly.

F73. Along column line “C”, between column lines “2 & 3”, at bag compartment “2”, the south external door is rusted thin and through 3” at the bottom and the door handle is broken.

F74. Along column line “C”, between column lines “3 & 4”, at bag compartment “3”, the center and south external doors are rusted thin and through 6” at the bottom.

F75. Along column line “C”, between column lines “4 & 5”, at bag compartment “4”, the north and south external doors are rusted thin and through 6” at the bottom.
**West Elevation (cont.)**

**F76.** Along column line “C”, between column lines “5 & 6”, at bag compartment “5”, the north, center and south external doors are rusted thin and through 6” at the bottom.

**F77.** Along column line “C”, between column lines “6 & 7”, at bag compartment “6”, the center and south external doors are rusted thin and through 6” at the bottom.

**F78.** Along column line “C”, between column lines “7 & 8”, at bag compartment “7”, the center and south external doors are rusted thin and through 6” at the bottom.

**F79.** Along column line “C”, between column lines “8 & 9”, at bag compartment “8”, the center and south external doors are rusted thin and through 6” at the bottom.

**F80.** Along column line “C”, between column lines “9 & 10”, at bag compartment “9”, the center and south external doors are rusted thin and through 6” at the bottom.

**F81.** Along column line “C”, between column lines “10 & 11”, at bag compartment “10”, the center and south external doors are rusted thin and through 6” at the bottom.

**F82.** Along column line “C”, between column lines “11 & 12”, at bag compartment “11”, the north, center and south external doors are rusted thin and through 6” at the bottom.

**R71. to** Replace the doors "In-Kind" as required.

**R82. P2.** (Refer to American Air Filter dwgs.B-1104 & B-1179)

**INTERNAL SHEETING AND DOORS @ EL. 738'-0"**

**West Elevation**

(Refer to dwg. BH2-SK4)

(Reference American Air Filter dwgs. B-1179 & B-1104)

**F83.** Along column line “C”, between column lines “1 & 2”, at bag compartment “1”, the external door is missing.

**F84.** Along column line “C”, between column lines “2 & 3”, at bag compartment “2”, the external door is rusted thin and through, bent and mangled at the bottom 1'-0". *(Photo 31)*
West Elevation (cont.)

F85. Along column line “C”, between column lines “3 & 4”, at bag compartment “3”, the external door is rusted thin and through, bent and mangled at the bottom 1'-0". (Photo 31)

F86. Along column line “C”, between column lines “4 & 5”, at bag compartment “4”, the external door is rusted thin and through, bent and mangled at the bottom 1'-0". (Photo 31)

F87. Along column line “C”, between column lines “5 & 6”, at bag compartment “5”, the external door is missing.

R83. to Replace the doors “In-Kind” as required.
R87. P3. (Refer to American Air Filter dwgs.B-1104 & B-1179)

F88. Along column line “C”, at column line “6”, at bag compartment “6”, the internal divider wall sheeting is bent and wavy.

R88. P4. Replace the sheeting “In-Kind” as required.

F89. Along column line “C”, between column lines “6 & 7”, at bag compartment “6”, the external door is rusted thin and through, bent and mangled at the bottom 1'-0". (Photo 31)

F90. Along column line “C”, between column lines “7 & 8”, at bag compartment “7”, the external door is missing.
West Elevation (cont.)

F91. Along column line “C”, between column lines “8 & 9”, at bag compartment “8”, the external door is missing.

F92. Along column line “C”, between column lines “9 & 10”, at bag compartment “9”, the external door is missing.

F93. Along column line “C”, between column lines “10 & 11”, at bag compartment “10”, the external door is missing.

F94. Along column line “C”, between column lines “11 & 12”, at bag compartment “11”, the external door is missing.

R89. to Replace the doors “In-Kind” as required.
R94. P3. (Refer to American Air Filter dwgs.B-1104 & B-1179)
2015 STRUCTURAL INSPECTION

No.1 Bag house

Prepared for

QSEM Solutions
and
Globe Metallurgical, Inc.

QSEM Solutions Reference No.: 2059-006-1

EQ Engineers, LLC Reference No.: 02-1751-00

Inspection Date: February 16 through February 19, 2015
March 20, 2015

QSEM Solutions, Inc.
6120 S. Gilmore Rd.
Suite 204
Fairfield, OH 45014
USA

Attention: Mr. Ron Hawks
Process Engineering Manager

Subject: Globe Metallurgical, Beverly, OH
No.1 Bag house Structural Framing
2015 Structural Inspection
QSEM Solutions Ref. No.: 2059-006-1
EQ Engineers, LLC Ref. No.: 02-1751-00

Dear Mr. Ron Hawks:

In reference to the above subject, we are issuing this report summarizing the results of the cursory inspection along with corresponding repair recommendations where applicable.

