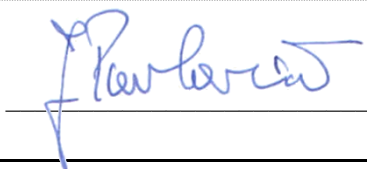
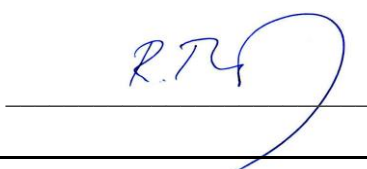


Project part:	Process project				
Client:	JP Elektroprivreda Srbije, Carice Milice 2, Belgrade				
Facility:	FGD Construction Project for TPP Nikola Tesla A, Location: Obrenovac, K.P. 1934, K.O. Urovci				
Doc. type:	IDR - Conceptual design				
Type of works:	New construction				
Designer:	delta inženjering, Zaplanska br. 86, 11010 Beograd – Voždovac				
Designer's representative:	Jugoslav Pavlović, dipl.ing.maš., director				
Sign and stamp:	 				
Main designer:	Radoje Tufegdzic, dipl.ing.teh.				
License number:	371 5696 03				
Sign and personal stamp:	 				
Doc. number:	NTFGD- -IDR-7.1				
Contract	Facility	Doc. type	Project part	Book part	Revision
NTFGD		IDR	7	1	0
Place and date:	Belgrade, 2018				

2018	0	IDR - Conceptual design		
Datum:	Rev.	Vrsta tehničke dokumentacije:	Uradio:	Odobrio:
✉ Zaplanska br. 86, 11010 Beograd – Voždovac ☎ Telefon: +381-11-78.56.903 📠 Faks: +381-11-31.21.788 🌐 www.deltainzenjering.rs			  	
Šifradelatnosti: 7112;	Matični/Registracioni broj: 17085123;	PIB: SR100062229,	PDV br.: 386473	

	Investitor:	JP Elektroprivreda Srbije, Carice Milice 2, Belgrade				
	Objekat:	FGD Construction Project for TPP Nikola Tesla A, Lokacija: Obrenovac, K.P. 1934, K.O. Urovci				
	Vrsta teh. dokum.:	IDR - Conceptual design				
Deo projekta:		NTFGD- -IDR-7.1	Process project.		List: 1.2.1	Rev.: 0

1.2 BOOK CONTENTS						
No	Document name	Document No	Format	Page	Rev.	Date
1.1	BOOK COVER PAGE	NTFGD- -IDR-7.1 -00	A4		0	
1.2	BOOK CONTENTS	NTFGD- -IDR-7.1 -00	A4		0	
1.3	DECISION ON APPOINTING THE MAIN DESIGNER	NTFGD- -IDR-7.1 -00	A4		0	
1.4	STATEMENT OF THE RESPONSIBLE DESIGNER	NTFGD- -IDR-7.1 -00	A4		0	
1.5	TEXTUAL DOCUMENTATION	NTFGD- -IDR-7.1 -00	A4		0	
1.5.2	Technical description	NTFGD- -IDR-7.1 -00	A4		0	
1.6.	NUMERICAL DOCUMENTATION	NTFGD- -IDR-7.1 -00	A4		0	
1.6.1	FGD plant mass balances	NTFGD- -IDR-7.1 -00	A4		0	
1.7.	GRAPHICAL DOCUMENTATION	NTFGD- -IDR-7.1 -00	A4		0	
	General layout plot plan	NTFGD-S0.0-IDR-6.0.0- 000-001D-rev00	A1	1	0	
	FGD process flow diagram	NTFGD-S0.0-IDR-7.0.0-000-002D-rev00	A1	1	0	
	Mass balance – Case 1-1	NTFGD-S0.0-IDR-7.0.0-000-003D-rev00	A1	2	0	
	Mass balance – Case 1-2	NTFGD-S0.0-IDR-7.0.0-000-004D-rev00	A1	2	0	
	Mass balance – Case 2-1	NTFGD-S0.0-IDR-7.0.0-000-005D-rev00	A1	2	0	
	Mass balance – Case 2-2	NTFGD-S0.0-IDR-7.0.0-000-006D-rev00	A1	2	0	
	Mass balance – Case 3-1	NTFGD-S0.0-IDR-7.0.0-000-007D-rev00	A1	1	0	
	Mass balance – Case 3-2	NTFGD-S0.0-IDR-7.0.0-000-008D-rev00	A1	1	0	

	Investitor:	JP Elektroprivreda Srbije, Carice Milice 2, Belgrade			
	Objekat:	FGD Construction Project for TPP Nikola Tesla A, Lokacija: Obrenovac, K.P. 1934, K.O. Urovci			
	Vrsta teh. dokum.:	IDR - Conceptual design			
Deo projekta:	NTFGD- -IDR-7.1	Process project.	List:	1.3.1	Rev.: 0

1.3

DECISION ON APPOINTING THE MAIN DESIGNER

According to the Article 128a of Law on Planning and Construction (Official Gazette of RS, no. 72/09, 81/09-correction 64/10-decision US, 24/11 and 121/12, 42/13 decision US, 50/2013 – decision US, 98/2013 – decision US, 132/14 and 145/14) and regulations of the Rulebook on content, manner and process of making and conducting of technical documentation control according to class and purpose of the facility (Official Gazette of RS, no. 23/2015, 77/2015, 58/2016, 96/2016 and 67/2017) as:

MAIN DESIGNER

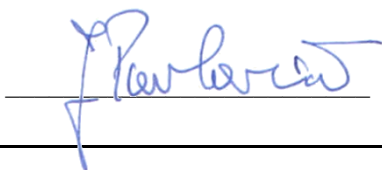
 Zaplanska br. 86, 11010 Beograd – Voždovac	No. <u>397 /18</u> 06.02.18
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For preparation of technical documentation:

Project part:	Process project
Facility:	FGD Construction Project for TPP Nikola Tesla A, Location: Obrenovac, K.P. 1934, K.O. Urovci
Doc. type:	IDR - Conceptual design
Type of works:	New construction

is appointing:

Main designer:	Radoje Tufegdžić, dipl.ing.teh.
License number:	371 5696 03

Designer:	delta inženjering , Zaplanska br. 86, 11010 Beograd – Voždovac
Designer's representative:	Jugoslav Pavlović, dipl.ing.maš., direktor
Sign and personal stamp:	 
Doc. number:	NTFGD- -IDR-7.1
Place and date:	Belgrade, 2018

	Client:	JP Elektroprivreda Srbije, Carice Milice 2, Belgrade			
	Facility:	FGD Construction Project for TPP Nikola Tesla A, Lokacija: Obrenovac, K.P. 1934, K.O. Urovci			
	Doc. type:	IDR - Conceptual design			
Project part:	NTFGD- -IDR-7.1 -00	Process project	Page	1.4.1	Rev.: 0
1.4 DECLARATION OF RESPONSIBLE DESIGNER					

Responsible designer for the preparation of technical documentation:

Project part	Process project,
Facility:	FGD Construction Project for TPP Nikola Tesla A, Location: Obrenovac, K.P. 1934, K.O. Urovci
Doc. type:	IDR - Conceptual design
Type of works:	New construction

Responsible designer:	Radoje Tufegdžić, dipl.ing.
License number:	371 5696 03

I DECLARE

- that the project is entirely in compliance with: other technical documentation for the facility
- that the project was made in accordance with the Law on planning and construction, regulations, standards and norms in the field of construction and rules of the profession;
- that during the project preparation are complied all the prescribed and defined measures and recommendations for meeting the essential requirements for the facility and that the project is prepared in accordance with the measures and recommendations by which is proven the fulfillment of basic requirements.

Responsible designer:	Radoje Tufegdžić, dipl.ing.
License number:	371 5696 03
Sign and personal stamp:	 
Doc. number:	NTFGD- -IDR-7.1
Place and date:	Belgrade, 2018

	Investitor:	JP Elektroprivreda Srbije, Carice Milice 2, Belgrade			
	Objekat:	FGD Construction Project for TPP Nikola Tesla A, Lokacija: Obrenovac, K.P. 1934, K.O. Urovci			
	Vrsta teh. dokum.:	IDR - Conceptual design			
Deo projekta:	NTFGD- -IDR-7.1	Process project.	List:	1.5.1	Rev.: 0

1.5	TEXTUAL DOCUMENTATION
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1.5.2		Technical description				

1.5.2.1 Preface and capacity

TPP Nikola Tesla A (TENT A) is the largest thermal power plant in Serbia, with six units with total capacity of 1,650 MW. It is located on the right bank of the Sava River, near Obrenovac and is the largest individual producer of electricity in the Serbian electric power system. On average it produces more than 8000 GWh per year. Its first unit with capacity of 210 MW, was put into operation on March 7, 1970. Six months later unit A2 of the same capacity, was put into operation. They were back then, the most economical units. The construction was continued after five years, so by the end of 1979 EPS was strengthened with another four units of 305 + 3x308.5 MW, and TENT A reached the country's single largest energy facility. Table 1.1 shows the capacity of TENT A units, with the projected coal quality and coal consumption.

Table 1.1 TENT A boiler capacity and coal consumption

		A1	A2	A3	A4	A5	A6
Unit capacity	MW	210	210	329	308,5	340	347,5
Coal LHV	kJ/kg	6700	6700	6700	6700	6700	6700
Coal consumption	t/h	350	350	440	440	440	490
Specific coal consumption	t/MWh	1,66	1,66	1,34	1,43	1,29	1,41

All TENT A units emit sulfur dioxide (SO₂) in significant amounts, which exceed the emission limit values set by domestic and EU regulations.

Following the adoption of the environmental protection laws, which were imposed at the end of 2004, as well as the Law on Ratification of the Treaty establishing the Energy Community of South East Europe, Elektroprivreda Srbije (EPS) has initiated a series of activities aimed at fulfilling the obligation to harmonize the operation of thermal power plants with the requirements of EU regulations regarding air protection. Bearing in mind the contribution of thermal power plants to the total emissions of certain pollutants (sulfur dioxide, nitrogen oxides and dust particles), the necessary funds and the necessary time for the realization of the projected technical protection measures, priority was given to the projects of reducing the dust emissions on the existing boilers. It should be emphasized that these reconstructions were also a condition for the introduction of measures for reduction of sulfur dioxide emissions on boilers, since the wet limestone-gypsum process was chosen as the optimal flue gas desulphurization technology for lignite fired boilers with a power exceeding 300 MW.

After many years of activities to tackle the problem of TENT A flue gas desulphurization, a contract was signed with a consortium led by Mitsubishi Hitachi Power Systems (MHPS). MHPS will build the FGD plant in TENT A in Serbia. The project envisions the construction of flue gas desulphurization facilities for blocks A3, A4, A5 and A6. Blocks A1 and A2 are omitted because they will be put out of use due to end-of-life.

FGD on blocks A3, A4, A5 and A6 will be applied with a wet limestone method, using limestone as a sorbent. By-product is gypsum, of construction grade quality. As can be seen from the basic scheme in Figure 1.1, the flue gas desulphurization technology with a wet limestone process generally includes the following technological operations:

- After removal of solid particles in electrostatic filters (two per unit), flue gases are fed into two absorbers, one for the units A3 and A4, and the other for the units A5 and A6;
- For the desulphurization process, water is pumped into the absorbers, fine limestone slurry prepared in a wet ball mill is added, and the necessary amount of air that provides oxygen for the reaction to unfold;

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- In the reaction of limestone, water, oxygen and SO₂ from flue gases, gypsum (CaSO₄x2H₂O) and CO₂ are produced, and gypsum from the absorber is sent to thickening and filtration, or to thickening and deposition on TENT A ash landfill;
- The cleaned flue gas is discharged from the absorber, through a wet stack, into the environment.

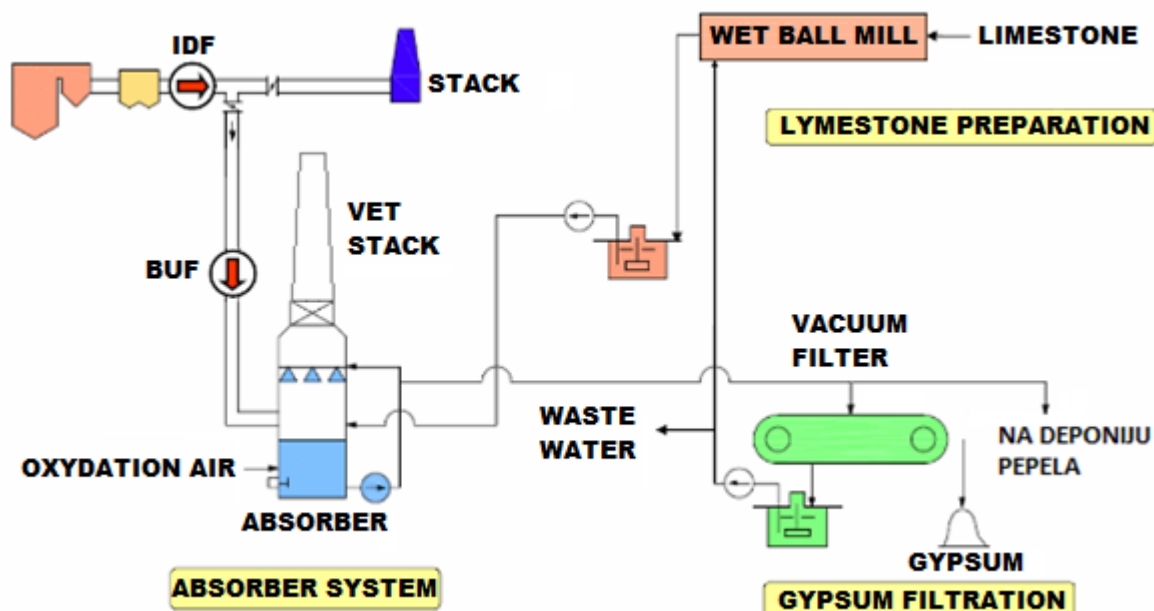


Figure 1.1 Basic scheme of wet limestone FGD

For the realization of this project, it was agreed that the capacity for each unit A3 to A6 will be 350 MW. The project aims to achieve significant reductions in emissions of harmful gases such as sulfur dioxide, hydrogen fluoride and hydrogen chloride. As the maximum amount of sulfur dioxide, a quantity of 9180 kg/h per unit is predicted, and after desulphurization with an efficiency of 96.7%, it will be reduced to 305 kg/h or expressed as concentration, to 200 mg/Nm³ (with 6% O₂). The significance of the realization of the FGD plant for A3 to A6 TENT A units can be best seen from the table in Table 1.2, where the quantities of SO₂ per block are shown before and after the FGD plant is put into operation.

Tabela 1.2: SO₂ quantities before and after the FGD plant is put into operation

Tona SO ₂	Blok A3	Blok A4	Blok A5	Blok A6	Ukupno A3-A6
Before FGD					
t/h	9,180	9,180	9,180	9,180	37,720
t/day	220,320	220,320	220,320	220,320	881,280
t/year	73440	73440	73440	73440	293760
After FGD					
t/h	0,305	0,305	0,305	0,305	1,22
t/day	7,32	7,32	7,32	7,32	29,28
t/year	2440	2440	2440	2440	9760
Difference in SO₂ – SO₂ removed through gypsum					
t/h	8,875	8,875	8,875	8,875	35,500
t/day	213	213	213	213	852
t/year	71000	71000	71000	71000	284000

The figures clearly show the efficiency of the future ODG plant, however, in practice, the input quantities of sulfur dioxide will be less than predicted, for the most unfavorable case. This can be seen through the coal

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consumption estimate for units A3 to A6 and the content of combustible sulfur in coal that is emitted as SO₂ with flue gases. Specific coal consumption depends on the quality of coal, but it can be considered realistic at 1.5 t/MWh, which for unit capacity of 350 MW converts to 457.5 t/h. The projected mass of SO₂ of 9180 kg/h means the amount of sulfur of 4590 kg/h (the sulfur content of sulfur dioxide is 50%) and the content of the combustible sulfur would be about 1,003% which is very high for Kolubara basin lignite. In any case, this assures that the FGD plant is adequate even in case of significant deterioration in the coal quality.

1.5.2.2 FGD plant purpose and characteristics limestone (rawmaterial) and gypsum (product)

The purpose of the FGD plant is to reduce the concentration of SO₂ emitted, to a level below 200 mg/Nm³. It is also the task of the ODG plant to reduce the emissions of HCl and HF gases. For the adopted wet limestone procedure, the desulphurization efficiency of 96.7% is predicted. This means that the maximum amount of SO₂ of 9180 kg/h from a single TENT A unit can be reduced to less than 305 kg/h of SO₂ by the FGD plant. For this process, the most important reactant is limestone supplied by rail or trucks and the characteristics of the limestone should be as follows:

- limestone granulation: 100% -20 mm
- limestone purity: 96,6% CaCO₃
- limestone molecular mass: 100
- limestone density: 2,65 g/cm³
- limestone grindability index: 15 kWh/t
- milled limestone granulation: 95% -45 microne
- limestone suspension : : 30% S

A product of wet limestone FGD process is gypsum with the following characteristics:

- gypsum purity: 96%
- chemical formula: CaSO₄x2H₂O (mol. mass 172)
- gypsum density: 2,3 g/cm³
- dewatered gypsum: 10% moisture content
- disposal gypsum: 50% S

1.5.2.3 Technical description of connecting existing TENT A facilities with the FGD plant

The general layout of the existing TENT A facilities, with new flue gas desulphurization plant buildings, that are labeled C1 to C42, are shown on the drawing numbered NTFGD-S0.0-IDR-6.0.0-000D-rev00.

As seen on the afore mentioned general layout, the absorber of the A3 and A4 units is located in the immediate vicinity of the stack for the units A1, A2 and A3, and the absorber for the units A5 and A6 is located in the immediate vicinity of unit A6, to the southeast.

The absorbers will be equipped with wet stack, so the clean flue gases are not directed to the existing TENT A stacks, but from the absorber, via wet stacks, emitted to the environment. Wet stacks are visible on the 3D depiction of FGD plant, shown on figure 2.1.

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1.5.2		Technical description				

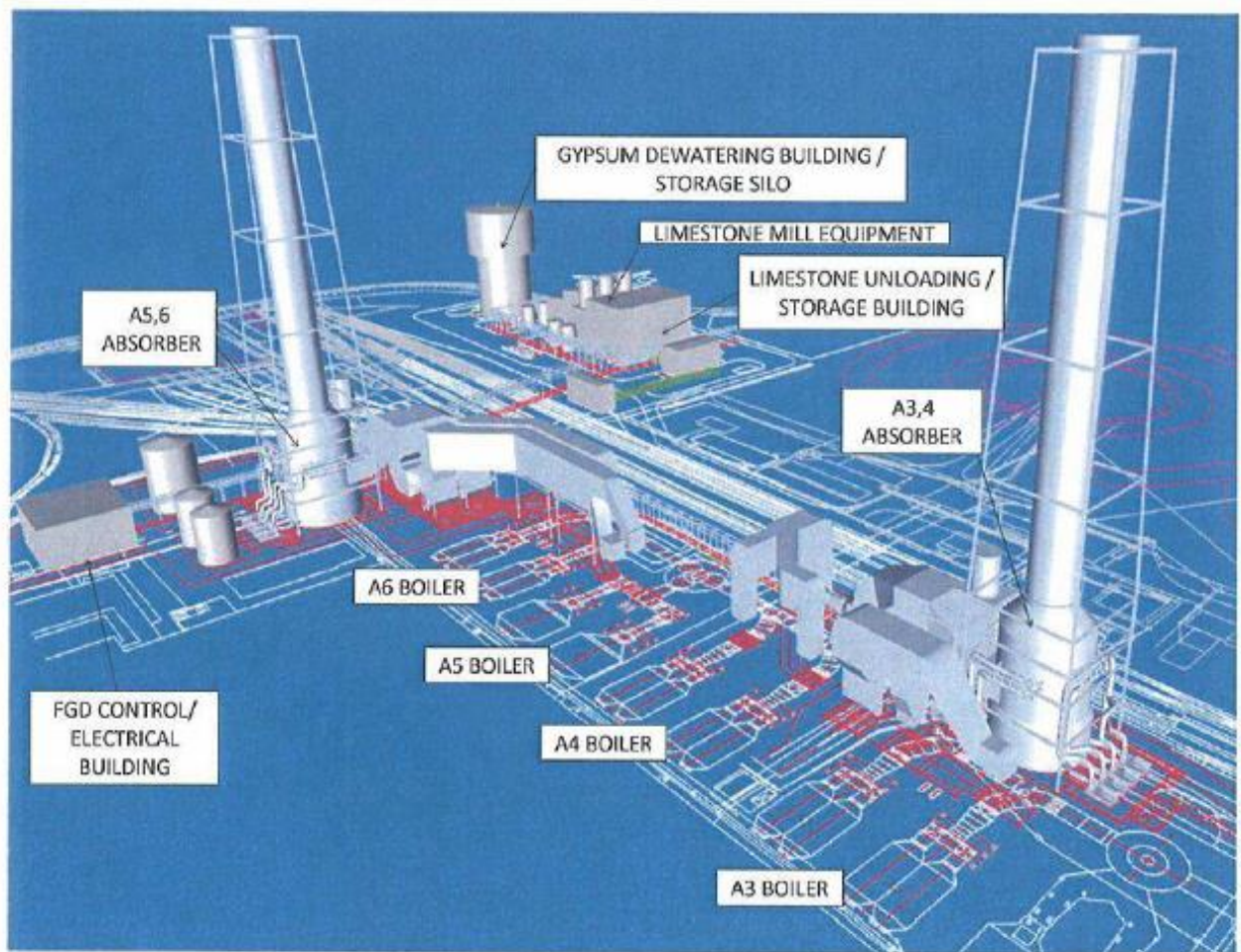


Figure 2.1: 3D layout of FGD plant

Wet stack diameter is 12.5 m and the height is 105 m above the absorber. For the construction of wet stack on the absorbers, the following explanation should be given.

