EXHIBIT A

PLANT DESCRIPTION

The Plant will be located at Dane County Landfill Site No. 2 (Figure 1 & 2):

7102 U.S. Highway 12 & 18

Madison, WI 53718.

The Plant will consist of a two-stage Carbotech pressure swing adsorption (PSA) biogas upgrading plant (BUP) to handle landfill gas flow between the flows of 500 to 2,500 scfm. A Major Equipment list is provided in Table 1.

Note, the final O&M Manual will include complete Process and Instrumentation Diagram (P&ID), Process Flow Diagram (PFD), and descriptions of major equipment.

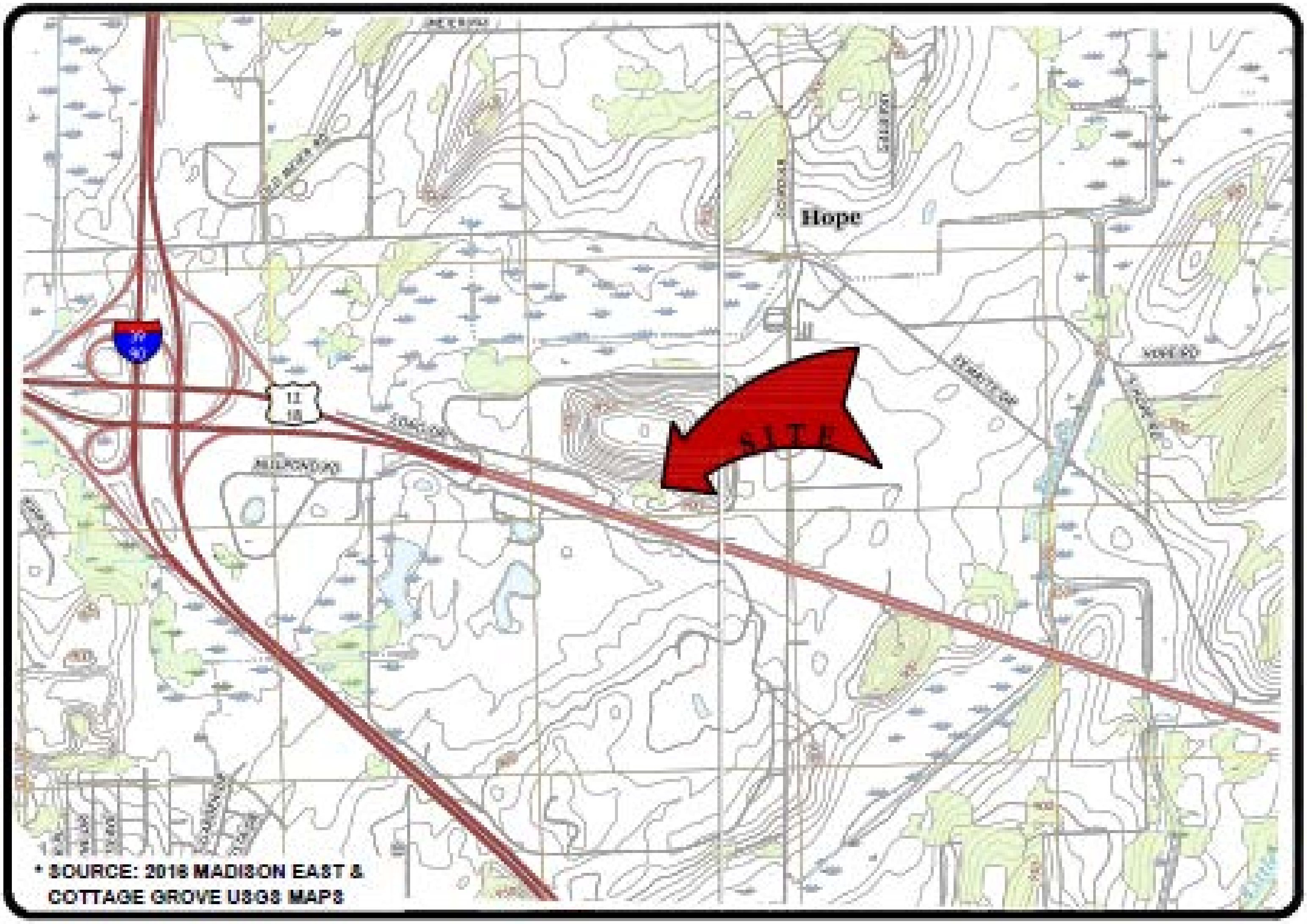


Figure 1: Site Location Overview

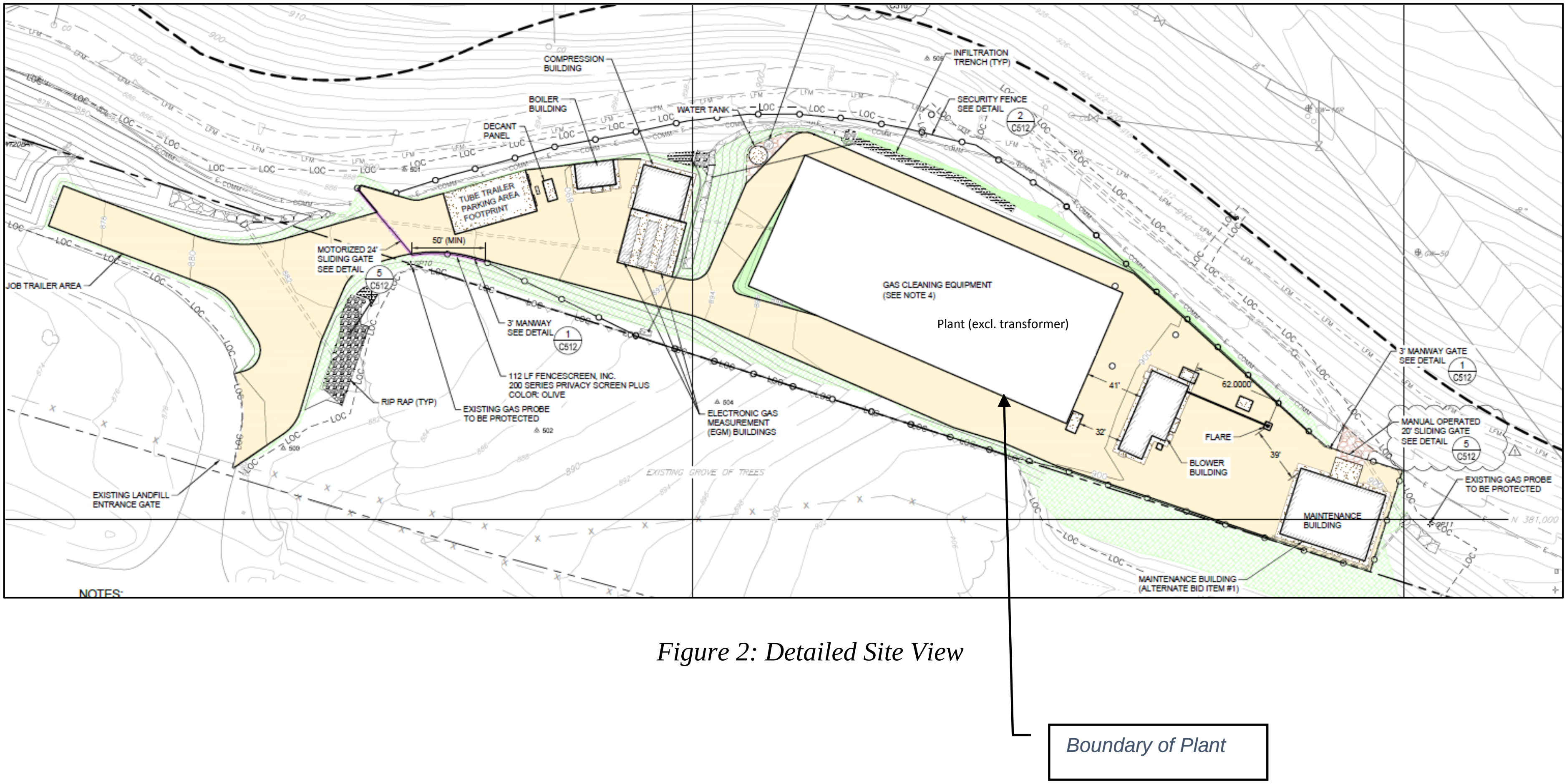


Figure 2: Detailed Site View

Table 1: Major Equipment

Major Equipment Description	Number of Units
Biological Desulfurization Tank	2
Biological Desulfurization Pump Skid	1
Landfill Gas Blower	2
Landfill Gas Compressor	2
Desulfurization Polishing Beds	2
TSA Skid for VOC Removal	1
PSA Valve Skid, 1st Stage	2
PSA Valve Skid, 2nd Stage	1
Vacuum Pumps	12
Product Gas Compressor	2
Radiator, Dry Cooler	2
Chilled Water Unit, Gas Cooling	2
Chilled Water Unit, Dehydration	1
Off-gas Blower	2
Regeneration Gas Blower	1
Off-gas Combustion System, TOX	1
Exchange Heaters	1 (set)
Instrument Air Compressor Skid (one skid with two compressors)	1 (set)

Total equipment at the Dane County Biogas system skid, based on the Phase 3 contract equipment scope defined in the contract, associated amendments, and change orders.

Additional equipment may be added or removed and the defined list may change and would need to be updated by the Plant Operator.

EXHIBIT B

OPERATION & MAINTENANCE PRICING SCHEDULE

Item Number	Task	Annual Price	Notes
1	H2S Polishing Media Change-out	$96,000.00	Includes five (5) individual vessel change-outs. Additional change-outs to be billed at actual cost plus 20% profit margin.
2	VOC Media Change-out	$35,000.00	Includes two (2) individual vessel change-outs. Additional change-outs to be billed at actual cost plus 20% profit margin.
3	Biological Desulphurization Fertilizer	$16,000.00	Includes 2,000 gallons of fertilizer. Additional fertilizer to be billed at actual cost plus 20% profit margin.
4	Maintenance	$91,000.00	Includes scheduled maintenance as outlined in Exhibit F.
5	Labor	$250,000.00	Includes two (2) full-time operators and 300 hours of a third operator. If third operator works more than 300 hours, additional hours to be billed at $100 per hour.
6	24/7 Monitoring	$17,000.00	
7	General Operational Overhead	$35,000.00	
8	BIOFerm Adder (20% Profit Margin)	$135,000.00	
	Total	**$675,000.00**	All costs in excess of the Total shall have approval by Owner, prior to commencement of Work.

EXHIBIT C

OPERATOR SCOPE OF SERVICES

During the Term, Operator shall provide Owner all Services required to be performed in accordance with Applicable Laws and Prudent Industry Practices. Operation and maintenance of the Plant shall be in accordance with the Operation and Maintenance (O&M) Manual and vendor specifications and recommendations. Any costs outside of the Exhibit B must be approved by Owner prior to commencement.

No.	Scope	Arranged by		Paid for by		Remarks
		Operator	Owner	Operator	Owner	
				Part of Fixed Fee	Reimbursable Cost (directed by Owner)	
1	**Plant Operation**					
1.1	Ensure operation within permitted limits.	☒	☐	☒	☐	Owner shall supply Operator with permit materials.
1.2	Coordinate with landfill operations.	☒	☐	☒	☐	
1.3	Plant equipment operations.	☒	☐	☒	☐	Operator to maintain in good operating condition.
1.4	System tuning.	☒	☐	☒	☐	
1.5	Maintenance planning and scheduling for tuning.	☒	☐	☒	☐	
1.6	Routine and preventative maintenance.	☒	☐	☒	☐	Refer to Exhibit F.
1.7	Unexpected maintenance outside of routine.	☒	☐	☐	☒	The intent of this item is to capture maintenance items which are not part of the listed routine maintenance and/or maintenance items which require the Operator to hire a third party to complete some or all of the Work. This work must be approved by the Owner in advance.
1.8	Operational cost when Landfill Gas is outside of Exhibit G.	☒	☐	☐	☒	

BIOFERM™
Carbotech Gas Systems GmbH
Schmack VIESSMANN Group

2	**Operational Maintenance**					
2.1	Daily inspections and functional checks.	☒	☐	☒	☐	Refer to Exhibit O.
2.2	Corrective adjustments.	☒	☐	☒	☐	Refer to Exhibit O or as required to ensure operation.
2.3	Calibration of analyzers and sensors.	☒	☐	☒	☐	Refer to Exhibit O or as required to ensure operation.
2.4	Cleaning.	☒	☐	☒	☐	Does not include special equipment such as power washer, sand blaster, etc.
2.5	Lubrication.	☒	☐	☒	☐	Does not include spare part consumables (Exhibit E).
2.6	Adsorbent unloading and loading.	☒	☐	☒	☐	Outside consultant services is a reimbursable expense
2.7	Adsorbent disposal.	☒	☐	☐	☒	
2.8	Refill regeneration salt and ion exchange resin.	☒	☐	☒	☐	Operator to provide refills. Owner responsible for material cost.
2.9	Provide caustic materials.	☒	☐	☐	☒	

3	**Routine and Preventative Maintenance**					
3.1	Plan and organize scheduled maintenance and preventative maintenance.	☒	☐	☒	☐	Refer to Exhibit O and Exhibit F.
3.2	Order, coordinate and instruct sub-contractors.	☒	☐	☒	☐	
3.3	Provide service parts for maintenance.	☒	☐	☒	☐	Refer to Exhibit O and Exhibit F.
3.4	Disposal of oil, oil filters, cleaning materials and other waste that originates from maintenance or repairs.	☒	☐	☐	☒	Owner shall be responsible for environmental disposal fees.
3.5	Carry out maintenance and support sub-contractors.	☒	☐	☒	☐	Refer to Exhibit O and Exhibit F.
3.6	Safety procedures.	☒	☐	☒	☐	Operator shall develop SOP required for site operations.

4	Troubleshooting and Repair					
4.1	24/7 remote fault monitoring.	☒	☐	☒	☐	Owner must ensure internet availability.
4.2	Correction of faults during normal business hours.	☒	☐	☒	☐	Intervention starts no later than 15 minutes after occurrence of fault.
4.3	Correction of faults outside normal business hours and holidays.	☒	☐	☒	☐	Intervention starts no later than 60 minutes after occurrence of fault. If correction requires an Operator on-site, then Operator must be on-site within 120 minutes of fault.
4.4	Repair of defective parts.	☒	☐	☒	☐	Operator shall transfer warranties to Owner. Owner to pay if outside the warranty period. Owner to pay all uncovered costs associated with repairs performed under warranty.
4.5	Replacement of defective parts.	☒	☐	☒	☐	Operator shall transfer warranties to Owner. Owner to pay if outside the warranty period. Owner to pay all uncovered costs associated with repairs performed under warranty.
4.6	Troubleshooting.	☒	☐	☒	☐	Operator shall transfer warranties to Owner. Owner to pay if outside the warranty period. Owner to pay all uncovered costs associated with repairs performed under warranty.
4.7	Expediting with suppliers.	☒	☐	☒	☐	
4.8	Expedited delivery costs from Vendor	☒	☐	☐	☒	

9	Warranty claims.	☒	☐	☒	☐	Operator shall transfer warranties to Owner. Owner to pay if outside the warranty period. Owner to pay all uncovered costs associated with repairs performed under warranty.
4.10	Engineering design.	☐	☒	☐	☒	For modifications to existing Plant design.
4.11	Programming support or special programming.	☐	☒	☐	☒	For modifications to existing Plant design.

5	**Recurring Statutory Testing and Inspections**					
5.1	Ensure compliance with statutory testing periods.	☒	☐	☒	☐	Owner shall provide necessary documentation to ensure compliance (Exhibit L).
5.2	Carry out recurring statutory testing and inspections.	☐	☒	☐	☒	Refer to Exhibit L.
5.3	Order, coordinate and instruct testing bodies and regulatory inspectors.	☐	☒	☐	☒	
5.4	Corrective measures if Plant is found in deviation from statutory requirements.	☒	☒	☒	☒	Addressed on a case-by-case basis.
5.5	Pressure vessel inspections.	☒	☐	☒	☐	
5.6	Safety valve inspections.	☒	☐	☒	☐	
5.7	Electrical installation inspections.	☒	☐	☒	☐	
5.8	Perform additional inspections per the Plant O&M Manual.	☒	☐	☒	☐	
6	**Materials, Consumables and Special Tools**					
6.1	Adsorbent for H_2S polishing beds.	☒	☐	☒	☐	See Exhibit B, for additional clarification.
6.2	Adsorbent for VOC removal beds.	☒	☐	☒	☐	See Exhibit B, for additional clarification.
6.3	Calibration gases.	☒	☐	☒	☐	
6.4	Nitrogen for purging.	☒	☐	☒	☐	
6.5	Caustic soda.	☒	☐	☐	☒	
6.6	Fertilizer biological desulfurization.	☒	☐	☒	☐	See Exhibit B, for additional clarification.
6.7	Regeneration salt.	☒	☐	☐	☒	
6.8	Machine oil and other lubricants.	☒	☐	☐	☒	
6.9	Filters.	☒	☐	☐	☒	

6.10	Gaskets, o-rings, packing, sealant, etc.	☒	☐	☐	☒	
6.11	Material handling, warehousing and pest control.	☒	☐	☒	☐	Warehouse to be supplied by Owner; material organization, handling logistics, coordination, and pest control to be addressed by Operator. Pest control services or materials are a reimbursable expense. Operator communicate to Owner per County procedure.
6.12	Material handling equipment	☒	☐	☐	☒	If Owner has equipment capable of material handling, Owner will make equipment available. Operator to coordinate logistics.
7	**Spare Parts and Special Tools**					
7.1	Provision of spare parts.	☒	☐	☐	☒	Refer to Exhibit E.
7.2	Provision of special tools.	☒	☐	☐	☒	Refer to Exhibit D.
7.3	Warehouse building maintenance and repair (outside of Plant boundary).	☐	☒	☐	☒	
7.4	Spare parts inventory.	☒	☐	☒	☐	Operator communicate to Owner per County procedure.

8	**Safety and Security**					
8.1	HSE representative.	☒	☐	☒	☐	For Plant boundary only (see Exhibit A).
8.2	First aid, first aid materials.	☒	☐	☒	☐	
8.3	PPE for staff, operators and subcontractors.	☒	☐	☒	☐	PPE is defined as hardhat, safety vest, and safety glasses.
8.4	PPE for visitors.	☒	☐	☐	☒	PPE is defined as hardhat, safety vest, and safety glasses.
8.5	Health and safety OSHA training.	☒	☐	☒	☐	
8.6	Fencing, entry system, security controls & site access.	☐	☒	☐	☒	Operator shall coordinate with Owner at Plant interfaces. Operator shall keep a time log-in/out of all personal at Plant.
8.7	Overall site & security camera system.	☐	☒	☐	☒	
8.8	Maintain site lighting (outside Plant boundary).	☐	☒	☐	☒	Refer to Exhibit A.
8.9	Maintain Plant lighting (within Plant boundary).	☒	☐	☒	☐	Refer to Exhibit A.
8.10	Fire extinguishers.	☒	☐	☒	☐	Operator shall provide fire extinguishers to the Plant based on the specific needs & environmental conditions.
8.11	Specialized PPE (PPE outside of that specified in 8.3 and 8.4).	☒	☐	☐	☒	Owner shall provide specialized PPE for work requiring such PPE.
8.12	Emergency response.	☒	☒	☒	☒	Operator or Owner shall notify 911 in case of any known emergency requiring immediate fire or medical response.

9	**Quality Control, Testing**					
9.1	Maintenance logs.	☒	☐	☒	☐	Maintain and archive.
9.2	Test reports.	☒	☐	☒	☐	Maintain and archive.
9.3	Operational logs.	☒	☐	☒	☐	Maintain and archive.
9.4	Operator and visitor logs.	☒	☐	☒	☐	Maintain and archive.
10	**Other Works**					
10.1	Plant clearing and access ways from snow, ice, dirt and/or other debris.	☒	☐	☒	☐	Cost not to exceed $10,000.00, any cost above is reimbursable by County.
10.2	Clear access ways from entrance and along access roads of snow, ice or other dirt and/or obstructions.	☐	☒	☐	☒	Snow plowing services and removal of any obstructions to access Plant.
10.3	Management of public affairs including communication, stakeholder management and publications.	☐	☒	☐	☒	Owner shall manage public affairs and communicate data and information required by Operator. Operator shall supply data and information as requested by Owner for public affairs.
10.4	Plant tours, organization of plant tours.	☐	☒	☐	☒	Owner shall address logistics of Plant tours. Operator shall provide support as requested by Owner.
10.5	Special events.	☐	☒	☐	☒	Owner shall address logistics of special events. Operator shall provide support as requested by Owner.
10.6	Communication & marketing support.	☐	☒	☐	☒	
10.7	Receive, review and respond to complaints, inquiries or requests from the general public regarding the operation and maintenance of the Plant.	☒	☒	☒	☒	Operator shall receive and review feedback, and provide information to Owner. Owner shall address as necessary.