The following is a list of items inspected on February 16 through February 19, 2015 by EQ Engineers, LLC:

- No.1 Bag house Structural Framing
- Concrete Pedestals
- Internal Sheetings
- External Sheetings
- Bag Compartment Doors and Framing

The results of the inspection along with the repair recommendations are contained within the body of this report. Refer to American Air Filter Drawings for use by Globe Metallurgical Inc. personnel.

EQ is submitting (3) three copies of the report, plus an electronic copy for your use. The submission of this report completes EQE’s Scope of Services.

As always, it has been a pleasure working with you and your staff on this project. Should you have any questions concerning any aspect of this report, please contact our office.

Sincerely,

EQ Engineers, LLC

John A. Gill
Inspection Services
Senior Lead Inspector
TABLE OF CONTENTS

SECTION

I. EXECUTIVE SUMMARY

II. INTRODUCTION

III. REPAIR RECOMMENDATIONS, INSPECTION FINDINGS AND PHOTOS

IV. INSPECTION DRAWINGS
I. **EXECUTIVE SUMMARY**

A detailed visual inspection on February 16 through February 19, 2015 of the Globe Metallurgical Inc. – No.1 Bag house Structural Framing, Concrete Pedestals, Sheeting and Bag Compartment Doors, was conducted to determine the condition of the present structures, which are deemed to be in "Fair" condition. The deficiencies encountered during the course of this inspection are in brief description as follows:

1. Baghouse W8 x 28 columns are bent and twisted, twisted and rusted thin and through.
2. Base plates, flanges and webs have 30% to 40% deterioration.
3. X-brace gusset plates are rusted thin and through with 60% to 80% deterioration.
4. Concrete pedestals are cracked and spalled with exposed rebar.
5. Stairway column is bent and twisted.
6. Baghouse W18 x 50 webs are rusted thin and through, at the ends.
7. Walkway grating is rusted thin and through, which is a (SR) safety related finding.
8. External sheeting is loose.
9. Internal sheeting has holes.
10. Internal sheeting is loose and missing.
11. C4 x 5.4 internal sheeting girt is bent down.
12. Internal sheeting is wet.
13. Sheeting screws are pulled loose.
14. Corner flashing is rusted thin and through.
15. Bottom of the doors are rusted thin and through.
16. Door headers are rusted thin and through.
17. Door headers are crushed.
18. Upper bag house has 2'-0" dirt and debris above doorways.
Individual repair recommendations for these deficiencies are provided within the body of this report.

In conclusion, it is recommended that Globe Metallurgical Inc. - Maintenance Department review the contents of this report and develop/implement a comprehensive repair program to address all deficiencies contained herein to prevent their propagation to a more serious condition.
II. INTRODUCTION

A. FORMAT AND PRIORITY SCHEDULE

The following report is formatted by dividing the structure into its basic functional components. The inspection findings (Section III) are numbered sequentially and are in descriptive form. These findings are then followed by repair recommendations which are referenced to their corresponding finding numbers and are based on the following priority schedule:

P1. Emergency Condition – Immediate repairs are required. Operations of the equipment involved should cease until repairs are made.

NOTE: This rating is used when component failure is imminent or has already occurred or if there exists a potential hazard to the safety of personnel or the potential for serious damage to the equipment or machinery.

P2. Critical Condition – Repairs should be made as soon as possible, but in no event should they go unrepaired for more than thirty (30) days.

NOTE: This rating is less serious than a "P1"; however, it is a deficiency that may develop into an emergency condition if it is not repaired within the thirty (30) days.

P3. Primary Deficiency – Repairs should be made within six (6) months or less.

NOTE: This condition does not represent failure or instability at the present time, but may produce additional damage if not repaired.

P4. Secondary Deficiency – Repairs should be made during routine maintenance and in no more than one (1) year.

NOTE: This condition, if neglected for any great length of time, may cause or contribute to future damage.

P5. For Reference Only – No repairs are required at the present time.

NOTE: This deficient condition is minor in nature and is noted only because the condition is less than new.
Safety Related Condition (SR) – Plant Operations should be notified and be made aware that there may be a potential safety hazard to personnel.

Globe Metallurgical Inc. shall review the identified potential safety hazard and prioritize it in accordance with their decision and procedures.

