TECHNICAL DOCUMENT

SUMMARY

Grecian Magnesite S.A. (hereinafter referred to as the "Purchaser") is procuring the main equipment and detail engineering services for a prototype demonstrative desulphurization installation for its Rotary Kiln No 3. Main characteristic of the demonstrative installation is the use of reactive Caustic Calcined Magnesia (MgO) as the reagent. Procurement is part of the LIFE15 ENV/GR/000338 project.

The flowsheet, mass balance, flue gas data, general layout of the installation and main equipment specification are according to an already finished basic engineering study.

The process flowsheet includes the following stages:

- Receiving the rotary kiln flue gases from the existing chimney. Flue gas quantity 28.000 Nm^3/h to 48.000 Nm^3/h at temperatures ranging from 160°C to 280°C. SO_2 content is 3.000-5.500 mg/Nm^3 dry @10% O_2. Dust load 0,2-2,0 g/Am^3. The kiln flue gas is treated in an Electrostatic Precipitator.

- Conditioning of the flue gases in a Gas Conditioning Tower GCT. Cooling by water injection, to a temperature of 160°C. Except of cooling the flue gas stream the GCT is increasing the humidity of the flue gas in order to increase the efficiency of the desulphurization reagent. Water flow 50-4.000 l/h.

- Dosing and injecting of dry MgO reagent into the stream of flue gas in a specially designed Reactor Pipe. The Reactor Pipe connects the GCT with the Recycling Bag Filter.

- Flue gas and reagent flow into a Recycling Bag filter. Operation of the filter with a thick filter cake to increase interaction time between reagent and gas. Off-line jet-pulse, multi compartment in-line bag filter.

- Collection of the filter dust in a mixing device. Dosing and injecting part of the collected dust back to the Reactor Pipe. The rest of the collected dust is delivered for further handling.

- Delivery of the treated flue gases to a stack.

The main equipment to be procured are the following:

- Gas Conditioning Tower. Size Ø3.000 mm x 12.000 mm evaporative way. All main equipment included (spray nozzles, ring pipe accessories, pump and valve skid pre-assembled and wired). Body shell, support structure, water ring pipes as engineering services for local manufacturing by the Purchaser.

- Dosing and injecting equipment for reagent. One line for fresh additive under silo provided by the Purchaser. Second line for recycled additive under Recycling Bag Filter.

- Recycling bag filter. Off-line, jet pulse, multi compartment filter. Inlet flow 51.000-82.000 Am^3/h. Net filter area 1.300 m^2. PPS filter clothes. Complete, with electronic control unit, filter dust screw conveyor and rotary valve. Support structure and insulation to be manufactured locally by the Purchaser.

- Main Radial Fan, 82.000 Am^3/h, 1.500 rpm, 160 kW installed power, max total pressure increase 4.600 Pa.

- Mixing device for reagent recirculation. Mixing vessel with agitating device, dosing screw for extraction of the recycling portion and extraction screw for discharging the rest of the dust. To be installed under the bag filter.

- Duct equipment (dampers, expansion joints)

- Engineering services for equipment to be manufactured or procured locally by the Purchaser:

    - Crude gas duct from existing chimney to GCT
    - GCT shell and support structure
    - Reactor Pipe and support structure
    - Filter support structure
    - Clean gas duct from filter to fan and new Stack
    - New Stack
    - Reagent Pneumatic transportation equipment.

The required flue gas emissions are:

- < 35 mg/Nm^3 for dust load

- < 1500 mg/Nm^3 dry @10% O_2

The total maximum budget for the above is 720.000€.

The Purchaser will procure locally or manufacture by its own the following:

- Concrete foundations

- Steel support structures
- Ductwork
- Erection
- Electrical panels and distribution and automation
- Peripheral equipment (compressors, silos, etc.)

Due to topographical constrains (unit to be installed close to the kiln and between existing installations and buildings, the general layout foreseen in the basic engineering should be respected.

DETAILED DESCRIPTION – EQUIPMENT SPECIFICATION

CONTENTS

1. Basic Information for Rotary Kiln No3

Rotary Kiln No 3 is used by the Purchaser for production of both Caustic Calcined Magnesia (CCM) and Dead Burned Magnesia (DBM). The feed material is raw magnesite ($MgCO_3$). Magnesite decomposes into the kiln in magnesium oxide (MgO) and CO_2. Caustic calcined magnesia is MgO calcined at a max, temperature of 1.000-1.200°C. Dead Burned Magnesia is chemically MgO, but it is produced at higher temperatures of 1.800-2.000°C. In this case a sintering stage takes part in the last section of the rotary kiln after the calcinations stage. The material becomes inert with a high specific density and has refractory properties.

The combustion gases with the produced CO_2 and dust go after the kiln to an Electrostatic Precipitator for dedusting and then to the existing stack. Heavy Fuel Oil and Petroleum Coke are used as the main fuels. Typical mixture is 90-100% for petroleum coke and 0-10% for heavy fuel oil.

The kiln has a diameter of 3 m and a total length of 90 m. The Run-Of-Kiln material is fed to a rotary cooler to exchange heat with the secondary combustion air. A simplified flowsheet is shown in **Figure 1**.

The kiln produces different grades of CCM and DBM with different chemical and physical properties. The productivity of the kiln and the quantity and analysis of flue gases differ substantially from case to case. One main distinction is between CCM and DBM. Within, each family of products, there are more variations according to the grade in production. The production batches are small and range from one day to one week. Therefore, quantity, temperature and analysis of the flue gas at the stack ranges within wide ranges.