11	**Facilities and Vehicles**					
11.1	Sanitary facilities (toilets, showers, washbasins, etc.).	☐	☒	☐	☒	Owner will make existing facilities available during business hours. Outside of business hours, Owner shall provide a Porta Potty.
11.2	Cellphones.	☒	☐	☒	☐	
11.3	Storage facilities.	☐	☒	☐	☒	Owner will make existing facilities available.
11.4	Work space.	☐	☒	☐	☒	Owner will make existing facilities available.
11.5	General tools for fitters and electricians.	☒	☐	☒	☐	
11.6	Truck less than ¾ tons.	☒	☐	☒	☐	
11.7	Truck greater than ¾ tons.	☒	☐	☐	☒	Operator may intermittently use truck previously purchased by Owner for specific events, only with prior approval of Owner.
11.8	Lifting devices and temporary platforms.	☒	☐	☐	☒	Operator may intermittently use lifting devices and temporary platforms previously purchased by Owner for specific events, only with prior approval of Owner.

12	**Permits, Insurance etc.**					
12.1	Insurance.	☒	☒	☒	☒	Owner and Operator shall maintain insurance per Article XV.
12.2	Follow instructions of air permit.	☒	☐	☒	☐	Owner shall supply all air permit requirements to Operator. Operator to assist in maintaining compliance.
12.3	Keep operational records as required by air permit.	☒	☐	☒	☐	Owner shall communicate all reporting requirements.
12.4	Environmental permit management.	☐	☒	☐	☒	Owner shall maintain all environmental permits necessary for the operation of the Plant.
12.4	Environmental monitoring and reporting.	☒	☐	☒	☐	Owner shall provide Operator with reporting requirements.
12.5	Books, plans, designs, studies, reports and other documents and records related to the design, construction, expansion, operation and maintenance of the Plant for the period required by appropriate governmental authorities.	☒	☐	☒	☐	Owner shall clearly communicate all reporting and governmental requirements as well as materials for the site Operator does not have, but is part of the documentation noted to be kept at the Plant.
13	**Utilities**					
13.1	Electrical Power.	☐	☒	☐	☒	
13.2	Natural Gas.	☐	☒	☐	☒	
13.3	Fresh Water.	☐	☒	☐	☒	
13.4	Internet.	☐	☒	☐	☒	

- Tools and Materials: Operator shall purchase and maintain an inventory of Consumables adequate to support the operation of the Plant. Operator shall take reasonable precautions to ensure that all such Consumables are stored and maintained in a safe and secure manner in accordance with the requirements of the suppliers thereof and Prudent Industry Practices. Operator shall, annually or as otherwise reasonably requested by Owners in writing, prepare and present to Owners an inventory and reconciliation of all Consumables.

- Compliance and Regulatory Filings: Operator shall use all reasonable efforts to ensure that Owner is in full compliance with all federal, state and municipal laws, ordinances, regulations and orders relative to Owner's assets and shall prepare and file all regulatory filings required to be filed by Owner with respect to its assets. Operator shall use all reasonable efforts to cause the appropriate parties to remedy any violation of any such law, ordinance, rule, regulation or order which comes to its attention and shall promptly notify Owner of any such violation.

- Records: Operator shall maintain on behalf of Owner all certificates, licenses, permits and approvals from all governmental agencies with jurisdiction for the Plant Owner's supplies to Operator, all contracts (including, without limitation, purchase orders) negotiated with persons providing products or services in connection with Owner's assets, the results of any tests or analyses obtained in connection with Owner's assets and copies of invoices, checks and other accounting materials related to Owner's assets as may be reasonably requested by Owner for tax and accounting purposes. Operator shall prepare revisions to the plans and specifications of Owner's assets to reflect the final configuration of those assets and maintain such additional records relating to Owner's assets as may be reasonable or necessary to permit Owner to operate, maintain and, if applicable, further expand those facilities. All records shall be maintained in strict compliance with all regulatory requirements of any state, federal or local governmental agency having jurisdiction over all or any portion of Owner's assets.

- Spare Parts Procurement: Operator shall be responsible for the procurement of spare parts, raw materials and services from other Persons, with respect to the Plant; provided, that, all such procurement shall be conducted in accordance with the procurement summary attached as Exhibit E;

- Warehouse: Operator shall be responsible for purchasing warehouse management spare parts (as shown on attached Exhibit E); the location of warehouse shall be located in close proximity to the facility (within 10 miles of the Plant).

EXCLUDED SERVICES

- Incurrence of capital expenditures with respect to expansions, additions or major changes to the Plant (other than the capital expenditures required in connection with ordinary course maintenance of the Plant or required in the opinion of the Operator to meet the safety and environment requirements of the Plant).

- Disposal or impairment of any assets other than scrapping items that arise out of normal course of business that do not change the operation or operability of the Plant.

- Approval of any changes to or entering into any new product offtake arrangement in connection with the Product Gas from the Plant.

- Management of treasury function including financial reporting, management accounting, budgets, cost accounting, credit control, audit, or insurance management.

- Management of Owner's legal compliance, agreement preparation, and negotiation.

- Owner's human resource management including recruitment and training.

- Consumables:

    - Consumables not covered would include H_2S media change out exceeding the change outs noted in Exhibit B.
    - Consumables not covered would include VOC media change out exceeding the change outs noted in Exhibit B.
    - Consumables not covered would include Biological Desulphurization Fertilizer exceeding the volume noted in Exhibit B.
    - Sodium Hydroxide cost for the effluent pH neutralization system shall be considered a reimbursable consumable.
    - Spare parts costs shall be considered a reimbursable consumable (includes packaging, loading, offloading, shipping and handling, insurance and currency risks).

EXHIBIT D

SPECIAL TOOLS

Procurement of Special Tools are a reimbursable expense and shall become Dane County property after payment. This list may be amended, with prior approval from Dane County.

Special Tool	Number of Units
Impact wrench, 120VAC, 7.5 Amps, 1/5"	1
Impact socket, 1/2" drive, 36 mm	1
Continuity Tester	1
Glycol Antifreeze refractometer	1
Phase Sequence tester, 40-600VAC	1
Stripping tool, 8 AWG to 750 MCM Cap.	1
Angle Grinder Electric 125mm	1
Flat Scraper, FLSCHAB-GR10	1
Fitter Hammer, 200gr	1
Fitter Hammer, 500gr	1
VDE-Screwdriver Set (insulated 1000V)	1
Worktop ORSYbull; 620x430.20mm	1
System Box Drawers	1
Megapress tool set (RP340 + crimping jaws) with an extra set of crimping jaws for the sizes (1/2” to 2”)	1

<u>EXHIBIT E</u>

Spare Parts List

Dane County Sanitary Landfill

These are estimated as the spare parts needed, but this list may change, and is dependent on the operations of the facility.

BIOFERM™ ENERGY SYSTEMS

customer Dept. of Public Works, County of Dane
project reference prepared by Robert
issued checked by Dina

**Part of fixed Price

Pos.	Module	Component	Part	BIOFerm Part #	BIOFerm Description	critical	Category	Quantity	Unit price USD	Subtotal USD	Lead time weeks
1 Biological Desulfurization SRU TS Umwelt											
1.00	**Biological Desulfurization System**										
1.01	Biological Desulfurization System	TS Umwelt biological desulfurization unit	pH/T-electrode	ART2000372	pH/T-electrode	critical	Wear	2	$ 957.39	$ 1,914.77	6
1.02	Biological Desulfurization System	TS Umwelt biological desulfurization unit	ball valve DN 25 with pneumatic motor drive		ball valve DN 25 with pneumatic motor drive	critical	Spare	1	$ 1,120.00	$ 1,120.00	6
1.03	Biological Desulfurization System	TS Umwelt biological desulfurization unit	ball valve DN 65 with pneumatic motor drive		ball valve DN 65 with pneumatic motor drive	critical	Spare	2	$ 1,821.15	$ 3,642.29	6
1.04	Biological Desulfurization System	TS Umwelt biological desulfurization unit	ball valve DN 15	ART2000567	ball valve DN 15	critical	Spare	2	$ 23.87	$ 47.73	6
1.05	Biological Desulfurization System	TS Umwelt biological desulfurization unit	ball valve DN 20	ART2000568	ball valve DN 20	critical	Spare	5	$ 22.88	$ 114.40	6
1.06	Biological Desulfurization System	TS Umwelt biological desulfurization unit	ball valve DN 25	ART2000569	ball valve DN 25	critical	Spare	5	$ 28.91	$ 144.53	6
1.07	Biological Desulfurization System	TS Umwelt biological desulfurization unit	ball valve DN 40		ball valve DN 40	critical	Spare	5	$ 59.79	$ 298.93	6
1.08	Biological Desulfurization System	TS Umwelt biological desulfurization unit	ball valve DN 50	ART2000570	ball valve DN 50	critical	Spare	5	$ 59.79	$ 298.93	6
1.09	Biological Desulfurization System	TS Umwelt biological desulfurization unit	dosing pump	ART2000373	dosing pump	critical	Wear	2	$ 489.07	$ 978.13	6
1.10	Biological Desulfurization System	TS Umwelt biological desulfurization unit	centrifugal pump SHM 65-50		centrifugal pump SHM 65-50	critical	Spare	1	$ 10,784.56	$ 10,784.56	6
1.11	Biological Desulfurization System	TS Umwelt biological desulfurization unit	heating pump UP 25-120	ART2000848	heating pump UP 25-120	critical	Spare	2	$ 40,000.00	$ 80,000.00	6
1.16	Biological Desulfurization System	TS Umwelt biological desulfurization unit	centrifugal pump SHM 65-50		centrifugal pump SHM 65-50		Spare	1	10,784.56	$ 10,784.56	
1.17	Biological Desulfurization System	TS Umwelt biological desulfurization unit	overpressure protection/ safety valve 1/2"		overpressure protection/ safety valve 1/2"		Spare	1	31.23	$ 31.23	
1.18	Biological Desulfurization System	TS Umwelt biological desulfurization unit	solenoid valve DN 25 EV250B		solenoid valve DN 25 EV250B		Spare	2	455.01	$ 910.01	
1.19	Biological Desulfurization System	TS Umwelt biological desulfurization unit	manometer GG 902		manometer GG 902		Spare	1	157.61	$ 157.61	
1.20	Biological Desulfurization System	TS Umwelt biological desulfurization unit	limit switch for flow meter		limit switch for flow meter		Spare	1	199.86	$ 199.86	
1.21	Biological Desulfurization System	TS Umwelt biological desulfurization unit	magnetic switch for filling level		magnetic switch for filling level		Spare	1	478.73	$ 478.73	
1.22	Biological Desulfurization System	TS Umwelt biological desulfurization unit	level control		level control		Spare	1	266.09	$ 266.09	
1.23	Biological Desulfurization System	TS Umwelt biological desulfurization unit	relay small		relay small		Spare	5	58.00	$ 290.00	
1.24	Biological Desulfurization System	TS Umwelt biological desulfurization unit	relay large		relay large		Spare	5	61.09	$ 305.45	
1.27	Sulfur Removal Unit (SRU)	Biological H_2S scrubber vessel	Bacteria for biological desulfurization unit		Bacteria for biological desulfurization unit		Spare	1	16,000.00		8
2 Biogas Blower											
2.00	**Biogas blower**	**Multistage Centrifugal Gas Blower**	**Complete Blower unit**		**Complete Biogas Blower unit**		**Spare**	**1**			
2.01	Biogas blower	Multistage Centrifugal Gas Blower	BK081/082 Bearing Kit		BK051/052 Bearing Kit	critical	Wear	1	$ 441.00	$ 441.00	2
2.02	Biogas blower	Multistage Centrifugal Gas Blower	UHMW Labyrinth Seal		UHMW Labyrinth Seal	critical	Spare	1	$ 200.00	$ 200.00	2
2.03	Biogas blower	Multistage Centrifugal Gas Blower	Inlet side shaft seal		Inlet side shaft seal	critical	Spare	2	$ 1,258.00	$ 2,516.00	2
2.04	Biogas blower	Multistage Centrifugal Gas Blower	Coupling E30		Coupling E30	critical	Spare	2	$ 475.00	$ 950.00	2
2.10	**LFG separator**	**LFG Filter Separator**									
3 Biogas Booster											

Spare Parts List **Dane County Sanitary Landfill**

These are estimated as the spare parts needed, but this list may change, and is dependent on the operations of the facility.

BIOFERM™ ENERGY SYSTEMS

customer Dept. of Public Works, County of Dane
project reference prepared by Robert
issued checked by Dina

**Part of fixed Price

Pos.	Module	Component	Part	BIOFerm Part #	BIOFerm Description	critical	Category	Quantity	Unit price USD	Subtotal USD	Lead time weeks
3.00	**Biogas compressor**	**SK 8100**	**VPT Compressor Package**	**ART2000365**	**VPT Compressor Package**		**Spare**	**1**			
3.01	Biogas compressor	SK 8100	mechanical seal compressor stage		mechanical seal compressor stage	critical	Spare	2	$ 5,304.00	$ 10,608.00	8
3.02	Biogas compressor	SK 8100	directional valve		directional valve	critical	Spare	2	$ 9,187.20	$ 18,374.40	8
3.03	Biogas compressor	SK 8100	LDS displacement sensor including O-ring		LDS displacement sensor including O-ring	critical	Spare	2	$ 4,851.24	$ 9,702.48	8
3.04	Biogas compressor	SK 8100	ex-safety barrier for LDS-sensor		ex-safety barrier for LDS-sensor	critical	Spare	2	$ 3,164.40	$ 6,328.80	8
3.05	Biogas compressor	SK 8100	O-rings for suction and pressure nozzles		O-rings for suction and pressure nozzles	critical	Spare	2	$ 146.88	$ 293.76	8
3.06	Biogas compressor	SK 8100	oil pump, complete without motor		oil pump, complete without motor	critical	Spare	2	$ 12,321.60	$ 24,643.20	8
3.08	Biogas compressor	SK 8100	oil separator		oil separator	critical	Wear	2	$ 1,039.32	$ 2,078.64	8
3.10	Biogas compressor	SK 8100	repair kit / spring for non-return valve		repair kit / spring for non-return valve	critical	Spare	2	$ 385.44	$ 770.88	8
3.11	Biogas compressor	SK 8100	repair kit / spring for non-return valve		repair kit / spring for non-return valve	critical	Spare	2	$ 279.84	$ 559.68	8
3.12	Biogas compressor	SK 8100	shut-off valve 1/2"		shut-off valve 1/2"	critical	Spare	2	$ 63.36	$ 126.72	8
3.13	Biogas compressor	SK 8100	shut-off valve 1"		shut-off valve 1"	critical	Spare	2	$ 121.44	$ 242.88	8
3.14	Biogas compressor	SK 8100	e/p-positioner		e/p-positioner	critical	Spare	2	$ 2,966.52	$ 5,933.04	8
3.15	Biogas compressor	SK 8100	pressure reduer for e/p-positioner		pressure reduer for e/p-positioner	critical	Spare	2	$ 640.80	$ 1,281.60	8
3.16	Biogas compressor	SK 8100	vessel heater temperature control TR 0…70 °C, setpoint: 40 °C		vessel heater temperature control TR 0…70 °C, setpoint: 40 °C	critical	Spare	2	$ 112.20	$ 224.40	8
3.17	Biogas compressor	SK 8100	vessel heater safety temperature limiter TB = 120 °C		vessel heater safety temperature limiter TB = 120 °C	critical	Spare	2	$ 122.76	$ 245.52	8
3.19	Biogas compressor	SK 8100	sealing oil vessel lid		sealing oil vessel lid	critical	Wear	2	$ 39.36	$ 78.72	8
3.30	**Drying Separator**	**Compressor filter separator**									

Spare Parts List

Dane County Sanitary Landfill

These are estimated as the spare parts needed, but this list may change, and is dependent on the operations of the facility.

BIOFERM™ ENERGY SYSTEMS

customer Dept. of Public Works, County of Dane
project reference prepared by Robert
issued checked by Dina

**Part of fixed Price

Pos.	Module	Component	Part	BIOFerm Part #	BIOFerm Description	critical	Category	Quantity	Unit price USD	Subtotal USD	Lead time weeks
4 TSA System, VOC & SiO_x Removal											
4.00	**VOC Vessel**	**VOC Vessel**									
	VOC Vessel	VOC Vessel	10" vanessa valve		10" vanessa valve	critical	Spare	1	$ 5,733.33	$ 5,733.33	27
4.04	VOC Vessel	VOC valve	8" Vanessa valves		150#RF	critical	Spare	2	$ 4,000.00	$ 8,000.00	27
4.05	VOC Vessel	VOC valve	1" 150#RF control valve		VC.AE.01.01.01.20	critical	Spare	1	$ 6,244.00	$ 6,244.00	4
4.10	**TSA dust filter**	**TSA dust filter**									
4.20	**TSA to tailgas filter**	**TSA to tailgas filter**									
5 Polishing Beds Desulfurization											
5.00	**Desulfurization Vessel**	**Desulfurization Vessel**									
5.03	Desulfurization Vessel		8" 150#RF pentair keystore butterfly valve		8" 150#RF pentair keystore butterfly valve	Critical	Spare	2	$ 1,628.00	$ 3,256.00	20-22
5.10	**Desulfurization dust filter**	**Desulfurization dust filter**									
6 PSA											
6.00	**PSA System**										
6.01	PSA System	PSA pneumatic control Valve	5" Keystone 37, 300#, LUG w/ Morin B-059U actuator, spring return fail close, Norgren		5" Butterfly valve w/ morin B-059U actuator	critical	Spare	2	$ 8,000.00	$ 16,000.00	20-22
6.02	PSA System	PSA pneumatic control Valve	10" Keystone 37, 300#, LUG w/ Morin B-135U actuator, spring return fail close, Norgren		10" butterfly valve w/ morin B-135U actuator	critical	Spare	2	$ 13,333.33	$ 26,666.67	20-22
6.03	PSA System	PSA pneumatic control Valve	4" Keystone 37, 300#, LUG w/ Fig. 89U-032 SR actuator, spring return fail close, Norgren		4" butterfly valve w/ Fig. 89U-032 actuator	critical	Spare	2	$ 8,000.00	$ 16,000.00	20-22
6.04	PSA System		6" Keystone 37, 300#,		6" butterfly valve	critical	Spare	2	$ 5,333.33	$ 10,666.67	20-22
6.05	PSA System		6" Keystone 37, 300#, LUG w/ Fig. 89U-032 SR actuator, spring return fail close, Norgren		6" Butterfly valve w/o actuator	critical	Spare	2	$ 10,666.67	$ 21,333.33	20-22
6.06	PSA System	PSA butterfly valve	5" Keystone 37, 300#, LUG		5" Butterfly valve w/o actuator	critical	Spare	2	$ 10,666.67	$ 21,333.33	8
6.07	PSA System	PSA butterfly valve	10" Keystone 37, 300#, LUG		10" butterfly valve w/o actuator	critical	Spare	2	$ 13,333.33	$ 26,666.67	8
6.08	PSA System	PSA butterfly valve	4" Keystone 37, 300#, LUG		4" butterfly valve w/o actuator	critical	Spare	2	$ 8,000.00	$ 16,000.00	8
6.09	PSA System	Repair kit for pneumatic valve	Repair kit for 5" Keystone 37, 300#, LUG		Repair kit for 5" Keystone 37, 300#, LUG	critical	Wear	2	$ 6,000.00	$ 12,000.00	8
6.10	PSA System	Repair kit for pneumatic valve	Repair kit for 4" Keystone 37, 300#, LUG		Repair kit for 5" Keystone 37, 300#, LUG	critical	Wear	2	$ 6,000.00	$ 12,000.00	8
6.11	PSA System	Repair kit for pneumatic valve	Repair kit for 10" Keystone 37, 300#, LUG		Repair kit for 5" Keystone 37, 300#, LUG	critical	Wear	2	$ 6,000.00	$ 12,000.00	8
7 Vacuum Pump											
7.00	**Vacuum pump**	**RA1600 B**	**Pump**	**ART2000675**	**Busch pump Vacuum, RA1600B**		**Spare**				
7.02	Vacuum pump	RA1600 B	Full wear parts kit G(i)/GD(o) RA1600B excl. service parts		Full wear parts kit G(i)/GD(o) RA1600B excl. service parts	critical	Wear	6	$ 9,186.36	$ 55,118.16	4
8 RNG Compressor											
8.00	**RNG Compressor**										
8.03	RNG Compressor	A352 Frame	Element, breather		Element, breather	critical	Spare	2	$ 196.32	$ 392.64	2
8.07	RNG Compressor	4.5" 2nd Stage Cylinders	O-ring, packing		O-ring, packing	critical	Spare	1	$ 6.60	$ 6.60	2
9 Cooling Water System											
9.00	**Cooling Water Unit**	**Dry Cooler**	**Dry Cooler, Radiator unit full system**	**ART2000299**	**Dry Cooler, Radiator unit full system**		**Spare**				
9.01	Cooling Water Unit	Dry Cooler recireculation Pump	Coolent Recirculation Pump			critical	Spare	1	$ 1,595.00	$ 1,595.00	4

Spare Parts List **Dane County Sanitary Landfill**

These are estimated as the spare parts needed, but this list may change, and is dependent on the operations of the facility.