Wet stacks are chosen because the existing stacks in TENT A are designed for operation with hot flue gas, whose temperature is significantly above dew point. The flue gas exiting the absorbers with a lower temperature and a high amount of moisture would cause an intense accumulation of moisture on the inner stack walls, additional condensation and formation of droplets that would go into the atmosphere with the gas flow, which, due to the content of dissolved acid oxides, would cause significant damage to the stack walls and put in question the integrity of the stack itself.

Because of all this, it would be necessary to line the stack interior with a special coating, resistant to corrosion. Reconstruction of the existing stack would require activities several months long, needing the units to be stopped during that period.

The above reasons clearly indicate why the wet stack is necessary.

In other words, wet stacks are to be designed, which are intended for working with flue gas at the saturation point at the exit from the absorbers and which ensures optimum conditions of smoke gas dispersion after its exit from the stack.

Wet stack can be implemented in two ways. First implies building a separate stack, and the other mounting a stack on top of absorber.

The above reasons clearly indicate why the wet stack is necessary.

In other words, wet stacks are to be designed, which are intended for working with flue gas at the saturation point at the exit from the absorbers and which ensures optimum conditions of smoke gas dispersion after its exit from the stack.

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In the case of the FGD plant in TENT A, the solution of the wet stack on absorbers was adopted as optimal. In this way, the following positive effects are achieved:

- construction of new long, large cross section clean gas ducts to the separate stack is avoided;
- minimal unit downtime;
- less space is needed;
- minimal investment;
- condensate is drained directly into the absorber.

The selected position for the absorbers allows the flue gas from the A3 and A4 blocks to be directed to the absorber 01 (C1), or if the FGD system is not in operation, it goes into the existing stack. For Absorber 02 (C2), there is also the possibility of redirecting the flue gases into the stack if the FGD system is not operational. The flue gas delivery to the absorbers is done with new flue gas ducts using a buster fan (two per absorber, C13 ÷ C16).

The most important component for the FGD process is the limestone, which is delivered by railway, through the railway unloading station (C39); or by trucks, through truck unload building (C18). All facilities for limestone reception, limestone storage and ultimately wet milling of limestone, are located west of block A6, over the railway tracks, so a piping and electrical rack will be built to support necessary pipelines and cables (C38.1).

In the immediate vicinity of the limestone milling plant is the gypsum filtering system. The system vacuum filters the gypsum to 10% moisture and sends it to the gypsum silo (C30).

In the immediate vicinity of the absorbers themselves the compressor stations for oxidation (C4-2HTD and C6-1HTD) are situated. These house the blowers which provide the needed air, precisely oxygen from the air, to carry out the reaction to produce gypsum.

The second possibility for the gypsum obtained in the absorber in reaction with the limestone suspension, is to be transported to the landfill, after thickening to 50% solid content. The gypsum slurry from the absorber goes to hydrocyclone battery. The overflow of the hydrocyclone battery is accepted into the disposal filtrate tank (C37), located north of the absorber 01, near the coal depot. The hydrocyclone battery underflow is transported to the disposal filtrate tank (out of scope). This tank, as well as further treatment of gypsum slurry and transportation to landfill, is the subject of another project: "System for external transport and deposit of gypsum suspension and backflow water system".

Fresh water, supplied by pumps to the FGD process water tank (C9), is provided from the units A3, A4, A5 and A6 cooling water supply system. Water in the system is obtained by filtration of water from the Sava river.

The main FGD control/electrical building (C5), with the necessary installations for managing the new FGD plant, will be located near the absorber 02 (absorber for units A5 and A6).

Extensive measurements and automatic regulation of all influential parameters in the process are planned. The most important thing in regulating the process is that the consumption of limestone is harmonized with the amount of SO₂ to be removed from flue gases.

1.5.2.4 Implementation of the FGD plant

Whole FGD process, as well as the systems are shown on the process flow diagram NTFGD-S0.0-IDR-7.0.0-001D-rev00 attached.

Absorption system

For units A3 and A4, absorber 01 (C1) is provided, and the second absorber 02 (C2) for units A5 and A6. Each absorber is an independent system. The absorbers are of the same dimensions and consist of the following sections:

- recirculation tank, in which oxidation of calcium sulfite into calcium sulfate (CaSO₃ in CaSO₄·2H₂O) is carried out with the help of added oxygen;
- absorption part, in which contact of CaCO₃ suspension and SO₂ is achieved;

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1.5.2		Technical description				

- the highest part of the absorber is the mist eliminator, which catches droplets of liquid taken up by the gas stream.

The dedusted flue gas from the A3 and A4 units is directed to the induced draft fans and buster fans (C16 and C15) and discharged into the absorber 01. The same applies to the flue gases of the units A5 and A6 which are directed with the buster fans (C14 and C13) into the absorber 02. The flue gas temperature at the inlet of the absorber is 178 ° C, and after cleaning, at the outlet, the gas temperature is 67 ° C. Clean flue gases are then discharged into the atmosphere through the wet stack.

Flue gas cleaning is carried out in contact with limestone suspension. This process takes place during the flow of flue gas through the absorbers 01 and 02 of the desulphurization system. Flue gas and suspension in the absorber are in counter current flow. Flue gas is introduced into the lower part of the absorber and flows upwards, coming into contact with the spray of limestone suspension, which drops downwards. The absorbers have several spray levels, thus increasing the efficiency of SO₂ removal.

The number of spray levels depends on the required desulphurization efficiency, as well as the given range of input concentrations of sulfur dioxide. The gas retention time in the absorber is about 3.3 seconds and the gas velocity is 4 m/s. The moisture content of the purified flue gas is 12.7 l/m³.

Suspension in absorbers has 15% of solids and nominal pH of 5.6. Fresh limestone suspension has 30% of limestone. Suspension circulating the absorbers, using recirculation pumps (C3-1HTD and C4-1HTD for Absorber 01 and C3-2HTD and C4-2HTD for Absorber 02), is lifted and pushed through the spray nozzles spread evenly over the cross-section of the absorber, where it disperses to fine droplets and thus leads to greater contact area with flue gas flow. Droplets of suspension absorb SO₂ from the flue gas in reaction that occurs between SO₂ and the sorbent from the suspension (CaCO₃). Hydrogen chloride (HCl), located in the flue gas, is also absorbed and neutralized in reaction with limestone, forming soluble salt (CaCl₂), which leads to the accumulation of chloride ions in the absorber suspension.

Water is necessary for the reaction in absorber to take place. Process water is taken from the units cooling water system (filtered water from the Sava River) and pumps lead it to process water tankas from which water is added to the appropriate absorber or, if necessary, other consumers (preparation of limestone suspension or wash screen filter in the case of gypsum filtration).

In addition to water, air from the oxidation blowers is added to the recirculation portion of the absorber in order to provide the required oxygen for the oxidation of the formed calcium sulfite. This part of the absorber is equipped with agitators, to prevent settling.

The cleaned flue gas passes through the mist eliminator to remove droplets of water before entering the wet stack. After entering the absorber, the flue gas is suddenly cooled in contact with water, and a certain amount of water evaporates so that the flue gas at the exit of the absorber is saturated with moisture.

In the immediate vicinity of the absorber, a blowdown tank is provided for the absorber suspension in case of unplanned halt, as well as in the event of a high level of suspension in the absorber.

Limestone handling system

The most important component in the process of flue gas desulphurization is limestone, which is added to the absorber in form of a finely ground limestone, granulation 90% -45 microns, in a water suspension of 30% solid content. The daily consumption of limestone at the maximum projected concentration of SO₂ in flue gases exceeds 1450 t/day for both absorbers. For this reason, the following limestone handling system for the FGD process in TENT A. is intended:

- limestone crushed to 100% -20mm is delivered to the TENT A, by trucks or trains;
- there are two unloading docks in the truck unloading station (C18), and one at the railway unloading station ;
- The limestone is taken from the receiving hoppers by conveyor belts and bucket elevators and transported to the limestone storage building;

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- Reclaiming of limestone from the depot is provided by scrapers, and then limestone is lifted, by conveyor belts and elevators, to the day silos housed in the limestone mill building (C24);
- Three day limestone silos are planned. Each provides enough limestone for full days work of each of the three wet mill sections.

Limestone slurry preparation system

Preparation of limestone slurry is carried out in the limestone mill building (C24), in which wet milling of limestone takes place in closed cycle wet ball mills.

There will be three identical grinding sections with wet ball mills, each section covering the needs of one absorber in operation. The first two sections cover the needs of both absorbers and the third mill section is a spare, in case any of the first two sections brake.

Limestone granulated -20 mm is added with belt feeder to wet the ball mill. Process water is also added to maintain the suspension limestone content at about 60% S. Ground suspension exiting the mill has a 100%granulation -300 micron and $d_{30}=30$ micron.

The limestone slurry exiting the mill is temporarily stored and diluted in the limestone mill slurry tank. Then the slurry is classified in the hydrocyclone battery. The hydrocyclone battery overflow, 30% S and 90% -45 micron, is taken to the limestone slurry feed tank (C28). From this tank, the fresh limestone slurry is fed to the absorbers, through a loop continuously recirculating the suspension from the absorber. Required amount of fresh limestone slurry is determined by the process parameters (pH of the suspension in the absorber or the ratio of the input and output concentration of SO_2 to the absorber).

The hydrocyclone battery underflow is the coarse fraction and is returned to the mill for additional grinding, together with the fresh limestone.

Gypsum dewatering system

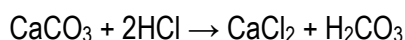
The gypsum formed in the reactions in the absorber is continuously pumped from the absorber and can be, depending on the possible placement on the market, sent to gypsum dewatering system or, if there is no placement, to gypsum disposal system.

In case the gypsum is designated to gypsum dewatering system, the suspension from the absorber (15% S) is pumped into the hydrocyclone battery, where the gypsum is thickened (underflow 50% S). Thickened gypsum falls on the vacuum belt filter (building C30), where water is gradually vacuumed from the gypsum until 10% gypsum moisture content is achieved.

The required vacuum is achieved with a vacuum pump. To wash the filter fabric, fresh rinse water is supplied, to prevent the clogging of the filter fabric. The used water from the fabric washing is then collected and partially used to wash the filtered gypsum on the belt.

The first hydrocyclone battery overflow is led to the second hydrocyclone battery. Second hydrocyclone battery overflow is extracted as waste water which, in addition to sludge, contains about 20 g/l calcium chloride. It is then transported to the existing FGD system wastewater treatment plant. Chlorine originates from coal. After coal combustion, hydrogen chloride appears in the flue gas. In reaction with limestone, calcium chloride ($CaCl_2$) is formed and is diluted in the suspension.

Reaction between calcium chloride and limestone is as follows:



The underflow of the second hydrocyclone battery and the filtrate from the vacuum filter, are returned to the absorber and are continuously recirculated.

Filtered gypsum, with 10% moisture, is deposited in the gypsum silo (C30), from which the trucks are filled for dispatch to consumers.

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1.5.2						

For each absorber, one gypsum dewatering line will be built, so that it can meet the needs of the process and possible customers.

Gypsum disposal system

In the event that there is no placement for dewatered gypsum, the gypsum suspension does not go to dewatering, but to the hydrocyclone battery in which it is thickened to about 52% solid. Underflow of the hydrocyclone battery is collected in the disposal gypsum tank (out of scope), and the overflow into the disposal filtrate tank (C37) and then returns to the absorber. A part of overflow is still extracted, in order to avoid a surplus in the recirculation and dilute the thick underflow to the density of about 50% solid. Diluted underflow slurry can then be directed to the TENT A ash landfill with ash and slag(out of scope).

Odgovorni projektant:	Radoje Tufegdžić, dipl.ing.	 
Broj licence:	371 5696 03	

	Investitor:	JP Elektroprivreda Srbije, Carice Milice 2, Belgrade			
	Objekat:	FGD Construction Project for TPP Nikola Tesla A, Lokacija: Obrenovac, K.P. 1934, K.O. Urovci			
	Vrsta teh. dokum.:	IDR - Conceptual design			
Deo projekta:	NTFGD- -IDR-7.1	Process project.	List:	1.6.1	Rev.: 0

1.6	NUMERICAL DOCUMENTATION
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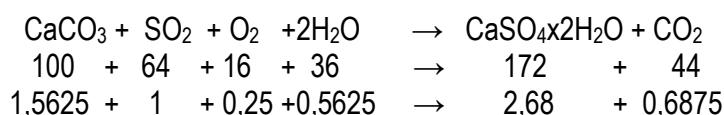
Deo projekta: Project part	NTFGD- -IDR-7.1	Process project.	List: Page	1.6.2	Rev.: Rev.:	0
1.6.1		Calculation				

When preparing the mass balance in the process of flue gases desulphurization in TENT A, the baseline were the conditions set by EPS, as the Investor of the project. Table 3.1 shows the project conditions that are most likely to be expected during the lifetime of the new FGD plant.

Table 3.1 Baseline conditions for FGD plant for units A3, A4, A5 i A6, TENT A, Obrenovac

Unit capacity MW	Single unit	Both units	Remark
	350	2x350	
Flue gas parameters			
-Flue gas flow entering FGD plant (Nm ³ /h)	2170000	4340000	
-Dry flue gas flow entering FGD plant (Nm ³ /h)	1712130	3424260	
- Flue gas mass flow (kg/h)	2684555	5369110	
-H ₂ O (vol %)	21,1	21,1	
-O ₂ (vol % dry)	7,6	6,1	
-SO ₂ (mg/Nm ³ dry)	6000	6000	6% O ₂ dry
-HCl (mg/Nm ³ dry)	150	150	6% O ₂ dry
-HF (mg/Nm ³ dry)	25	25	6% O ₂ dry
-Fly ash (mg/Nm ³ dry)	50	50	6% O ₂ dry
-Flue gas temperature entering FGD plant (°C)	175	175	Exiting IDF
-SO ₂ (mg/Nm ³ dry)	5362	5362	Real O ₂
-SO ₂ mass flow entering FGD plant (kg/h)	9180	18360	
Limestone purity (%)	96,6%	96,6	as CaCO ₃
Process water Cl (ppm)	50	50	
FGD plant requirements			
- SO ₂ concentration on FGD exit (mg/Nm ³ dry)	200	200	Wet stack
- SO ₂ removal efficiency (%)	96,7	96,7	
-Temperature on FGD exit stack (°C)	Sat. temp.	Sat. temp.	

Limestone (CaCO₃) reacts with sulfur dioxide (SO₂), hydrogen chloride (HCl) and hydrogen fluoride (HF), from the flue gas entering the absorber. Numerous reactions are taking place in the absorber, but the most important is the reaction between limestone, SO₂, oxygen and water; producing gypsum and CO₂:



From the stoichiometric relationship in the aforementioned chemical reaction, it can be seen that the theoretical translation of 1t of SO₂ into gypsum requires 1,5625 t of pure CaCO₃, 0.25t of O₂ and 0.5625 t of water and the reaction yields 2.68 t of gypsum and 0.6875 t of CO₂. For successful removal of 9180 kg/h SO₂, the consumption of 14877 kg/h of limestone in the process was adopted, which, with a purity of 96.6% CaCO₃, gives the amount of 15400.6 kg/h limestone needed for one unit:. In the table below, consumption of limestone and impurities in different cases is given:

Material	A3	A4	A3+A4	A5	A6	A5+A6	A3÷A6
CaCO ₃	14877	14877	29754	14877	14877	29754	59508
Impurities	523	523	1047	523	523	1047	2094
Total limestone	15400	15400	30800	15400	15400	30800	61600

Deo projekta: Project part	NTFGD- -IDR-7.1	Process project.	List: Page	1.6.3	Rev.: Rev.:	0
1.6.1		Proračun / Calculation				

The following cases are possible in FGD plant operation:

Case 1-1: 100% dewatering of gypsum from the absorber 01 (C1) for units A3 and A4, and the absorber 02 (C2) is not in operation,

Case 1-2: 100% disposal of gypsum from the absorber 01 (C1) for units A3 and A4 and the absorber 02 (C2) is not in operation;

Case 2-1: 100% dewatering of gypsum from the absorber 02 (C2) for units A5 and A6, and absorber 01 (C1) is not in operation,

Case 2-2: 100% disposal of gypsum from the absorber 02 (C2) for units A5 and A6 and absorber 01 (C1) is not in operation,

Case 3-1: 100% dewatering of gypsum from one absorber and 100% disposal of gypsum from another absorber;

Case 3-2: 100% disposal of gypsum from both absorbers;

Table 3.2 gives a summary of the mass balances of raw materials involved in the FGD process.

Tabela 3.2 Summary of the mass balances of raw materials involved in the FGD process

	Case 1-1 and/or 2-1	Case 1-2 and/or 2-2	Case 3-1	Case 3-2	„Future”	Primedbe
No. of active units	2	2	4	4	4	A3 and A4 or A5 and A6
Unit cappacity (MW)	350 each	350 each	350 each	350 each	350 each	
No. of active absorbers	1	1	2	2	2	
Byproduct treatment:						1 absorber
-Gypsum dewatering	100	0	50	0	100	One or the
-Gypsum disposal	0	100	50	100	0	other working
Flue gas exiting the absorber						
- SO ₂ (mg/Nm ³ dry)	200	200	200	200	200	6% O ₂ dry
-Fly ash (mg/Nm ³ dry)	13	13	13	13	13	
-Flu gas temperature (°C)	67	67	67	67	67	FGD total
-SO ₂ mass flow(kg/h)	610	610	1220	1220	1220	FGD total
-Fly ash mass flow (kg/h)	61	61	122	122	122	
Limestone consumption (t/h)	30,8	30,8	61,6	61,6	61,6	96,6% CaCO ₃
Process water consumption (t/h)	336	353	631	706	706	
Byproduct and waste:						
-Dewatered gypsum (t/h)	55,8	0	55,8	0	111,6	10% water
-Disposal gypsum (t/h)	0	100,8	100,8	201,7	0	50% S
-Waste water (t/h)	26,6	0	0	0	53,1	1% S

Plant working time and raw material consumption:

FGD plant for units A3, A4, A5 and A6 is designed for the following effective working hours:

- No. of working days per year : 333 days
- Working hours per day : 24 h
- Effective operating time: 8000 h/year.

In accordance with the stated working hours, the maximum consumption of limestone will be as follows:

Deo projekta: Project part	NTFGD- -IDR-7.1	Process project.	List: Page	1.6.4	Rev.: Rev.:	0
1.6.1		Proračun / Calculation				

Limestone:

- Annually consumption: 492800 t/year
- Daily consumption: 1478,4 t/day
- Hourly consumption: 30,8 t/h for one absorber
- Hourly consumption: 61,6 t/h for two absorbers

Hereinafter, the mass balances of the FGD process will be processed in more detail in the above cases. In all cases, the preparation of limestone in the form of a fine suspension with a 30% solid phase and a fineness of grinding of 90% -45 microns is necessary, and Figure 3.1 shows a wet ball mill mass balance with a capacity of 30,8 t/h.