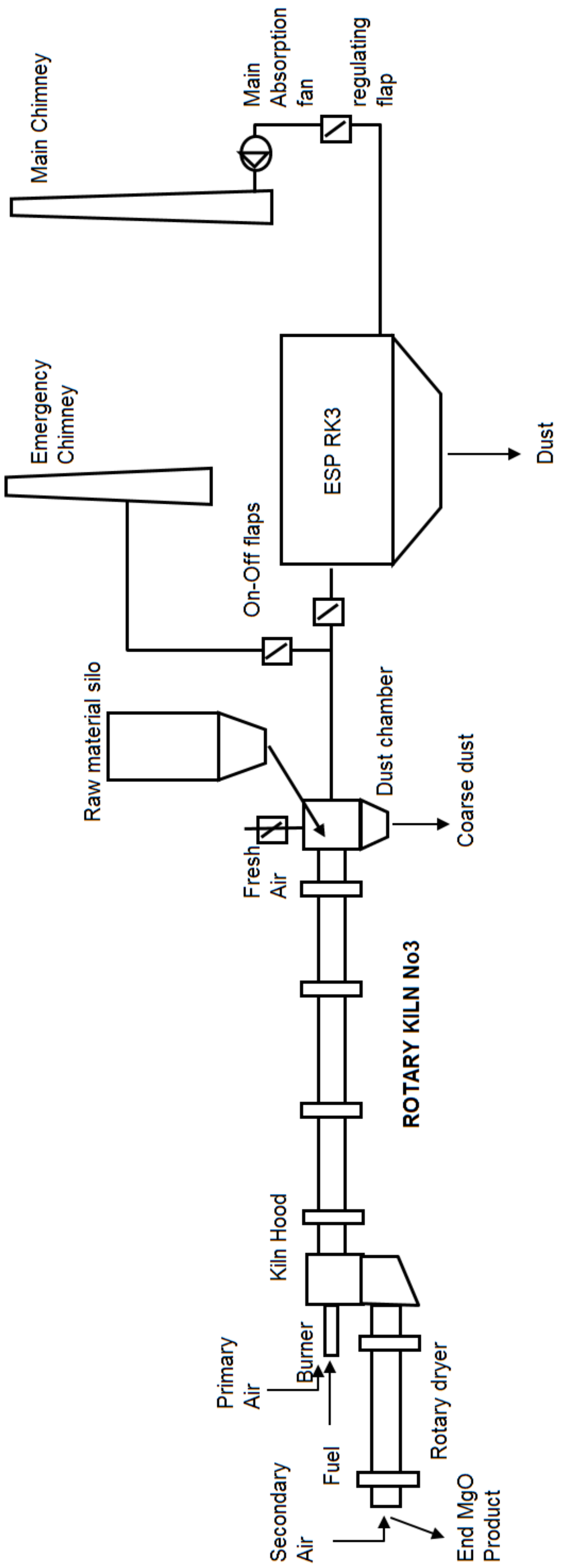


FIGURE 1 : CURRENT FLOWSHEET

2. Flue gas data

During the period 28/7/16 - 23/8/16, the Purchaser conducted a series of measurements at the stack of kiln No 3 (internal diameter of 1,58 m) during the production of various products. The measurements reflect normal operation of a range of typical products and were found as follows:

Flue gas temperature:	246-256°C
Oxygen concentration:	5,27-6,08 % v/v
SO_2 concentration @ 10% O_2:	4.200-4.900 mg/Nm^3_{dry}
Moisture content:	4,5-10% v/v
Volumetric Flow:	53.600 – 61.900 Am^3_{wet}/h
	28.100 – 31.900 Nm^3_{wet}/h
CO_2 calculated:	23-27% v/v

The data were also verified by theoretical calculations. The data above cannot reflect the whole variation therefore we present 4 different scenarios that we believe cover most of the gas data range:

Scenarios (Stack of Kiln No 3)				
	DBM A	DBM B	CCM A	CCM B
Stack temperature, °C	220	280	160	250
Nm^3/h, wet	28.000	40.000	48.000	30.000
Am^3/h, wet	50.600	81.050	76.150	57.500
O_2, % v/v	5	10	10,8	6

	DBM	CCM
SO_2 (10% O_2, mg/Nm^3_{dry})	3.500-5.500	3.000-5.000
Moisture, % v/v	6-10	4-8

For the case of DBM, two scenarios are presented, A & B. This can be considered as minimum/maximum respectively. DBM A is based on one of the recent measurements but chosen with low temperature and % O_2 to reflect a low gas generation/low false air scenario. DBM B was chosen to cover high temperature and false air. B should be considered a max scenario for DBM. SO_2 and moisture are given in the DBM subsection of the table as ranges. Note that these ranges do not necessarily coincide with A and B scenarios as they are mostly determined by other factors and can represent subcases for both A and B.

For the case of CCM, again two scenarios are presented. CCM B reflects one of the recent measurements and can be considered here as the “minimum” CCM scenario. CCM A is a combination of older measurements and used here as the max CCM scenario. Currently, such volumetric flows may be unrealistically high but it could be used as a safety design value for the filter. As with DBMs, CCMs could potentially cover the whole range between cases A and B. SO_2 and moisture are given in the CCM subsection of the table as ranges. Again note that these ranges do not necessarily coincide with A and B scenarios as they are mostly determined by other factors and can represent subcases in both A and B.

The above data where used for the basic design and dimensioning of the pilot unit. There are presented here as background information.

3. Flowsheet of pilot installation

The flowsheet of the pilot desulphurization unit is shown in the following figure. The main stages are as follows:

- Receiving of the kiln flue gases from the top of the existing stack. The stack upper part will be cut to install a new T section and Damper No1 with a new upper stack part. When the Damper 01 is open Damper No2 on the duct to the pilot unit will be closed. Flue gas is exiting the existing stack and the pilot unit is OFF. When Damper No1 is closed and No2 is open the flue gas is treated in the pilot unit.