BIOFERM ENERGY SYSTEMS

customer Dept. of Public Works, County of Dane
project reference prepared by Robert
issued checked by Dina

**Part of fixed Price

Pos.	Module	Component	Part	BIOFerm Part #	BIOFerm Description	critical	Category	Quantity	Unit price USD	Subtotal USD	Lead time weeks
9.02	Cooling Water Unit	Dry Cooler	Fan (Dry Cooler) w/ fan, motor, and guard	ART2000642	Fan (Dry Cooler) w/ fan, motor, and guard	critical	Spare	1	$ 1,214.00	$ 1,214.00	2
10 Chilled Water System											
10.00	**Chilled Water System**	**Chiller 30RAP020**		**ART2001229**	**Chiller 30RAP020**		**Spare**				
10.02	Chilled Water System (1)	Chiller 30RAP020	Compressor oil		Compressor oil	critical	Spare	1			4
10.03	Chilled Water System (1)	Chiller 30RAP020	High pressure switch		High pressure switch	critical	Spare	1			4
10.04	Chilled Water System (1)	Chiller 30RAP020	Pressure transducers		Pressure transducers	critical	Spare	1			4
10.05	Chilled Water System (1)	Chiller 30RAP020	Thermistor		Thermistor	critical	Spare	1			4
10.06	Chilled Water System (1)	Chiller 30RAP020	Fan blade		Fan blade	critical	Spare	1	$ 1,800.00	$ 1,800.00	4
10.07	Chilled Water System (1)	Chiller 30RAP020	Fan motor		Fan motor	critical	Spare	1			4
10.08	Chilled Water System (1)	Chiller 30RAP020	Fan contactor		Fan contactor	critical	Spare	1			4
10.09	Chilled Water System (1)	Chiller 30RAP020	Compressor contactor		Compressor contactor	critical	Spare	1			4
10.10	Chilled Water System (1)	Chiller 30RAP020	Fuses		Fuses	critical	Spare	1			4
10.12	Chilled Water System (2)	Chiller 30RAP115	Compressor oil		Compressor oil	critical	Spare	1			4
10.13	Chilled Water System (2)	Chiller 30RAP115	High pressure switch		High pressure switch	critical	Spare	1			4
10.14	Chilled Water System (2)	Chiller 30RAP115	Pressure transducers		Pressure transducers	critical	Spare	1			4
10.15	Chilled Water System (2)	Chiller 30RAP115	Thermistor		Thermistor	critical	Spare	1			4
10.16	Chilled Water System (2)	Chiller 30RAP115	Fan blade		Fan blade	critical	Spare	1	$ 2,300.00	$ 2,300.00	4
10.17	Chilled Water System (2)	Chiller 30RAP115	Fan motor		Fan motor	critical	Spare	1			4
10.18	Chilled Water System (2)	Chiller 30RAP115	Fan contactor		Fan contactor	critical	Spare	1			4
10.19	Chilled Water System (2)	Chiller 30RAP115	Compressor contactor		Compressor contactor	critical	Spare	1			4
10.20	Chilled Water System (2)	Chiller 30RAP115	Fuses		Fuses	critical	Spare	1			10
11 Instrument Air Compressor Unit											
11.00	**Instrument Air**	**Instrument air compressor package**									
11.04	Biogas blower	Instrument air compressor package	Air/oil separator		Air/oil separator	critical	Wear	4	$ 320.00	$ 1,280.00	4

Spare Parts List

Dane County Sanitary Landfill

These are estimated as the spare parts needed, but this list may change, and is dependent on the operations of the facility.

customer Dept. of Public Works, County of Dane
project reference
issued

prepared by Robert
checked by Dina

**Part of fixed Price

Pos.	Module	Component	Part	BIOFerm Part #	BIOFerm Description	critical	Category	Quantity	Unit price USD	Subtotal USD	Lead time weeks
12 Tail Gas System											
12.00	**Tailgas blower**	**Multistage Centrifugal Gas Blower**	**Complete Blower unit**		**Complete Tailgas Blower unit**		**Spare**				
12.01	Tailgas blower	Multistage Centrifugal Gas Blower	BK051/052 Bearing Kit		BK051/052 Bearing Kit	critical	Wear	1	$ 228.00	$ 228.00	2
12.02	Tailgas blower	Multistage Centrifugal Gas Blower	UHMW Labyrinth Seal		UHMW Labyrinth Seal	critical	Spare	1	$ 175.00	$ 175.00	2
12.03	Tailgas blower	Multistage Centrifugal Gas Blower	Coupling (E10)		Coupling (E10)	critical	Spare	1	$ 279.00	$ 279.00	2
12.05	Tailgas blower	Main Drive	Motor Bearings		Motor Bearings	critical	Spare	1	$ 138.00	$ 138.00	2
12.10	**Air blower**	**Air blower for bladder tank**	**Complete fan unit**		**Air blower for bladder tank**	critical	**Spare**				
12.11	Air blower	Air blower for bladder tank	Shaft seal, 5x5x1/8"		Shaft seal, 5x5x1/8"	critical	Spare	1	$ 50.00	$ 50.00	3
12.12	Air blower	Air blower for bladder tank	Shaft seal, 1-1/8"		Shaft seal, 1-1/8"	critical	Spare	1	$ 92.00	$ 92.00	3
12.13	Air blower	Air blower for bladder tank	Wheel w/ hub, CW, 1 1/8"		Wheel w/ hub, CW, 1 1/8"	critical	Spare	1	$ 1,438.00	$ 1,438.00	3
13 Recirculate System											
13.00	**Recirculate Blower**	**Multistage Centrifugal Gas Blower**	**Complete Blower unit**		**Complete Biogas Blower unit**		**Spare**	**1**	**$ 22,496.00**	**$ 22,496.00**	**12-14**
13.01	Recirculate Blower	Multistage Centrifugal Gas Blower	BK051/052 Bearing Kit		BK051/052 Bearing Kit	critical	Wear	1	$ 228.00	$ 228.00	2
13.02	Recirculate Blower	Multistage Centrifugal Gas Blower	UHMW Labyrinth Seal		UHMW Labyrinth Seal	critical	Spare	1	$ 175.00	$ 175.00	2
13.03	Recirculate Blower	Multistage Centrifugal Gas Blower	Coupling (E10)		Coupling (E10)	critical	Spare	1	$ 279.00	$ 279.00	2
13.10	**Air blower**	**Air blower for bladder tank**	**Complete fan unit**		**Air blower for bladder tank**	critical	**Spare**	**1**	**$ 3,032.00**	**$ 3,032.00**	**4**
13.11	Air blower	Air blower for bladder tank	Shaft seal, 5x5x1/8"		Shaft seal, 5x5x1/8"	critical	Spare	1	$ 50.00	$ 50.00	3
13.12	Air blower	Air blower for bladder tank	Shaft seal, 1-1/8"		Shaft seal, 1-1/8"	critical	Spare	1	$ 92.00	$ 92.00	3
13.13	Air blower	Air blower for bladder tank	Wheel w/ hub, CW, 1 1/8"		Wheel w/ hub, CW, 1 1/8"	critical	Spare	1	$ 1,438.00	$ 1,438.00	3

Spare Parts List **Dane County Sanitary Landfill**

These are estimated as the spare parts needed, but this list may change, and is dependent on the operations of the facility.

BIOFERM™ ENERGY SYSTEMS

customer Dept. of Public Works, County of Dane
project reference prepared by Robert
issued checked by Dina

**Part of fixed Price

Pos.	Module	Component	Part	BIOFerm Part #	BIOFerm Description	critical	Category	Quantity	Unit price USD	Subtotal USD	Lead time weeks
14 Regenerative Thermal Oxidizer											
14.00	**Regenerative Thermal oxidizer**	**Regenerative Thermal oxidizer**									
14.01	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Fuse, low peak, 10amp		Fuse, low peak, 10amp	critical	Spare	4			4
14.02	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Timer, FM approved		Timer, FM approved	critical	Spare	1			4
14.03	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Power supply, 24vdc		Power supply, 24vdc	critical	Spare	1			4
14.04	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Limit controller, high temp		Limit controller, high temp	critical	Spare	1			4
14.05	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Pressure switch, weatherproof housing, 4-20"		Pressure switch, weatherproof housing, 4-20"	critical	Spare	1			4
14.06	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Actuator motor, 30 sec 160 degree travel, 4-20mA input Burner, FAD		Actuator motor, 30 sec 160 degree travel, 4-20mA input Burner, FAD	critical	Spare	1			4
14.07	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Proximity switch		Proximity switch	critical	Spare	1			4
14.08	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Pressure switch, high negative		Pressure switch, high negative	critical	Spare	1			4
14.09	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Pressure switch, fan differential		Pressure switch, fan differential	critical	Spare	1			4
14.10	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Pressure transmitter, differential, 0-10"w.c.		Pressure transmitter, differential, 0-10"w.c.	critical	Spare	1			4
14.11	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Pressure switch, 15-150psig, compressed air		Pressure switch, 15-150psig, compressed air	critical	Spare	1			4
14.12	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Valve, solenoid, poppet		Valve, solenoid, poppet	critical	Spare	1			4
14.13	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Flexible coupling (combustion air piping)		Flexible coupling (combustion air piping)	critical	Spare	1			4
14.14	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	UV scanner, self-checking		UV scanner, self-checking	critical	Spare	1			4
14.15	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Spark ignitor		Spark ignitor	critical	Spare	1	$ 19,000.00	$ 19,000.00	4
14.16	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Flame safeguard, Fireye, Chassis		Flame safeguard, Fireye, Chassis	critical	Spare	1			4
14.17	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Flame safeguard, Fireye, Base		Flame safeguard, Fireye, Base	critical	Spare	1			4
14.18	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Flame safeguard, Fireye, Amplifier		Flame safeguard, Fireye, Amplifier	critical	Spare	1			4
14.19	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Flame safeguard, Fireye, Programmer		Flame safeguard, Fireye, Programmer	critical	Spare	1			4
14.20	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Valve, main gas		Valve, main gas	critical	Spare	1			4
14.21	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Valve, actuator, main gas		Valve, actuator, main gas	critical	Spare	1			4
14.22	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Valve, solenoid, pilot gas		Valve, solenoid, pilot gas	critical	Spare	1			4
14.23	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Pressure switch, high gas		Pressure switch, high gas	critical	Spare	1			4
14.24	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Pressure switch, low gas		Pressure switch, low gas	critical	Spare	1			4
14.25	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	One complete cylinder		One complete cylinder	critical	Spare	1			4
14.26	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Thermocouple		Thermocouple	critical	Spare	1			4
14.27	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Roller guide for Poppet Shaft		Roller guide for Poppet Shaft	critical	Spare	1			4
14.28	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Pneumatic Actuator, 4-20mA, hot gas bypass damper		Pneumatic Actuator, 4-20mA, hot gas bypass damper	critical	Spare	1			4
14.29	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Main process fan bearing		Main process fan bearing	critical	Spare	1			4
14.30	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	Mix box with dilution damper		Mix box with dilution damper	critical	Spare	1	$ 5,500.00	$ 5,500.00	4
14.31	Regenerative Thermal oxidizer	Regenerative Thermal oxidizer	LEL safety devices		LEL safety devices	critical	Spare	1	$ 70,000.00	$ 70,000.00	4

Spare Parts List **Dane County Sanitary Landfill**

These are estimated as the spare parts needed, but this list may change, and is dependent on the operations of the facility.

BIOFERM™ ENERGY SYSTEMS

customer Dept. of Public Works, County of Dane
project reference prepared by Robert
issued checked by Dina

**Part of fixed Price

Pos.	Module	Component	Part	BIOFerm Part #	BIOFerm Description	critical	Category	Quantity	Unit price USD	Subtotal USD	Lead time weeks
15 Effluent Neutralization											
15.00	**Effluent Neutralization System**	**Effluent Neutralization**									
15.01	Effluent Neutralization System	TS Umwelt biological desulfurization unit	centrifugal pump SHM 65-50		centrifugal pump SHM 65-50	critical	Spare	1	$ 4,666.67	$ 4,666.67	10
15.02	Effluent Neutralization System		NaOH dossing Pump		NaOH dossing Pump	critical	Spare	1	$ 666.67	$ 666.67	10
15.02	Effluent Neutralization System	TS Umwelt Effluent Treatment System	pH-electrode CPS11D Memosens (Endress+Hauser)		pH-electrode CPS11D Memosens (Endress+Hauser)	critical	Spare	1	$ 528.80	$ 528.80	6
15.03	Effluent Neutralization System	TS Umwelt Effluent Treatment System	pump MTH Pump Model: C51AB Size: 1/2 X 3/4 X 5, 304SS Construction w/ 3/4hp, 3500rpm, 3ph, TEFC, 208-230/460V @ 60Hz Motor	ART001229	pump	critical	Spare	1	$ 1,198.67	$ 1,198.67	6
15.04	Effluent Neutralization System	TS Umwelt Effluent Treatment System	Barmesa pump model IA1-7.5-2; 1 1/2" x 1" x 7" T; 85 GPM@162', 7.5 HP, 3 Phase, 3500 RPM, TEFC	ART001229	pump	critical	Spare	1	$ 1,584.00	$ 1,584.00	6
16 Condensate System											
16.00	Condonsate system		Samson Control valve		1" 150# RF	critical	spare	2	$ 8,000.00	$ 16,000.00	6
16.01	Condonsate system	PSA butterfly valve	1" Keystone 37, 150#, LUG		1" Butterfly valve w/o actuator	critical	Spare	2	$ 13,333.33	$ 26,666.67	6
16.02	Condonsate system		Level Indicator		siemens level indicator	critical	Spare	1	$ 22,000.00	$ 22,000.00	6
	Gas analyzer										
17.00	Gas analyzer										
17.01	Gas analyzer		solenoid valve			critical	spare	5	$ 8,000.00	$ 40,000.00	6
17.02	Gas analyzer		Diapharm Pump			critical	spare	1	$ 13,333.33	$ 13,333.33	6
17.03	Gas analyzer		Procss analyzer		Raw gas analyzer	critical	spare	1	$ 8,000.00	$ 8,000.00	6
	Miscellaneous Components										
18.00	Misc. Valves	Valves and controls			Valves and controls						
18.01	Misc. Valves				pneum. actuator		Spare	1	$ 5,171.00	$ 5,171.00	
18.02	Misc. Valves				pneum. actuator		Spare	1	$ 2,244.00	$ 2,244.00	
18.03	Misc. Valves				pneum. actuator		Spare	1	$ 980.00	$ 980.00	
18.04	Misc. Valves				pneum. actuator		Spare	1	$ 952.00	$ 952.00	
18.05	Misc. Valves				pneum. actuator		Spare	1	$ 1,928.00	$ 1,928.00	
18.06	Misc. Valves				pneum. actuator		Spare	1	$ 646.00	$ 646.00	
18.07	Misc. Valves				pneum. actuator		Spare	1	$ 347.00	$ 347.00	
18.08	Misc. Valves				Keystone Butterfly Valve Fig. 362 LUG 12"		Spare	1	$ 3,107.00	$ 3,107.00	
18.09	Misc. Valves				Keystone Butterfly Valve Fig. 362 LUG 8"		Spare	1	$ 1,561.00	$ 1,561.00	
18.10	Misc. Valves				Keystone Butterfly Valve Fig. 362 LUG 4"		Spare	1	$ 761.00	$ 761.00	
18.11	Misc. Valves				Keystone Butterfly Valve Fig. 362 LUG 12"		Spare	1	$ 318.00	$ 318.00	
18.12	Misc. Valves				Keystone Butterfly Valve Fig. 362 LUG 8"		Spare	1	$ 185.00	$ 185.00	
18.13	Misc. Valves				Keystone Butterfly Valve Fig. 362 LUG 4"		Spare	1	$ 110.00	$ 110.00	
18.14	Misc. Valves								$ -	$ -	

Spare Parts List

Dane County Sanitary Landfill

These are estimated as the spare parts needed, but this list may change, and is dependent on the operations of the facility.

customer Dept. of Public Works, County of Dane
project reference prepared by Robert
issued checked by Dina

**Part of fixed Price

Pos.	Module	Component	Part	BIOFerm Part #	BIOFerm Description	critical	Category	Quantity	Unit price USD	Subtotal USD	Lead time weeks
18.15	Misc. Valves				butterfly valve		Spare	1	$ 273.00	$ 273.00	
18.16	Misc. Valves				butterfly valve		Spare	1	$ 335.00	$ 335.00	
18.17	Misc. Valves				butterfly valve		Spare	1	$ 517.00	$ 517.00	
18.18	Misc. Valves				butterfly valve		Spare	1	$ 626.00	$ 626.00	
18.19	Misc. Valves				butterfly valve		Spare	1	$ 662.00	$ 662.00	
18.20	Misc. Valves				GRL 2" FKM w/Handle		Spare	1	$ 137.00	$ 137.00	
18.21	Misc. Valves				GRL 3" FKM w/Handle		Spare	1	$ 167.00	$ 167.00	
18.22	Misc. Valves				GRL 4" FKM w/Handle		Spare	1	$ 257.00	$ 257.00	
18.23	Misc. Valves				GRL 5" FKM w/Handle		Spare	1	$ 312.00	$ 312.00	
18.24	Misc. Valves				GRL 6" FKM w/Handle		Spare	1	$ 329.00	$ 329.00	
18.25	Misc. Valves								$ -	$ -	
18.26	Misc. Valves				Regulating valve		Spare	1	$ 827.00	$ 827.00	
18.27	Misc. Valves				Regulating valve		Spare	1	$ 754.00	$ 754.00	
18.28	Misc. Valves				manometer gauge valve		Spare	1	$ 99.00	$ 99.00	
18.29	Misc. Valves				Ball valve		Spare	2	$ 12.00	$ 24.00	
18.30	Misc. Valves				Ball valve		Spare	1	$ 103.00	$ 103.00	
18.31	Misc. Valves				Ball valve		Spare	1	$ 24.00	$ 24.00	
18.32	Misc. Valves				Ball valve		Spare	1	$ 130.00	$ 130.00	
18.33	Misc. Valves				Ball valve		Spare	1	$ 934.00	$ 934.00	
18.34	Misc. Valves				Liquid Drain Trap		Spare	1	$ 1,434.00	$ 1,434.00	
18.35	Misc. Valves				lift check valve		Spare	1	$ 261.00	$ 261.00	
18.36	Misc. Valves				lift check valve		Spare	1	$ 486.00	$ 486.00	
18.37	Misc. Valves				Control valve - Positioner		Spare	1	$ 2,111.00	$ 2,111.00	
18.38	Misc. Valves				Control valve - Positioner		Wear	1	$ 198.00	$ 198.00	
18.39	Misc. Valves				Control valve - Positioner		Wear	1	$ 74.00	$ 74.00	
18.40	Misc. Valves				Control valve (individual per CV)		Spare	1	$ 510.00	$ 510.00	
18.41	Misc. Valves				Control valve (individual per CV)		Spare	1	$ 447.00	$ 447.00	
18.42	Misc. Valves				Control valve (individual per CV)		Spare	1	$ 44.00	$ 44.00	
18.43	Misc. Valves				Control valve (individual per CV)		Spare	1	$ 19.00	$ 19.00	
18.44	Misc. Valves				Control valve (individual per CV)		Spare	1	$ 976.00	$ 976.00	
18.45	Misc. Valves				Control valve (individual per CV)		Spare	1	$ 5.00	$ 5.00	
18.46	Gaskets				Gaskets				$ -	$ -	
18.47	Gaskets				Flat gasket, Corrugated metallic w/ graphite		Spare	4	$ 3.00	$ 12.00	
18.48	Gaskets				Flat gasket, Corrugated metallic w/ graphite		Spare	4	$ 3.00	$ 12.00	

Spare Parts List **Dane County Sanitary Landfill**

These are estimated as the spare parts needed, but this list may change, and is dependent on the operations of the facility.