In development of the mass balance scheme, it was assumed that the circular batch in the grinding cycle was 500% and that the mill suspension density is 60% of solid phase. Already in the introduction it was noted that the density of limestone was 2.65 g/cm³ and the water consumption per section of grinding was 71.87 m³/h.

The final product is 83.49 m³ of pulp, or expressed in pulp density, 1.229 t/m³ or kg/l or 1229 g/l. The volume of limestone of $30,8/2,65 = 11,62\text{m}^3/\text{h}$ and water of 71,87 m³/h gives a pulp volume of 83,49 m³/h. The specific pulp density is obtained when the mass of the pulp (water + limestone) is divided by the volume of the pulp.

The grinding process will be completely controlled, from measuring the mass of the limestone and proportionally adding input water at the entrance, through the measurement of the suspension flow and density, and also the sampling of the pulp in order to control the grinding fineness achieved.

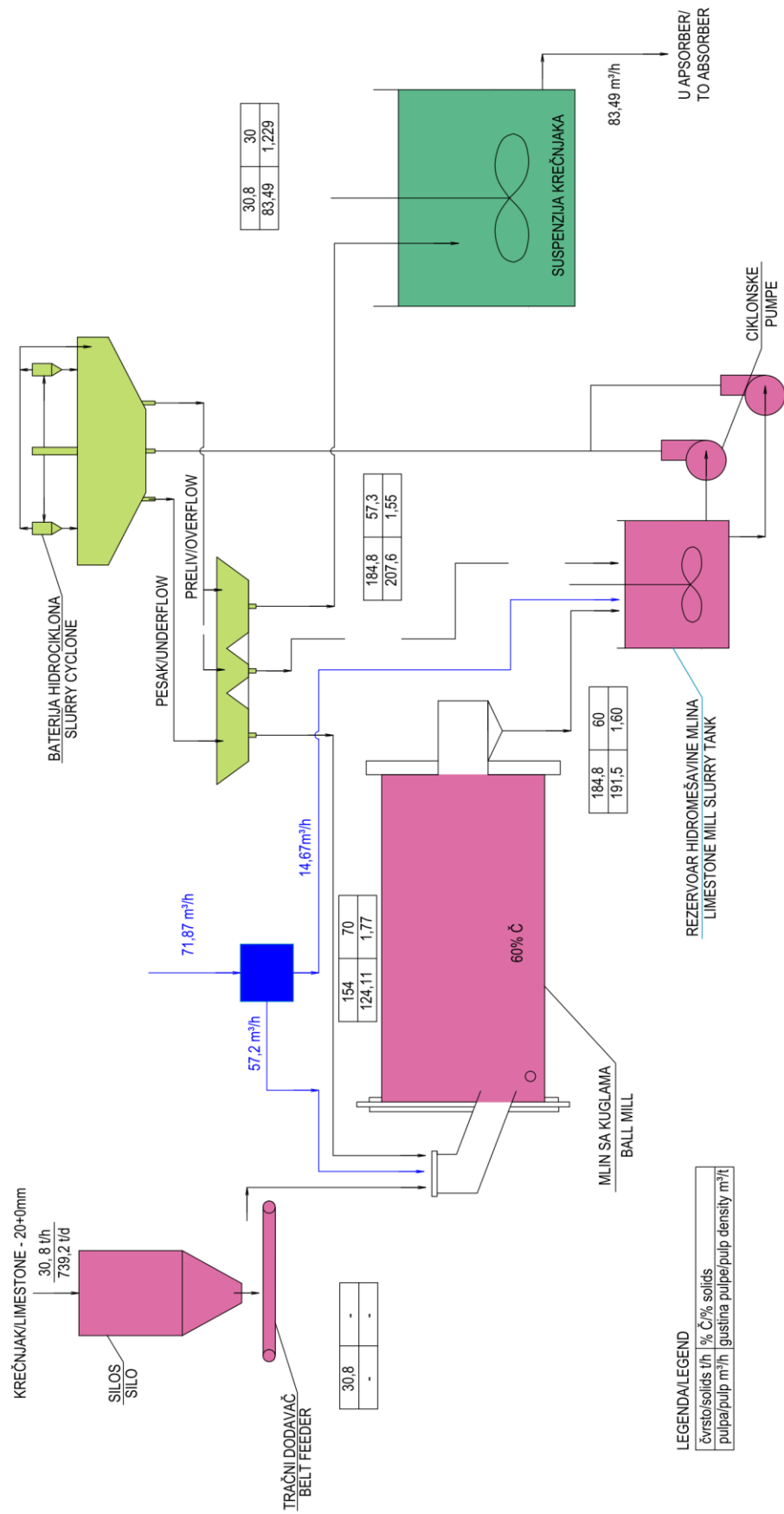


Figure 3.1 - Wet limestone mill mass balance

Deo projekta: Project part	NTFGD- -IDR-7.1	Process project.	List: Page	1.6.6	Rev.: Rev.:	0
1.6.1		Proračun / Calculation				

In the following text, all the cases of FGD plant operation are reviewed.

Case 1-1: 100% dewatering of gypsum from the absorber 01 (C1) for units A3 and A4, and the absorber 02 (C2) is not in operation

Process mass balance and process flow lines case 1-1 are presented on the drawing NTFGD-S0.0-IDR-7.0.0-000-002D-rev00. Figure 3.2, below, shows a simplified diagram of mass balance, in order to see the consumption of water and water losses from the process.

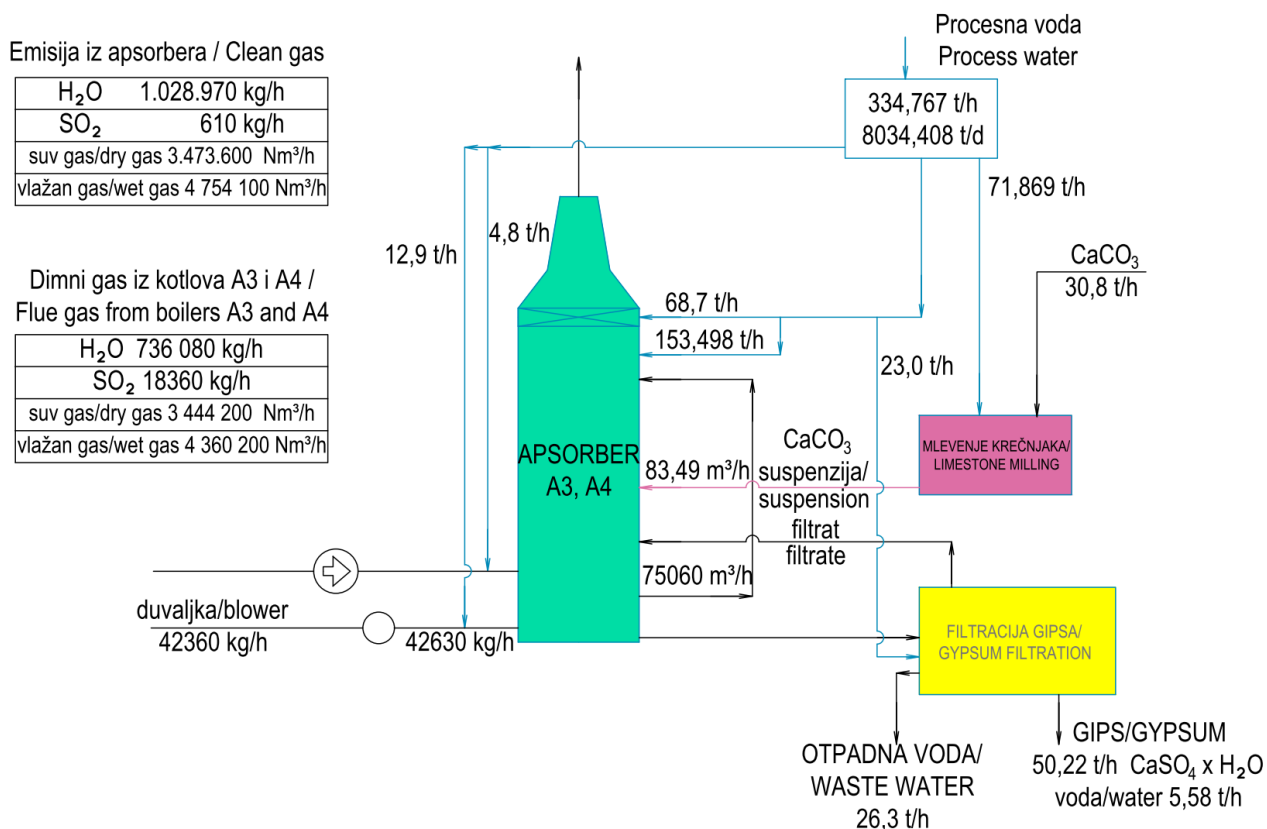


Figure 3.2 - FGD mass balance - Case 1-1

Table 3.3 shows process water consumption and losses for FGD process for the case 1-1.

Deo projekta: Project part	NTFGD- -IDR-7.1	Process project.	List: Page	1.6.7	Rev.: Rev.:	0
1.6.1		Proračun / Calculation				

Table 3.3 Process water consumption and losses for FGD process - Case 1-1

Water consumption	t/h	Line No.
Limestone milling	71,869	63
Vacuum filter cloth wash	23,000	64
Absorber – higher level	68,700	66
Aabsorber – lower level	153,498	67
Flue gas entering the absorber	4,800	68
Oxidation air	12,900	69
Water consumption total	334,767	61
Water losses		
Flue gas exiting the absorber	292,890	4
Gypsum moisture	5,580	26
Waste water	26,300	46
Gypsum structural water (2 H ₂ O molecules)	9,997	
Water losses total	334,767	

In Table 3.4 the results of the inputs and outputs from the FGD process for the case 1-1 are summarized.

Table 3.4 FGD input/output - Case 1-1

Flow/product	Unit	Base conditions	Remark
a) Flue gas enering the absorber	Nm ³ /h (wet)	4340000	
b) Flue gas enering the absorber	Nm ³ /h (dry)	3424260	
c) SO ₂ concentration entering the absorber	mg/Nm ³ (dry)	5360	real O ₂
d) SO ₂ concentration entering the absorber	mg/Nm ³ (dry)	6000	6% O ₂
e)O ₂ concentration entering the absorber	% (suvo)	7,60	
f) HCl concentration entering the absorber	mg/Nm ³ (suvo)	150	6% O ₂
g) Dust concentration entering the absorber	mg/Nm ³ (suvo)	50	6% O ₂
h) Flue gas exiting the absorber	Nm ³ /h (vlažno)	4754100	
i) Flue gas exiting the absorber	Nm ³ /h (suvo)	3473600	
j) SO ₂ conentration exiting the absorber	mg/Nm ³ (suvo)	200	6% O ₂
k) Dust conentration exiting the absorber	mg/Nm ³ (suvo)	20	6% O ₂
l) HCl conentration exiting the absorber	mg/Nm ³ (suvo)	7	6% O ₂
m) Evaporated water	kg/h	292870	
n) Flue gas temperature			
1) Flue gas enering the absorber	°C	175	
2) Flue gas exiting the absorber	°C	67	
o) Waste water	kg/h	26566	
p) Dewatered gypsum	kg/h	55800	
q) Gypsum surface moisture	%	10	
r) Gypsum purity	% (dry)	95	
s) Disposal gypsum	kg/h	0	
t) Solids content in disposal gypsum	%	-	
u) Limestone consumption	kg/h	30801	
v) Waste water Cl ⁻ ion concentration	mg/l	20000	
w) Oxidation air consumption	Nm ³ /h (wet)	33240	

Deo projekta: Project part	NTFGD- -IDR-7.1	Process project.	List: Page	1.6.8	Rev.: Rev.:	0
1.6.1		Proračun / Calculation				

Case 1-2: 100% disposal of gypsum from the absorber 01 (C1) for units A3 and A4 and the absorber 02 (C2) is not in operation

Process mass balance and process flow lines case 1-2 are presented on the drawing NTFGD-S0.0-IDR-7.0.0-000-003D-rev00. Figure 3.3, below, shows a simplified diagram of mass balance, in order to see the consumption of water and water losses from the process.

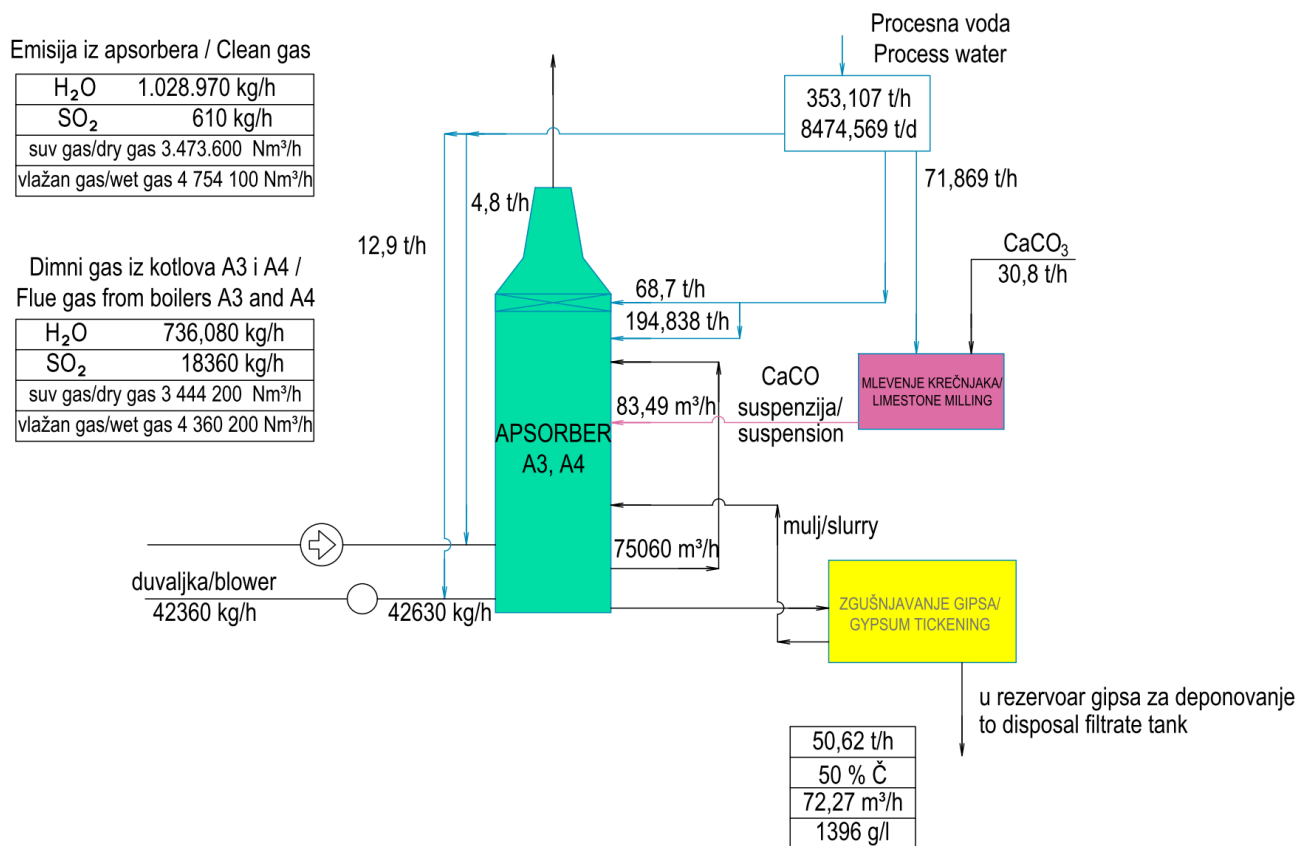


Figure 3.3 - FGD mass balance - Case 1-2

Table 3.5 shows process water consumption and losses for FGD process for the case 1-2.

Deo projekta: Project part	NTFGD- -IDR-7.1	Process project.	List: Page	1.6.9	Rev.: Rev.:	0
1.6.1		Proračun / Calculation				

Table 3.5 Process water consumption and losses for FGD process - Case 1-2

Water consumption	t/h	Line No.
Limestone milling	71,869	63
Absorber – higher level	68,700	66
Aabsorber – lower level	194,838	67
Flue gas entering the absorber	4,800	68
Oxidation air	12,900	69
Water consumption total	353,107	61
Water losses		
Flue gas exiting the absorber	292,890	4
Gypsum suspension	50,22	29+33
Gypsum structural water (2 H ₂ O molecules)	9,997	
Water losses total	353,107	

In Table 3.6 the results of the inputs and outputs from the FGD process for the case 1-2 are summarized.

Table 3.6 FGD input/output - Case 1-2

Flow/product	Unit	Base conditions	Remark
a) Flue gas enering the absorber	Nm ³ /h (wet)	4340000	
b) Flue gas enering the absorber	Nm ³ /h (dry)	3424260	
c) SO ₂ concentration entering the absorber	mg/Nm ³ (dry)	5360	real O ₂
d) SO ₂ concentration entering the absorber	mg/Nm ³ (dry)	6000	6% O ₂
e) O ₂ concentration entering the absorber	% (suvo)	7,60	
f) HCl concentration entering the absorber	mg/Nm ³ (suvo)	150	6% O ₂
g) Dust concentration entering the absorber	mg/Nm ³ (suvo)	50	6% O ₂
h) Flue gas exiting the absorber	Nm ³ /h (vlažno)	4754100	
i) Flue gas exiting the absorber	Nm ³ /h (suvo)	3473600	
j) SO ₂ conentration exiting the absorber	mg/Nm ³ (suvo)	200	6% O ₂
k) Dust conentration exiting the absorber	mg/Nm ³ (suvo)	20	6% O ₂
l) HCl conentration exiting the absorber	mg/Nm ³ (suvo)	7	6% O ₂
m) Evaporated water	kg/h	292870	
n) Flue gas temperature			
1) Flue gas enering the absorber	°C	175	
2) Flue gas exiting the absorber	°C	67	
o) Waste water	kg/h	0	
p) Dewatered gypsum	kg/h	0	
q) Gypsum surface moisture	%	-	
r) Gypsum purity	% (dry)	-	
s) Disposal gypsum	kg/h	100,440	
t) Solids content in disposal gypsum	%	50	
u) Limestone consumption	kg/h	30801	
v) Waste water Cl ⁻ ion concentration	mg/l	-	
w) Oxidation air consumption	Nm ³ /h (wet)	33240	

Deo projekta: Project part	NTFGD- -IDR-7.1	Process project.	List: Page	1.6.10	Rev.: Rev.:	0
1.6.1 Proračun / Calculation						

Case 2-1: 100% dewatering of gypsum from the absorber 02 (C2) for units A5 and A6, and absorber 01 (C1) is not in operation

Process mass balance and process flow lines for case 2-1 are presented on the drawing NTFGD-S0.0-IDR-7.0.0-000-004D-rev00. Figure 3.4, below, shows a simplified diagram of mass balance, in order to see the consumption of water and water losses from the process.