- Cooling and conditioning of the flue gases in a Gas Conditioning Tower (GCT). Evaporative cooling to 160°C and increase of the gas moisture to assist the performance of the additive. Twin phase nozzles (air-water) are to be used for the injection of water. A valve skid includes all equipment to deliver the water to the nozzles. It will be housed in a small building at the base of the GCT. Compressed air and water tank to be supplied by the Purchaser. Dust collected at the bottom of the GCT is pneumatically transported to an existing dust storage silo. The pneumatic transportation system is the responsibility of the Purchaser.

- Interaction of the flue gas stream and dry powder MgO additive in a specially designed Reactor Pipe. This pipe connects the GCT with the Recycling Bag Filter. There are two injection points:
    - One for fresh additive coming from the additive storage silo
    - One for recycled additive collected from the Recycling Bag Filter. This recycling stream aims at improving the degree of usage of the additive.
- The shape of the pipe has been studied with Computational Fluid Dynamics to assure the correct mixing and interaction of additive and gases.
- The Recycling Bag Filter. The objective of this bag filter is:
    - To collect the used additive and dust contained in the flue gas
    - To provide a second stage of interaction between additive and flue gas during the period that the additive is in the filter cake on the surface of the bags.
- It is an off-line jet pulse cleaning, multi compartment filter with the objective to operate with relatively big intervals between cleaning to provide more time for reaction between additive and flue gas.
- Dosing station for fresh additive. The silo for storing the MgO additive is the responsibility of the Purchaser. A dosing device is under the silo and feeds a pneumatic conveying line for injecting the fresh additive into the Reactor Pipe.
- Mixing and Recycling device for the collected additive. The additive collected by the Recycling Bag Filter is fed in a mixing and dosing device. The objective is to keep the partly used additive in agitation and dose a part of it back to the Reactor Pipe. The remaining additive and dust are extracted, in order to be transported pneumatically to a storage silo (by the Purchaser).
- A pneumatic transportation line for recycled additive to be injected into the Reactor Pipe.
- Clean gas duct after the Bag filter to the radial fan.
- Radial fan of the unit, which covers the flue gas movement from the existing stack to the new stack (i.e. the new unit).
- A new stack for the treated flue gases.

4. General layout drawing

In the attached drawings the general arrangement of the unit is shown. The unit has to be close to the Rotary Kiln No 3 stack and has to fit between existing buildings. The available space is a rectangular area between Rotary Kiln No3 and the Mill building. Between the new unit and RK3 complex a service road has to be available for service vehicles.

The above space restrictions indicate that:

- The GCT, Reactor Pipe, Recycling Bag Filter and radial fan and stack are arranged in line in parallel to the mill building.
- The Bag filter has to be of the in-line compartment configuration, with raw gas entrance and clean gas exit from the one long side. The footprint of the filter has to be
- 9,4 x 4,3 m, the width of 4,3 m should include the width of the side inlet/outlet channel.

The above are depicted in the attached general arrangement drawings.

5. Mass balance

The mass balance for the 4 flue gas flow scenarios is given in the attached PDF document.

APPENDIX –

DETAILED SCOPE OF SUPPLY & SERVICES

1. Raw gas duct from existing stack to GCT

From battery limit at the existing stack to the entrance in the GCT, including emergency stack, dampers and compensators, consisting of:

1.1. Hardware supply - Dampers DA01 and DA02

Damper DA01 to emergency exit - Open / Close max. temperature 320°C

Damper DA02 to desulfurization - Open / Close max. temperature 320°C

2 pcs Shut-off Damper round NW 1400, with Pneumatic Rotary Actuator, single-acting, spring return

1.2. Hardware supply - Compensators

2 pcs. Compensators NW 1400, L = approx. 400 mm, with guide cones

Temperature flex. joints max. 350°C, steel parts made of boiler sheet H2

1.3. Detail engineering raw gas ductwork for local manufacturing

Included are, arrangement drawings, detail drawings for each part, without cutting contours and without bill of materials.

Estimated amount of local manufacturing: 5.500 kg

1.4. Basic engineering for raw gas duct support steel-structure for local manufacturing

Included are static loads for foundation, dimensions of main structure beams, details of foundation anchoring, details of connection between duct and steel structure, general dimensions (without manufacturing workshop drawings, without bill of materials)

2. GCT - Gas conditioning tower

Water and compressed air / Evaporation cooler

Cylindrical body Ø 3000 mm, L = approx. 15 m (evaporation way approx. 12 m)

Max. Temperature cooling tower inlet:	320°C
Temperature cooling tower outlet:	160°C
Max. water consumption:	4.400 l/h
Volume flow compressed air:	180 Nm³/h

2.1. Detail engineering GCT - body for local manufacturing

Consists of the following:

- Arrangement drawings
- Detail drawings without cutting contours and without bill of materials
- Specification for material, pressure resistance, temperature resistance, insulation, surface treatment
- Static calculation of casing and loads to the support structure (structure itself by the Purchaser, detail engineering as well as hardware supply)
- Connecting details GCT- body to the steel structure

Estimated amount of local manufacturing: 19.500 kg

2.2. Basic engineering for maintenance platform at lance level for local manufacturing

Included are, static loads for foundation, dimensions of main structure beams, details of foundation anchoring, details of connection between duct and steel structure, general dimensions (without manufacturing workshop drawings, without bill of materials)

2.3. Hardware supply – 1 pc Rotary valve below GCT

Rotary valve for conveying of bulk materials.

Drive type:	Direct via coupling
Inlet/outlet flange dimensions:	500 x 315 mm
Conveying volume @ 0,6% full:	0,63 m^3/h (500 kg/h)
Gear motor:	1,5 kW

Zero speed switch

2.4. Hardware supply - Pump and valve skid unit with twin fluid nozzle lances for GCT

Consists of the following:

- 3 pcs. Nozzle lances / each one nozzle, type twin fluid, flange mounting, protection tube and accessories.
- 1 pcs. Pump and Valve skid unit. Preassembled, twin pump unit, with required control valves for regulation of flow to the nozzles (water & air), with pump switchover valves and instrumentation and accessories.