BIOFERM™ ENERGY SYSTEMS

customer Dept. of Public Works, County of Dane
project reference prepared by Robert
issued checked by Dina

**Part of fixed Price

Pos.	Module	Component	Part	BIOFerm Part #	BIOFerm Description	critical	Category	Quantity	Unit price USD	Subtotal USD	Lead time weeks
18.49	Gaskets				Flat gasket, Corrugated metallic w/ graphite		Spare	4	$ 4.00	$ 16.00	
18.50	Gaskets				Flat gasket, Corrugated metallic w/ graphite		Spare	4	$ 5.00	$ 20.00	
18.51	Gaskets				Flat gasket, Corrugated metallic w/ graphite		Spare	4	$ 20.00	$ 80.00	
18.52	Gaskets				Flat gasket, Corrugated metallic w/ graphite		Spare	6	$ 2.00	$ 12.00	
18.53	Gaskets				Flat gasket, Corrugated metallic w/ graphite		Spare	6	$ 3.00	$ 18.00	
18.54	Gaskets				Flat gasket, Corrugated metallic w/ graphite		Spare	6	$ 3.00	$ 18.00	
18.55	Gaskets				Flat gasket, Corrugated metallic w/ graphite		Spare	6	$ 4.00	$ 24.00	
18.56	Gaskets				Flat gasket, Corrugated metallic w/ graphite		Spare	6	$ 5.00	$ 30.00	
18.57	Gaskets				Flat gasket, Corrugated metallic w/ graphite		Spare	6	$ 8.00	$ 48.00	
18.58	Gaskets				Flat gasket, Corrugated metallic w/ graphite		Spare	6	$ 9.00	$ 54.00	
18.59	Gaskets				Flat gasket, Corrugated metallic w/ graphite		Spare	6	$ 11.00	$ 66.00	
18.60	Gaskets				Flat gasket, Corrugated metallic w/ graphite		Spare	6	$ 16.00	$ 96.00	
18.61	Gaskets				Flat gasket, Corrugated metallic w/ graphite		Spare	6	$ 25.00	$ 150.00	
18.62	Gaskets				Flat gasket Centellen WS3822		Spare	6	$ 1.00	$ 6.00	
18.63	Gaskets				Flat gasket Centellen WS3822		Spare	6	$ 1.00	$ 6.00	
18.64	Gaskets				Flat gasket Centellen WS3822		Spare	6	$ 2.00	$ 12.00	
18.65	Gaskets				Flat gasket Centellen WS3822		Spare	6	$ 2.00	$ 12.00	
18.66	Gaskets				Flat gasket Centellen WS3822		Spare	6	$ 4.00	$ 24.00	
18.67	Gaskets				Flat gasket (Garlock 3000 1/8")		Wear	2	$ 71.00	$ 142.00	
18.68	Gaskets				Flat gasket (Garlock 3000 1/8")		Spare	2	$ 320.00	$ 640.00	
18.69	Gaskets				Flat gasket (Flexitallic Style, CG, 316SS)		Spare	1	$ 25.00	$ 25.00	
18.70	Gaskets				Flat gasket (Garlock 3000 1/8")		Spare	1	$ 175.00	$ 175.00	
18.71	Gaskets				Desulfurization Towers		Spare	1	$ 219.00	$ 219.00	
									Subtotal	763,230.76	
									Shipping	228,969.23	
									Total	992,199.99	

EXHIBIT F

DANE COUNTY MAINTENANCE SCHEDULE

	4000h	8000h	12000h	16000h
Gas Detection Manufacturer: LSP GmbH	1x XCD Transmitter	1x XCD Transmitter	1x XCD Transmitter	1x XCD Transmitter
	1x XCD Transmitterfurther chanel	1x XCD Transmitterfurther chanel	1x XCD Transmitterfurther chanel	1x XCD Transmitterfurther chanel
	2x 3000 sensing head	2x 3000 sensing head	2x 3000 sensing head	2x 3000 sensing head
Remarks:	**12 hours; 8 hour plant shut down; BioD can run**	**12 hours; 8 hour plant shut down; BioD can run**	**12 hours; 8 hour plant shut down; BioD can run**	**12 hours; 8 hour plant shut down; BioD can run**
Biogas Compressor Manufacturer: VPT — Tag #	PU.AN.01.01.01.38	PU.AN.01.01.01.38	PU.AN.01.01.01.38	PU.AN.01.01.01.38
	Oil change, if neccesary (barrel for used Oil and waste by client)	Oil change, if neccesary (barrel for used Oil and waste by client)	Oil change, if neccesary (barrel for used Oil and waste by client)	Oil change, if neccesary (barrel for used Oil and waste by client)
	Change of filter cartridge - lube Oil circuit, control oil circuit (cartridge not included)	Change of filter cartridge - lube Oil circuit, control oil circuit (cartridge not included)	Change of filter cartridge - lube Oil circuit, control oil circuit (cartridge not included)	Change of filter cartridge - lube Oil circuit, control oil circuit (cartridge not included)
	Functional check of all non-return valves	Functional check of all non-return valves	Functional check of all non-return valves	Functional check of all non-return valves
	Check of suction and discharge side gas filter/s (differential pressure measuring)	Check of suction and discharge side gas filter/s (differential pressure measuring)	Check of suction and discharge side gas filter/s (differential pressure measuring)	Check of suction and discharge side gas filter/s (differential pressure measuring)
	Change of filter cartridge/s (cartridge/s not included)	Change of filter cartridge/s (cartridge/s not included)	Change of filter cartridge/s (cartridge/s not included)	Change of filter cartridge/s (cartridge/s not included)
	Check of separator cartridges (differential pressure measuring) and rest Oil content	Check of separator cartridges (differential pressure measuring) and rest Oil content	Check of separator cartridges (differential pressure measuring) and rest Oil content	Check of separator cartridges (differential pressure measuring) and rest Oil content
	Change of separator cartridge/s (cartridge/s not included)	Change of separator cartridge/s (cartridge/s not included)	Change of separator cartridge/s (cartridge/s not included)	Change of separator cartridge/s (cartridge/s not included)
	Check of Oil and gas after cooler	Check of Oil and gas after cooler	Check of Oil and gas after cooler	Check of Oil and gas after cooler
	Check of all couplings, main motor and auxiliarys	Check of all couplings, main motor and auxiliarys	Check of all couplings, main motor and auxiliarys	Check of all couplings, main motor and auxiliarys
	Check of starting sieve	Check of starting sieve	Check of starting sieve	Check of starting sieve
	Check of all electrical motors, main motor and auxiliarys	Check of all electrical motors, main motor and auxiliarys	Check of all electrical motors, main motor and auxiliarys	Check of all electrical motors, main motor and auxiliarys
	Check of all gears	Check of all gears	Check of all gears	Check of all gears
	Leakage check	Leakage check	Leakage check	Leakage check
	Temperature measuring oil and gas after coolers	Temperature measuring oil and gas after coolers	Temperature measuring oil and gas after coolers	Temperature measuring oil and gas after coolers
	Test run, functional check (acc. to DIN-DVGW and UVV codes)	Test run, functional check (acc. to DIN-DVGW and UVV codes)	Test run, functional check (acc. to DIN-DVGW and UVV codes)	Test run, functional check (acc. to DIN-DVGW and UVV codes)
	Preparing of a maintenance protocol	Preparing of a maintenance protocol	Preparing of a maintenance protocol	Preparing of a maintenance protocol
Remarks:	**24 to 48 hours - Shut down not necessary; reduction of flow needed for service**	**24 to 48 hours - Shut down not necessary; reduction of flow needed for service**	**24 to 48 hours - Shut down not necessary; reduction of flow needed for service**	**24 to 48 hours - Shut down not necessary; reduction of flow needed for service**
	Electrical Check	**Electrical Check**	**Electrical Check**	**Electrical Check**
	Functional Test of all pressure switches	Functional Test of all pressure switches	Functional Test of all pressure switches	Functional Test of all pressure switches
	Functional test of solenoid valves	Functional test of solenoid valves	Functional test of solenoid valves	Functional test of solenoid valves
	Functional test of all temperature switches	Functional test of all temperature switches	Functional test of all temperature switches	Functional test of all temperature switches
	Visual check of all components in the switch/control cabinet	Visual check of all components in the switch/control cabinet	Visual check of all components in the switch/control cabinet	Visual check of all components in the switch/control cabinet
	Material	**Material**	**Material**	**Material**
	-2x Separator cartridge	2x Separator cartridge	-2x Separator cartridge	2x Separator cartridge
	-1x oil filter cartridge	1x oil filter cartridge	-1x oil filter cartridge	1x oil filter cartridge
	-1x Thermostat inset	Oil 300l/compressor	-1x Thermostat inset	Oil 300l/compressor
	-1x repair kit for pressure retention valve		-1x repair kit for pressure retention valve	
	-4x V-belt		-4x V-belt	
RNG Compressor Manufacturer: Cobey — Tag #	PU.AP.01.01.01.80	PU.AP.01.01.01.80	PU.AP.01.01.01.80	PU.AP.01.01.01.80
	- Record cylinder lubricator divider block cycle time, record seconds/cycle	- Record cylinder lubricator divider block cycle time, record seconds/cycle	- Record cylinder lubricator divider block cycle time, record seconds/cycle	- Record cylinder lubricator divider block cycle time, record seconds/cycle
	- Adjust compressor frame oil supply pressure as required when unit is at normal operating speed and temperature. Note: Gemini frames = 45-55 psig normal operating pressure, CFA frames = 70-75 psig normal	- Adjust compressor frame oil supply pressure as required when unit is at normal operating speed and temperature.	- Adjust compressor frame oil supply pressure as required when unit is at normal operating speed and temperature. Note: Gemini frames = 45-55 psig normal operating pressure, CFA frames = 70-75 psig normal	- Adjust compressor frame oil supply pressure as required when unit is at normal operating speed and temperature.
	- Check for any leaks- oil or gas, correct as required	- Check for any leaks- oil or gas, correct as required	- Check for any leaks- oil or gas, correct as required	- Check for any leaks- oil or gas, correct as required
	- Check gas vents for leakage – piston rod packing, blow down and pressure safety valves	- Check gas vents for leakage – piston rod packing, blow down and pressure safety valves	- Check gas vents for leakage – piston rod packing, blow down and pressure safety valves	- Check gas vents for leakage – piston rod packing, blow down and pressure safety valves
	- Record cylinder lube line check valves for high temperature and/or leakage	- Record cylinder lube line check valves for high temperature and/or leakage	- Record cylinder lube line check valves for high temperature and/or leakage	- Record cylinder lube line check valves for high temperature and/or leakage
	- Record distance piece and packing vent drains for high temperature and/or leakage	- Record distance piece and packing vent drains for high temperature and/or leakage	- Record distance piece and packing vent drains for high temperature and/or leakage	- Record distance piece and packing vent drains for high temperature and/or leakage
	- Check oil filter differential pressure	- Check oil filter differential pressure	- Check oil filter differential pressure	- Check oil filter differential pressure
	- Check for leaking gauges, relace if necessary	- Check for leaking gauges, relace if necessary	- Check for leaking gauges, relace if necessary	- Check for leaking gauges, relace if necessary
	- Inspect and clean Main motor fan for any material build-up	- Inspect and clean Main motor fan for any material build-up	- Inspect and clean Main motor fan for any material build-up	- Inspect and clean Main motor fan for any material build-up
	- Oil- Check CE-PAG Oil Level in 5 Gallon Day Tank	- Oil- Check CE-PAG Oil Level in 5 Gallon Day Tank	- Oil- Check CE-PAG Oil Level in 5 Gallon Day Tank	- Oil- Check CE-PAG Oil Level in 5 Gallon Day Tank
	- Check for any loose connections in the Motor Control Center	- Check for any loose connections in the Motor Control Center	- Check for any loose connections in the Motor Control Center	- Check for any loose connections in the Motor Control Center
	- Record compressor valve covers' temperature in maintenance log	- Record compressor valve covers' temperature in maintenance log	- Record compressor valve covers' temperature in maintenance log	- Record compressor valve covers' temperature in maintenance log
	- Drain blowdown tank as required	- Drain blowdown tank as required	- Drain blowdown tank as required	- Drain blowdown tank as required
	- Drain collection pot in base frame of compressor	- Drain collection pot in base frame of compressor	- Drain collection pot in base frame of compressor	- Drain collection pot in base frame of compressor
	- Note any unusual noises or vibrations	- Note any unusual noises or vibrations	- Note any unusual noises or vibrations	- Note any unusual noises or vibrations
	- Check and clean skid of any debris that may have entered through louvers or doors	- Check and clean skid of any debris that may have entered through louvers or doors	- Check and clean skid of any debris that may have entered through louvers or doors	- Check and clean skid of any debris that may have entered through louvers or doors
	- Inspect and tighten tube and pipe brackets	- Inspect and tighten tube and pipe brackets	- Inspect and tighten tube and pipe brackets	- Inspect and tighten tube and pipe brackets
		- Test all E-stop push buttons kill control 480V and 120V power supplies		- Test all E-stop push buttons kill control 480V and 120V power supplies
Remarks:	**Compltete maintenances need 2 days. Plant shut down for 4 hr to replace inlet filter. BioD system can still run.**	**Compltete maintenances need 2 days. Plant shut down for 4 hr to replace inlet filter. BioD system can still run.**	**Compltete maintenances need 2 days. Plant shut down for 4 hr to replace inlet filter. BioD system can still run.**	**Compltete maintenances need 2 days. Plant shut down for 4 hr to replace inlet filter. BioD system can still run.**

	Remarks:	- Test all E-stop push buttons kill control 480V and 120V power supplies - Clean gas cooler fins - Inspect instrumentation for any loose connections, bent probes or degrading wiring - Check pre-lube pump pressure - Check frame and crosshead guide mounting bolts for tightness, shim and re-torque as required to eliminate any "soft-foot" found - External frame and cylinder fasteners, for loose or broken bolts - Grease main motor, gas cooler and oil pump bearings in compliance with specifications. Use Mobil polyrex EM - Calibrate Methane Detector - Inspect cylinder bores for wear or damage, record micrometer readings - Change compressor crankcase oil, or as recommended by monthly oil analysis - Measure critical frame running gear clearances- main bearing, connecting rod bearing, thrust bearing, crosshead pin/bushing and crosshead guide clearances, record readings. If readings outside tolerance limits, repair or Replace affected components as required. - Replace pin roller bearings, If so equipped. - rebuild packing cases - Pull cylinder's piston rod assembly-Clean & Inspect for wear, Replace worn or damaged components as required **4 to 8 hour plant shutdown; BioD can run**	'- Clean gas cooler fins - Inspect instrumentation for any loose connections, bent probes or degrading wiring - Check pre-lube pump pressure - Check frame and crosshead guide mounting bolts for tightness, shim and re-torque as required to eliminate any "soft-foot" found - External frame and cylinder fasteners, for loose or broken bolts - Grease main motor, gas cooler and oil pump bearings in compliance with specifications. Use Mobil polyrex EM - Calibrate Methane Detector - Inspect and tighten terminal connections in control panel - Replace Coalescing Filter elements - Inspect cylinder's valve for damaged or broken components, rebuild or replace as - Check and adjust main motor to compressor shaft alignment, record in maintenance log - Inspect cylinder bores for wear or damage, record micrometer readings - Change compressor crankcase oil, or as recommended by monthly oil analysis - Measure critical frame running gear clearances- main bearing, connecting rod bearing, thrust bearing, crosshead pin/bushing and crosshead guide clearances, record readings. If readings outside tolerance limits, repair or Replace affected components as required. - Replace pin roller bearings, If so equipped. - rebuild packing cases - Pull cylinder's piston rod assembly-Clean & Inspect for wear, Replace worn or damaged components as required. **4 to 8 hour plant shut down to replace inlet filter; BioD can run**	- Test all E-stop push buttons kill control 480V and 120V power supplies - Clean gas cooler fins - Inspect instrumentation for any loose connections, bent probes or degrading wiring - Check pre-lube pump pressure - Check frame and crosshead guide mounting bolts for tightness, shim and re-torque as required to eliminate any "soft-foot" found - External frame and cylinder fasteners, for loose or broken bolts - Grease main motor, gas cooler and oil pump bearings in compliance with specifications. Use Mobil polyrex EM - Calibrate Methane Detector - Inspect cylinder bores for wear or damage, record micrometer readings - Change compressor crankcase oil, or as recommended by monthly oil analysis - Measure critical frame running gear clearances- main bearing, connecting rod bearing, thrust bearing, crosshead pin/bushing and crosshead guide clearances, record readings. If readings outside tolerance limits, repair or Replace affected components as required. - Replace pin roller bearings, If so equipped. - rebuild packing cases - Pull cylinder's piston rod assembly-Clean & Inspect for wear, Replace worn or damaged components as required **4 to 8 hour plant shutdown; BioD can run**	'- Clean gas cooler fins - Inspect instrumentation for any loose connections, bent probes or degrading wiring - Check pre-lube pump pressure - Check frame and crosshead guide mounting bolts for tightness, shim and re-torque as required to eliminate any "soft-foot" found - External frame and cylinder fasteners, for loose or broken bolts - Grease main motor, gas cooler and oil pump bearings in compliance with specifications. Use Mobil polyrex EM - Calibrate Methane Detector - Inspect and tighten terminal connections in control panel - Replace Coalescing Filter elements - Inspect cylinder's valve for damaged or broken components, rebuild or replace as - Check and adjust main motor to compressor shaft alignment, record in maintenance log - Inspect cylinder bores for wear or damage, record micrometer readings - Change compressor crankcase oil, or as recommended by monthly oil analysis - Measure critical frame running gear clearances- main bearing, connecting rod bearing, thrust bearing, crosshead pin/bushing and crosshead guide clearances, record readings. If readings outside tolerance limits, repair or Replace affected components as required. - Replace pin roller bearings, If so equipped. - rebuild packing cases - Pull cylinder's piston rod assembly-Clean & Inspect for wear, Replace worn or damaged components as required. - Replace pin roller bearings, If so equipped. - rebuild packing cases - Pull cylinder's piston rod assembly-Clean & Inspect for wear, Replace worn or damaged components as required **4 to 8 hour plant shut down to replace inlet filter; BioD can run**
Vacuum Pump Manufacturer: Busch	Tag #		PU.DD.01.01.01.05 - PU.DD.01.02.04.05 **Maintenance** - Oil change - inspection of compression chamber - inspection of rotor disk - inprection of non-return valve - inspection of lube oil system - inspection of oil cooler - inspection of filter resistence pressure gauge - inspection of electrical installation for function and damages - change oil filters - check of intake strainer - check of slide damper - inspection of Atex-clutch - functional test of float valve for oil recirculation - check of lube for electrical motor **Material** 1x filter cartridge, 40L Oil VE101 2x oil filter 2x flange gasket 1x disposal of oleiferous equipment, waste oil **Remarks: Complete maintenance will take 5 days; BioD can work**		PU.DD.01.01.01.05 - PU.DD.01.02.04.05 **Maintenance** - Oil change - inspection of compression chamber - inspection of rotor disk - inprection of non-return valve - inspection of lube oil system - inspection of oil cooler - inspection of filter resistence pressure gauge - inspection of electrical installation for function and damages - change oil filters - check of intake strainer - check of slide damper - inspection of Atex-clutch - functional test of float valve for oil recirculation - check of lube for electrical motor **Material** 1x filter cartridge, 40L Oil VE101 2x oil filter 2x flange gasket 1x disposal of oleiferous equipment, waste oil **Remarks: Complete maintenance will take 5 days; BioD can work**
Sulfur Removal Unit Manufacturer: TS Umweltanlagenbau	Tag # Remarks:	PU.AD.01.01.01.44 Maintenance (h) including small spare parts of a sum up to $120k Inspection- visual check of he entire plant Cleaning of the sieves and filters; caustic tank Cleaning of the circulation pumps and the floats; caustic dose pump Maintenance of electrical components, calibration of pH/T-probe; neutralization reactor & PID Inspection and cleaning of the liquid Level sensors, flushing of the plant via separate pumps Monitoring the functioning of the nuetrualization, quantity of discharge Determining the pH nuetralization rate and check if outlet > 8 pH Setting of the optimum performance parameters for the plant **16 hours; 8 hours plant shut down, no BioD**	PU.AD.01.01.01.44 Maintenance (h) including small spare parts of a sum up to $120k Inspection- visual check of he entire plant Cleaning of the sieves and filters Cleaning of the circulation pumps and the floats Maintenance of electrical components, calibration of pH/T-probe Inspection and cleaning of the liquid level sensors, flushing of the plant via separate pumps Inspection and cleaning of the liquid level sensors, flushing of the plant via separate pumps Monitoring the functioning of the desulphurization, quantity of discharge Determining the H2S elimination rate and check if outlet < 150 ppm Setting of the optimum performance parameters for the plant Rinsing via jetting lances **16 hours; 8 hours plant shut down, no BioD**	PU.AD.01.01.01.44 Maintenance (h) including small spare parts of a sum up to $120k Inspection- visual check of he entire plant Cleaning of the sieves and filters; caustic tank Cleaning of the circulation pumps and the floats; caustic dose pump Maintenance of electrical components, calibration of pH/T-probe; neutralization reactor & PID Inspection and cleaning of the liquid Level sensors, flushing of the plant via separate pumps Monitoring the functioning of the nuetrualization, quantity of discharge Determining the pH nuetralization rate and check if outlet > 8 pH Setting of the optimum performance parameters for the plant **16 hours; 8 hours plant shut down, no BioD**	PU.AD.01.01.01.44 Maintenance (h) including small spare parts of a sum up to $120k Inspection- visual check of he entire plant Cleaning of the sieves and filters Cleaning of the circulation pumps and the floats Maintenance of electrical components, calibration of pH/T-probe Inspection and cleaning of the liquid level sensors, flushing of the plant via separate pumps Inspection and cleaning of the liquid level sensors, flushing of the plant via separate pumps Monitoring the functioning of the desulphurization, quantity of discharge Determining the H2S elimination rate and check if outlet < 150 ppm Setting of the optimum performance parameters for the plant Rinsing via jetting lances **16 hours; 8 hours plant shut down, no BioD**