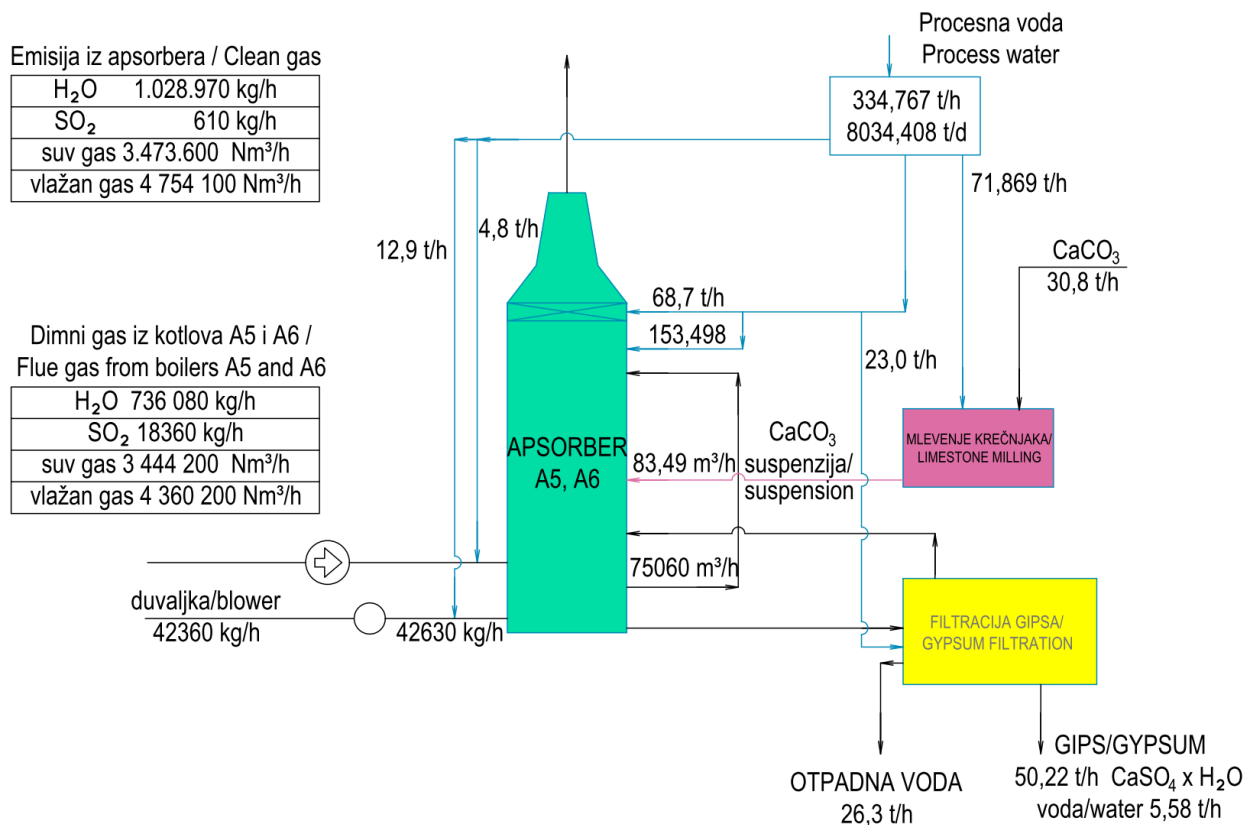


Figure 3.4 - FGD mass balance - Case 2-1

Table 3.7 shows process water consumption and losses for FGD process for the case 2-1, which are equal to case 1-1, except that absorber 02 (C2) is operational.

Deo projekta: Project part	NTFGD- -IDR-7.1	Process project.	List: Page	1.6.11	Rev.: Rev.:	0
1.6.1		Proračun / Calculation				

Table 3.7 Process water consumption and losses for FGD process - Case 2-1

Water consumption	t/h	Line No.
Limestone milling	71,869	93
Vacuum filter cloth wash	23,000	94
Absorber – higher level	68,700	96
Aabsorber – lower level	153,498	97
Flue gas entering the absorber	4,800	98
Oxidation air	12,900	99
Water consumption total	334,767	91
Water losses		
Flue gas exiting the absorber	292,890	8
Gypsum moisture	5,580	76
Waste water	26,300	56
Gypsum structural water (2 H ₂ O molecules)	9,997	
Water losses total	334,767	

Deo projekta: Project part	NTFGD- -IDR-7.1	Process project.	List: Page	1.6.12	Rev.: Rev.:	0
1.6.1 Proračun / Calculation						

Case 2-2: 100% disposal of gypsum from the absorber 02 (C2) for units A5 and A6 and absorber 01 (C1) is not in operation

Process mass balance and process flow lines for case 2-2 are presented on the drawing NTFGD-S0.0-IDR-7.0.0-000-005D-rev00. Figure 3.5, below, shows a simplified diagram of mass balance, in order to see the consumption of water and water losses from the process.

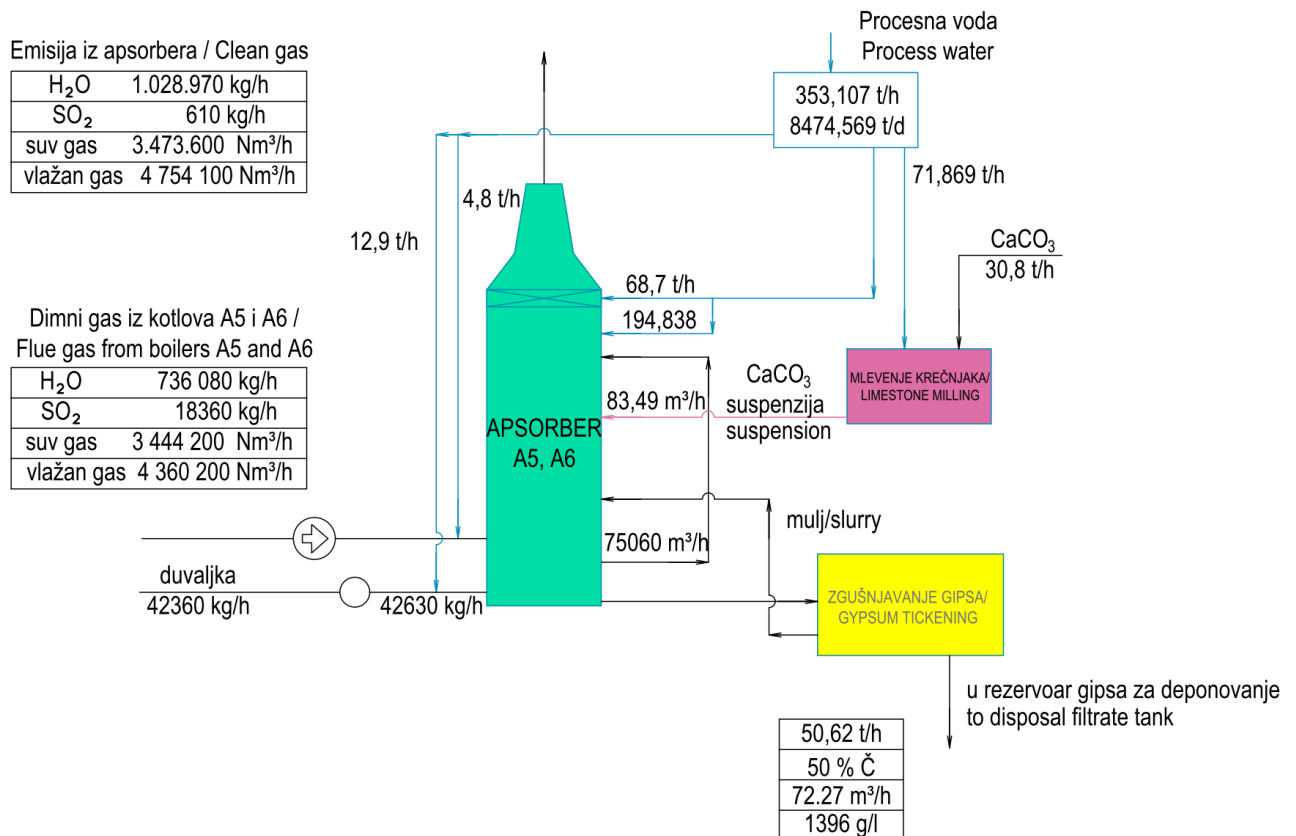


Figure 3.5 - FGD mass balance - Case 2-2

Table 3.8 shows process water consumption and losses for FGD process for the case 2-2, which are equal to case 1-2, except that absorber 02 (C2) is operational.

Deo projekta: Project part	NTFGD- -IDR-7.1	Process project.	List: Page	1.6.13	Rev.: Rev.:	0
1.6.1 Proračun / Calculation						

Table 3.8 Process water consumption and losses for FGD process - Case 2-2

Water consumption	t/h	Line No.
Limestone milling	71,869	93
Absorber – higher level	68,700	96
Aabsorber – lower level	194,838	97
Flue gas entering the absorber	4,800	98
Oxidation air	12,900	99
Water consumption total	353,107	91
Water losses		
Flue gas exiting the absorber	292,890	8
Gypsum suspension	50,22	79+83
Gypsum structural water (2 H ₂ O molecules)	9,997	
Water losses total	353,107	

Case 3-1: 100% dewatering of gypsum from one absorber and 100% disposal of gypsum from another absorber

Process mass balance and process flow lines for case 3-1 are presented on the drawing NTFGD-S0.0-IDR-7.0.0-000-006D-rev00. Figure 3.6, below, shows a simplified diagram of mass balance, in order to see the consumption of water and water losses from the process.

Table 3.9 shows process water consumption and losses for FGD process for the case 3-1, when gypsum is dewatered from one absorber and disposed from the other.

Table 3.9 Process water consumption and losses for FGD process - Case 3-1

Absorber 01 gypsum dewatering			Absorber 02 gypsum disposal		
Water consumption	t/h	Line No.	Water consumption	t/h	Line No.
Limestone milling	71,869	93	Limestone milling	71,869	93
Vacuum filter cloth wash	23,000	94	Absorber – higher level	67,700	96
Absorber – higher level	68,700	96	Aabsorber – lower level	194,838	97
Aabsorber – lower level	153,498	97	Flue gas entering the absorber	4,800	98
Flue gas entering the absorber	4,800	98	Oxidation air	12,900	99
Oxidation air	12,900	99			
Water consumption total	334,767	91	Water consumption total	353,107	91
Water losses			Water losses		
Flue gas exiting the absorber	292,890	8	Flue gas exiting the absorber	292,890	8
Gypsum moisture	5,580	76	Gypsum suspension	50,22	79+83
Waste water	26,300	56	Gypsum structural water (2 H ₂ O molecules)	-	-
Gypsum structural water (2 H ₂ O molecules)	9,997			9,997	
Water losses total	334,767		Water losses total	353,107	

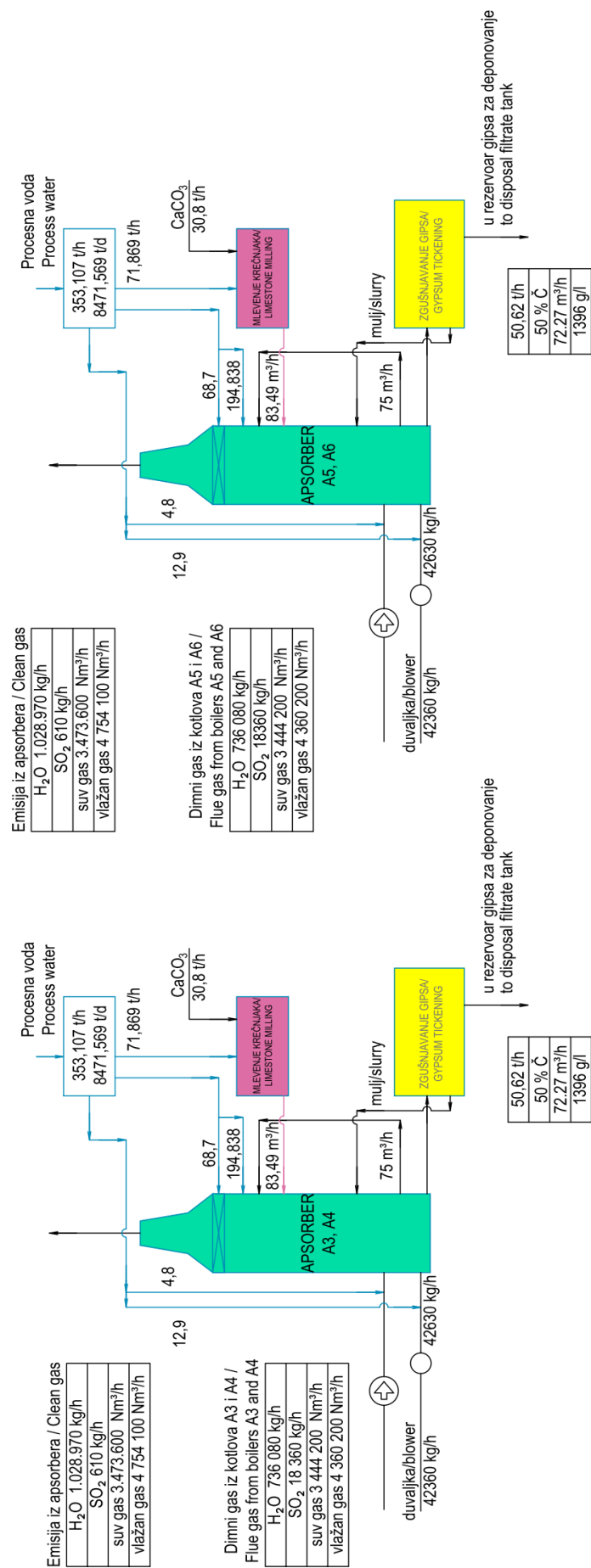


Figure 3.6 - FGD mass balance - Case 3-1

Deo projekta: Project part	NTFGD- -IDR-7.1	Process project.	List: Page	1.6.15	Rev.: Rev.:	0
1.6.1		Proračun / Calculation				

Case 3-2: 100% disposal of gypsum from both absorbers

Process mass balance and process flow lines for case 3-2 are presented on the drawing NTFGD-S0.0-IDR-7.0.0-000-007D-rev00. Figure 3.7, below, shows a simplified diagram of mass balance, in order to see the consumption of water and water losses from the process.

Table 3.10 shows process water consumption and losses for FGD process for the case 3-1, when gypsum is disposed from both absorbers.

Table 3.10 Process water consumption and losses for FGD process - Case 3-2

Absorber 01 gypsum disposal			Absorber 02 gypsum disposal		
Water consumption	t/h	Linija broj	Water consumption	t/h	Linija broj
Limeston milling	71,869	63	Limeston milling	71,869	93
Absorber – higher level	68,700	66	Absorber – higher level	68,700	96
Aabsorber – lower level	194,838	67	Aabsorber – lower level	194,838	97
Flue gas entering the absorber	4,800	68	Flue gas entering the absorber	4,800	98
Oxidation air	12,900	69	Oxidation air	12,900	99
Water consumption total	353,107	61	Water consumption total	353,107	91
Water losses			Water losses		
Flue gas exiting the absorber	292,890	4(4-3)	Flue gas exiting the absorber	292,890	8 (8-7)
Gypsum suspension	50,22	29+33	Gypsum suspension	50,22	79+83
Gypsum structural water (2 H ₂ O molecules)	9,997		Gypsum structural water (2 H ₂ O molecules)	9,997	
Water losses total	353,107		Water losses total	353,107	

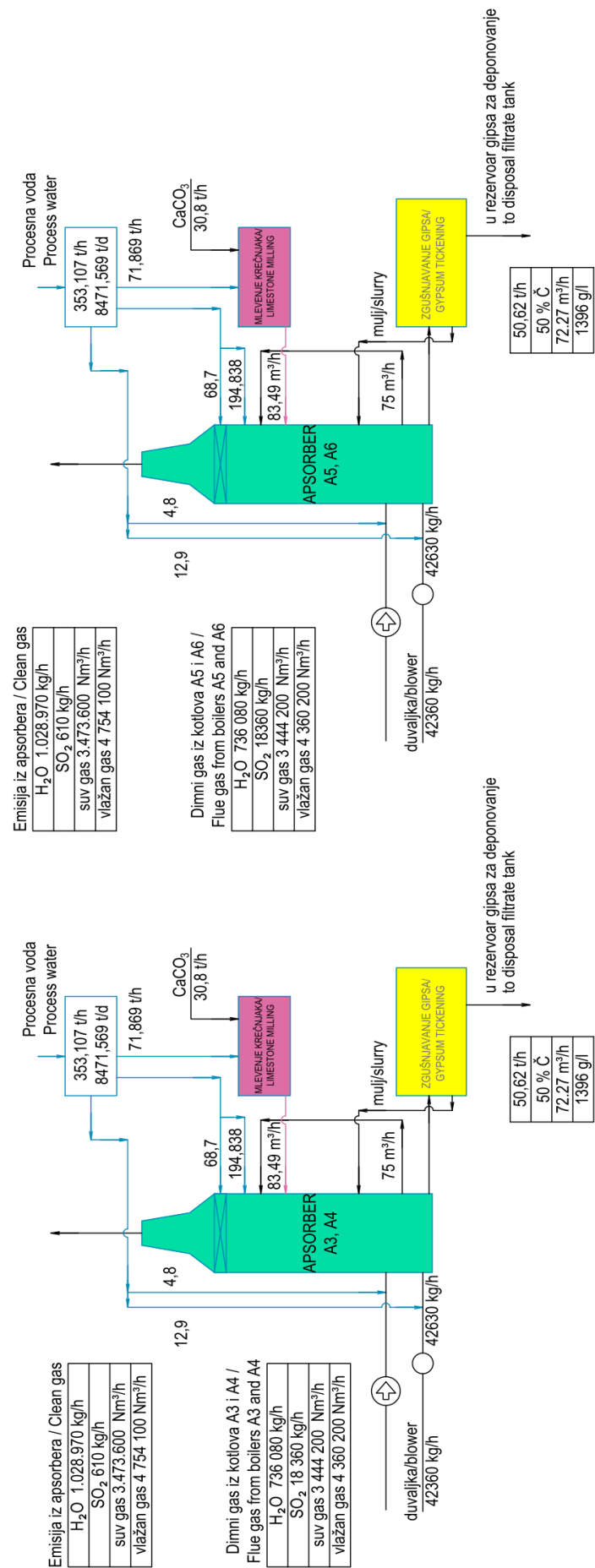


Figure 3.7 - FGD mass balance - Case 3-2

Deo projekta: Project part	NTFGD- -IDR-7.1	Process project.	List: Page	1.6.17	Rev.: Rev.:	0
1.6.1	Proračun / Calculation					

Main designer:	Radoje Tufegdžić, dipl.ing.	 
License number:	371 5696 03	

	Investitor:	JP Elektroprivreda Srbije, Carice Milice 2, Belgrade			
	Objekat:	FGD Construction Project for TPP Nikola Tesla A, Lokacija: Obrenovac, K.P. 1934, K.O. Urovci			
	Vrsta teh. dokum.:	IDR - Conceptual design			
Deo projekta:	NTFGD- -IDR-7.	Process project.	List:	1.7.1	Rev.: 0

1.7

GRAPHICAL DOCUMENTATION

LEGENDA NOVOPROJEKTOVANIH OBJEKATA / LEGEND OF NEWLY DESIGNED BUILDINGS:

FAZA 1/STAGE 1 - SISTEM ZA PRERADU KREČNJAKA I GIPSA/ LIMESTONE AND GYPSUM AREA

FAZA 2/ STAGE 2 - ZONA ABSORBERA / ABSORBERS AREA

SISTEM 1 / SYSTEM 1 - SISTEM APSORBERA 01 / ABSORBER 01

SISTEM 2 / SYSTEM 2 - SISTEM APSORBERA 02 / ABSORBER 02

SISTEM 3 / SYSTEM 3 - SISTEM DIMNIH GASOVA / FLUE GAS SYSTEM

SISTEM 4 / SYSTEM 4 - SISTEM FOR PROCESS WATER, WASTE WATER AND GYPSUM

SLURRY SUSPENSION / SISTEM PROCESNE VODE.