2.5. Hardware supply - Accessories for ring pipeline

Consists of the following:

- Pressure transmitter with shut-off valve for each ring main
- Pressure gauge with shut-off valve for each ring main
- Ball valves

2.6. Hardware supply - Wiring and cabling of pump and valve skid unit

Consists of the following:

- Valve skid unit wired up in accordance with DIN
- Junction box wired up in accordance with DIN
- Integration of the junction box on the valve skid unit
- Instrument air hoses to the distributor
- Power wiring of the pumps is not included (by the Purchaser)
- Including engineering consisting of compiling of the wiring diagrams

2.7. Engineering for a temperature control system for GCT- Hardware supply by the Purchaser

Developing a control concept for the operation of the GCT and the flue gas temperature control.

Verbal description of the temperature control, including:

- Automatic, semi-automatic, and manual operation
- Testing and creating operational readiness
- Cyclical switchover of the pumps

2.8. Basic engineering for water ring pipeline

Consists of the following:

- Arrangement drawings
- Detail drawings without bill of materials
- Specification for: material, pressure resistance, temperature resistance, insulation, surface treatment
- Connecting details GCT- water pipe

3. Reactor pipe from GCT to Filter

3.1. Hardware supply - Compensators

1 pcs. Compensators NW 1250 - L = approx. 300 mm, with guide cones

Temperature flex. joint max. 200 °C, steel parts made of 1.0038 carbon steel

1 pcs. Compensators NW 1600 - L = approx. 300 mm, with guide cones

Temperature flex. joint max. 200 °C, steel parts made of 1.0038 carbon steel

3.2. Detail engineering reactor pipe for local manufacturing

Consists of the following:

- Arrangement drawings
- Detail drawings for each part, without cutting contours and without bill of material.
- Specification for: material, pressure resistance, temperature resistance, insulation, surface treatment

Estimated amount of local manufacturing: 9.500 kg

3.3. Basic engineering - support structure for reactor pipe / stair tower

Consists of the following:

- Static loads for foundation
- Dimensions of main structure beams
- Details of foundation anchoring
- Details of connection between duct and steel structure
- General dimensions (without manufacturing workshop drawings, without bill of materials)

4. Recirculation pulse jet bag filter

For min. 51.000 Am^3/h and max. 82.000 Am^3/h.

4.1. Basic engineering - Filter support structure

Consists of the following:

- Static loads for foundation
- Dimensions of main structure beams
- Details of foundation anchoring
- Details of connection between filter and steel structure
- General dimensions (without manufacturing workshop drawings, without bill of materials)

4.2. Bag filter- Hardware supply

Chamber filter with intermediate walls in raw- and clean gas side for off-line jet pulse cleaning.

Configuration: single-row, in-line. Footprint to be about 9,4 x 4,3 m. The width value should include the width of side channel for inlet/outlet of gas.

Gas flow min.:	51.000 m^3/h
Gas flow max.:	82.000 m^3/h
Gas temperature:	160°C
Bag material:	PPS550
Filter area gross:	--- m^2
Filter area net (off-line cleaning):	1310 m^2
Casing material:	1.0038

Max. neg. pressure:	8000 Pa (mech. body)
Max. temperature (mech. body):	250°C
Max. temperature (bags continuously):	180°C
Diaphragm valves:	2"
Material of support cages:	ecp-coated
Design:	2-split
Number of wires:	10 pcs

Price for filter bags to be provided separately as option.

4.3. Control & Cleaning system for filter – Hardware supply

Cleaning controller for fully automatic control of cleaning pulses (single valve actuation), actuation and/or position detection of raw-/clean gas dampers.

Cleaning can be timer based, continuous or differential pressure based. Off-line cleaning programs and on-line cleaning programs.

All relevant operating data are recorded, various interfaces (PROFIBUS) and digital and analog in- and output signals are available for communication to process control systems. System can be accessed for remote maintenance via internet.

4.4. Shut-off slides, discharging screw conveyor– Hardware supply

4.4.1. Shut-off Slide Gates

250 x 250 mm slide gates, manually operated, for dust discharge at each compartment above screw conveyor

4.4.2. Filter dust Screw Conveyor

Trough screw conveyor for conveying of bulk materials (filter dust)

Screw diameter:	400 mm
Conveying volume @ 38 % full:	18,13 m^3/h (14.500Kg/h) @ 24,0 rpm
Density of bulk material:	800 kg/m^3
Temperature of bulk material:	150°C
Inclination:	0°
Gear motor:	5,5 kW, foot-mounted,

Zero speed switch

4.5. Rotary valve for filter dust discharging – Hardware supply

Rotary Valve for conveying of bulk materials.

Drive type:	Direct via coupling
Inlet/outlet flange dimensions:	400 x 250 mm
Bulk material temperature approx..:	< 150°C
Conveying volume @ 29,8% full:	18,13 m^3/h (14.500 kg/h)
Specific weight of bulk material:	800 kg/m^3
Speed:	39 rpm
Gear motor:	1,1 kW, foot-mounted

Zero speed switch

4.6. Filter penthouse - Basic engineering

Consists of the following:

- General layout drawing of penthouse enclosure
- Detailed engineering for connection points filter to penthouse
- Static calculation and loads to the filter (structure itself by the Purchaser, detailed engineering as well as hardware supply)

4.7. Fresh air emergency flap

Shut-off flap NW710, temp. max 250°C, material carbon steel, welded design, with flanges. Pneumatic rotary actuator, single acting spring return. Position indicator. To protect bag filter from overheating in case of emergency.