Neutralization System Manufacturer: TS Umweltanlagenbau	Maintenance (h) including small spare parts of a sum of up to $120k - Inspection- visual check of he entire plant - cleaning of the sieves and filters; caustic tank - cleaning of the circulation pumps and the floats; caustic dose pump - maintenance of electrical components, calibration of pH/T-probe; neutralization reactor & PID - inspection and cleaning of the liquid level sensors, flushing of the plant via separate pumps - Monitoring the functioning of the nuetralization, quantity of discharge - Determining the pH nuetralization rate and check if outlet > 8 pH - setting of the optimum performance parameters for the plant	Maintenance (h) including small spare parts of a sum of up to $120k '- Inspection- visual check of he entire plant - cleaning of the sieves and filters; caustic tank - cleaning of the circulation pumps and the floats; caustic dose pump - maintenance of electrical components, calibration of pH/T-probe; neutralization reactor - inspection and cleaning of the liquid level sensors, flushing of the plant via separate pum - Monitoring the functioning of the neutralization, quantity of discharge - Determining the pH neutralization rate and check if outlet > 8 pH - setting of the optimum performance parameters for the plant	Maintenance (h) including small spare parts of a sum of up to $120k - Inspection- visual check of he entire plant - cleaning of the sieves and filters; caustic tank - cleaning of the circulation pumps and the floats; caustic dose pump - maintenance of electrical components, calibration of pH/T-probe; neutralization reactor & PID - inspection and cleaning of the liquid level sensors, flushing of the plant via separate pumps - Monitoring the functioning of the nuetralization, quantity of discharge - Determining the pH nuetralization rate and check if outlet > 8 pH - setting of the optimum performance parameters for the plant	Maintenance (h) including small spare parts of a sum of up to $120k '- Inspection- visual check of he entire plant - cleaning of the sieves and filters; caustic tank - cleaning of the circulation pumps and the floats; caustic dose pump - maintenance of electrical components, calibration of pH/T-probe; neutralization reactor & PID - inspection and cleaning of the liquid level sensors, flushing of the plant via separate pumps - Monitoring the functioning of the neutralization, quantity of discharge - Determining the pH neutralization rate and check if outlet > 8 pH - setting of the optimum performance parameters for the plant
Remarks:	**16 hours**	**16 hours**	**16 hours**	**16 hours**
Dew Point Tag #		PU.FC.01.01.01.00		PU.FC.01.01.01.00
Manufacturer: Michell		**Maintenance** Dew point transmitter		**Maintenance** Dew point transmitter
RTO Off gas combustion Tag #	PU.DF.01.01.01.04	PU.DF.01.01.01.04	PU.DF.01.01.01.04	PU.DF.01.01.01.04
Manufacturer: TANN	**Maintenance** - Inspect poppet valve blade - Inspect poppet valve seat assy - Verify proper blade to seat connection - Test manual gas valves operation - Check air / gas ratio - Inspect Fan Coupling Remarks: **Maintenance will take 1-day shut down, BioD can run.**	**Maintenance** - Test pressure switches - Visually check ignition cable and connector - Inspect piping for leaks - Inspect burner components - Clean orifice plate - Inspect motor - Inspect fan shaft - Inspect fan support structure - Inspect fan wheel - Manufacturer to Inspect **Remarks: 24 to 48 hours shut down; BioD can run**	**Maintenance** - Inspect poppet valve blade - Inspect poppet valve seat assy - Verify proper blade to seat connection - Test manual gas valves operation - Check air / gas ratio - Inspect Fan Coupling **Maintenance will take 1-day shut down, BioD can run.**	**Maintenance** - Test pressure switches - Visually check ignition cable and connector - Inspect piping for leaks - Inspect burner components - Clean orifice plate - Inspect motor - Inspect fan shaft - Inspect fan support structure - Inspect fan wheel - Manufacturer to Inspect **Remarks: 24 to 48 hours shut down; BioD can run**
Bladder Tanks Manufacturer: Tecon	Torque the anchor bolt Nm (tight fit 60 Nm) Service any bolts or loose parts Services to torque should be completed every 6 months Inspect the gas content of the outlet air in the pressure control valves Leakage test and visual inspection of the outer membrane Leak test of the gas holder and valves Soaping the contact points Sikaflex inspection to validate seals are in good condition Checking the safety valves Check for contamination/frost in the inlet grill, the suction area of the blower must be kept free from foliage and similar deposits within 1 meter Check for vibration or operating noises in the supporting air blower Check weekly that the intake grill of the blower is free from foreign objects. Depending on the installation location the blower grill can often freeze during the autumn/winter transition period. This ice can be removed by tapping lightly. Repair protective paint coat of the housing parts Valve inspection Remarks: **16 to 20 hours**	Torque the anchor bolt Nm (tight fit 60 Nm) Service any bolts or loose parts Services to torque should be completed every 6 months Inspect the gas content of the outlet air in the pressure control valves Leakage test and visual inspection of the outer membrane Leak test of the gas holder and valves Soaping the contact points Sikaflex inspection to validate seals are in good condition Checking the safety valves **Remarks: 16 to 20 hours** Check the gas pipe connecting the gas compartment and the safety valve is not dirty and constricted Check for vibration or operating noises in the supporting air blower Check weekly that the intake grill of the blower is free from foreign objects. Depending on the installation location the blower grill can often freeze during the autumn/winter transition period. This ice can be removed by tapping lightly. **4 to 8 hour plant shutdown; BioD can run** Repair protective paint coat of the housing parts Valve inspection Replacement of ball bearings according to manufacturer Inspection by a specialist of the manufacturer **Remarks: 4 to 8 hour plant shutdown; BioD can run (both shutdown efforts could occur at the same time)**	Torque the anchor bolt Nm (tight fit 60 Nm) Service any bolts or loose parts Services to torque should be completed every 6 months Inspect the gas content of the outlet air in the pressure control valves Leakage test and visual inspection of the outer membrane Leak test of the gas holder and valves Soaping the contact points Sikaflex inspection to validate seals are in good condition Checking the safety valves Check for contamination/frost in the inlet grill, the suction area of the blower must be kept free from foliage and similar deposits within 1 meter Check for vibration or operating noises in the supporting air blower Check weekly that the intake grill of the blower is free from foreign objects. Depending on the installation location the blower grill can often freeze during the autumn/winter transition period. This ice can be removed by tapping lightly. Repair protective paint coat of the housing parts Valve inspection **16 to 20 hours**	Torque the anchor bolt Nm (tight fit 60 Nm) Service any bolts or loose parts Services to torque should be completed every 6 months Inspect the gas content of the outlet air in the pressure control valves Leakage test and visual inspection of the outer membrane Leak test of the gas holder and valves Soaping the contact points Sikaflex inspection to validate seals are in good condition Checking the safety valves **Remarks: 16 to 20 hours** Check the gas pipe connecting the gas compartment and the safety valve is not dirty and constricted Check for vibration or operating noises in the supporting air blower Check weekly that the intake grill of the blower is free from foreign objects. Depending on the installation location the blower grill can often freeze during the autumn/winter transition period. This ice can be removed by tapping lightly. **4 to 8 hour plant shutdown; BioD can run** Repair protective paint coat of the housing parts Valve inspection Replacement of ball bearings according to manufacturer Inspection by a specialist of the manufacturer **Remarks: 4 to 8 hour plant shutdown; BioD can run (both shutdown efforts could occur at the same time)**
Others: BIOFerm	**Preparing for Maintenance** Purchasing of manufacturers Coordination of manufacturers	**Preparing for Maintenance** Purchasing of manufacturers Coordination of manufacturers	**Preparing for Maintenance** Purchasing of manufacturers Coordination of manufacturers	**Preparing for Maintenance** Purchasing of manufacturers Coordination of manufacturers
Remarks:	**12 hours; no shut down needed**	**12 hours; no shut down needed**	**12 hours; no shut down needed**	**12 hours; no shut down needed**
	General Maintenance Visual inspection of electrical stationary equipment Check of flashlights Check emergency stop and PLT protective devices Check of ELCB- , residual current- and fault-voltage protective switch for a flawless function Check all valves in system Check and correct alignment Check pipe supports Check trace heating Check and clean all orifice plates in condensate system Check electrical heating (in housings)	**General Maintenance** Visual inspection of electrical stationary equipment Check of flashlights Check emergency stop and PLT protective devices Check of ELCB- , residual current- and fault-voltage protective switch for a flawless function Check all valves in system Check and correct alignment Check pipe supports Check trace heating Check and clean all orifice plates in condensate system Check electrical heating (in housings)	**General Maintenance** Visual inspection of electrical stationary equipment Check of flashlights Check emergency stop and PLT protective devices Check of ELCB- , residual current- and fault-voltage protective switch for a flawless function Check all valves in system Check and correct alignment Check pipe supports Check trace heating Check and clean all orifice plates in condensate system Check electrical heating (in housings)	**General Maintenance** Visual inspection of electrical stationary equipment Check of flashlights Check emergency stop and PLT protective devices Check of ELCB- , residual current- and fault-voltage protective switch for a flawless function Check all valves in system Check and correct alignment Check pipe supports Check trace heating Check and clean all orifice plates in condensate system Check electrical heating (in housings)
Remarks:	**Maintenance will take 1 day - no need to shut down the plant for instrument air**	**Maintenance will take 1 day - no need to shut down the plant for instrument air**	**Maintenance will take 1 day - no need to shut down the plant for instrument air**	**Maintenance will take 1 day - no need to shut down the plant for instrument air**

	Control air system pneumatic valves: check of operation (time for switching, torque), if required check of seal collar	**Control air system** pneumatic valves: check of operation (time for switching, torque), if required check of seal collar	**Control air system** pneumatic valves: check of operation (time for switching, torque), if required check of seal collar	**Control air system** pneumatic valves: check of operation (time for switching, torque), if required check of seal collar
	Housing ventilation - check lubrication conditions - check of dirtiness and parts erosion - check of motor bearing for lubrication	**Housing ventilation** - check lubrication conditions - check of dirtiness and parts erosion - check of motor bearing for lubrication	**Housing ventilation** - check lubrication conditions - check of dirtiness and parts erosion - check of motor bearing for lubrication	**Housing ventilation** - check lubrication conditions - check of dirtiness and parts erosion - check of motor bearing for lubrication
	Wall/ roof ventilator: check of bearing and bearing oil Check of cabeling and balance test	**Wall/ roof ventilator:** check of bearing and bearing oil Check of cabeling and balance test	**Wall/ roof ventilator:** check of bearing and bearing oil Check of cabeling and balance test	
	Cooling Water: - Swap out bearing motor; where applicable, clean and repair - Swap out bolts - Swap out blades or wheel - Change in heat exchanger setting found: restore required heat exchanger setting (concentration, inhibition) - Repair affected unit part - Corrosion or damage on core tubes, fins, support structure, tube connections, fixtures: repair unit sections affected		**Cooling Water:** - Swap out bearing motor; where applicable, clean and repair - Swap out bolts - Swap out blades or wheel - Change in heat exchanger setting found: restore required heat exchanger setting (concentration, inhibition) - Repair affected unit part - Corrosion or damage on core tubes, fins, support structure, tube connections, fixtures: repair unit sections affected	
Remarks:	**12 to 14 hours; will require shut-down; BioD can run**		**12 to 14 hours; will require shut-down; BioD can run**	
	VOC Regeneration Gas heater remove heating element assembly for visual inspection of heater sheath check temperature control and limit control operation check electrical connections and retighten connections. replace wire and wire terminal that show signs of oxidation	**VOC Regeneration Gas heater** remove heating element assembly for visual inspection of heater sheath check temperature control and limit control operation check electrical connections and retighten connections. replace wire and wire terminal that show signs of oxidation	**VOC Regeneration Gas heater** remove heating element assembly for visual inspection of heater sheath check temperature control and limit control operation check electrical connections and retighten connections. replace wire and wire terminal that show signs of oxidation	**VOC Regeneration Gas heater** remove heating element assembly for visual inspection of heater sheath check temperature control and limit control operation check electrical connections and retighten connections. replace wire and wire terminal that show signs of oxidation
Remarks:	**12 to 14 hours; will require shut-down; BioD can run**	**12 to 14 hours; will require shut-down; BioD can run**	**12 to 14 hours; will require shut-down; BioD can run**	**12 to 14 hours; will require shut-down; BioD can run**
	LFG blowers + Recirculate blower + Tail gas blowers inspect foundation and correct level condition as necessary check condition of isolations pads and replace as necessary make sure lubrication maintenance schedule is established and adhered to keep oiler bottle clean so oil or lack of can be seen follow motor manufacturer's recommendations for motor maintenance take vibration readings and temperature readings	**LFG blowers + Recirculate blower + Tail gas blowers** inspect foundation and correct level condition as necessary check condition of isolations pads and replace as necessary make sure lubrication maintenance schedule is established and adhered to keep oiler bottle clean so oil or lack of can be seen follow motor manufacturer's recommendations for motor maintenance take vibration readings and temperature readings	**LFG blowers + Recirculate blower + Tail gas blowers** inspect foundation and correct level condition as necessary check condition of isolations pads and replace as necessary make sure lubrication maintenance schedule is established and adhered to keep oiler bottle clean so oil or lack of can be seen follow motor manufacturer's recommendations for motor maintenance take vibration readings and temperature readings	**LFG blowers + Recirculate blower + Tail gas blowers** inspect foundation and correct level condition as necessary check condition of isolations pads and replace as necessary make sure lubrication maintenance schedule is established and adhered to keep oiler bottle clean so oil or lack of can be seen follow motor manufacturer's recommendations for motor maintenance take vibration readings and temperature readings
Remarks:	**12 to 14 hours; LFG blower will require shut down; Bio-D can run ; 12 to 14 hours Recirculate and Tail gas blower ; will require shut down; Bio-D can run**	**12 to 14 hours; LFG blower will require shut down; Bio-D can run ; 12 to 14 hours Recirculate and Tail gas blower ; will require shut down; Bio-D can run**	**12 to 14 hours; LFG blower will require shut down; Bio-D can run ; 12 to 14 hours Recirculate and Tail gas blower ; will require shut down; Bio-D can run**	**12 to 14 hours; LFG blower will require shut down; Bio-D can run ; 12 to 14 hours Recirculate and Tail gas blower ; will require shut down; Bio-D can run**
	H2S-Sensor Biomethane calibration with 10ppm span gas	**H2S-Sensor Biomethane** calibration with 10ppm span gas	**H2S-Sensor Biomethane** calibration with 10ppm span gas	**H2S-Sensor Biomethane** calibration with 10ppm span gas
Remarks:	**2 hours**	**2 hours**	**2 hours**	**2 hours**
	Biogas and Biomethane analysis calibration with span gas, zero gas and air	**Biogas and Biomethane analysis** calibration with span gas, zero gas and air	**Biogas and Biomethane analysis** calibration with span gas, zero gas and air	**Biogas and Biomethane analysis** calibration with span gas, zero gas and air
Remarks:	**2 hours**	**2 hours**	**2 hours**	**2 hours**
	O2-Sensors (Michell) change H2S filter, calibrating with test gas	**O2-Sensors (Michell)** change H2S filter, calibrating with test gas	**O2-Sensors (Michell)** change H2S filter, calibrating with test gas	**O2-Sensors (Michell)** change H2S filter, calibrating with test gas
Remarks:	**2 hours**	**2 hours**	**2 hours**	**2 hours**
	Diode laser spectrometer (AP2E) change sonic nozzle, check pump	**Diode laser spectrometer (AP2E)** change sonic nozzle, check pump, calibration with test gas	**Diode laser spectrometer (AP2E)** change sonic nozzle, check pump	**Diode laser spectrometer (AP2E)** change sonic nozzle, check pump, calibration with test gas
Remarks:	**2 hours**	**2 hours**	**2 hours**	**2 hours**
	Gas coolers/gas sampling system	**Gas coolers/gas sampling system**	**Gas coolers/gas sampling system**	**Gas coolers/gas sampling system**
Remarks:	**2 hours**	**2 hours**	**2 hours**	**2 hours**
		Instrument Air Compressor Change air and oil filters Change oil separator Instrument air dryer Change inlet filter Change desiccant Replace coalescence filter and H2S Desiccant (biogas) **Remarks: 4 to 8 hour shut down may be needed**		**Instrument Air Compressor** Change air and oil filters Change oil separator Instrument air dryer Change inlet filter Change desiccant Replace coalescence filter and H2S Desiccant (biogas) **Remarks: 4 to 8 hour shut down may be needed**

	Chiller 1 & 2 Clean the filters, check pump and compressor, check glycol levels in the units	**Chiller 1 & 2** Clean the filters, check pump and compressor, check glycol levels in the units Swap out bearing motor, bolts, blades or wheel. Change in heat exchanger setting found: restore required heat exchanger setting (concentration, inhibition) Restore required brine-side conditions, corrosion or damage on core tubes, fins, repair unit sections affected Check all electrical connections, inspect all contractors and relays, replace as necessary check accuracy of thermistors - check to be sure that the proper concentration of anti-freeze is present int he chilled water loop - check chilled water strainers, cooler heater operation, condition of condenser fan blades and that they are securely fastened to the motor shaft - perform service test - check for excessive cooler approach - clean cooler vessel if necessary **Remarks: 8 hour plant shut down; Bio-D can be ran, see condition - chiller and dry cooler cannot be shut down at same time in order to run Bio-D**	**Chiller 1 & 2** Clean the filters, check pump and compressor, check glycol levels in the units	**Chiller 1 & 2** Clean the filters, check pump and compressor, check glycol levels in the units Swap out bearing motor, bolts, blades or wheel. Change in heat exchanger setting found: restore required heat exchanger setting (concentration, inhibition). Restore required brine-side conditions, corrosion or damage on core tubes, fins, repair unit sections affected Check all electrical connections, inspect all contractors and relays, replace as necessary check accuracy of thermistors - check to be sure that the proper concentration of anti-freeze is present int he chilled water loop - check chilled water strainers, cooler heater operation, condition of condenser fan blades and that they are securely fastened to the motor shaft - perform service test - check for excessive cooler approach - clean cooler vessel if necessary **Remarks: 8 hour plant shut down; Bio-D can be ran, see condition - chiller and dry cooler cannot be shut down at same time in order to run Bio-D**
Remarks:	**8 hour plant shut down; Bio-D can be ran, see condition - chiller and dry cooler cannot be shut down at same time in order to run Bio-D**		**8 hour plant shut down; Bio-D can be ran, see condition - chiller and dry cooler cannot be shut down at same time in order to run Bio-D**	
	Calibration Gases - multiple		**Calibration Gases - multiple**	
	Carbon Media Change Change media on H2S and VOC vessels - gasket needed 8000 lbs of carbon per vessel - follow change out O&M Manual Isolation valve check	**Carbon Media Change** Change media on H2S and VOC vessels - gasket needed 8000 lbs of carbon per vessel - follow change out O&M Manual Isolation valve check	**Carbon Media Change** Change media on H2S and VOC vessels - gasket needed 8000 lbs of carbon per vessel - follow change out O&M Manual Isolation valve check	**Carbon Media Change** Change media on H2S and VOC vessels - gasket needed 8000 lbs of carbon per vessel - follow change out O&M Manual Isolation valve check
Remarks:	**24 hour plant shut down; Bio_D could be run**	**24 hour plant shut down; Bio_D could be run**	**24 hour plant shut down; Bio_D could be run**	**24 hour plant shut down; Bio_D could be run**
	LFG Filters and Drying Separator Check the filters and replace	**LFG Filters and Drying Separator** Check the filters and replace	**LFG Filters and Drying Separator** Check the filters and replace	**LFG Filters and Drying Separator** Check the filters and replace
Remarks:	**12-hour plant shut down; BioD cannot be run**	**12-hour plant shut down; BioD cannot be run**	**12-hour plant shut down; BioD cannot be run**	**12-hour plant shut down; BioD cannot be run**
	Material Dust filter cartridge Oil filter cartridge Methane 4.5 and 10% CO2 in N2	**Material** Dust filter cartridge Oil filter cartridge Methane 4.5 and 10% CO2 in N2 Instrument air compressor filters and oil separator Instrument air drier inlet filter and desiccant H2S Desiccant Coalescence filter Dewpoint transmitter calibration/spare	**Material** Dust filter cartridge Oil filter cartridge Methane 4.5 and 10% CO2 in N2	**Material** Dust filter cartridge Oil filter cartridge Methane 4.5 and 10% CO2 in N2 Instrument air compressor filters and oil separator Instrument air drier inlet filter and desiccant
SHUT-DOWN TIME:				
W/ BioD RUNNING	**120-132 Hours**	**120-166 Hours + 5 days for Vacuum Pump**	**120-132 Hours**	**120-166 Hours + 5 days for Vacuum Pump**
TOTAL PLANT SHUT-DOWN	**20 Hours**	**20 Hours**	**20 Hours**	**20 Hours**