SISTEM 5 / SYSTEM 5 - INFRASTRUKTURNI OBJEKTI SISTEMA ODG / INFRASTRUCTURE

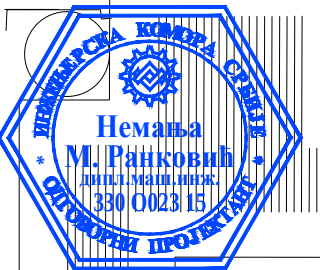
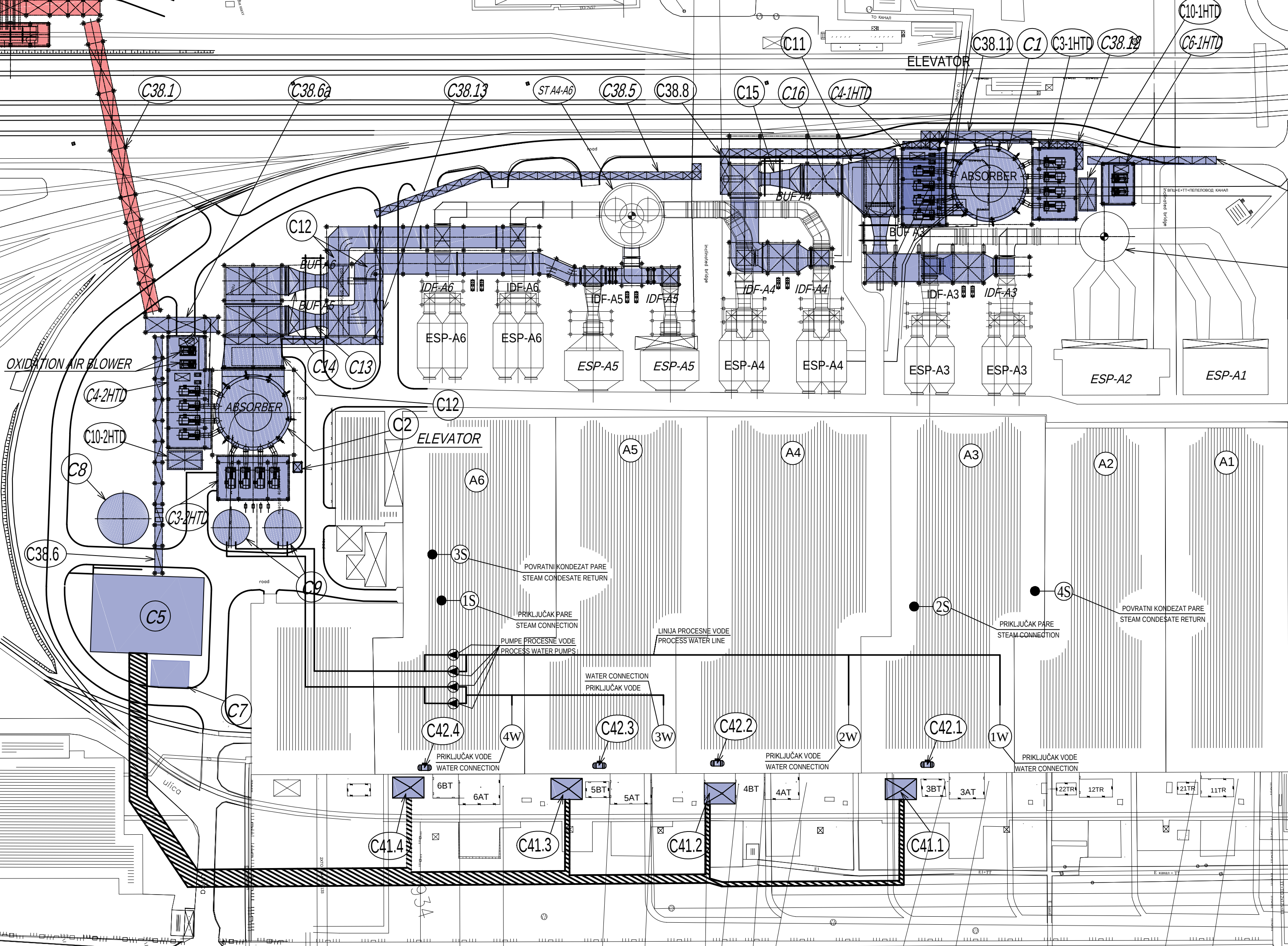
FACILITIES OF FGD COMPLEX

BR. / NO.	NAZIV OBJEKTA / NAME
C1	01 APSORBER / ABSORBER (1HTD)
C2	02 APSORBER / ABSORBER (2HTD)
C3-1HTD	ZGRADA RECIRKULACIONIH PUMPI 1HTD-1/ RECIRCULATION PUMP BUILDING 1
C4-1HTD	ZGRADA RECIRKULACIONIH PUMPI 1HTD-2/ RECIRCULATION PUMP BUILDING 2
C3-2HTD	ZGRADA RECIRKULACIONIH PUMPI 2HTD-1/ RECIRCULATION PUMP BUILDING 1
C4-2HTD	ZGRADA RECIRKULACIONIH PUMPI I DUVALJKI 2HTD-2 / RECIRCULATION PUMP & OXIDATION AIR BLOWER
C5	GLAVNA ELEKTRO-KOMANDNA ZGRADA / FGD CONTROL - ELECTRICAL BUILDING
C6-1HTD	ZGRADA DUVALJKI 1HTD / OXIDATION AIR BLOWER BUILDING
C7	ZGRADA DIZEL AGREGATA / EMERGENCY DIESEL GENERATOR
C8	REZERVOAR ZA PRAŽNJENJE APSORBERA / ABSORBER BLOW DOWN TANK
C9	REZERVOAR PROCESNE VODE / FGD PROCESS WATER TANK
C10-1HTD	DRENAŽNA JAMA 1HTD / ABSORBER DRAIN PIT
C10-2HTD	DRENAŽNA JAMA 2HTD / ABSORBER DRAIN PIT
C11	DIMNI KANALI BLOKOVA A3 I A4 / DUCT FOR UNITS A3 & A4
C12	DIMNI KANALI BLOKOVA A5 I A6 / DUCT FOR UNITS A5 & A6
C13	BUSTER VENTILATOR BLOKA A6 / A6 BUF
C14	BUSTER VENTILATOR BLOKA A65 / A5 BUF
C15	BUSTER VENTILATOR BLOKA A64 / A4 BUF
C16	BUSTER VENTILATOR BLOKA A3 / A3 BUF
C18	ISTOVARNA STANICA ZA KAMIONE / LIMESTONE TRUCK UNLOADING BUILDING
C19	TRANSPORT IZMEĐU ISTOVARNE STANICE VAGONA I KAMIONA / LIMESTONE TRANSFER CONVEYOR
C22	ZGRADA SKLADIŠTENJA KREČNJAKA / LIMESTONE STORAGE BUILDING
C23	ELEKTRO-KOMANDNA ZGRADA KREČNJAKA I GIPSA / LIMESTONE AND GYPSUM ELECTRICAL BUILDING
C24	ZGRADA MLEVENJA / LIMESTONE MILL BUILDING
C28	REZERVOAR HIDROMEŠAVINE KREČNJAKA / LIMESTONE SLURRY FEED TANK
C29.1	KOLSKA VAGA 1 / TRUCK SCALE 1
C29.2	KOLSKA VAGA 2 / TRUCK SCALE 2
C30	SILOS GIPSA / GYPSUM STORAGE SILO

C32.1	REZERVOAR FILTRATA GIPSA 1 / GYPSUM FILTRATE TANK 1
C32.2	REZERVOAR FILTRATA GIPSA 2 / GYPSUM FILTRATE TANK 2
C33.1	REZERVOAR TEHNIČKE VODE 1 / WASTE WATER FEED TANK 1
C33.2	REZERVOAR TEHNIČKE VODE 2 / WASTE WATER FEED TANK 2
C35	PORTIRNICA / GATE HOUSE
C36	KOMPRESORSKA STANICA / COMPRESSOR STATION
C37	ZGRADA ZA ZGRUŠIVANJE HIDROMEŠAVINE GIPSA / GYPSUM SLURRY DISPOSAL SYSTEM TANK
C38.1	CEVNI MOST 1 / PIPING AND ELECTRICAL RACK 1
C38.2	CEVNI MOST 2 / PIPING AND ELECTRICAL RACK 2
C38.3	CEVNI MOST 3 / PIPING AND ELECTRICAL RACK 3
C38.4	CEVNI MOST 4 / PIPING AND ELECTRICAL RACK 4
C38.5	CEVNI MOST 5 / PIPING AND ELECTRICAL RACK 5
C38.6	CEVNI MOST 6 / PIPING AND ELECTRICAL RACK 6
C38.6a	CEVNI MOST 6a / PIPING AND ELECTRICAL RACK 6a
C38.7	CEVNI MOST 7 / PIPING AND ELECTRICAL RACK 7
C38.8	CEVNI MOST 8 / PIPING AND ELECTRICAL RACK 8
C38.9	CEVNI MOST 9 / PIPING AND ELECTRICAL RACK 9
C38.10	CEVNI I ELEKTRO KANAL / PIPING AND ELECTRICAL TRENCH
C38.11	CEVNI MOST 11 / PIPING AND ELECTRICAL RACK 11
C38.12	CEVNI MOST 12 / PIPING AND ELECTRICAL RACK 12
C38.13	CEVNI MOST 13 / PIPING AND ELECTRICAL RACK 13
C39	ISTOVARNA STANICA KREČNJAKA ZA VAGONE / LIMESTONE RAILWAY UNLOADING
C41.1	TRANSFORMATOR 3BT1 / TRANSFORMER - 3BT1
C41.2	TRANSFORMATOR 4BT1 / TRANSFORMER - 4BT1
C41.3	TRANSFORMATOR 5BT1 / TRANSFORMER - 5BT1
C41.4	TRANSFORMATOR 6BT1 / TRANSFORMER - 6BT1
C42.1	REZERVOAR PROTIVPOŽARNE VODE ZA TRANSFORMATOR 3BT1/ TRANSFORMER FP TANK 3BT1
C42.2	REZERVOAR PROTIVPOŽARNE VODE ZA TRANSFORMATOR 4BT1 / TRANSFORMER FP TANK 4BT1
C42.3	REZERVOAR PROTIVPOŽARNE VODE ZA TRANSFORMATOR 5BT1 / TRANSFORMER FP TANK 5BT1
C42.4	REZERVOAR PROTIVPOŽARNE VODE ZA TRANSFORMATOR 6BT1 / TRANSFORMER FP TANK 6BT1

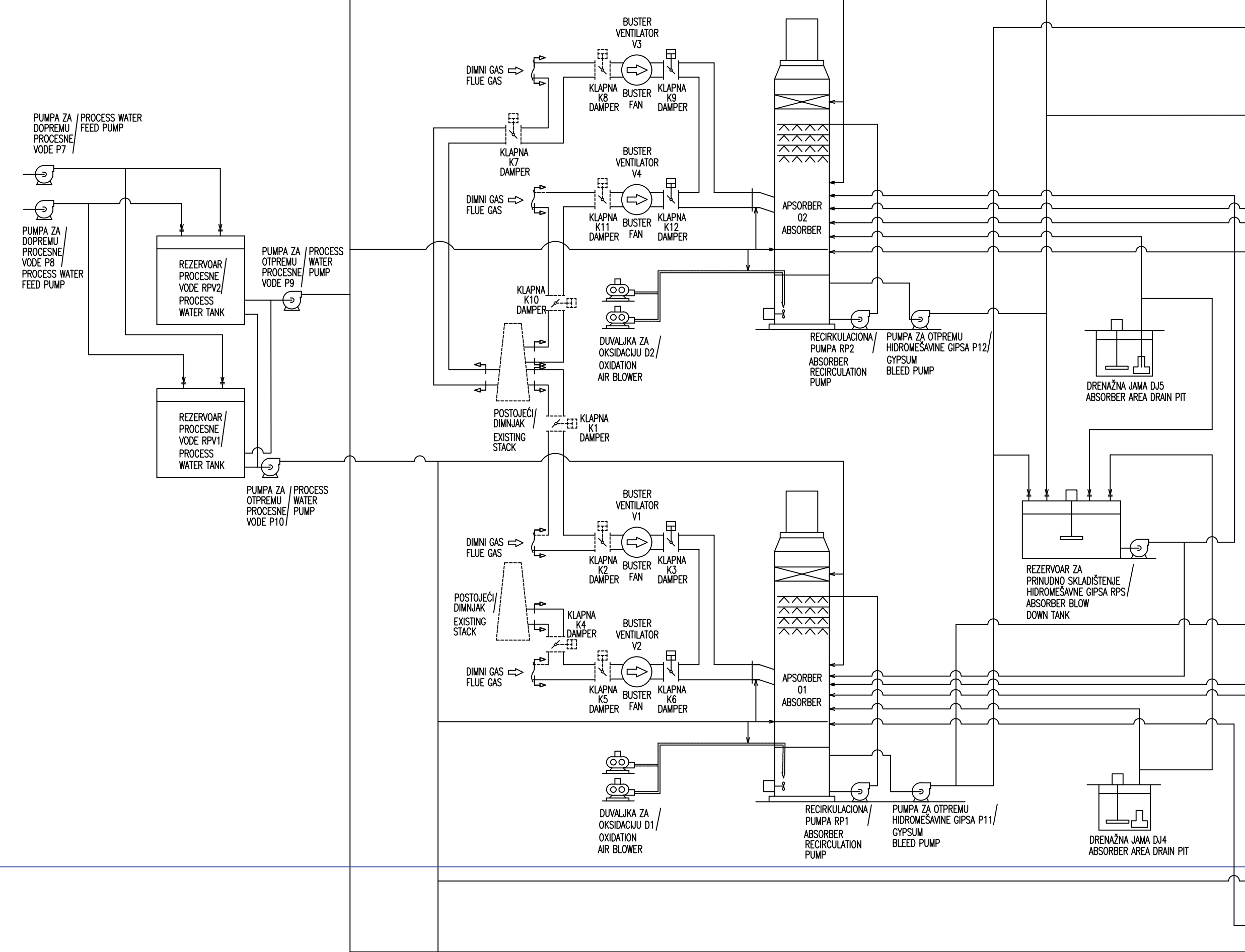
LEGENDA POSTOJEĆIH OBJEKATA VEZANIH ZA SISTEM ODG (nije predmet projekta) :
LEGEND OF EXISTING BUILDINGS RELATED TO FGD PROCESS (out of scope of works) :

R. Br./No.	NAZIV / NAME
A1	BLOK A1 / UNIT A1
A2	BLOK A2 / UNIT A2
A3	BLOK A3 / UNIT A3
A4	BLOK A4 / UNIT A4
A5	BLOK A5 / UNIT A5
A6	BLOK A6 / UNIT A6
ST A1-A3	POSTOJEĆI DIMNJAK BLOKOVA A1-A3 / EXISTING STACK FOR UNITS A1-A3
ST A4-A6	POSTOJEĆI DIMNJAK BLOKOVA A4-A6 / EXISTING STACK FOR UNITS A4-A6
ESP-A1	ELEKTROFILTER A1 / ELECTROSTATIC PRECIPITATOR A1
ESP-A2	ELEKTROFILTER A2 / ELECTROSTATIC PRECIPITATOR A2
ESP-A3	ELEKTROFILTER A3 / ELECTROSTATIC PRECIPITATOR A3
ESP-A4	ELEKTROFILTER A4 / ELECTROSTATIC PRECIPITATOR A4
ESP-A5	ELEKTROFILTER A5 / ELECTROSTATIC PRECIPITATOR A5
ESP-A6	ELEKTROFILTER A6 / ELECTROSTATIC PRECIPITATOR A6
IDF-A3	VENTILATOR A3 / ID FAN A3
IDF-A4	VENTILATOR A4 / ID FAN A4
IDF-A5	VENTILATOR A5 / ID FAN A5
IDF-A6	VENTILATOR A6 / ID FAN A6
WWTP	POSTROJENJE ZA PRERADU OTPADNE VODE / WASTE WATER TREATMENT PLANT

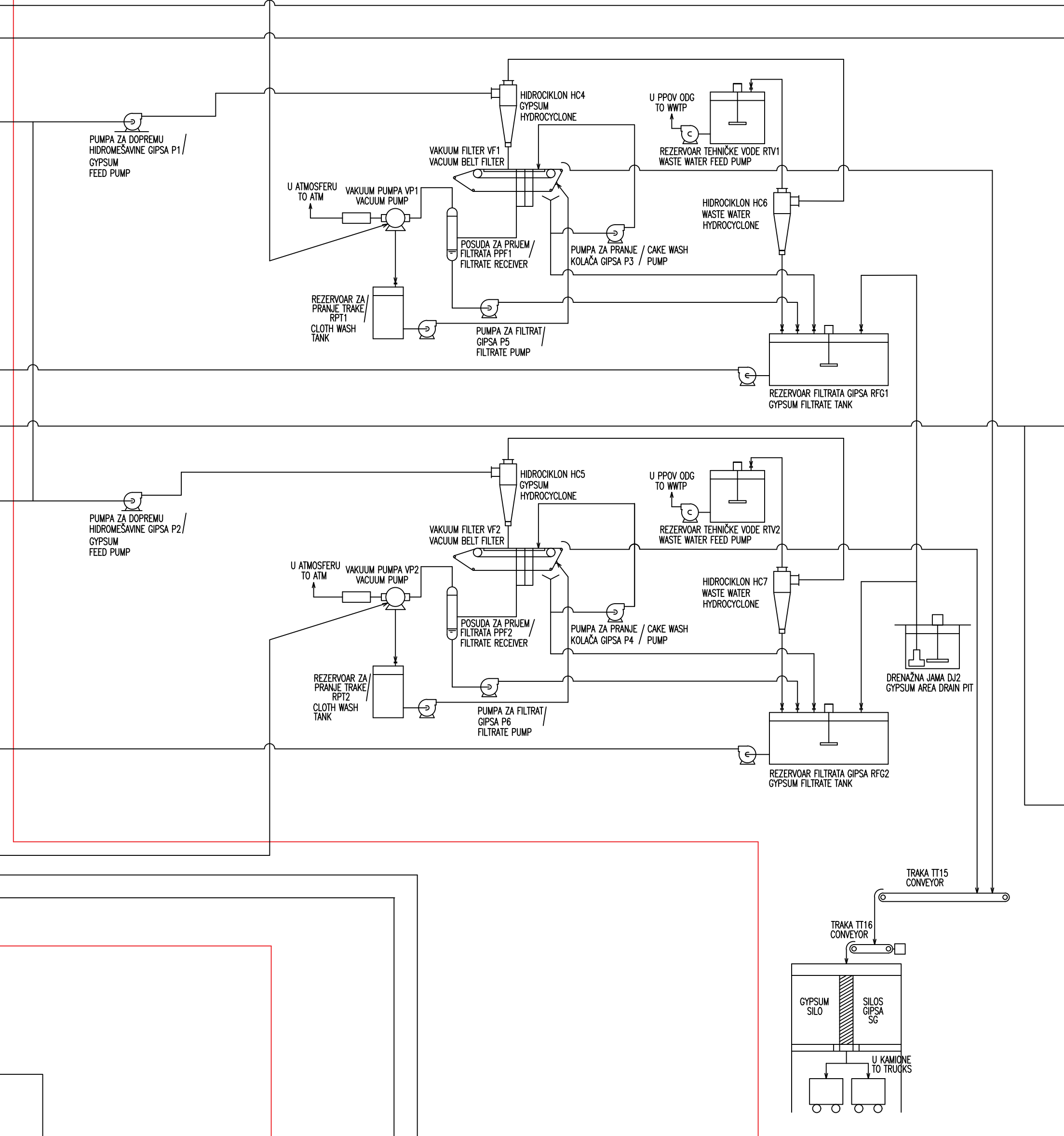


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Broj ugovora / Contract No :12.01.12625/52-17							
Korporatum: Consortium:							
Odg. projektant: Respon. designer: Licenca odg. proj. Res. des. license: Vista teh. dok.: IDR - Idejno rešenje IDR - Conceptual design Datum: Date: Deo projekta: Project part:		Ime i prezime / Name: Nemanja Ranković 330 0023 15 IDR - Idejno rešenje IDR - Conceptual design 25.01.2018. Projekcija Projection: Mašinski Projekat Mechanical Design		Paraf/Sign: Investitor: Client: JP ELEKTROPRIVREDA SRBIJE PE ELEKTROPRIVREDA SERBIJA Dizajner: Complex: Postrojenje za ODG za TE Nikola Tesla A FGD Construction Project for TPP Nikola Tesla Postrojenje: Facility: Dio postrojenja: Unit:		Revizija: Revision: 1/1000	
Računski Scale: 1/1000		Naziv crteža Drawing name: Situacioni plan General layout plot plan		Listof Pageof: 1/1		Rev. Rev.	