5. Clean gas duct from filter to fan and from fan to stack

5.1. Hardware supply - Compensator

1 pcs. Compensators NW 1400 - L = approx. 300 mm, with guide cones

Temperature flex. joint max. 200 °C, steel parts made of 1.0038 carbon steel

5.2. Detail engineering clean gas ductwork for local manufacturing

Consists of the following:

- Arrangement drawings
- Detailed drawings for each part, without cutting contours and without bill of materials
- Specification for: material, pressure resistance, temperature resistance, insulation, surface treatment
- Static loads for foundation

6. Radial fan 82.000 Am³/h

For variable speed drive, frequency converter to be supplied by the Purchaser.

6.1. Radial Fan - Hardware supply

With motor (but without frequency converter)

Radial fan in industrial duty design, fan wheel with backwardly curved blades

Drive type: direct via coupling

Max.operating conditions:

Medium:	Clean gas
Volumetric flow:	82.000 m^3/h
Temperature:	160ºC
Density at standard conditions:	1,293 kg/m^3
Total pressure increase:	4.633 Pa
Pressure increase:	4.314 Pa
Negative pressure at inlet:	3.000 Pa
Density at inlet:	0,781 kg/m^3
Elevation:	100 m above sea level
Fan speed:	1.476 rpm
Max. fan speed (mech.):	1.500 rpm
Temperature rating (mechanical):	Max. 250ºC
Shaft power consumption at operating condition:	125,0 kW
Motor power:	160 Kw

Min. operating conditions:

Medium:	Clean gas
Volumetric flow:	51.000 m^3/h
Temperature:	160ºC
Density at standard conditions:	1,293 kg/m^3
Total pressure increase:	3.671 Pa
Pressure increase:	3.548 Pa
Negative pressure at inlet:	3.000 Pa
Density at inlet:	0,781 kg/m^3
Elevation:	100 m above sea level
Fan speed:	1.250 rpm
Max. fan speed (mech.):	1.500 rpm
Temperature rating (mechanical):	Max. 250ºC
Shaft power consumption at operating condition:	65,2 kW
Motor power:	160 kW
Casing material:	1.0038
Impeller material:	1.0038

Shaft material:	Ck45
Fan base material:	1.0038 (S235JR)
Bearing:	2 pillow-block bearings
Accessories:	3-phase motor 160 kW, 1485 rpm
	Vibration dampers
	Expansion joints inlet/outlet

6.2. Fan monitoring equipment - Hardware supply

Consists of the following:

- Zero speed switch
- Resistance temperature sensor (2 pcs.) for bearing temperature monitoring
- Vibration monitoring

7. Stack Ø 1400 mm - Engineering

Single wall stack. “Scruton” strakes at the upper part for oscillation dumping. Made of carbon steel for the lower and median part. Stainless steel for the upper part with the Scruton strakes. Local insulation for the lower part.

Stack dimensions:

Exhaust height of the stack:	+ 28,90 m
Base of the stack:	- 0,60 m
Stack length:	29,50 m
Stack diameter:	1400 mm

1 nr. measuring platform, 360°

1 nr. safety ladder

7.1. Detail engineering for Stack

1set Engineering Documentation comprising the following:

- Proof able static and dynamic calculations
- Anchorage Drawing with Foundation Loads
- General Arrangement Drawing for approval
- 1 set of Shop Drawings
- Erection Method Statement

7.2. Basic engineering for emission measuring platform

Consists of the following:

- Static calculation
- Dimensions of main structure beams
- Details of connection between stack and steel structure
- General dimensions (without manufacturing workshop drawings, without bill of materials)

8. FRESH - Additive dosing system

Without additive silo

8.1. Filter for silo ventilation - Hardware supply

Silo-top filter with fan and control unit with fully automatic ONLINE-cleaning of the filter bags with compressed air

Gas volume:	2500 m^3/h
Gas temperature:	50ºC
Filter bag material:	PE 550
Filtering area:	19 m^2
Diaphragm valves:	1 ½ "
Cleaning controller:	Timer based
Assorted fan:	2500 m^3/h / 3kW / 2-pole motor

8.2. Fresh additive dosing system - Hardware supply

Consists of the following:

- Shut-off slide below silo
- Dosing device 100 - 1000 kg /h, gear motor able for frequency converter operation
- Discharge rotary valve
- Pneumatic conveying system (i.e. blower, feed injector, conveying tube 20 m, conveying pressure monitoring system). Basic engineering only. Hardware by the Purchaser.

8.2.1. Silo shut-off slide

DN250 hand operated

8.2.2. Dosing device

Volumetric dry material dosing device for trickling hard flowing materials.

- Connection flange 400 x 700 mm
- Dosing capacity 100-1000 kg/h
- Dosing accuracy ±5%
- Geared motor for frequency control, forced cooling

8.2.3. Rotary valve

- Capacity 3300l/h
- Rotor stainless steel
- Direct drive, with coupling
- Geared motor 0,55 kW
- Zero speed sensor

8.2.4. Basic engineering for dosing system and pneumatic transportation system

Consists of the following:

- General layout drawing
- P&I diagram
- Functional description and programming specification
- Equipment and piping specification for pneumatic transportation system

9. RECIRCULATION - Additive dosing system

Consists of the following:

- Mixing – dosing device for recirculation with dosing screw for 14.500 kg/h
- Extraction screw conveyor Ø 200 for extracted (exhausted) additive 1.500 kg/h
- Rotary valve for extracted additive approx. 1500 kg/h
- Rotary valve for recirculated additive approx. 14.500 kg/h
- Pneumatic conveying system for recirculated additive (i.e. blower, feed injector, conveying tube 20 m, conveying pressure monitoring system). Basic engineering only. Hardware by the Purchaser.