EXHIBIT G

LANDFILL GAS SPECIFICATIONS

Parameter	Column A Raw Landfill Gas (required to meet the 80% Methane Recovery)[1]	Column B Raw Landfill Gas (required to meet the 86% Methane Recovery)[1]	Column C Raw Landfill Gas (required to meet the 92% Methane Recovery)[1]
Flow (scfm)	$500 < F < 2{,}500$	$1{,}000 < F < 2{,}500$	$1{,}000 < F < 2{,}500$
Heating Value (BTU/ft^3)	$505 < HV < 606$	N/A (see CH_4 content)	N/A (see CH_4 content)
Hydrogen Sulfide (ppmv)	$0 < H_2S < 2{,}400$	$0 < H_2S < 2{,}400$[2]	$0 < H_2S < 2{,}400$[2]
Total Sulfur (ppmv)	$0 < S < 2{,}400$	N/A	N/A
Water Vapor (lb. / $1x10^6$ ft^3)	$0 < WV < 1{,}800$	$0 < WV < 1{,}800$	$0 < WV < 1{,}800$
Temperature (deg. F)	$86 < T < 130$	$86 < T < 130$	$86 < T < 130$
Hydrocarbon Dewpoint (deg. F)	-	See other constituents	See other constituents
Other constituents	-[3]	$0\% < X < 120\%$[4]	$0\% < X < 120\%$[4]
Pressure (psig)	$2 < P < 4$	$2 < P < 4$	$2 < P < 4$
General			
Carbon Dioxide (% by volume)[5]	$30 < CO_2 < 50$		
Methane (% by volume)	$50 < CH_4 < 60$		
Oxygen (% by volume)	$0.20 < O_2 < 2.00$		
Balance (% by volume) [6]	$0.00 < N_2 < 14.00$		
Low Carbon Dioxide Scenario			
Carbon Dioxide (% by volume)	-	$30 < CO_2 < 40$	$30 < CO_2 < 40$
Methane (% by volume)	-	$49 < CH_4 < 60$	$49 < CH_4 < 60$
Oxygen (% by volume) [7]	-	$0.20 < O_2 < 1.00$	$0.20 < O_2 < 1.00$
Balance (% by volume) [6][8]	-	$7.50 \leq N_2 \leq 11.00$	$0.00 \leq N_2 \leq 7.50$
High Carbon Dioxide Scenario			
Carbon Dioxide (% by volume)	-	$40 < CO_2 < 48$	$40 < CO_2 < 48$
Methane (% by volume)	-	$50 < CH_4 < 60$	$50 < CH_4 < 60$
Oxygen (% by volume) [7]	-	$0.20 < O_2 < 1.0\ 0$	$0.20 < O_2 < 1.0\ 0$
Balance (% by volume) [6][8]	-	$0.00 < N_2 < 5.00$	$0.00 < N_2 < 4.00$

(1) Values are not interdependent on one another.
(2) If $3(H_2S) < O_2 < O_{MAX}$
(3) As per Dane County gas sample.
(4) Relative deviation from sample value.
(5) With CO_2 less than 1,150 scfm.
(6) Balance shall be 100% - [$\%CH_4 + \%CO_2 + \%O_2 + \%H_2S$].
(7) Includes O_2 from addition of air within BUP system for sulfur removal.
(8) Includes Balance from addition of air within BUP system for sulfur removal.

Please note:

- Higher concentrations of H_2S are acceptable at lower flow rates, so long as the total volume of H_2S does not exceed the equivalent of 2,400 ppmv at 2,500 scfm.
- The criteria noted above for efficiency and uptime shall not be applicable when Raw Landfill Gas Balance values jump up by 2.00% or greater within 60 minutes.
- The maximum O_2 injected with instrumentation air shall be 0.5%.

EXHIBIT H

PRODUCT GAS SPECIFICATIONS

BIOFerm agrees to inject pipeline quality gas from conditioned landfill gas. The pipeline quality gas shall meet ANR Product Gas Specifications as outlined in Table H.1, below.

Table H.1 - ANR Product Gas Specifications

Parameter	ANR Pipeline Specifications
Heating Value (BTU/ft^3)	967 - 1,200
Hydrogen Sulfide (ppmv)[1]	< 4
Total Sulfur (ppmv)[2]	< 320
Oxygen (% by volume)	< 1.00
Carbon Dioxide (% by volume)	< 2.00
Nitrogen (% by volume)	< 3.00
Water Vapor ($lb./1x10^6\ ft^3$)	< 7
Temperature (deg. F)	40 < T < 120
Hydrocarbon Dewpoint (deg. F)[3]	≤ 15
Pressure (psig)[4]	600 - 975

[1] 16 ppmv ~1 grain/100 ft^3

[2] Including sulfur in any hydrogen sulfide and mercaptans

[3] Additional language in Federal Energy Regulatory Commission (FERC) Gas Tariff for ANR Pipeline Company (Third Revised Volume No. 1) – Section 6.13

[4] Additional language in FERC Gas Tariff for ANR Pipeline Company (Third Revised Volume No. 1) – Section 6.11

BIOFerm acknowledges that anytime injected gas is outside of the aforementioned parameters, ANR will shut-in the system and negatively impact Owners availability to inject into the pipeline. In the event of a shut-in, ANR has one (1) business day from Owner notification, to reopen their valve for injection. If these shut-in events occur three (3) times over the course of one (1) year, ANR may terminate the injection agreement held between Owner and ANR. The delays caused by ANR reopening the valve to the pipeline and failure to meet Table H.1 specifications are considered Forced Outage Hours (FOH) when the issue causing the failure are directly and clearly due to BIOFerm operations but shall not exceed a duration of 24 hours for each shut-in event.

Due to the economic risk of shut-in events, BIOFerm shall provide their best efforts to maintain gas parameters below ANR Product Gas Specifications as outlined in Owner Product Gas Specifications (Table H.2). Owner Product Gas Specifications are slightly more stringent than ANR Product Gas Specifications to protect Owner from previously mentioned shut-in events. Owner may adjust Table H.2 values any time throughout the contract term based on uniformity of Product Gas production and quality. For instances where Product Gas meets ANR Product Gas Specifications but does not meet Owners Product Gas Specifications, the delays are considered Other Shutdown Hours (OSH).

Table H.2 - Owner Product Gas Specifications

Parameter	Dane County Alarm to BIOFerm	Dane County Shut-In
Heating Value (BTU/ft^3)	980 ≥ BTU/ft^3 ≥ 1,180	972 ≥ BTU/ft^3 ≥ 1,190
Hydrogen Sulfide (ppmv)	≥ 3.60	≥ 3.80
Total Sulfur (ppmv)	≥ 290	≥ 310
Oxygen (% by volume)	≥ 0.75	≥ 0.90
Carbon Dioxide (% by volume)	≥ 1.20	≥ 1.50
Nitrogen (% by volume)	≥ 2.65	≥ 2.70
Water Vapor (lb./1X10^6 ft^3)	≥ 4.90	≥ 6.00
Temperature (deg. F)	50 ≥ F≥ 110	45 ≥ F ≥ 115

EXHIBIT I

TOTAL AVAILABILITY OF PLANT GUARANTEE

1. *TOTAL AVAILABILITY OF PLANT (TAP) GUARANTEE EQUATION:*

TAP shall be calculated on a quarterly basis.

$$\textit{Total Availability of Plant} = \frac{\text{ATH}-\text{SOH}-\text{OSH}-\text{FOH}}{\text{ATH}-\text{SOH}-\text{OSH}} \times 100$$

Where:

ATH = Available Time Hours (shall be 8,760 hours for each Term).
SOH = Scheduled Outage Hours. SOH not to exceed 336 hours for each year based on the Exhibit F, excess hours shall be deemed FOH.
OSH = Other Shutdown Hours (Hours when the Plant is available but not in operation due to reasons for which the <u>Owner is responsible</u> or as a result of Force Majeure, as defined in Article XII.).
FOH = Forced Outage Hours (Hours when the Plant is not able to produce gas as outlined in Table H.1 (Exhibit H),without restrictions at the load that the Owner desires, due to reasons for which the <u>Operator is responsible</u>).

In case the Plant is running but providing less than 100% capacity this partial performance will be translated into percentage availability. For example, at 1,650 scfm achieved capacity instead of 1,750 scfm desired capacity the availability factor is 0.94 multiplied by the hours the plant is running under partial performance (e.g.10 hours : 0.94 x 10 hours = 9.4 hours = 0.6 hours will be deemed as not available).

TAP Guarantee is further outlined in Article V of the Contract.

2. *TOTAL AVAILABILITY OF PLANT GUARANTEE EXAMPLE CALCULATION:*

$$\text{Total Availability of the Plant} = \frac{\text{ATH}-\text{SOH}-\text{OSH}-\text{FOH}}{\text{ATH}-\text{SOH}-\text{OSH}} \times 100$$

ATH: 8,760 hours per year

SOH: 260 hours per year to perform plant and equipment scheduled maintenance

OSH: 100 hours per year for unexpected shutdown outside of Plant

FOH: 200 hours per year for unexpected shutdown inside of Plant

$$\boldsymbol{\textit{Total Availability of the Plant} = \frac{8760-260-100-200}{8760-260-100} \times 100\% = 97.6\%}$$

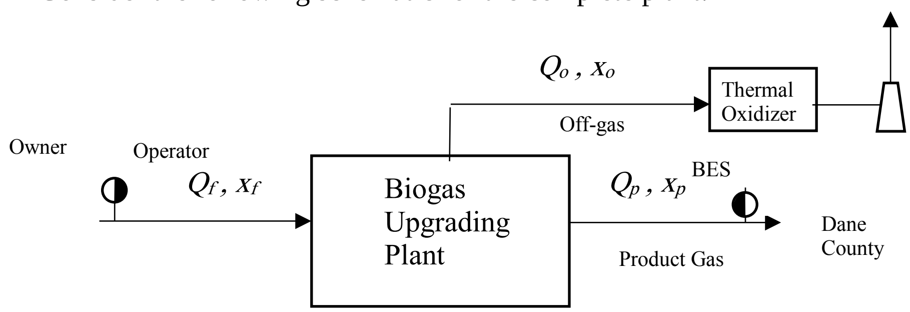
EXHIBIT J

PRODUCT GAS PRODUCTION GUARANTEE

1. PRODUCT GAS PRODUCTION (PGP) GUARANTEE EQUATION:

PGP Guarantee is only applicable when landfill gas meets Exhibit G specifications. Guarantee to be calculated when Plant is in operation and producing product gas regardless of whether product gas meets Owner or ANR Product Gas Specifications. **PGP shall be calculated on a time weighted average based on time spent in each column in Exhibit G.**

Consider the following schematic for the complete plant:



where, Q represents molar flow (SCFM) and x represents mole fraction of Methane (CH_4). The subscripts f, p, o respectively stands for feed, product gas and off-gas. Note that neither product gas nor landfill gas is used as extra fuel.

$$\textit{Product Gas Production} \quad = \quad 1 - \left[\left(\frac{x_f - x_p}{x_o - x_p}\right)\left(\frac{x_o}{x_f}\right)\right] \geq 92\%$$

Where:

x_f = *Mole fraction of methane for feed gas (BIOFerm feed analyzer, averaged quarterly).*

x_p = *Mole fraction of methane for product gas (BIOFerm Gas Chromatograph, averaged quarterly).*

x_o = *Mole fraction of methane for off-gas (BIOFerm flue analyzer, averaged quarterly).*

2. PRODUCT GAS PRODUCTION GUARANTEE EXAMPLE CALCULATION:

$$\textit{Product Gas Production} \quad = \quad 1 - \left[\left(\frac{x_f - x_p}{x_o - x_p}\right) \times \left(\frac{x_o}{x_f}\right)\right] \geq 92\ \%$$

x_f*: 0.52 mole fraction of methane for feed gas*

x_s*: 0.98 mole fraction of methane for product gas*

x_o*: 0.08 mole fraction of methane for off-gas*

$$\textit{Product Gas Production} \quad = \quad 1 - \left[\left(\frac{0.52 - 0.98}{0.08 - 0.98}\right) \times \left(\frac{0.08}{0.52}\right)\right] = 92.1\%$$

EXHIBIT K

INCENTIVE CLAUSE

1. TOTAL METHANE RECOVERY (TMR) GUARANTEE EQUATION:

$$TMR_g = TAP_g \times PGP_g$$

Where:

TMR_g = Total Methane Recovery Guarantee (in decimal percent)
TAP_g = Total Availability of Plant Guarantee (Exhibit I)
PGP_g = Product Gas Production Guarantee (Exhibit J)

2. INCENTIVE CLAUSE EQUATION:

$$TMR_a = TAP_a \times PGP_a$$

Where:

TMR_a = Actual Total Methane Recovery (in decimal percent from quarterly average)
TAP_a = Actual Total Availability of Plant (in decimal percent from quarterly average)
PGP_a = Actual Product Gas Production (in decimal percent from quarterly average)

Bonus incentives are enforced when $TMR_a > TMR_g$. Similarly, liquidated damages are enforced when $TMR_a < TMR_g$. Bonus incentives and liquidated damages shall be assessed quarterly and paid annually.

3. SHARED REVENUE EQUATION:

$$Revenue = E_a \times (TMR_a - TMR_g) \times \beta \times \alpha \times \gamma$$

Where:

TMR_a	=	*Actual Total Methane Recovery (in decimal percent from quarterly average)*
TMR_g	=	*Total Methane Recovery Guarantee (in decimal percent from quarterly average)*
E_a	=	*Actual Energy Production (MMBTU from quarter)*
β	=	*RIN Equivalency Value (per 40 CFR §80.1415(b)(5), 1 MMBTU = 11.727 RINs)*
α	=	*Market Price of RIN (based on quarterly average or selling price)*
γ	=	*Percentage shared with Operator (%)*

EXHIBIT L

OWNER PERMITS

Dane County

- Stormwater Management Permit No. SM2018-0055.

Wisconsin Department of Natural Resources (DNR)

- WDNR Air Pollution Control Operation Permit No. 113127300-P20.
- Wastewater Pretreatment System Project No. S-2019-0051.
- 2014 Plan of Operations and subsequent addenda, plan modifications, field modifications and variances for Dane County Landfill Site No. 2, WDNR License No. 3018.

Madison Metropolitan Sewerage District (MMSD)

- Industrial Wastewater Discharge Permit IP-44.01.

City of Madison

- Fire Protection System Work Permit, Project # FIRSPR-2018-00631.
- Fire Protection System Work Permit, Project # FIRALA-2018-01159.
- Fire Protection System Work Permit, Project # FIRALA-2019-00285.
- Major Alteration to Approved Planned Unit Development, Project # LNDMAP-2018-00011.
- Minor Alteration to Approved Planned Unit Development, Project # LNDMAP-2018-00054.
- Madison General Ordinance 24.08 (construction noise).

Environmental Protection Agency (EPA)

- Renewable Fuel Standard Registration Package, Company ID 7200, Facility ID 70441.

Department of Safety and Professional Services (DSPS)

- Boiler and compressor permits (BIOFerm)

EXHIBIT M

BIOFerm Energy Systems
440 Science Drive, Suite 300
Madison, WI 53711

Billing Rates

Legal	$475.00/hr
Senior Manager	$205.00/hr
Project Manager	$178.00/hr
Electrical Engineer	$155.00/hr
Multi-Discipline Engineer	$155.00/hr
Operations Specialist	$130.00/hr
Architect	$108.00/hr
Designer	$108.00/hr
Drafter	$108.00/hr
Technician	$108.00/hr
Project Assistant	$ 62.00/hr
Administrative Assistant	$ 54.00/hr
Mileage	IRS standard mileage rate for business
Consultants and Other	Cost x 1.20
B&W Plans	$0.84/sq. ft
Color Plans	$4.50/sq. ft

Notes:
International staff billing rates are subject to foreign currency to US$ exchange rate at the time of service.

Unless otherwise specified in contract, travel expenses are billed at cost and transit time is billed at half rate.

EXHIBIT N

ACORD®

CERTIFICATE OF LIABILITY INSURANCE

DATE (MM/DD/YYYY): 6/28/2019

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER
Ansay & Associates, LLC.
702 N High Point Road
Suite 201
Madison WI 53717

CONTACT NAME: Susan Simoneau
PHONE (A/C, No, Ext): 608-828-0235 FAX (A/C, No): 608-831-4777
E-MAIL ADDRESS: sue.simoneau@ansay.com

INSURER(S) AFFORDING COVERAGE	NAIC #
INSURER A : Western World Insurance Group	13196
INSURER B : Western National Insurance Group	15377
INSURER C :	
INSURER D :	
INSURER E :	
INSURER F :	

INSURED BIOFUSA-01
BIOFerm Energy Systems, Inc.
440 Science Drive STE 300
Madison WI 53711

COVERAGES **CERTIFICATE NUMBER:** 682308468 **REVISION NUMBER:**

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSD	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
A	X COMMERCIAL GENERAL LIABILITY	Y		EVP100049000	1/26/2019	1/26/2020	EACH OCCURRENCE	$ 1,000,000
	CLAIMS-MADE X OCCUR						DAMAGE TO RENTED PREMISES (Ea occurrence)	$ 50,000
							MED EXP (Any one person)	$ 5,000
							PERSONAL & ADV INJURY	$ 1,000,000
	GEN'L AGGREGATE LIMIT APPLIES PER:						GENERAL AGGREGATE	$ 2,000,000
	X POLICY PRO-JECT LOC						PRODUCTS - COMP/OP AGG	$ 2,000,000
	OTHER:							$
B	AUTOMOBILE LIABILITY			CPP1204955	3/1/2019	3/1/2020	COMBINED SINGLE LIMIT (Ea accident)	$ 1,000,000
	X ANY AUTO						BODILY INJURY (Per person)	$
	ALL OWNED AUTOS SCHEDULED AUTOS						BODILY INJURY (Per accident)	$
	X HIRED AUTOS X NON-OWNED AUTOS						PROPERTY DAMAGE (Per accident)	$
								$
A	UMBRELLA LIAB OCCUR			EVX100049100	1/26/2019	1/26/2020	EACH OCCURRENCE	$ 10,000,000
	X EXCESS LIAB X CLAIMS-MADE						AGGREGATE	$ 10,000,000
	DED RETENTION $							$
B	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY Y / N			WCV1027912	3/1/2019	3/1/2020	X PER STATUTE OTH-ER	
	ANY PROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBER EXCLUDED? (Mandatory in NH)	N / A					E.L. EACH ACCIDENT	$ 1,000,000
	If yes, describe under DESCRIPTION OF OPERATIONS below						E.L. DISEASE - EA EMPLOYEE	$ 1,000,000
							E.L. DISEASE - POLICY LIMIT	$ 1,000,000
A B	Equipment Floater Professional & Pollution Liability			EVP100049000 CPP1206101	1/26/2019 3/1/2019	1/26/2020 3/1/2020	Each Claim Limit Aggregate Limit	6,000,000 6,000,000

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (ACORD 101, Additional Remarks Schedule, may be attached if more space is required)

CERTIFICATE HOLDER

Dane County Dept. of Public Works
1919 Alliant Energy Center Way
Madison WI 53713

CANCELLATION

SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.

AUTHORIZED REPRESENTATIVE

Richard G Hagen

Operator Manual

BUP 2500i

Description: BUP 2500i Dane County
Type: Biogas Upgrading Plant
Manufacture no.: AUC 201
Year of construction: 2018

System capacity, max.: 2500 SCFM Biogas

Carbotech
Gas Systems GmbH

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30
D-45128 Essen
Phone +49 (0)201 50709-300
Fax +49 (0)201 50709-500
Web: www.carbotech.info
E-mail: mail@carbotech.info

BIOFERM™
BIOGAS RNG SOLAR

BIOFerm Energy Systems
440 Science Dr, Suite 300
Madison, WI, 53711
Phone (608) 467-5523
Fax (608) 233-7085
Web: www.biofermenergy.com
E-mail: info@biofermenergy.com

Table of Contents

List of Figures

List of Tables

 **NOTICE**	Passages marked yellow will be brought up-to-date during commissioning.

1 Preface

This manual explains the operation for the Biogas Upgrading Plant (BUP) installed at the Dane County Landfill. Due to the complexity of the system this manual is limited in scope to providing an overview of the operations of the system. For additional information about individual components, more complete information is included in the rest of the documentation supplied with the facility.

1.1 Operator's / Owner's / Employer's Responsibilities

This operating manual for a **Biogas Upgrading Plant** and the documentation for subcontractors, see documents in Appendix, must be read carefully and understood by all persons before working in the plant for the employer or before performing maintenance and installation work.

The warnings and instructions contained herein must be observed before:

- Transport and installation of the system or parts thereof,
- Commissioning and operation of the system or parts thereof,
- Inspection and maintenance of the system or parts thereof

The system manufacturer assumes no responsibility for operating errors or any damage resulting thereof.

Installation, operation, maintenance and repair work must be performed only by authorized and trained personnel.

The plant operator and owner are responsible for safe operating conditions of the plant.