Included in this report, when applicable, are repair standards and repair guidelines, which explains and illustrates the recommended repair for each inspection finding. The inspection location drawings (Section IV) provide the approximate locations of the specific inspection findings referenced in the report. Also, please refer to American Air Filter Drawings.
III. INSPECTION FINDINGS AND REPAIR RECOMMENDATIONS

This inspection report is not intended to serve as a repair document or contractor bid document. This report is also not intended to take the place of detailed engineering. The suggested repair recommendations described in this report are most often common generic repairs, which are currently used throughout the industry. Specific repairs to address particular deficiencies are recommended and described in further detail as required, again utilizing accepted industry practices. Therefore, the recommendations are meant to provide a preliminary scope of work and aid in identifying the magnitude of the required repairs.

The recommended repairs can be performed as maintenance type activities, providing procedures are in place to follow and adhere to current construction standards and practices. The repairs should also be based on the original design of the structure.

Where any repairs are suggested as temporary, they are specifically directed toward deficiencies, which require additional attention to restore the complete integrity of the structure. The anticipated life of the temporary repairs is unknown due to the many possible underlying causes of the observed deficiencies. However, these repairs should be performed as soon as possible until permanent long-term solutions can be developed and implemented. Consideration for all long-term solutions should be primarily, but not solely, based on client operating, maintenance, and/or budgetary constraints.

Where the report indicates that detailed engineering is required, a condition has been identified that, if not promptly addressed and repaired or replaced, has the potential to damage the integrity of the structure. Therefore, engineering analysis should be performed to develop corrective action(s) where appropriate. Activities that define the engineering analysis include, but are not limited to: detailed engineering, shop drawings, bills of material, welding specifications, material specifications, and construction procedures. These items are not included in this report.
III. **INSPECTION FINDINGS AND REPAIR RECOMMENDATIONS** (cont.)

The following list of current inspection findings (F) represents the structural deficiencies encountered during this inspection. Included with the findings are corresponding repair recommendations (R) and repair priorities (P) for each repair recommendation. For specific locations of the inspection findings, refer to the inspection location drawing(s) located in (Section IV) of this report.

**No. 1 BAGHOUSE**

**COLUMNS @ GRADE LEVEL**

**Column Line “1”**
(Refer to dwg. BH1-SK1)
(Reference to Wheelbrator-Frye dwg. No. 1575-9-100 & 1575-9-200)

F1. Along column line “1” and at column row “B”, the W8 x 28 column flange has 30% deterioration at the bottom 6”. (Photo 1)
Column Line “1” (cont.)

F2. Along column line “1” and at column row “C”, the W8 x 28 column flange has 30% deterioration at the bottom 6” (Photo 2)

R1. & R2. P5. Noted for customer use only, should be monitored annually.
Column Line "1" (cont.)

F3. Along column line "1" and at column row "D", the base plate has 30% deterioration. (Photo 3)

R3. P5. Noted for customer use only, should be monitored annually.
**Column Line “1” (cont.)**

**F4.** Along column line “1” and at column row “E”, the south x-brace gusset plate has 60% deterioration. *(Photo 4)*

**R4. P3.** Replace the gusset plate “In-Kind” as required.
*(Refer to Wheelbrator-Frye drawing No. 1575-9-200)*
Column Line "1" (cont.)

F5. Along column line "1" and at column row "E", the W8 x 28 flange has 40% deterioration at the bottom 3" (Photo 5)

R5. P3. Replace the bottom 4'-0" of the W8 x 28, base plate and anchor bolts "In-Kind" as required.
(Refer to Wheelbrator-Frye drawing No. 1575-9-200)
Column Line “1” (cont.)

F6. Along column line “1” and at column row “F”, the concrete pedestal is cracked and spalled in a 3” x 1’-0” area. (Photo 6)

F7. Along column line “1” and at column row “G”, the concrete pedestal is spalled with rebar exposed. (Photo 7)

R6. & R7. P3. Clean the spalled areas to sound concrete, apply a concrete bonding agent, form and pour new concrete “In-Kind” as required.
Argentina
Australia
Belgium
Brazil
Canada
China
Colombia
France
Germany
Hong Kong
Hungary
India
Indonesia
Ireland
Italy
Japan
Kazakhstan
Kenya
Malaysia
Mexico
Myanmar
The Netherlands

New Zealand
Norway
Panama
Peru
Poland
Portugal
Puerto Rico
Romania
Russia
Singapore
South Africa
South Korea
Spain
Sweden
Switzerland
Taiwan
Thailand
UAE
UK
US
Vietnam

ERM’s Cincinnati
9825 Kenwood Road
Suite 100
Cincinnati, Ohio
45219

T:+1 513.830.9030
F: +1 513.830.9031

www.erm.com