9.1. Recirculation mixing and dosing device – Hardware supply

9.1.1. Mixing - dosing device

A solid bin about $6m^3$ capacity in welded design with integrated discharging openings, twin mixing arms and bottom dosing screw Ø300 for the recirculated additive.

Dosing screw 5,5kW

Mixing arms 2 x 3,0 kW

9.1.2. Trace heater for mixing-dosing device

Installed heating power about 8 kW. For keeping mixing bin in constant temperature during start-up.

9.1.3. Screw Conveyor for extracted dust-additive, on top of mixing device

Pipe screw conveyor for conveying of bulk materials (filter dust)

Screw diameter:	200 mm
Pipe trough length:	4.000 mm
Conveying volume @ 30 % full:	3,00 m^3/h @ 39,0 rpm
Temperature of bulk material:	150ºC
Inclination:	0°
Gear motor:	1,5 kW foot-mounted
Zero speed switch	

9.1.4. Rotary Valve for extracted additive

Rotary Valve for conveying of bulk materials, under extracted additive screw conveyor.

Drive type:	Direct via coupling
Inlet/outlet flange dimensions:	250 x 250 mm
Bulk material temperature approx.:	< 150ºC
Conveying volume @ 12,1% full:	1,88 m^3/h (1.500 kg/h)
Gear motor:	0,75 kW, foot-mounted,
Zero speed switch	

9.1.5. Rotary Valve for recirculated additive

Rotary Valve for conveying of bulk materials, under mixing device dosing screw.

Inlet/outlet flange dimensions:	400 x 250 mm
Bulk material temperature approx.:	< 150°C
Conveying volume @ 29,8% full:	18,13 m^3/h (14.500 kg/h) @ 39rpm
Gear motor:	SEW 1,1 kW, foot-mounted

Zero speed switch

9.2. Basic engineering for dosing & pneumatic conveying system

Consists of the following:

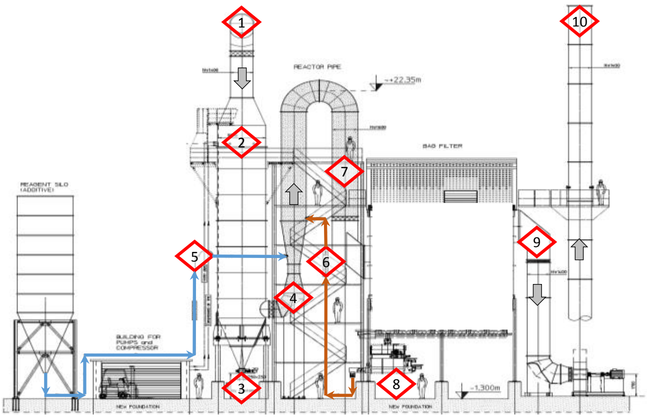
- General layout drawing
- P&I diagram
- Functional description and programming specification
- Equipment and piping specification for pneumatic transportation system

10. Daily rates for erection, supervision, and commissioning/start-up

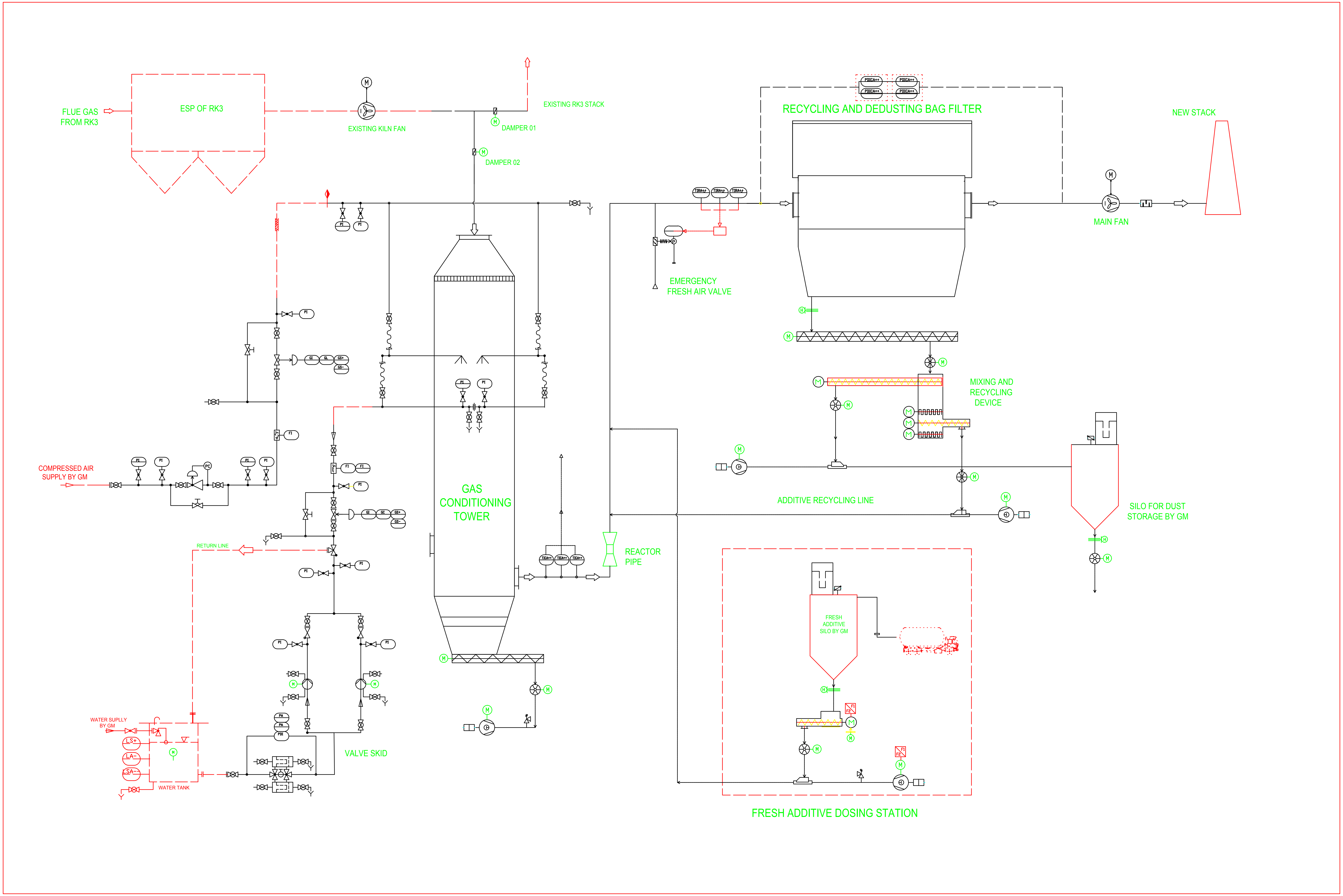
- Daily rate for an engineer for erection supervision, when necessary, at different stages of the project