Parts and components shall be replaced by the operator if they cannot ensure safe operating conditions.

1.2 Intended Use

The **Biogas Upgrading Plant** described in this manual shall be used solely for the production of biomethane also known as renewable natural gas (RNG) from biogas within the operating limits defined in the **Appendix "Data Sheet"**.

The intended use requires that, without the written permission of the **system manufacturer,** no modifications are made to the system in terms of:

- Construction
- Components
- Materials
- Control
- Operation
- Resources

and requires that the obligations specified in the **Chapter "Operator's / Owner's / Employer's Responsibilities"** are satisfied in addition to the obligations arising out of current applicable laws and regulations.

NOTICE	Improper use shall immediately void all warranty claims.

1.3 Safety Rules

All work for the installation, commissioning, operation and maintenance shall be performed with the utmost care and taking into account both, this operating manual and the installation documentation as well as instructions for individual system units.

In particular, compliance with the applicable safety regulations is required, both with those issued by the employer as well as the safety instructions of the manufacturers of the system components.

Prior to installation, maintenance, operation and repair work, the **Chapter "Safety"** of this operating manual must be read.

1.4 Warnings in this Manual

In this manual, the following symbols warn of possible sources of errors and possible hazards during the operation of the system:

NOTICE	Reference to a possible source of operating error or general note.

CAUTION	Reference to a source of danger, which can result in damaging the system or system components to in complete destruction.

DANGER	Reference to a source of danger to operators and maintenance personnel. There is a risk of serious accidents with physical damages, including death.

Important note, which will appear in various places:

 **NOTICE**	All specified project data and parameters relate to the state of the system at the transfer of risk. The currently valid status of all parameters and settings are part of the process control system and the switching control matrix. The operator is responsible for the current state of the documentation in the cause & effect matrix. Any change of system parameters and settings must be documented.

1.5 Abbreviations and Definitions

AH	Alarm High	Alarm for violation of upper limit
AL	Alarm Low	Alarm for violation of lower limit
AO	Automatic Operation	
BGFS	Biogas feed system	
BUP	Biogas upgrading plant	
CEP	Counter-current expansion phase	
CMS	Carbon molecular sieve	
COEP	Co-current expansion phase	
d.e.A.	Explosive Atmosphere	
Documentation	means the documents associated with the system, such as drawings, parts lists, subcontractor manuals, certificates, etc.	
DRPGM	Direct-Reading Portable Gas Monitor	
(E) I&C	(Electric) Instrumentation and Control	
E-room	electrical equipment room	
FGC	Functional group control	
F-PLC	Fail-safe PLC, PLC for safety-related control functions	
GPRM	Gas pressure regulation measurement system	
GUI	Graphical User Interface	
Instrument air	oil-free, dry instrument air or compressed air	
lead & lag	(1) Master and slave control loop (2) Way of arranging similarly function towers where they can be swapped between which one the process gas passes through first like the polish desulfurization vessels or the VOC filters	
LEL	Lower explosion limit	
LL1, LL2	Lower Limit 1 and 2, respectively	
OEL	Occupational Exposure Limits	
OS	Operator Station (operator PC)	
PCS	Process Control System	
PE	Pressure equalization phase	
PLC	Programmable Logic Controller	
PSA	Pressure Swing Adsorption - Process for the purification of the biogas flow that is taken into the biogas plant.	
RNG	Renewable Natural Gas (Biomethane)	
SGC	Subgroup Control	
SSV	Safety Shut-off Valve	

SIL	Safety Integrity Level -	Safety requirement level according to DIN EN 61508
System	System for the production of biomethane	
T1 - T6	Timer, time intervals of the PSA process	
Tag	Alphanumerical combination for identifying components	
UPS	Uninterruptible Power Supply	
VOC	Volatile Organic Compounds	
WH	Warning High	Warning for violation of upper limit
WL	Warning Low	Warning for violation of lower limit

Table 1.1 Terms A - Z

1.6 Units

In this manual, the following units are used for the physical quantities specified below.

Physical Quantity	Unit	Description
Temperature	[°F]	Degrees Fahrenheit
Pressure (specified as positive pressure, above atmospheric pressure)	[psi] resp. [psi (g)]	Pounds per square inch positive pressure
Mass	[lb]	Pounds (avdp)
Gas volumes (based on standard conditions at 60°F and 14.696 psi (absolute))	[SCF]	Standard cubic feet
Liquid volume (based on a standard temperature of 60°F)	[gal]	US liquid gallons
Volume flow, gases	[SCFM]	Standard cubic feet per minute
Volume flow, liquids	[GPM]	US liquid gallons per minute
Electric power	[kW]	Kilowatt
Electrical energy/heat	[kWh]	Kilowatt hour
Pressure dew point	lb/mmscf	Pounds per million standard cubic feet

Table 1.2 Units

The specifications % and ppm (parts per million) refer to volume in gas concentrations.

2 Safety

The system is capable of being used in a safe manner, but the system supplier cannot warrant its safety under all circumstances. Owner must install and use the system in a safe and lawful manner in compliance with applicable local, state, and federal health and safety regulations and laws and general standards of reasonable care.

2.1 General

The employer and system operator are responsible for the implementation and enforcement of applicable safety and accident prevention regulations in and around the plant.

In addition to the danger points listed below, the safety instructions of the manufacturers of individual system components must be observed.

The safety assessment and risk analysis with the appropriate safety equipment, in particular the definition of PCS protective devices, were carried out under the following assumptions:

- The system operates automatically.
- The observation and intervention for manual control take place via a permanent data connection from outside over long distances.
- No staff is present in the plant except for checks on a regular base and maintenance works.
- There categorically are no guided tours for visitors.
- The operator station that may be located in the electrical control room is not a permanent workplace.

NOTICE	In case of deviations from these requirements, the operator shall verify the safety assessment and risk analysis with respect to these deviations and, if necessary, take any additional action required for the safe operation of the system. Changes to the system must be coordinated and agreed with the system manufacturer.

NOTICE	All exit routes must be kept clear so they are always available as escape and rescue routes.

NOTICE	No flammable and/or hazardous materials or components must be stored inside of the system's rooms or on adjacent outside premises. Use of a separate storage container for tools, spare parts, and consumables is recommended.

Plant-specific features are described in Chapter **"8 Appendix"** and may contain more extensive safety regulations.

2.2 Accident Prevention Regulations

The system employer and operator are responsible for ensuring that all persons working in the plant are aware of all applicable regulations. These include, in particular, regulations/guidelines

- by international, national, state and local authorities/institutions
- for occupational safety
- by the system operator resp. the employer

Occupational safety is regulated nationally in the U.S.A. The respective regulations must be observed.

2.3 Hazards

Potential hazards which may result of plant operation or works are described below. The operator resp. the employer must take suitable measures, such as warning signs, to give notice of these hazards and take additional measures to prevent or to eliminate the hazards.

2.3.1 Explosive Atmosphere

DANGER	Methane and air can form an explosive gas mixture! For this purpose, the operator resp. employer must classify potentially hazardous locations in the plant according to the applicable regulations. In the process room of the container, and especially after system failures, an explosive or flammable atmosphere is to be occasionally expected. Sparks may cause fires and explosions at any time. Direct-Reading Portable Gas Monitors shall be carried on and used by personnel when entering the plant. DRPGMs are designed to alert workers to toxic gases, as well as oxygen-deficient and combustible atmospheres that may exist in their workplace environments.

It must always be ensured that no sources of ignition are present within the process room inside of the plant container. Some basic measures are:

- General prohibition of the use of fire, smoking, welding, or cutting in the entire plant area.
- Precautionary measures against static discharges, such as wearing of conductive shoes and cotton clothing, discharge on a metallic surface before entering, etc.
- All the tools, fittings, gauges, etc. used must be suitable for use in explosive atmospheres.
- Precautions for firefighting must be taken.

Prior to the commencement of repair work during which the piping of the system must be opened for short or longer periods of time, at least the affected part of the system must be inerted.

If the fixed combustible gas detection system warns of a potentially explosive atmosphere, all work within the process room must be terminated and the interior must be evacuated immediately until the explosive atmosphere is removed through forced ventilation and/or inerting of the system.

DANGER	Even if no gas alarm is triggered, there is still a risk that 40% LEL is already reached or exceeded in the process room. Entering the plant should be done only with personal protective equipment, i.e., with a portable gas detector (DRPGM).

To maintain the safeguards installed in the plant against formation or ignition of a hazardous explosive atmosphere, it is essential that the maintenance plan for the plant, specified in the Appendix in this manual, is followed.

The following steps must be performed in particular:

- Regular functional check and verification of the installed combustible gas detection system by authorized personnel
- Regular routine functional check of the technical ventilation of the system
- Leak test of the system after repair work
- Regular routine check of the technical leak tightness of the system

2.3.2 Toxic Atmosphere and/or Oxygen Deficiency

DANGER	Exposure to hazardous levels of toxic gases or to an oxygen-deficient atmosphere can cause workers to suffer serious injuries or illness, and even death. For this purpose, the operator resp. employer must classify potentially hazardous locations in the plant according to the applicable regulations. Direct-Reading Portable Gas Monitors shall be carried on and used by personnel when entering the plant. DRPGMs are designed to alert workers to toxic gases, as well as oxygen-deficient and combustible atmospheres that may exist in their workplace environments.

Toxic Gases

A toxic gas e.g. Hydrogen Sulfide (H_2S) is one which is capable of causing damage to living tissue, impairment of the central nervous system, severe illness or even death, when ingested, inhaled or absorbed by the skin or eyes. The degree of hazard that a substance poses to a worker depends upon several factors which include the gas concentration level and the duration of exposure.

Oxygen Deficiency

Normal ambient air contains an oxygen concentration of 20.8% by volume. When the oxygen level dips below 19.5% of the total atmosphere, the area is considered oxygen deficient. In oxygen-deficient atmospheres, life-supporting oxygen may be displaced by other gases, such as carbon dioxide (CO_2). This results in an atmosphere that can be dangerous or fatal when inhaled.

2.3.3 Pressure

DANGER	Sudden expansion of gas under pressure can cause serious injury or death.

Most of the piping in the system contains gas under pressure. To avoid accidents due to gas expansion, it must be ensured that:

- Any pressure is released from pipes, vessels, etc. before connections are opened.
- The used piping systems are suitable, closed, and well-maintained.
- Personal protective equipment, such as safety glasses is worn.

2.3.4 Moving Parts

Specific information applies to work on moving parts:

DANGER	Moving parts can cause serious injury or death.

NOTICE	**To avoid accidents, the following must be observed among others:** Stop the appropriate parts of the system and equipment. Turn them off and secure them against restart, e.g., by warning signs, disconnecting the power supply, or removing the corresponding fuses.

2.3.5 Electrical Power

 DANGER	Hazardous voltage will cause severe injury or death.
 NOTICE	LOCK OUT POWER before servicing.

The system uses electric current at voltages from 12 V to 480 V. Deviations specified by the operator are possible.

All work on the electrical system of the plant must be performed by qualified, trained and authorized personnel.

Before beginning work on the electrical system, measures must be taken to cut off power, such as disconnecting of power lines or switching off repair switches. The appropriate parts of the system must be disconnected and the power supply must be secured against being turned back on.

2.3.6 Temperature

 DANGER	High surface temperatures of piping and the like and sudden release of hot gases or liquids from piping can cause severe burns and scalds.

To avoid accidents, the system must be stopped before working on pipes or machine parts. Piping, surfaces, and the medium must be cooled and any internal pressure must be released.

Suitable protective clothing, such as gloves and safety goggles, must be worn.

2.3.7 Noise

DANGER	High noise levels can cause permanent hearing loss and/or lead to momentary dizziness and ear aches.

To avoid hearing damage, hearing protection must always be used when working around the plant where noise levels are 85 dB or higher.

2.4 Safety Features

The system is equipped with the safety systems described below, which must be checked on a regular basis to ensure reliable operation to protect against damage and to prevent hazards.

2.4.1 Emergency Shut-off or Emergency Stop System

The emergency stop system of the BUP consists of a number of emergency stop buttons connected in series and the associated safety relay. Upon triggering the emergency stop button or in case of an error in the safety circuit, the entire system is shut down by a release or tripping contact of the safety relay.

This is done by immediately disconnecting the power supply to the BUP, according to **Stop Category 0** via a feed power switch equipped with an undervoltage trigger, which is designed as an emergency-off main switch. In addition, the contactor coils of line contactors of switched outlets for drives and consumers are unlocked.

Classification of the **categories** according to international standards:

IEC 60204-1. **IEC 60947-5-5**, and **IEC 60364-4-46 Stop Category 0**

Not covered by the emergency stop function are the circuits for the plant and cabinet lighting, maintenance sockets, electric heat trace and the UPS buffered controls of the BUP. Their energy supplies must be manually turned off using their own power supply disconnection systems.

Emergency stop switches are positioned in the process room next to the doors and on the front door of the main switch cabinet in the e-room. Emergency stop switches can be used to stop the system operation immediately at any time.

Emergency stop by triggering an emergency stop switch:

- All drives are stopped immediately.
- All valves are set to their safe end position.
- The normal system operation is immediately terminated.

Resetting the emergency stop situation:

- Unlock the appropriate emergency stop switch by rotating and/or pulling.
- Press the reset button in the switch cabinet.

- Reset the main switch in the switch cabinet and switch it on.
- Acknowledge the emergency stop at the controller.

2.4.2 Safety Valves (Pressure Relief Valves)

Safety valves are installed for protection against excessive pressure. The corresponding pressure settings are listed in the Appendix of this operating manual.

2.4.3 Detonation Arrestors

Bidirectionally acting detonation arrestors are located in sub-system 16 between the gas treatment system and individual analyzers to protect the system from any external detonations.

2.4.4 PCS Safety Instrumented Equipment

The system is equipped with tested and approved PCS safety-instrumented equipment. The cause & effect matrix in system documentation contains a list of PCS safety-instrumented equipment with corresponding TAG numbers and limit values.

The corresponding SIL classification can be found in the system documentation.

NOTICE	In case of safety-related shutdowns, the corresponding limit values can be edited in the normal user interface for the controller module. However, the change will not be accepted. It is only possible to change these values in the safety-related control program.

2.4.5 Automatic Gas Alarm System

In the process room, two sensors for continuous monitoring of the ambient air for combustible gases are installed and connected to the SIS (Safety Instrumented System) PLC. The gas sensors of sub-system 14 are calibrated to 100% LEL of methane.

When 20% of the lower explosive limit (LEL) of methane is exceeded, an alarm is triggered and the ventilation of the process room is turned on (if not already in operation).

When exceeding 40% of the lower explosive limit, the gas-carrying system components, such as the biogas compressors, are shutdown and locked by use of a safety-instrumented system. This causes the subsequent shutdown of parts of the system.

NOTICE	The process room must not be entered as soon as 20% of the lower explosive limit is exceeded. Outside of the plant container acoustical and visual warning signals indicate a violation of the defined LEL.

Sources of ignition must be avoided, and appropriate safety measures must be taken. Personal protective equipment must be worn according to applicable regulations and employer's guidelines.

2.5 Inspection of Safeguarding Equipment

All safeguarding equipment must be regularly inspected by qualified personnel for possible damage and for function. The following information does not replace the detailed provisions of the respective manufacturers. In addition, the administrative regulations for inspecting the operation of safety devices must be observed.

2.5.1 Emergency Stop Switch

- Trigger at suitable times to check the shutdown of the system.
- Regular inspection of proper function by competent personnel.

2.5.2 Safety Valves (Pressure Relief Valves)

- Visual inspection for dirt or damage which may affect the proper function of the safety valve.
- Vent the safety valves by means of lever or thumb screw to check operation.
- Verify the trigger pressure at regular intervals according to applicable regulations and employer's guidelines:
  - Relieve the pressure in the corresponding part of the system
  - Demount safety valve
  - Mount safety valve on device with pressure gauge
  - Pressurize device to the desired relief pressure, for example with N_2 gas cylinder. If necessary, re-adjust safety valve according to the manufacturer's instructions.
- The inspection intervals must be defined by the employer in special instructions in accordance with the applicable laws, regulations, guidelines, etc.

2.5.3 Gas Detection Systems

Gas alarm systems must be checked by qualified personnel for operation and, if necessary, readjusted.

NOTICE	In the instruction manual, the gas detection equipment manufacturers recommend the application of procedures and maximum inspection intervals specified in the applicable regulations and recommended practices, such as **ANSI/ISA-RP12.13.02: Installation, Operation, and Maintenance of Combustible Gas Detection Instruments**, i.e.: • monthly visual inspection • functional check every 4 months The functional check replaces visual inspection due at the same time. • annual system check The system check replaces the functional check and visual inspection due at the same time.

2.5.4 Safety-instrumented Equipment / System

Resistance thermometers must be tested and calibrated at least annually (to maintain the integrity of the Safety Instrumented Function). It is recommended to conduct test and calibration at least semi-annually, provided no further specifications are given in the device documentation.

 **NOTICE**	The remaining measurement points of Safety Instrumented devices must be driven to their respective limits at suitable times, but at least every 24 months, and, if necessary, the measuring instruments must be recalibrated and/or replaced.

2.6 Safety Measures on Site

The detailed safety measures necessary for the particular installation site, e.g., buildings, rooms, streets, roads, etc., must be determined by the employer and system operator. This includes detailed work instructions for working in areas where mechanical and non-mechanical hazards exist.

Basic measures are:

- The entire system must be protected by the plant owner resp. employer through a main switch with emergency stop function. The main switch must be lockable to prevent restarting, e.g., when performing maintenance.
- All emergency stop switches must be easily accessible.
- Fire protection measures shall comply with the applicable regulations.
  These include:
  - Fire extinguishers in sufficient numbers
  - Sprinkler system (if required by regulations resp. the competent authority)
  - Smoke detectors (if required by regulations resp. the competent authority)
  - Fire alarms (if required by regulations resp. the competent authority)
- An emergency lighting system must be installed.
- Exit routes and Emergency Exits from rooms, buildings, plant complexes must be marked.
- First aid equipment must be provided in sufficient number and quality.
- Identification of the pipelines according to the medium, e.g., biogas, nitrogen, air, off-gas, etc., in the national language in accordance with the applicable regulations.
- Proof by the plant owner resp. employer of sufficient pipeline cross-sections for safety valve blow-off lines.
- All supply and return air openings must be kept fully clear over the entire cross section.
- In the installation rooms of the plant, only accessories may be stored that do not represent hazards, e.g., no combustible materials must be stored in the system rooms.
- Installation of a corresponding docking buffer for gas-bearing pipes and vessels outside.

- The operator must ensure that escape and rescue routes to the outside are always usable.

2.7 In an Emergency

Emergency plans must be established by the employer and operator in accordance with applicable regulations.

Basic measures include:

- If there is evidence or suspicion that the system or system parts are in a dangerous mode, press an emergency stop switch immediately.
- Immediately inform the responsible supervisor.
- Take measures according to the emergency plans. Firefighting; First aid; Exit routes, Evacuation etc.

3 System and Process Description

The system is designed for automatic operation. Start, stop, normal and partial load operation and emergency shutdown of the system are controlled automatically and monitored by the system control.

The entire system consists of several machine containers, cooling water units, and various pipe skids outdoors. The supply with the cooling water, chilled water, and instrument air resources is typically ensured within the system limits.

The system is remotely monitored via a data link.

The system is split into functional modules considering the handled medium in the individual sub-system. This way the different media handled inside the system are separated on the P&I diagrams for ease of understanding and retrieval.

P&I diagrams and the individual adjacent components are named accordingly.

The accompanying documentation is included in the Appendix of the Operations Manual.

3.1 Main Gas Path Subsystems

3.1.1 Description of Functions Sulfur Removal Unit (SRU) AD

3.1.1.1 Overview

The purpose of the continuously operated sulfur removal unit (SRU) is the reduction of hydrogen sulfide in the landfill gas, which enters sub-system AD. The biological trickle-bed reactor system uses aerobic microorganisms, which metabolize the H_2S to elemental sulfur.

The hydrogen sulfide is absorbed by the liquid phase in the reactor. It dissolves in the suspension as HS- ions. In this form, the microorganisms can ingest the hydrogen sulfide and oxidize it under a steady supply of oxygen (aerobic conditions). The various bacteria strains transform hydrogen sulfide into elemental sulfur and finally into sulfate. The chemical equations for these reactions are shown below.

1.) Direct oxidation of hydrogen sulfide to sulfate

$$H_2S + 2\ O_2 \rightarrow H_2SO_4$$

2.) Oxidation of the sulfate with elemental sulfur as intermediate

$$2\ H_2S + O_2 \rightarrow 2\ S + 2\ H_2O$$

$$2\ S + 2\ H_2O + 3\ O_2 \rightarrow 2\ H_2SO_4$$

The resulting sulfate sludge is pumped continuously to the domes of the large H_2S scrubber vessels where it is sprinkled over the packed bed media. The landfill gas flows in the same direction as the suspension from the top of the vessel to the bottom. Portions of the microorganisms are suspended in the sulfate sludge. Whereas the major portion of the micro-organisms are immobilized on packing media inside of the H_2S scrubber vessels which are made of fiber reinforced plastic (FRP). The FRP scrubber vessels are operated parallel.