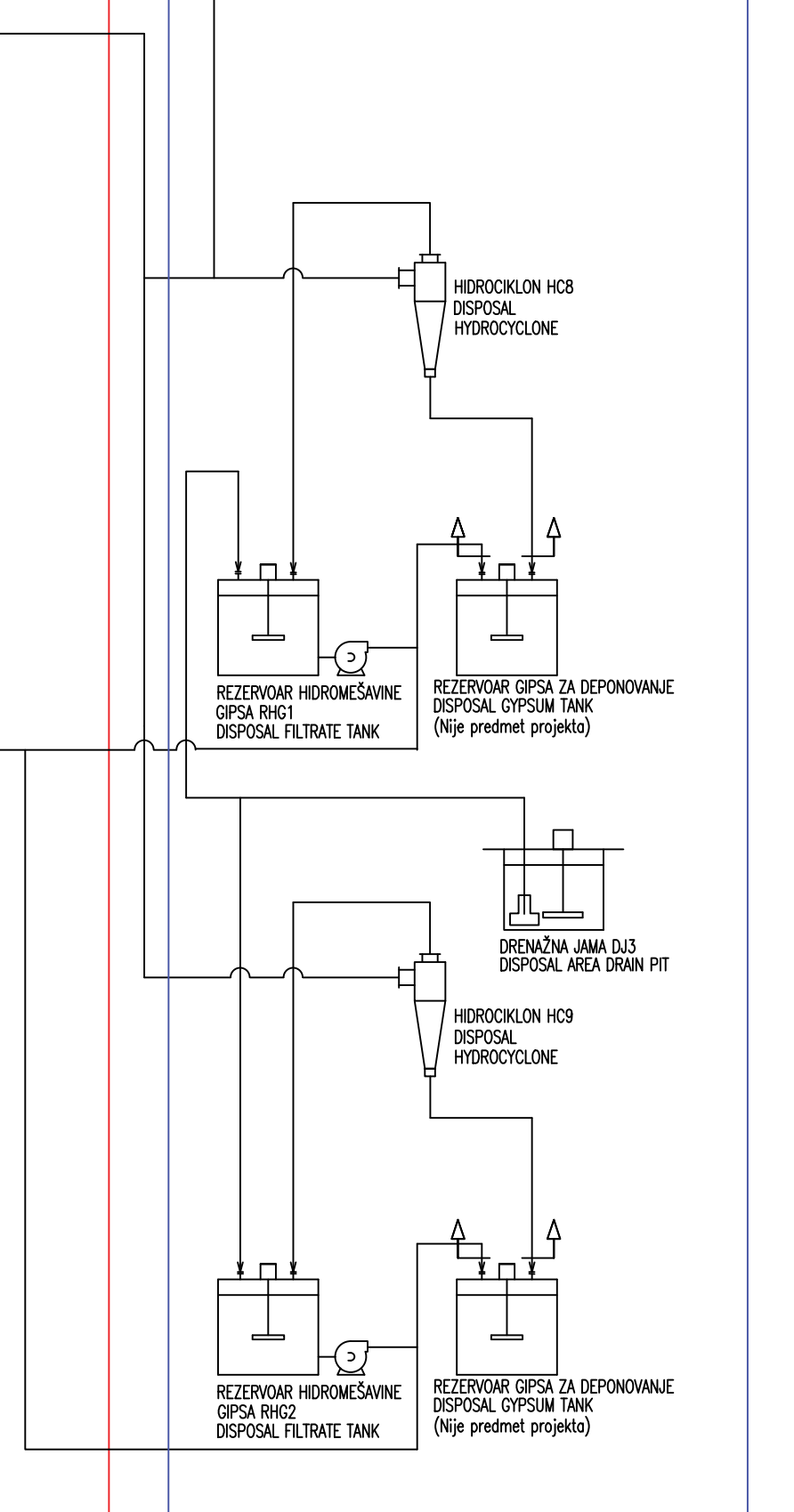
FAZA 2 / PHASE 2
SISTEM APSORBERA /
ABSORPTION SYSTEM



FAZA 1 / PHASE 1
SISTEM ZA FILTRIRANJE GIPSA / GYPSUM DEWATERING SYSTEM

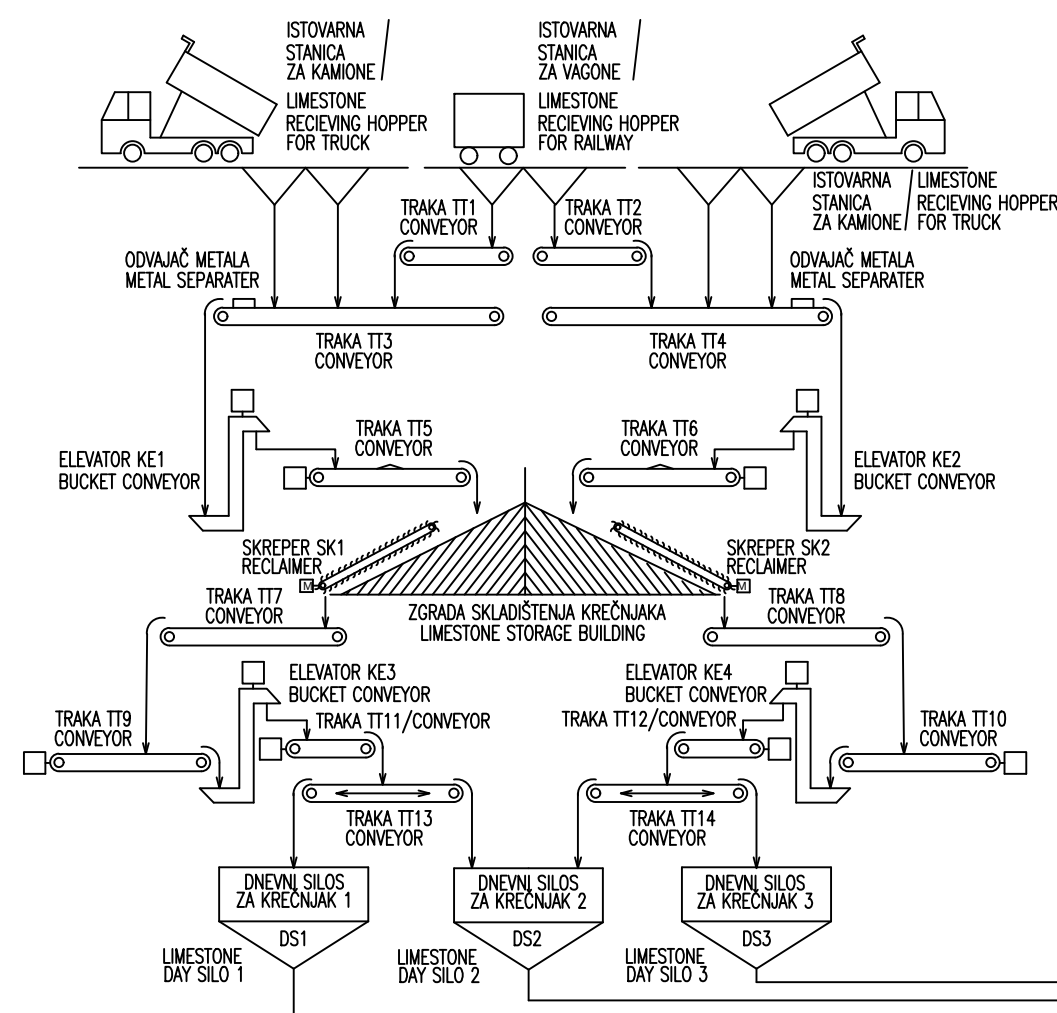


FAZA 2 / PHASE 2
SISTEM HIDROMEŠAVINE GIPSA /
GYPSUM DISPOSAL SYSTEM



FAZA 1 / PHASE 1

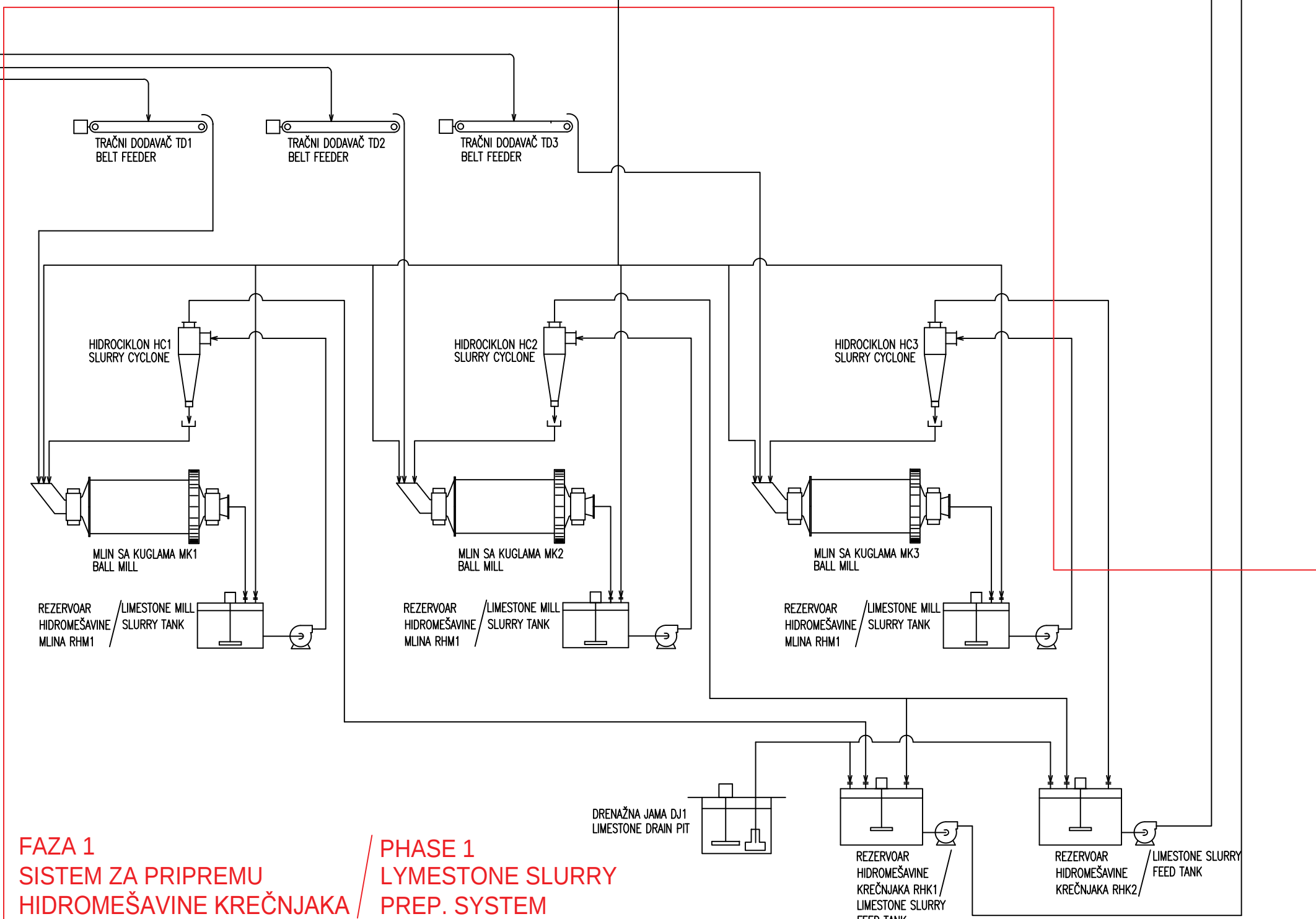
SISTEM ZA PRIJEM I SKLADIŠTENJE KREČNJAKA / LIMESTONE HANDLING SYSTEM



FAZA 1 / PHASE 1

SISTEM ZA PRIPREMU / LYMESTONE SLURRY

HIDROMEŠAVINE KREČNJAKA / PREP. SYSTEM

[illegible]

Dimni gas iz kotlova A3 i A4 / Flue gas from boilers A3 and A4	
H ₂ O	736 080 kg/h
SO ₂	18360 kg/h
suv gas/dry gas	3 444 200 Nm ³ /h
vlažan gas/wet gas	4 360 200 Nm ³ /h



File name / File name: NTFGD-SO-0-IDB-7 0 0-000-002D-rev00 - Mass balance Case 1-1 | 1 dwg

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LEGENDA GASA/GAS LEGEND			
t/h H ₂ O	suv gas/dry gas Nm ³ /h		
kg/h SO ₂	vlažan gas/wet gas Nm ³ /h		

367,93	1712130
9180	2170000

BUF A3

368	1722100
9180	2180100

BUF A4

367,93	1712130
9180	2170000

736	3444200
18360	4360200

0,27	32900
-	33240

1028,97	4.690.800
610	5.719.770

12,9 t/h
69
4,8 t/h
68

APSORBER
A3, A4

-	-
75	-

30,8	30
83,49	1,229

-	-
-	-

18,99	4,8
383,559	1,028

-	-
-	-

od rezervoara
filtrata gipsa

67,797	15
413,66	1,092

LEGENDA PULPE/PULP LEGEND			
čvrsto/solids t/h	% č/% solids		
pulpa/pulp m ³ /h	gustina pulpe/pulp density m ³ /t		

△	△	△	△	
REV.	Opis revizije / Revision description	Datum/Date	Crtao/Drawn	
Broj ugovora / Contract No :12.01.12625/52-17				
Konzorcijum: Consortium:	   			
 www.deltainzenjering.rs	Odg. projektant: Respon. designer:	Ime i prezime / Name	Paraf/Sign.	
	Licenca odg.proj.: Res. des. license:	371 5696 03		
	Vrsta teh. dok.: Project type:	IDR - Idejno rešenje IDR - Conceptual design		
	Datum: Date:	25.01.2018.	Projekcija: Projection:	
	Deo projekta: Project part:	Projekat tehnologije Technology design		
Razmera: Scale:	Naziv crteža: Drawing name:		Crtež broj: Drawing number:	
x/x	Šema kretanja masa pulpe - slučaj 1-1 Mass balance - case 1-1		NTFGD-S0.0-IDR-7.0.0-000-002D-rev00	
List/od: Page/of:			2/2	
Rev.			△	

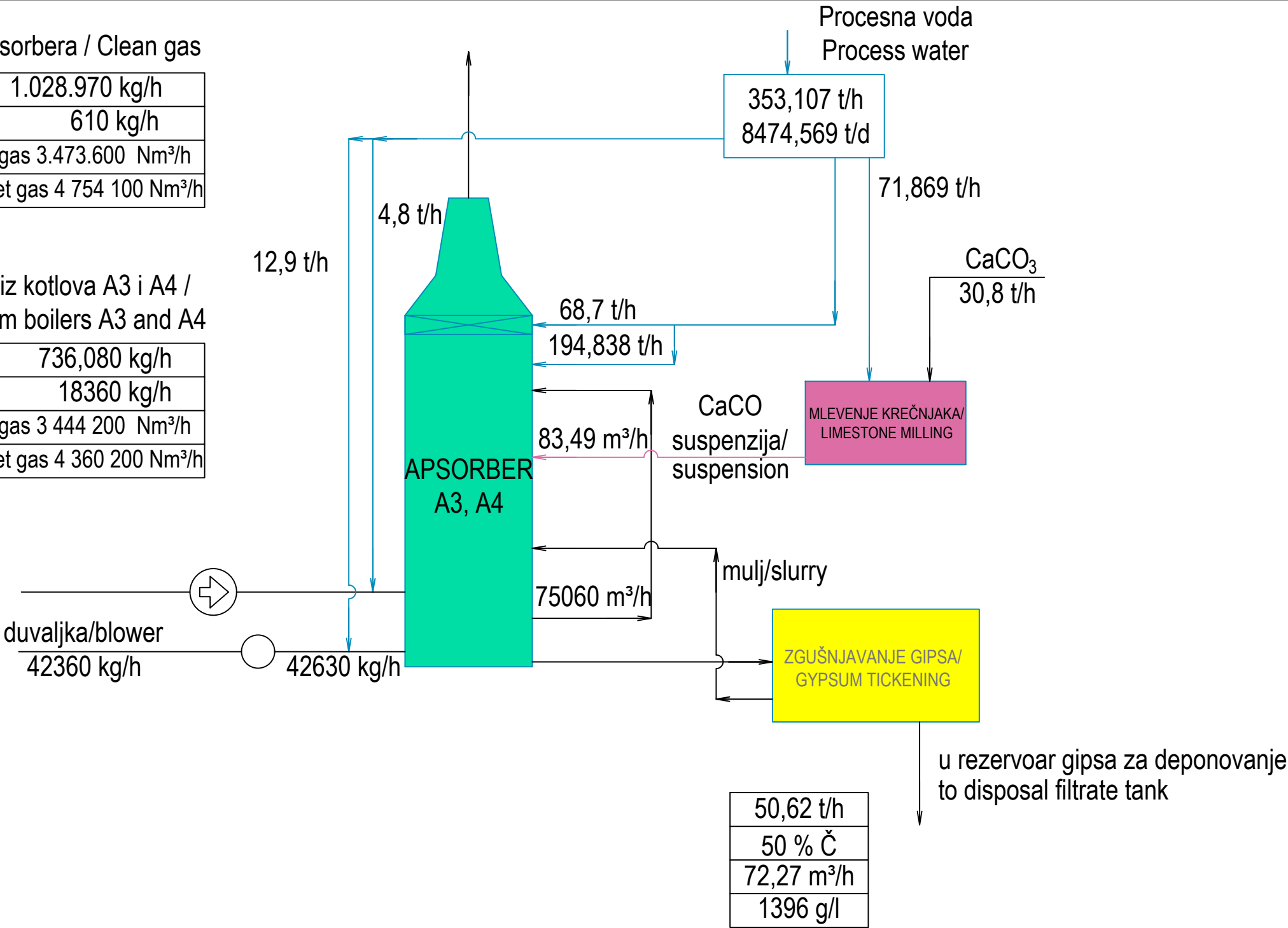
File name: NTF-GD-S0.0-IDR-7.0.0-000-002D-rev00 - Mass balance Case 1-1.dwg
25.01.2018 - Rev. 3 - 15.08.18

Emisija iz apsorbera / Clean gas

H ₂ O	1.028.970 kg/h
SO ₂	610 kg/h
suv gas/dry gas	3.473.600 Nm ³ /h
vlažan gas/wet gas	4 754 100 Nm ³ /h

Dimni gas iz kotlova A3 i A4 /
Flue gas from boilers A3 and A4

H ₂ O	736,080 kg/h
SO ₂	18360 kg/h
suv gas/dry gas	3 444 200 Nm ³ /h
vlažan gas/wet gas	4 360 200 Nm ³ /h



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Konzorcium: Consortium:					
					
 www.deltainzenjering.rs		Ime i prezime / Name	Paraf/Sign.	Investitor: Client:	 JP ELEKTROPRIVREDA SRBIJE PE ELEKTROPRIVREDA SERBIA
	Odg. projektant: Respon. designer:	Radoje Tufegdžić			
	Licenca odg.proj.: Res. des. license:	371 5696 03		Objekat: Complex:	Postrojenje za ODG za TE Nikola Tesla A FGD Construction Project for TPP Nikola Tesla
	Vrsta teh. dok.: Project type:	IDR - Idejno rešenje IDR - Conceptual design		Postrojenje: Facility:	
	Datum: Date:	25.01.2017	Projekcija: Projection:	 	
	Deo projekta: Project part:	Projekat tehnologije Technology design		Deo postrojenja: Unit:	
Razmera: Scale:	Naziv crteža: Drawing name:		Crtež broj: Drawing number:		List/od: Page/of:
x/x	Šema kretanja masa pulpe - slučaj 1-2 Mass balance - case 1-2		NTFGD-S0.0-IDR-7.0.0-000-003D-rev00		1/2
					Rev. 