- Daily rate for a commissioning engineer

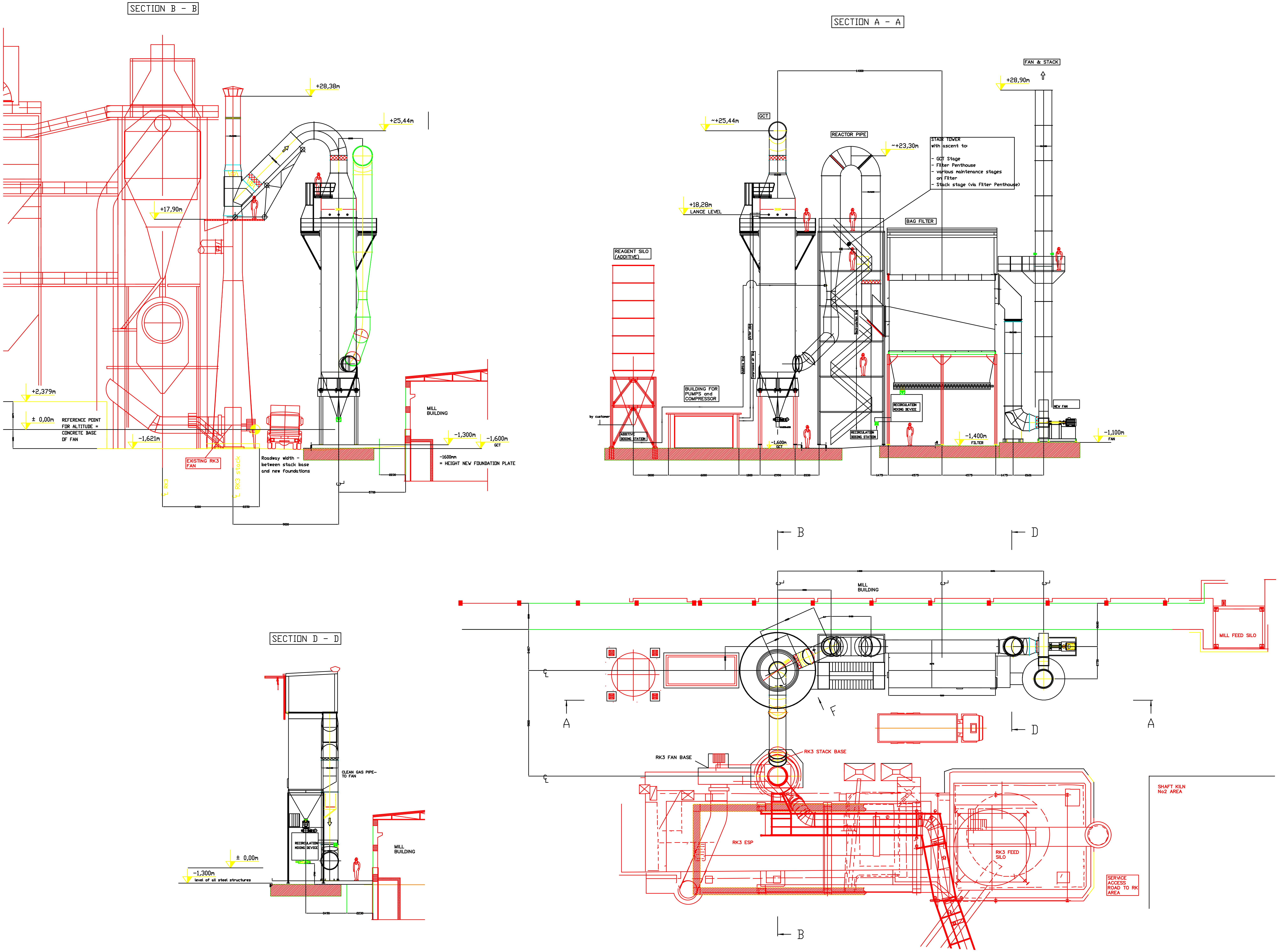
Summary of Balance sheets



Balance point / Scenario		DBM A		DBM B		CCM A		CCM B	
1 - from kiln									
Volume flow	Nm³/h, wet	28.000		40.000		48.000		30.000	
	m³/h, wet, approx.	51.100		82.000		77.000		58.000	
temperature	°C, nominal	220		280		160		250	
	°C, max	320		320		320		320	
dust load	g/Nm³, dry	7		7		7		7	
	g/m³, wet	3,5		3,1		4		3,3	
	kg/h	178,9		253,8		307,7		191,6	
pressure	bar (approx.)	1,002		1,002		1,002		1,002	
SO2 content, min	mg/Nm³, dry (@10% O2)	3.500		3.500		3.000		3.000	
SO2 content, max	mg/Nm³, dry (@10% O2)	5.500		5.500		5.000		5.000	
2 - water and compressed air / Cooling tower									
Volume flow water	m³/h, nominal	1,1		2,8		-		1,5	
	m³/h, @ max. inlet temperature	2,5		3,7		4,4		2,7	
Volume flow compressed air	Nm³/h	180		180		180		180	
pressure water	bar	2,7		4,8		5,7		3,3	
pressure compressed air	bar	2,7		4,3		5		3	
3 - dust seperation cooling tower									
mass flow	kg/h	53,7		76,1		92,3		57,5	
4 - cooling tower outlet									
Volume flow	m³/h, wet, approx.	47.400		70.500		77.000		52.000	
temperature	°C	160		160		160		160	
dust load	g/m³, wet	2,6		2,5		2,8		2,6	
pressure	bar (approx.)	0,997		0,997		0,997		0,997	
5 - additiv dosing									
Additiv type		Sorbacal SPS	Magnesium-oxid	Sorbacal SPS	Magnesium-oxid	Sorbacal SPS	Magnesium-oxid	Sorbacal SPS	Magnesium-oxid
stoich. Factor		3	10	3	10	3	10	3	10
dosing rate, min	kg/h (@min SO2 content)	280	500	400	720	480	870	230	420
dosing rate, max	kg/h (@max SO2 content)	540	1.000	770	1.400	810	1.460	500	910
conveying air	Nm³/h, approx.	300	300	300	300	300	300	300	300
6 - recirculation									
recirculation factor		5	10	5	10	5	10	5	10
recirculation rate, min	kg/h, approx.	1.400	5.000	2.000	7.200	2.400	8.700	1.150	4.200
recirculation rate, max	kg/h, approx.	2.700	10.000	3.850	14.000	4.050	14.600	2.500	9.100
conveying air	Nm³/h, approx.	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500
7 - filter inlet									
Volume flow, approx.	m³/h, wet	51.000		74.000		82.000		55.500	
temperature, approx.	°C	150		150		150		150	
dust load, approx.	g/Nm³, dry, min / max	70 / 120	205 / 400	70 / 130	210 / 400	70 / 115	215 / 360	53 / 110	160 / 345
	g/m³, wet, min / max	40 / 67	115 / 220	37 / 68	115 / 215	40 / 65	120 / 205	29 / 60	90 / 190