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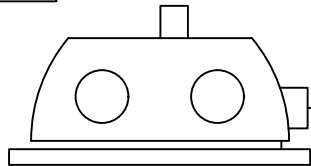
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LEGENDA GASA/GAS LEGEND			
t/h H ₂ O	suw gas/dry gas Nm ³ /h		
kg/h SO ₂	vlažan gas/wet gas Nm ³ /h		

367,93	1712130
9180	2170000



367,93	1712130
9180	2170000



0,27	32 900
-	33 240

736	3 444 200
18 360	4 360 200

368	1 722 100
9180	2 180 100

1028,97	4 690 800
610	5 719 770

4,8 t/h
12,9 t/h

APSORBER
A3, A4

-	-
75	-

30,8	30
83,49	1,229

17,75	5
344,91	1,029

-	-
-	-

-	-
-	-

-	-
-	-

-	-
-	-

-	-
-	-

-	-
-	-

-	-
-	-

-	-
-	-

-	-
-	-

-	-
-	-

-	-
-	-

281,238 t/h

LEGENDA PULPE/PULP LEGEND			
čvrsto/solids t/h	% &/% solids		
pulpa/pulp m ³ /h	gustina pulpe/pulp density m ³ /t		

ATM

GIPS

PPOV/WWTP

U REZERVOAR GIPSA ZA DEPONOVANJE
TO DISPOSAL FILTRATE TANK



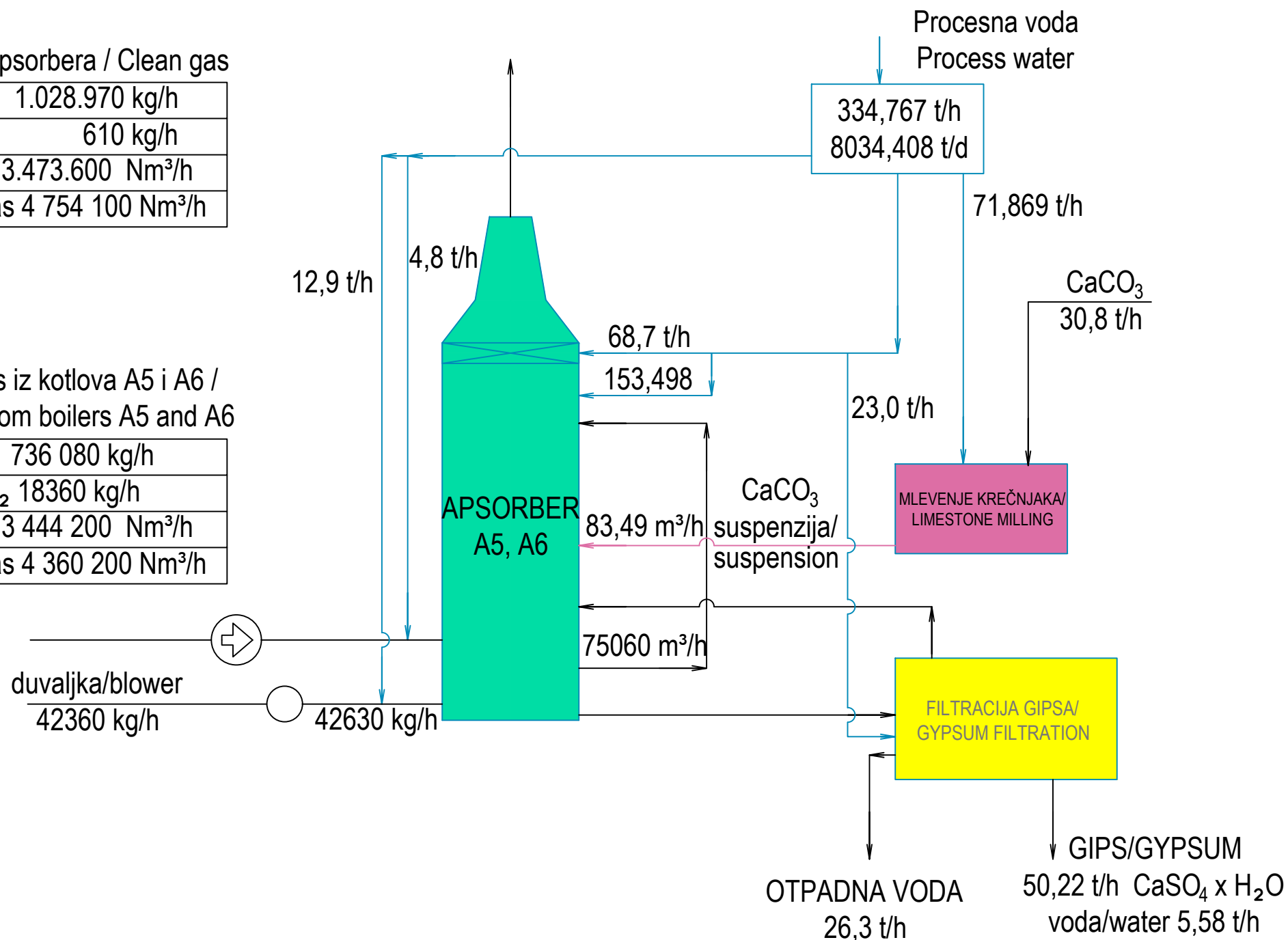
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	Licenca odg.proj.: Res. des. license:	371 5696 03		JP ELEKTROPRIVREDA SRBIJE PE ELEKTROPRIVREDA SERBIA
	Vrsta teh. dok.: Project type:	IDR - Idejno rešenje IDR - Conceptual design		Objekat: Complex:
	Datum: Date:	25.01.2018.	Projekcija: Projection:	Postrojenje: Facility:
	Deo projekta: Project part:	Projekat tehnologije Technology design		Deo postrojenja: Unit:
	Razmera: Scale:	x/x		
Naziv crteža: Drawing name:			Crtež broj: Drawing number:	
Šema kretanja masa pulpe - slučaj 1-2 Mass balance - case 1-2			NTFGD-S0.0-IDR-7.0.0-000-003D-rev00	
			List/od: Page/of:	2/2
			Rev.	△

Emisija iz apsorbera / Clean gas

H ₂ O	1.028.970 kg/h
SO ₂	610 kg/h
suv gas	3.473.600 Nm ³ /h
vlažan gas	4 754 100 Nm ³ /h

Dimni gas iz kotlova A5 i A6 /
Flue gas from boilers A5 and A6

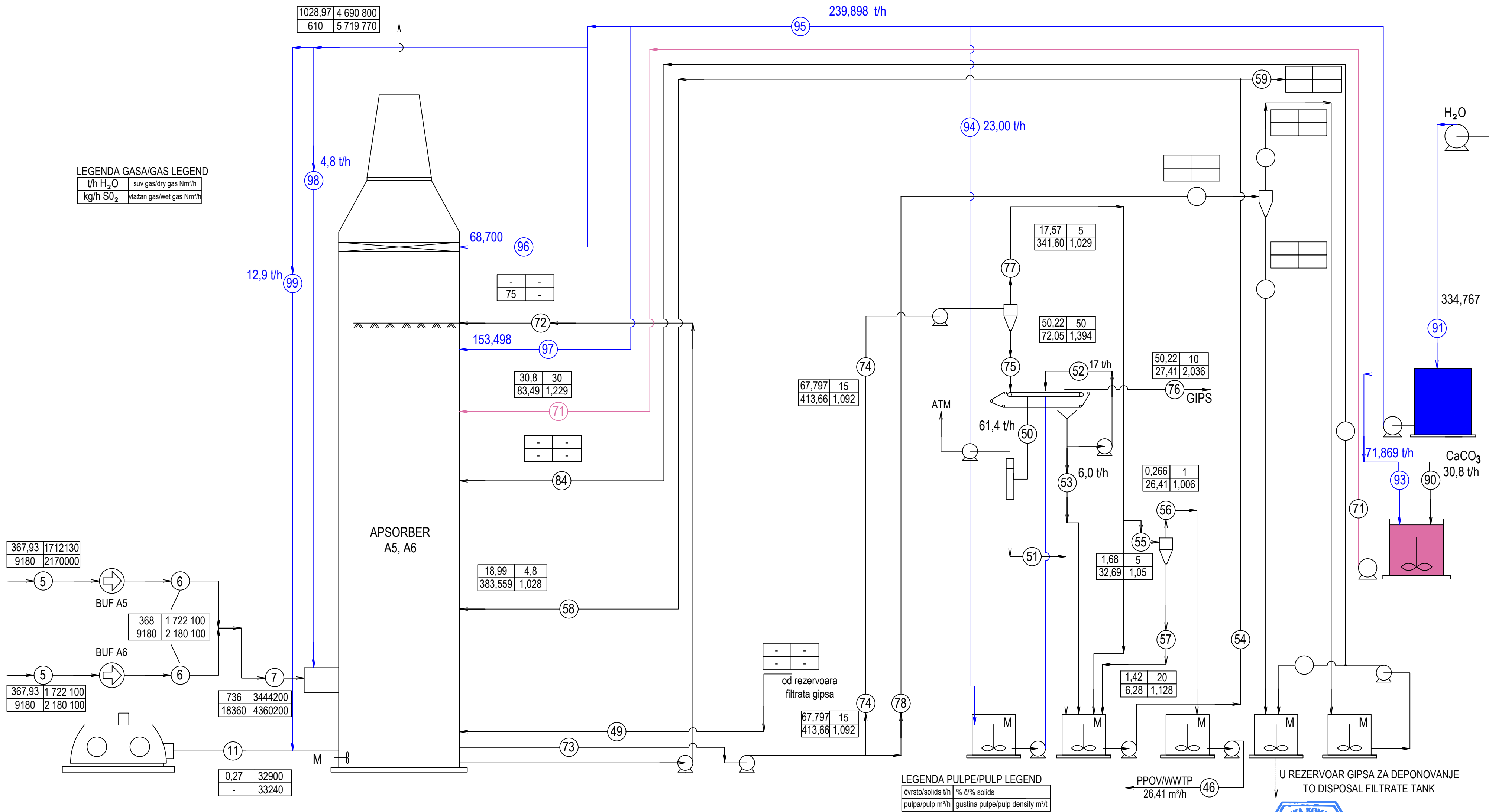
H ₂ O	736 080 kg/h
SO ₂	18360 kg/h
suv gas	3 444 200 Nm ³ /h
vlažan gas	4 360 200 Nm ³ /h



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	Odg. projektant: Respon. designer:	Radoje Tufegdžić			
	Licenca odg.proj.: Res. des. license:	371 5696 03		Objekat: Complex:	Postrojenje za ODG za TE Nikola Tesla A FGD Construction Project for TPP Nikola Tesla
	Vrsta teh. dok.: Project type:	IDR - Idejno rešenje IDR - Conceptual design		Postrojenje: Facility:	
	Datum: Date:	25.01.2017	Projekcija: Projection:	 	
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Razmera: Scale:	Naziv crteža: Drawing name:		Crtež broj: Drawing number:		List/od: Page/of:
x/x	Šema kretanja masa pulpe - slučaj 2-1 Mass balance - case 2-1		NTFGD-S0.0-IDR-7.0.0-000-004D-rev00		1/2
					Rev.
					

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	Licenca odg.proj.: Res. des. license:	371 5696 03		Objekat: Complex:
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x/x	Šema kretanja masa pulpe - slučaj 2-1 Mass balance - case 2-1		NTFGD-S0.0-IDR-7.0.0-000-004D-rev00	
			List/od: Page/of:	2/2
			Rev.	△

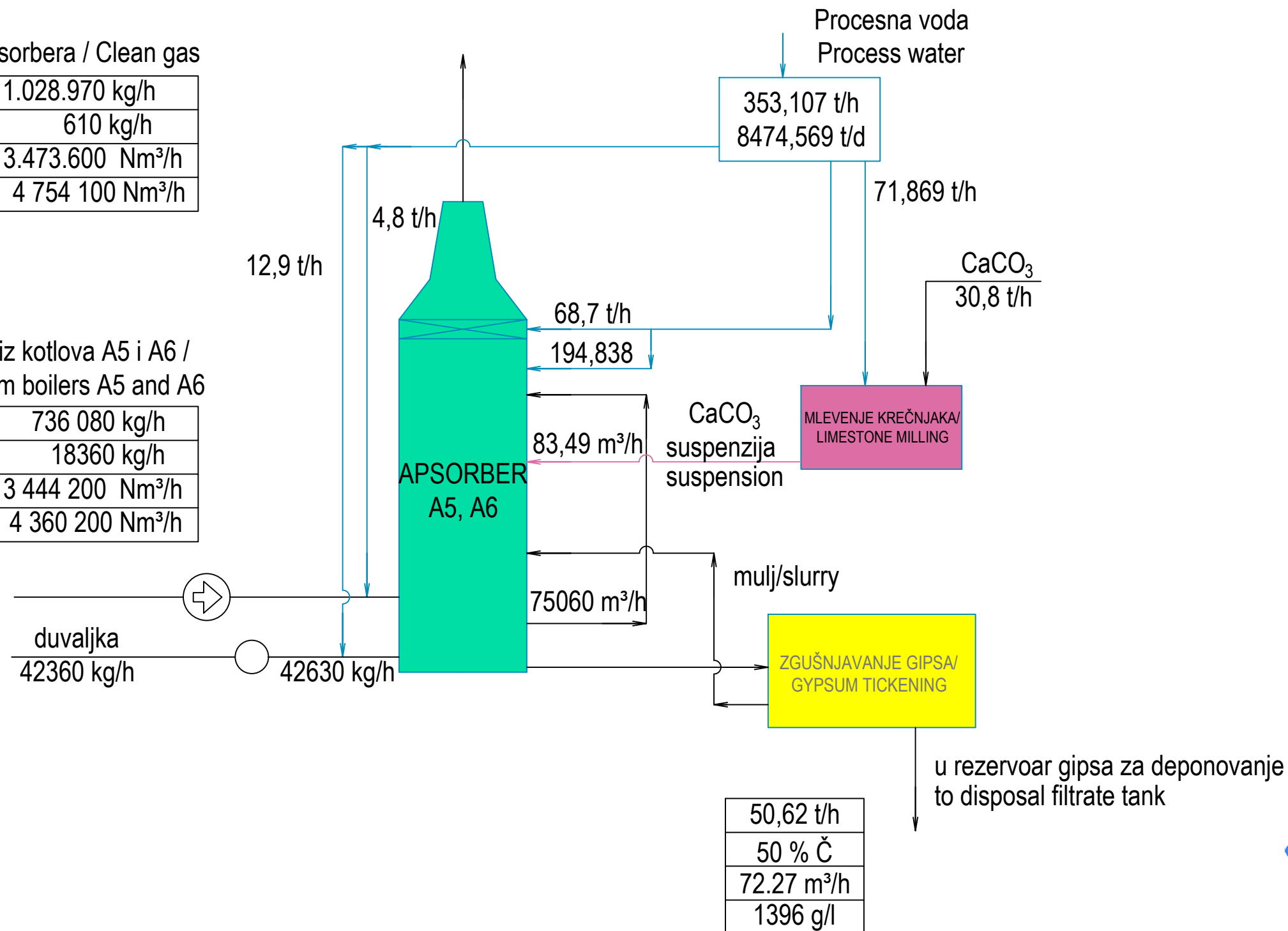
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Emisija iz apsorbera / Clean gas

H ₂ O	1.028.970 kg/h
SO ₂	610 kg/h
suv gas	3.473.600 Nm ³ /h
vlažan gas	4 754 100 Nm ³ /h

Dimni gas iz kotlova A5 i A6 /
Flue gas from boilers A5 and A6

H ₂ O	736 080 kg/h
SO ₂	18360 kg/h
suv gas	3 444 200 Nm ³ /h
vlažan gas	4 360 200 Nm ³ /h

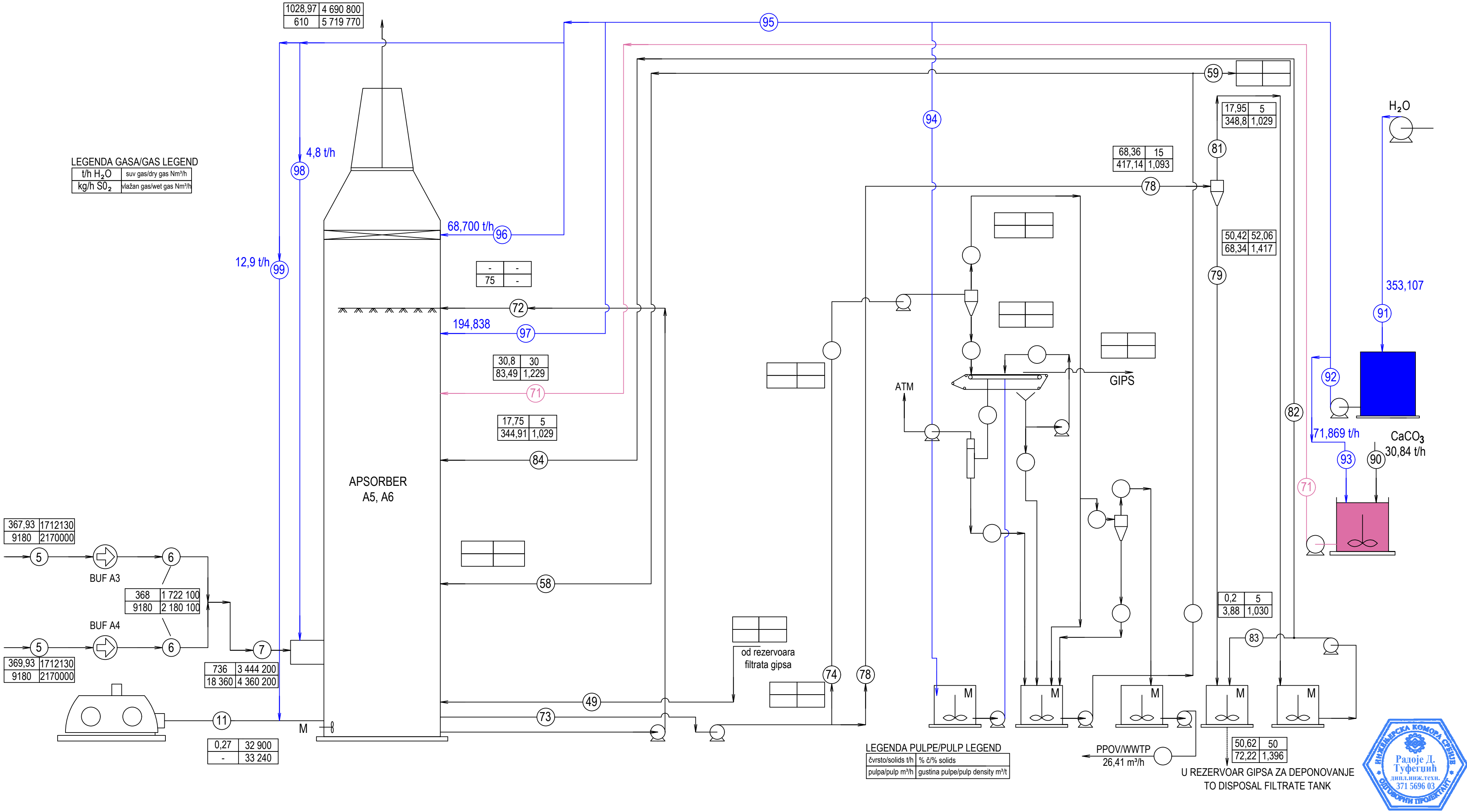


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REV.	Opis revizije / Revision description	Datum/Date	Crtao/Drawn	Overio/Appr.	
Broj ugovora / Contract No :12.01.12625/52-17					
Konzorcium: Consortium:					
					
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	Odg. projektant: Respon. designer:	Radoje Tufegdžić		 JP ELEKTROPRIVREDA SRBIJE PE ELEKTROPRIVREDA SERBIA	
	Licenca odg.proj.: Res. des. license:	371 5696 03		Objekat: Complex:	
	Vrsta teh. dok.: Project type:	IDR - Idejno rešenje IDR - Conceptual design		Postrojenje: Facility:	
	Datum: Date:	25.01.2017	Projekcija: Projection:	 	Deo postrojenja: Unit:
	Deo projekta: Project part:	Projekat tehnologije Technology design			
Razmera: Scale:	Naziv crteža: Drawing name:			Crtež broj: Drawing number:	
x/x	Šema kretanja masa pulpe - slučaj 2-2 Mass balance - case 2-2			NTFGD-S0.0-IDR-7.0.0-000-005D-rev00	
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LEGENDA GASA/GAS LEGEND			
t/h H ₂ O	suv gas/dry gas Nm ³ /h		
kg/h SO ₂	vlažan gas/wet gas Nm ³ /h		



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Broj ugovora / Contract No :12.01.12625/52-17				
Konzorcium: Consortium:		Investitor: Client:		
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 delta inženjering	Odg. projektant: Respon. designer:	Ime i prezime / Name	Paraf/Sign.	Objekat: Complex:
	Licenca odg.proj.: Res. des. license:	371 5696 03		Postrojenje za ODG za TE Nikola Tesla A FGD Construction Project for TPP Nikola Tesla
	Vrsta teh. dok.: Project type:	IDR - Idejno rešenje IDR - Conceptual design		Postrojenje: Facility:
	Datum: Date:	25.01.2018.	Projekcija: Projection:	
	Deo projekta: Project part:	Projekat tehnologije Technology design		Deo postrojenja: Unit:
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Razmera: Scale:	Naziv crteža: Drawing name:		Crtež broj: Drawing number:	List/od: Page/of:
x/x	Šema kretanja masa pulpe - slučaj 2-2 Mass balance - case 2-2		NTFGD-S0.0-IDR-7.0.0-000-005D-rev00	2/2
				Rev.