	kg/h, min / max	1.900 / 3.500	5.800 / 11.000	2.700 / 5.000	8.250 / 15.700	3.250 / 5.300	9.900 / 16.600	1.600 / 3.300	4.800 / 10.400
pressure, approx.	bar	0,989		0,989		0,989		0,989	
8 - dust to silo									
@ min dosing rate, approx.	kg/h	485	730	700	1.050	830	1.250	430	630
@ max dosing rate, approx.	kg/h	810	1.300	1.160	1.850	1.250	2.000	780	1.230
9 - filter outlet									
Volume flow, approx.	m³/h, wet	51.000		74.200		82.000		56.000	
temperature, approx.	°C	150		150		150		150	
dust load, approx.	g/Nm³, dry	<10		<10		<10		<10	
pressure, approx.	bar	0,974		0,974		0,974		0,974	
10 - chimney									
Volume flow, approx.	m³/h, wet	49.200		72.000		79.200		54.000	
temperature, approx.	°C	145		145		145		145	
dust load, approx.	g/Nm³, dry	<10		<10		<10		<10	
pressure, approx.	bar	1,007		1,007		1,007		1,007	
SO2 content	mg/Nm³, dry (@10% O2)	1.350		1.350		1.350		1.350	



FLUE GAS FROM RK3
ESP OF RK3
EXISTING KILN FAN
EXISTING RK3 STACK
DAMPER 01
DAMPER 02
RECYCLING AND DEDUSTING BAG FILTER
NEW STACK
MAIN FAN
EMERGENCY FRESH AIR VALVE
MIXING AND RECYCLING DEVICE
ADDITIVE RECYCLING LINE
SILO FOR DUST STORAGE BY GM
GAS CONDITIONING TOWER
REACTOR PIPE
COMPRESSED AIR SUPPLY BY GM
RETURN LINE
WATER SUPLLY BY GM
WATER TANK
VALVE SKID
FRESH ADDITIVE SILO,BY GM
FRESH ADDITIVE DOSING STATION


SECTION B - B
+28,38m
+25,44m
+17,90m
+2,379m
± 0,00m
REFERENCE POINT FOR ALTITUDE = CONCRETE BASE OF FAN
-1,621m
EXISTING RK3 FAN
RK3 STACK
Roadway width - between stack base and new foundations
-1,300m
-1,600m
GCT
MILL BUILDING
-1600mm = HEIGHT NEW FOUNDATION PLATE
SECTION A - A
FAN & STACK
+28,90m
~+25,44m
GCT
REACTOR PIPE
~+23,30m
STAIR TOWER with ascent to:
- GCT Stage
- Filter Penthouse
- various maintenance stages on Filter
- Stack stage (via Filter Penthouse)
+18,28m LANCE LEVEL
BAG FILTER
REAGENT SILO (ADDITIVE)
BUILDING FOR PUMPS and COMPRESSOR
by customer
ADDITIVE DOSING STATION
RECIRCULATION MIXING DEVICE
RECIRCULATION DOSING STATION
-1,600m GCT
-1,400m FILTER
-1,100m FAN
NEW FAN
SECTION D - D
CLEAN GAS PIPE- TO FAN
RECIRCULATION MIXING DEVICE
MILL BUILDING
± 0,00m
-1,300m level of all steel structures
B
D
MILL BUILDING
MILL FEED SILO
A
F
D
A
RK3 FAN BASE
RK3 STACK BASE
RK3 ESP
RK3 FEED SILO
SHAFT KILN No2 AREA
SERVICE ACCESS ROAD TO RK AREA
B