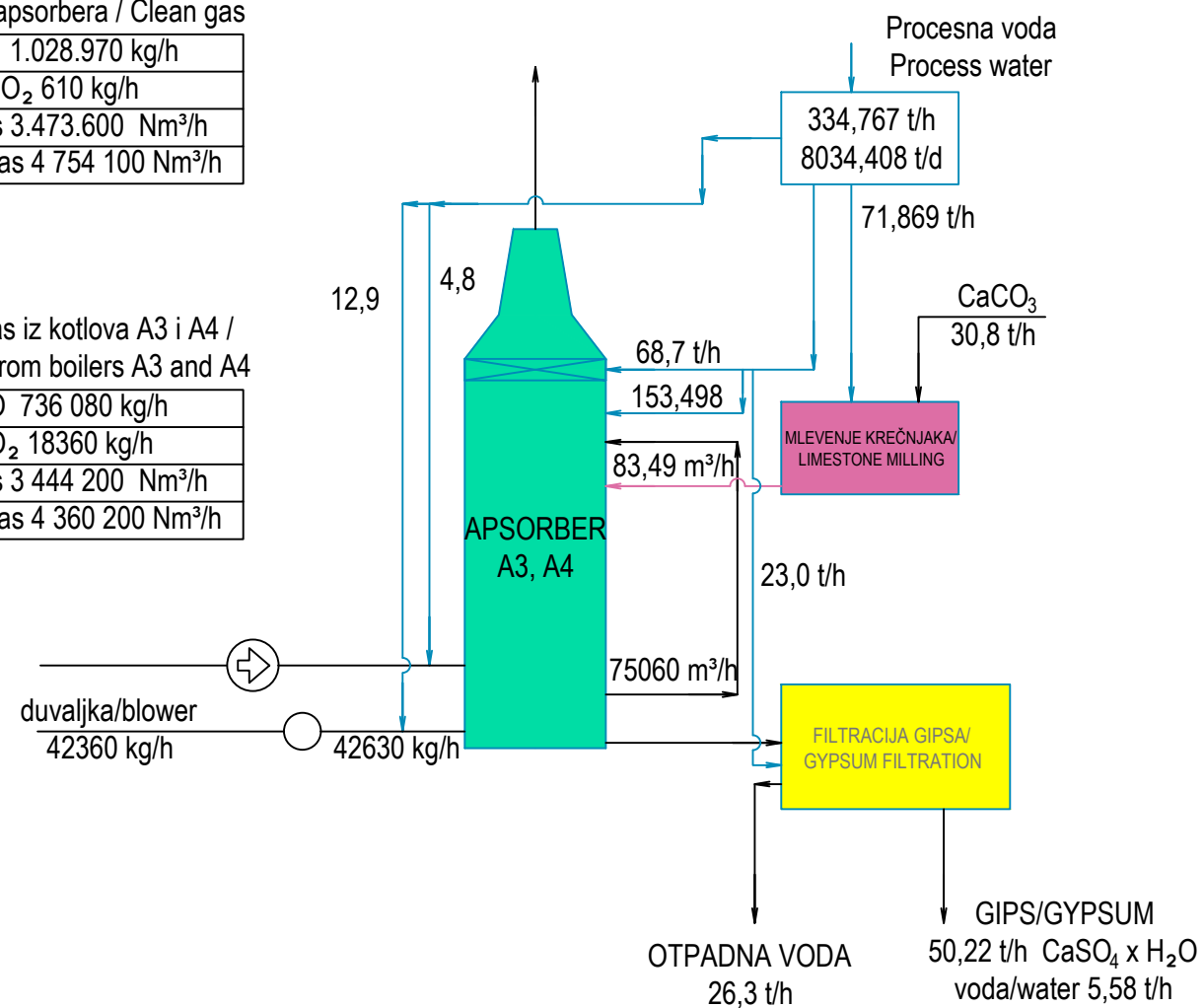
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ZAG01- Rev. 3-15.05.15

Emisija iz apsorbera / Clean gas

H ₂ O	1.028.970 kg/h
SO ₂	610 kg/h
suv gas	3.473.600 Nm ³ /h
vlažan gas	4 754 100 Nm ³ /h

Dimni gas iz kotlova A3 i A4 /
Flue gas from boilers A3 and A4

H ₂ O	736 080 kg/h
SO ₂	18360 kg/h
suv gas	3 444 200 Nm ³ /h
vlažan gas	4 360 200 Nm ³ /h

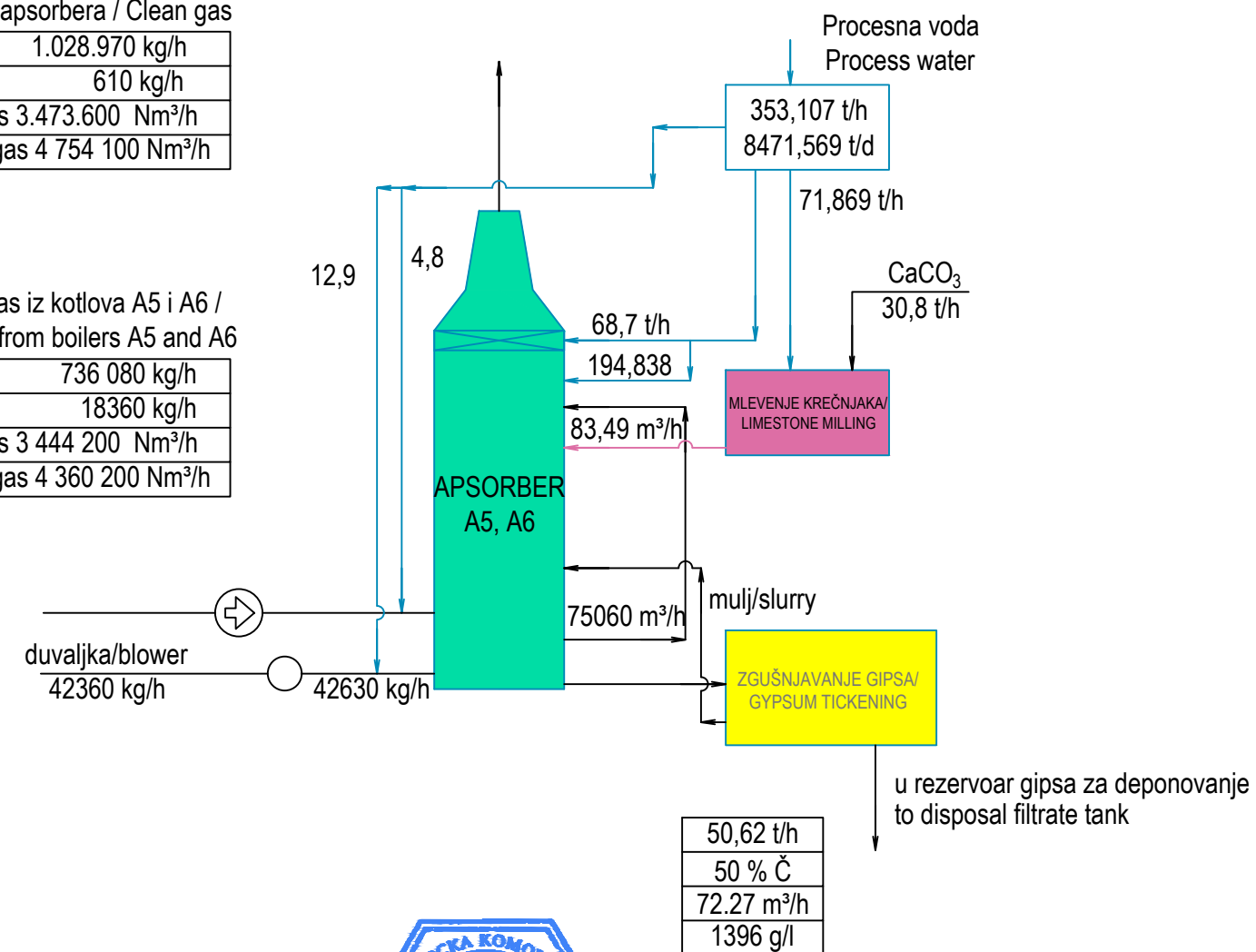


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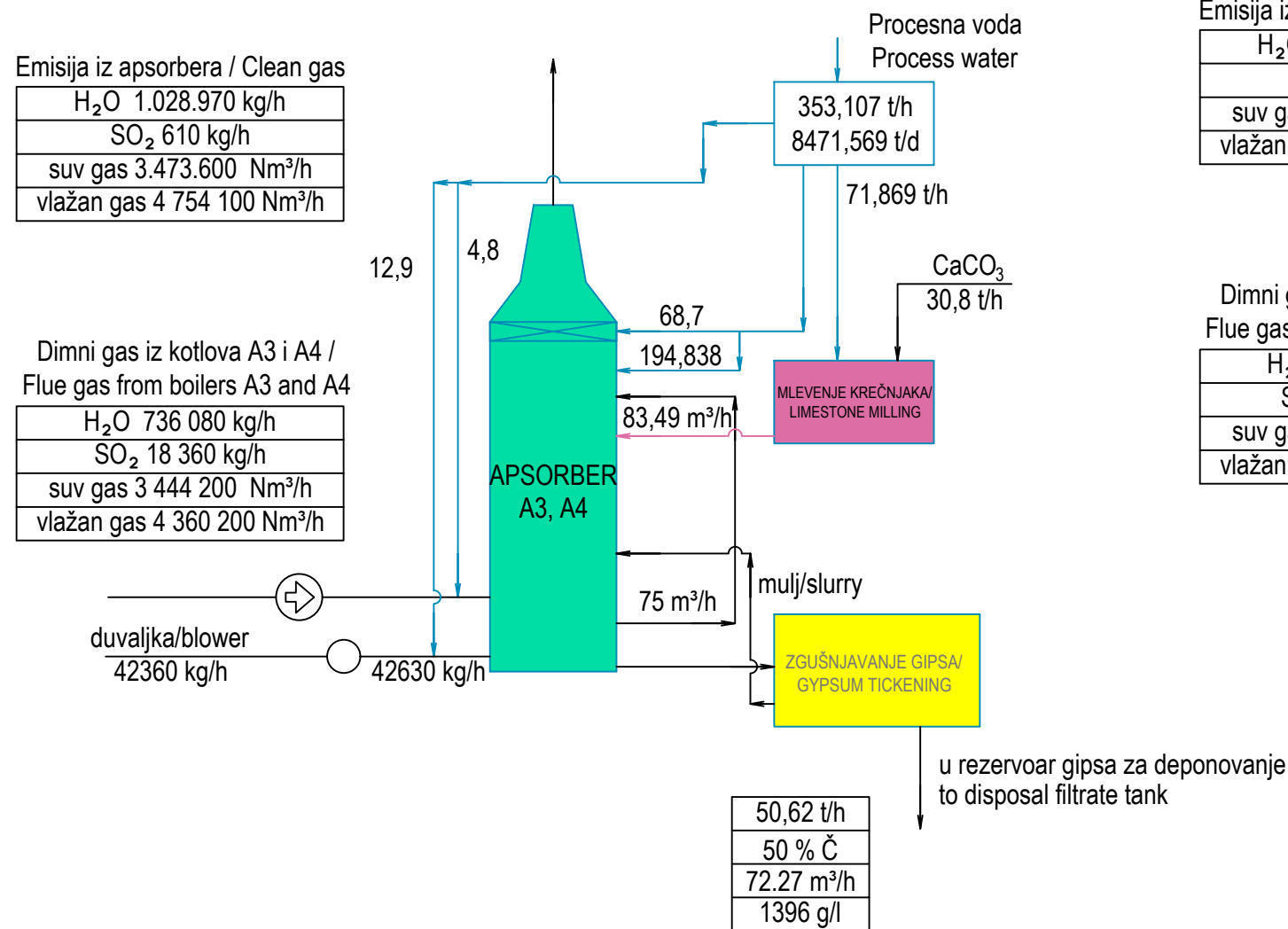
H ₂ O	1.028.970 kg/h
SO ₂	610 kg/h
suv gas	3.473.600 Nm ³ /h
vlažan gas	4 754 100 Nm ³ /h

Dimni gas iz kotlova A5 i A6 /
Flue gas from boilers A5 and A6

H ₂ O	736 080 kg/h
SO ₂	18360 kg/h
suv gas	3 444 200 Nm ³ /h
vlažan gas	4 360 200 Nm ³ /h



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REV.	Opis revizije / Revision description		Datum/Date	Crtao/Drawn	Overio/Appr.
Broj ugovora / Contract No :12.01.12625/52-17					
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	Vrsta teh. dok.: Project type:	IDR - Idejno rešenje IDR - Conceptual design		Postrojenje: Facility:	
	Datum: Date:	25.01.2017.	Projekcija: Projection:	 	
	Deo projekta: Project part:	Projekat tehnologije Technology design			Deo postrojenja: Unit:
Razmera: Scale:	Naziv crteža: Drawing name:			Crtež broj: Drawing number:	List/od: Page/of:
x/x	Šema kretanja masa pulpe - slučaj 3-1 Mass balance - case 3-1			NTFGD-S0.0-IDR-7.0.0-000-006D-rev00	1/1
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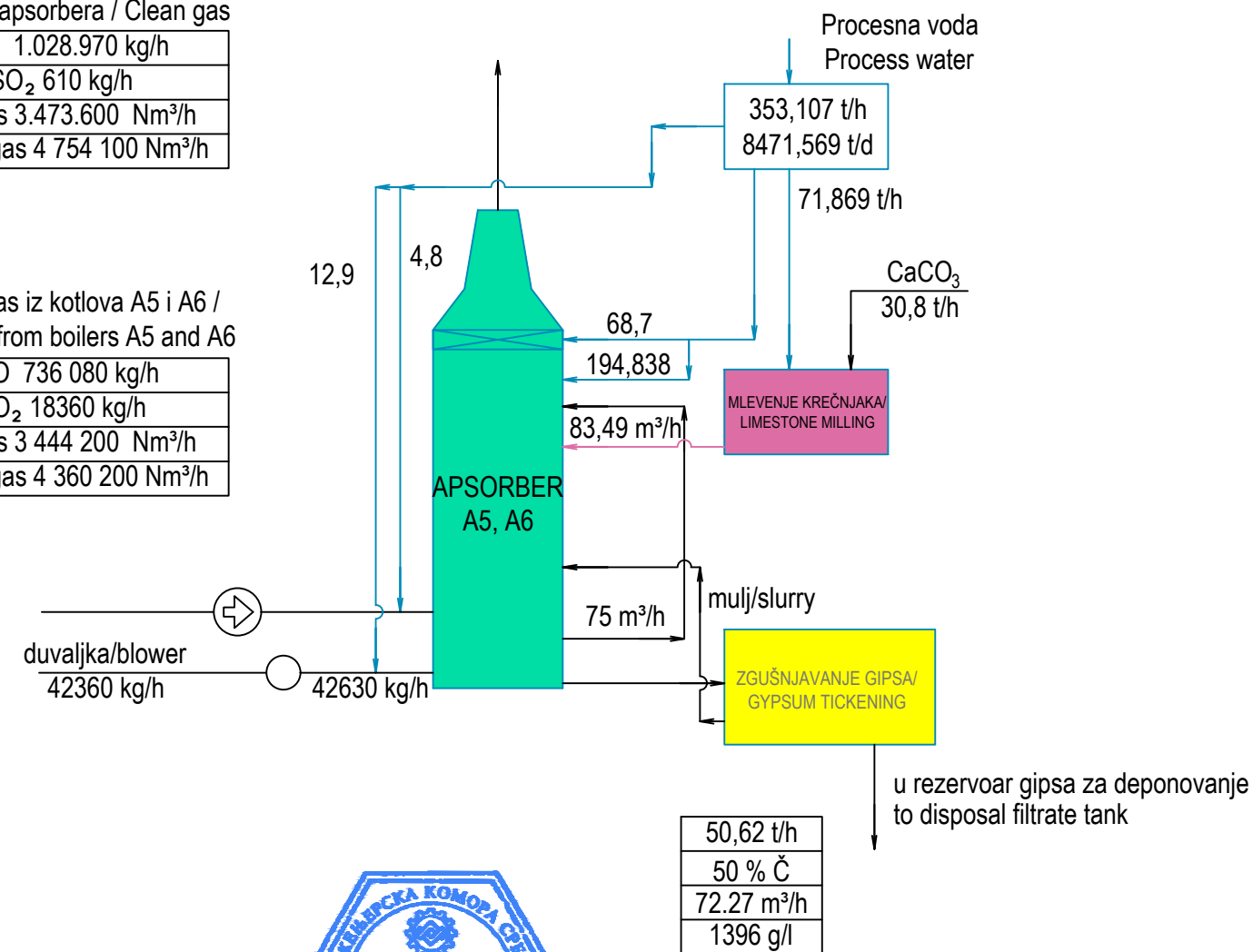


Emisija iz apsorbera / Clean gas

H ₂ O	1.028.970 kg/h
SO ₂	610 kg/h
suv gas	3.473.600 Nm ³ /h
vlažan gas	4 754 100 Nm ³ /h

Dimni gas iz kotlova A5 i A6 /
Flue gas from boilers A5 and A6

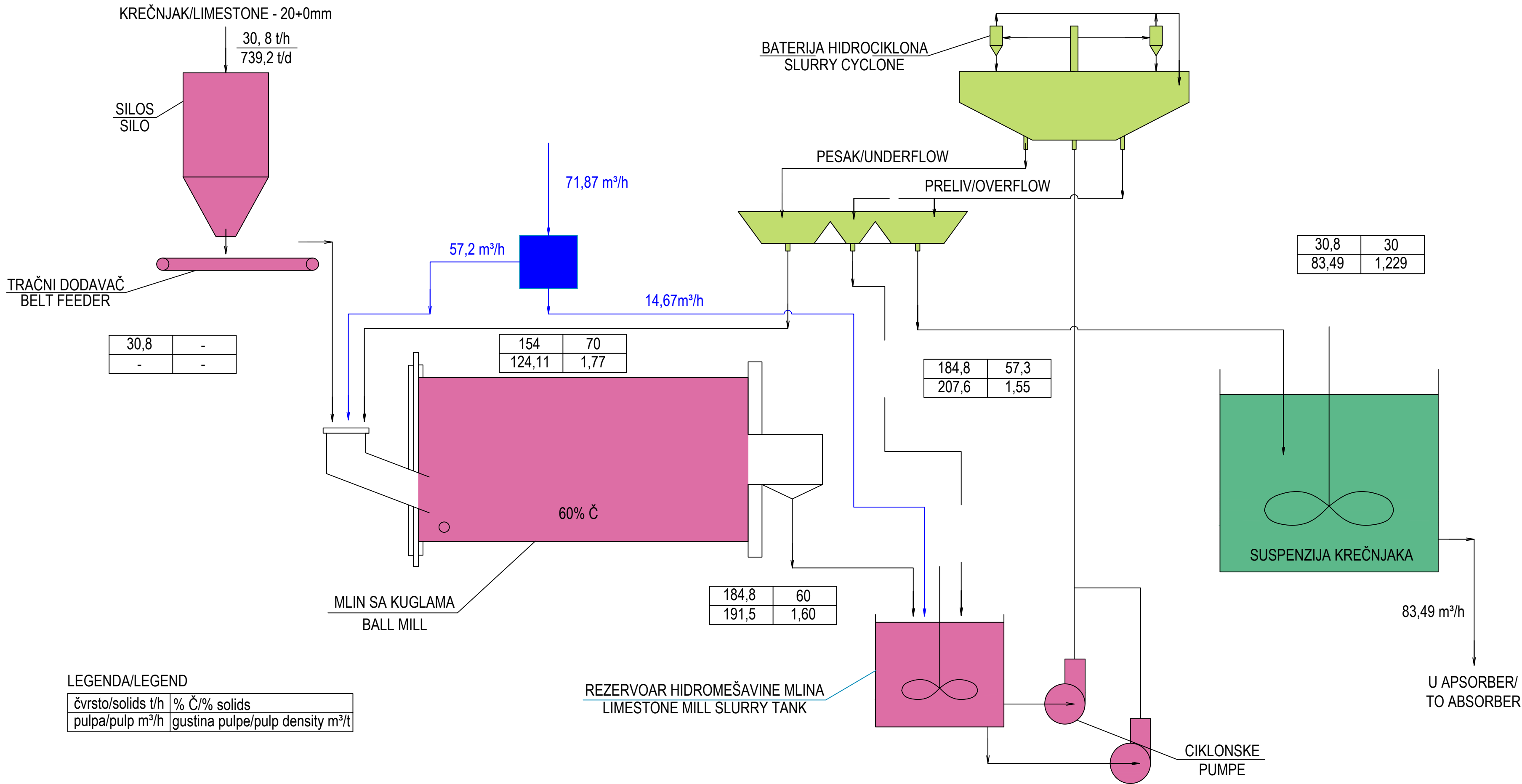
H ₂ O	736 080 kg/h
SO ₂	18360 kg/h
suv gas	3 444 200 Nm ³ /h
vlažan gas	4 360 200 Nm ³ /h



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	Vrsta teh. dok.: Project type:	IDR - Idejno rešenje IDR - Conceptual design		Postrojenje: Facility:	
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Razmera: Scale:	Naziv crteža: Drawing name:		Crtež broj: Drawing number:		
x/x	Šema kretanja masa - slučaj 3-2 Mass balance - case 3-2		NTFGD-S0.0-IDR-7.0.0-000-007D-rev00		
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			Rev.	△ 0	

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25.01.2018 - Rev. 3 - 15.08.18