Below listed conditions are crucial for the proper operation of the biological H_2S removal system.

- availability of oxygen

- existence of an oxidizable source of sulfur (e.g. hydrogen sulfide or organically bound sulfur)
- availability of ammonia as a nitrogen source
- availability of carbon dioxide (CO_2) for sulfur oxidizers or hydrocarbons (mercaptans etc.) as carbon source
- availability of phosphor, nitrogen, trace elements
- minimum pH value: 1 (i.e. make-up water is required to maintain a defined pH value range)
- optimal temperature range

Liquid fertilizer and fresh water are provided by this sub-system on a continuous basis. Depending on the pH-value of the suspension, the sulfate sludge is discharged periodically from the system. Along this discharge are the oxidation products sulfur and sulfate.

3.1.1.2 Description of Suspension Circuit (Sulfate Sludge)

Each H_2S scrubber vessel has two acid-resistant, magnetic coupled pumps for circulation of the suspension. To protect the pumps against cavitation and dry run, each pump is equipped with a flow switch low (FISL AD.01.01.01.29 for P.AD.01.01.01.24, -02.29 for P.AD.01.01.02.24, -03.29 for P.AD.01.01.03.24 and -04.29 for P.AD.01.01.04.24). In case of a low flow/no flow the corresponding pump is switched off. To achieve the minimal flow at the start of the pump a timer of 10s has been integrated.

In order to protect the suspension pumps and the packing inside the FRP vessels from clogging, strainers are installed on the suction side of each pump. Especially during the hot commissioning phase, these strainers must be cleaned 1-2 times a day (holding of smithereens of the packing bed media). Experience shows that after the commissioning the strainers need to be cleaned only 1-2 times per week.

Several ball valves, butterfly valves as well as a check valve in each pump circulation line allow for:

- Blocking the pump
- Adjusting volume flow and pressure
- Protecting against backflow

In normal operation mode one pump per H_2S scrubber vessel runs continuously to sprinkle the suspension over the packed bed media. Whereas the other pump is operated when the sulfate sludge needs to be heated (see Chapter 1.1.3). The second pump is also used for flushing the packed bed media by then applying double the volume flow of suspension together with the first pump. Flushing shall be carried out for only one H_2S scrubber vessel at a time.

To maintain the desired pH-Value in the system during normal operation the suspension is diluted with stabilization make-up water as well as liquid fertilizer via dosing pumps (see chapter 1.1.4 and 1.1.5).

When reaching the pre-set upper liquid level (LSH.AD.01.01.05.21) of the biological trickle-bed reactor system, the sulfate sludge is discharged by the continuously running pumps via a branch line using an actuated ball valve (KP.AD.01.01.05.27). The effluent is transferred via Tie-in point TP8 for further treatment. When the liquid level drops to the lower liquid level (LSL.AD.01.01.05.18) the ball valve is closed and discharge is stopped.

Once the lower liquid level switch (LSL.AD.01.01.05.18) is triggered, make-up water will be added to the suspension via solenoid valve KP.EH.01.01.01.12 until the upper liquid level switch (LSH.AD.01.01.05.21) is triggered. After that, the valve KP.EH.01.01.01.12 is closed again.

A third liquid level sensor (LAH.AD.01.01.05.20) is installed as an overfill protection in case of flooding the H_2S scrubber vessels. If this liquid level is reached, the fresh water supply valve will be closed (KP.EH.01.01.01.12). The valve is also locked while the effluent discharge valve (KP.AD.01.01.05.27) is opened. Likewise, the dosing pumps for the liquid fertilizer P.EH.01.01.03/04.03 will be locked in this case. The liquid level inside the H_2S scrubber vessels can be checked visually via the transparent standpipe LI.AD.01.01.05.19. A fourth liquid level sensor (LAL.AD.01.01.05.19) is installed to trigger the shutdown of the system in case of a major leakage.

During the effluent discharge the suspension in the tank is only drained to a point where it falls just below the lower liquid level (LSL.AD.01.01.05.21). Given that, normally, the liquid level decreases through the evaporation within the tank, fresh water and nutrients/ fertilizers (here, however, time-controlled and after each discharge of the suspension) are added quasi-continuously (yet in a controlled manner).

For overflow protection of the tank, the following interlocking has been installed. If the liquid level rises and LSH.AD.01.01.05.21 is reached, the draining is always done via the ball valve KP.AD.01.01.05.27 first.

The status of the liquid level of the biological trickle-bed reactor system is indicated by lights located on the front panel of the switch cabinet inside of the process room.

The liquid level lights depending on the liquid level are characterized in the following table:

Switch for fresh water in position Automatic (A)
Switch for sulfate discharge Automatic (A)

	Liquid level position	Lamp min	Lamp max	Lamp max/max	KP.EH.01.01.01.12 (BVP 27)	KP.AD.01.01.05.27 (BVP 14)
1	Below min LSL.AD.01.05.19	Off	Off	Off	Open	Closed
2	Above min between min and max LSL.AD.01.05.19 – LSHL.AD.01.01.05.21	Green	Off	Off	Closed or open dependent on pH value QI.AD.01.01.01.39	Closed
3	Above max but not max/max LSHL.AD.01.01.05.21 - LAH.AD.01.01.05.20	Green	Green	Off	Closed	Open as long as liquid level min is below, during this the lamps max and min will be off
4	max/max LAH.AD.01.01.05.20	Green	Green	Red Alarm signal	Closed	Open
5	Below min/min LAL.AD.01.01.05.22	Red Alarm signal	Red Alarm signal	Off		Closed /Open

Table 3.1 Liquid Level Indicators

The liquid level measuring tube LI.AD.01.01.05.19 itself can be blocked for cleaning purposes by use of corresponding ball valves (HH.AD.01.01.01.35, HH.AD.01.01.01.33, HH.AD.01.01.01.34, HH.AD.01.01.01.36). During operation the latter shall be kept open. For the cleaning of the liquid level measuring, a rinsing nozzle for ball valve (HH.AD.01.01.01.05.22) has been provided.

By closing the ball valves HH.AD.01.01.02.33 and BV.AD.01.01.02.35 it is also possible to block the liquid level tube LI.AD.01.01.05.23. The liquid level tube LISAHL.AD.01.01.05.01 can be blocked by closing the ball valves HH.AD.01.01.01/02.34 and HH.AD.01.01.01/02.36.

3.1.1.3 Description of Heating Circuit

Maintaining the optimal reaction temperature inside of the biological trickle-bed reactor system is crucial for the metabolism of the microorganisms. The optimum temperature ranges between 82 and 90 °F. The temperature is measured inside the circulation line by a Pt100 (TI.AD.01.01.01.40) and transmitted to the controller (integrated in the pH/T measuring device). If the temperature falls below 84 °F, the heating water pumps are turned on which supply heat exchangers E.AD.01.01.03.35 and E.AD.01.01.04.35 with hot water. Due to the thermal gradient (average temperature difference approximately 15-20 K) between the heating water and the suspension, the suspension is heated up. The heat exchangers E.AD.01.01.03.35 and E.AD.01.01.04.35 are made of polypropylene for corrosion protection reasons (inlet temperature of these heat exchangers shall not exceed 176 °F).

If the suspension reaches a temperature of 88 °F (hysteresis 2 °F, this can be adjusted at the Endress & Hauser measuring device/ controller panel TI.AD.01.01.01.40), the heating water pumps are turned off and thus the heating water supply is stopped.

To adjust the volume flows and temperature at the heat exchanger side the mixing valves VH.EC.01.01.04.12 and VH.EC.01.01.02.12 can be used. In the dependence of the position of the mixing valves the flow over the return pipe can be reduced or increased.

An additional heat exchanger E.EH.01.01.05.08 is installed to heat up the fresh water. If the solenoid valve KP.EH.01.01.01.12 is opened, the heating pump P.EC.01.01.05.14 will start to supply that heat exchanger with heating water to heat up the cold water.

The fresh water inlet temperature upstream the H_2S scrubber vessels is monitored by temperature measurement TI.EH.01.01.01.15.

3.1.1.4 Description of dosing of Make-up Water

The microorganisms tolerate pH values down to a minimum of pH 1. The target value range for this system has been defined to pH 1.3-2.0. This range is applicable for the degradation of the H_2S components in the biogas even though the optimum is at a value of pH 3. Other microorganisms cannot live at such low pH values so that the plant is operated in an almost sterile state. Normally the pH value of the suspension decreases due to the acidification process (sulfate).

A pH/T measuring device with controller and display is installed in a bypass of the suspension circulation line (lockable for calibration purposes by use of ball valves HH.AD.01.01.01.61, HH.AD.01.01.01.62 and HH.AD.01.01.01.61). The pH value is measured with this device (QI.AD.01.01.01.39). As a redundant pH/T measuring device QI.AD.01.01.04.39 is installed. This one can be blocked of by the ball valves HH.AD.01.01.02.61, HH.AD.01.01.02.62 and HH.AD.01.01.02.63. The respective values are processed by the controller.

To keep the pH value above 1.5 the fresh water supply valve (KP.EH.01.01.01.12) is opened in case of reaching the minimum value of 1.45 (QI.AD.01.01.01/04.39). Thus, fresh water with a pH value of about 7-8 flows into the sumps of the H_2S scrubber vessels and dilutes the suspension.

If the pH value rises to values > pH 1.55, the fresh water supply valve (KP.EH.01.01.01.12) is closed again. If in the meantime the liquid level (LSH.AD.01.01.05.21) is reached, the above mentioned procedures regarding the liquid levels come into operation (see Chapter 1.1.2)

In this case fresh water supply for pH value control is not possible at this time. Once this state has been reached, effluent discharge is performed until the lower liquid level (LSH.AD.01.01.05.21) is reached and the above mentioned valves are locked. The fresh water supply valve (KP.EH.01.01.01.12) as well as the dosing pumps (P.EH.01.01.03/04.03) for supply of liquid fertilizer are shut-off.

After reaching the lower liquid level, the procedure as described above (stabilization of pH values) is started again.

3.1.1.5 Description of dosing of Liquid Fertilizer

To supply the organisms with nutrients and trace elements, liquid fertilizer, which is stored in an IBC tank (V.EH.01.01.03.01) inside of the process room, is dosed as described below. The fertilizer is added to the biological trickle-bed reactor system via dosing pumps (P41.1/2 (P.EH.01.01.03/04.03)) 24 times per day (for timed intervals) from the installed storage tank (max. fill volume: 1000 l). For 1 kg of H_2S/h to be desulfurized, about 1.5-1.7 kg of liquid fertilizer (N,P,K 8,8,6) per day must be injected. For this case (maximum 3.2 kg H_2S/h) the system must be supplied with approx. 5.2 kg of pure liquid fertilizer per day, i.e. approx. 200 ml per cycle) at full load.

Therefore, the stored supply should suffice for at approx. 250 days at full load. A liquid level sensor has been installed in the lower third of the liquid fertilizer storage tank. If this level falls below the minimum value, an alarm/error (LS.EH.01.01.01.03.09) will be triggered and fertilizer must be refilled. However, the liquid fertilizer in the remaining lower third should then still be sufficient for another three weeks so that weekends and public holidays can be bridged without immediate refilling.

The liquid level inside the storage tank can be determined via the transparent tube LI.EH.01.01.03.01. The supply of nutrients serves, on the one hand, for the addition of phosphorus, nitrogen, trace elements etc., and as pH-buffering on the other. Through the salts contained in the water, complex compounds (sulfates) are formed so that considerably more sulfate/m^3 suspension, e.g. in comparison to distilled water, can be absorbed. This essentially reduces the water quantity required for dilution of the suspension.

Analogous to this, the dischargeable suspension quantity (waste product) and thus the required heat quantity are similarly decreased. The nominal width of the pipeline for the nutrient supply is rated in DN=20.

The liquid fertilizer supply line can be blocked (HH.EH.01.01.03/04.08 and HH.EH.01.01.03/04.04). The check valves R.EH.01.01.03/04.08 prevent a backflow to the tank in the event of a breakdown of the peristaltic pumps P.EH.01.01.03/04.03.

3.1.2 Subsystem Description LFG Booster Unit AM

3.1.2.1 Location of Installation:

Following the gas stream, the LFG booster Unit AM is installed between the biological sulfur removal unit AD and the LFG compression unit AN.

3.1.2.2 Function:

The landfill gas comes from unit AD and passes a non-return valve. It passes analyzing lines for CH_4, H_2S, CO_2 and O_2. The Gas is mixed with the returning gases from the units AA, AC, AE, AO and DD. The mixed gas is split into two equal parts.

Both parts are

- compressed by LFG blower B.AM.01.01.01.16 and -02.16,
- cooled by fin fans E.AM.01.01.01.37 and -02.37 against air and
- cooled by shell and tube heat exchanger E.AM.01.01.01.30 and -02.30 against chilled water.

Later both streams are directed through the LFG separator U.AM.01.01.01.39 and -02.39 where the condensate is separated from the gas. The filter U.AM.01.01.01.39 and -02.39 have two different chambers. In the lower of the two chambers the majority of the condensate is collected and drained to the condensate drain system unit AD.

Finally, both gas streams are reunited and directed to the LFG compressor Unit AN.

In special situations like the start up or unacceptable pressure at the outlet of this unit, it is possible to return the gas:

- upstream unit AD or
- to a gas flare.

3.1.2.3 Special situations:

1. During startup, it may be required to incinerate the gas via the flare. This is done pressure controlled via the control valve PIC.AM.01.01.01.26 / KC.AM.01.01.01.33. This flare is not part of the delivery of Carbotech/BIOFERM and therefore not described any further.
2. In case of a high pressure at the outlet of the mixed landfill gas at PISAHL.AM.01.01.01.26 the gas will be directed upstream unit AD via PIC.AM.01.01.01.26 / VC.AM.01.01.01.34.
3. In case of improper overpressure at the inlet of the LFG blower 1+2 B.AM.01.01.01.16 and -02.16, caused by the returning gases from the units AA, AC, AE, AO and DD, a pressure protection switch closes the inlet valve PIZAHL.AM.01.01.01.04 / KP.AM.01.01.01.02.
4. In case of improper low pressure at the inlet of the LFG blower 1+2, VC.AC.01.01.01.33 opens slightly and injects gas from downstream the desulfurization dust filter U.AC.01.01.01.27 at unit AC.
5. To avoid ice building at the condensate lines a heat trace is installed. The heat trace will be switched on and off automatically, depending on the outside temperature.
6. In case of an improper pressure drop at the separator U.AM.01.01.01.39 and/or -02.39, the separators can be isolated by the corresponding valves.

Render the filter inert. Set blind plates to avoid combustible gas to enter. Open the filter and clean/repair it. Close the filter. Remove/change the blind plate. Render inert again the filter. Recommission the filter.

3.1.3 Subsystem Description Biogas Compression Unit AN

3.1.3.1 Location of Installation:

Following the gas stream, the Biogas compressor Unit AN is installed between the LFG booster Unit AM and the Drying unit AF.

The compressors and the periphery are installed in an own container CT.GA.00.14.01.00. The container are equipped with a gas monitoring device.

The container is equipped with a gas monitoring device.

In case of reaching 20% of the lower explosion limit of methane, a fan is switch on to ventilate the container.

In case of reaching 40% of the lower explosion limit of methane the entire biogas upgrading plant is shut down. Visual and acoustical alarms are activated.

The temperature of the container is controlled.

- In case of high temperature a ventilation is switched on
- In case of low temperature the heater is/are turned on. They are temperature controlled

In case of emergency, one head light is equipped with a battery pack.

The light can be switched on at every door.

At every door an emergency shut-off is installed.

3.1.3.2 Function:

In the Biogas compression unit, the biogas is compressed to the required system pressure by two oil injected screw compressors C.AN.01.01.01.11 and C.AN.01.01.02.11.

The screw compressors are equipped with internal slide control valves for controlling fluctuations in the gas amount.

The injected oil serves as lubrication and cooling agent.

Oil is injected in the compressors. Later it is separated again from the gas stream in an oil separator and collected in an oil/ gas vessel (V.AN.01.01.01.21 and V.AN.01.01.02.21). Later it is pumped back to the compressor screw via a heat exchanger E.AN.01.01.01.63 and .02.63, where the oil is cooled indirectly with cooling water.

In case that the cooling is not sufficient anymore, and the discharge temperature is too high or the suction pressure is too low, the compressor stops.

3.1.4 Subsystem Description Gas Drying Unit AF

3.1.4.1 Location of Installation:

Following the gas stream, the drying unit AF is installed between the Compressors Unit AN and the VOC removal unit AE.

3.1.4.2 Function:

The entering biogas is dried by cooling it down in three consecutive shell and tube heat exchangers.

- In the first heat exchanger, 1st LFG cooler, E.AF.01.01.01.02 gas is cooled indirectly with cooling water.
- In the second exchanger, 2nd LFG cooler, E.AF.01.01.01.04 gas is cooled indirectly with chilled water 2 and
- in the third heat exchanger, LFG Dryer, E.AF.01.01.01.06 gas is cooled indirectly with chilled water 1.

By cooling down the landfill gas a pressure dew point of approximately 40°F is obtained.

Downstream the LFG Dryer, E.AF.01.01.01.06, the gas passes the drying separator U.AF.01.01.01.39 where condensate is separated from the gas. The filter has two different chambers. In the lower of the two chambers the majority of the condensate is collected and drained to the condensate drain system unit AD.

3.1.4.3 Special situations:

1. In case of an improper pressure drop at the separator U.AF.01.01.01.39 it can be isolated by the corresponding valves.

   Render the filter inert. Set blind plates to avoid combustable gas to enter. Open the filter and clean/repair it. Close the filter. Remove/change the blind plate. Render inert again the filter. Recommission the filter.

2. To avoid ice building at the condensate lines a heat trace is installed. The heat trace will be switched on and off automatically, depending on the outside temperature.

3.1.5 Subsystem Description VOC unit AE

3.1.5.1 Location of Installation:

Following the gas stream, the VOC Removal unit AE is installed between the Drying unit AF and the Desulfurization unit AC.

Optionally the order of units can be changed. It is possible to use the Desulfurization unit AC after the drying and before the VOC Removal unit AE. In this case the order would be: Drying unit AF, Desulfurization unit AC, VOC Removal unit AE and PSA unit AA.

3.1.5.2 Summary of this unit:

VOC (volatile organic compounds) and siloxanes, later stated as VOC only, are unwanted components in the landfill gas. They are removed by an adsorption system of specialized adsorbent.

The system consists of two vessels, which are operated alternately: The adsorption is carried out at operating pressure and ambient temperature in one vessel.

At the same time the other vessel is being regenerated at slight overpressure with heated tail gas.

The tail gas laden with VOC from the vessel in regeneration mode is incinerated.

The alternating operation mode of the vessels allows a continuous flow of the landfill gas, purified of VOC.

All numerical values in the VOC functional description are reference values, e.g. for pressure, temperature, time intervals etc. The final values will have to be determined and defined during functional optimization while commissioning.

3.1.5.3 Detailed Description:

The landfill gas coming from the drying unit AF is preheated in the heat exchanger TSA preheater E.AE.01.01.01.01 with cooling water. Afterwards the gas is injected into the active VOC-vessel.

The adsorption and desorption of VOC is carried out for each VOC vessel (V.AE.01.01.01.09 and V.AE.01.01.02.09) in an identical 24-hour rhythm offset by 12 hours. The vessel size and adsorbent are dimensioned to provide sufficient VOC removal, i.e. loading with VOC, within the 12 hour adsorption phase.

After the 12 hours of the adsorption phase in one vessel, the landfill gas flow is switched to the other VOC vessel. The regeneration of the loaded tank starts immediately afterwards.

After passing the VOC-vessels the landfill gas is filtered in the TSA dust filter U.AE.01.01.01.82, where dust and condensate are separated from the gas stream, before it is injected into the Desulfurization unit AC.

3.1.5.4 Regeneration

The regeneration of the vessel loaded with VOC proceeds in the following steps:

Step 1: Depressurizing the VOC Vessel

The VOC adsorption vessel is depressurized by isolating the vessel V.AE.01.01.01.09 or -.02.09 with the according valves and by releasing the free and adsorbed gas to the LFG booster unit AM via PIC.AE.01.01.01.63 and VC.AE.01.01.01.62.

After the depressurization, control valve VC.AE.01.01.01.62 is closed.

Step 1 takes about 30 minutes.

Step 2: Flushing of VOC Vessels with Tailgas
Tailgas is flow controlled injected via B.DE.01.01.01.15 / .02.15. into the VOC vessel V.AE.01.01.01.09 or -.02.09.

The gas is led via the VOC regeneration gas dust filter U.AE.01.01.01.57, to the outlet pipe of where dust and condensate are separated, into the pipeline DD.01.01.11 downstream the vacuum pumps of PSA stage 1-1 and PSA stage 1-2.

Step 2 takes about 30 minutes.

Step 3: Heating and Desorption
The adsorbents in the VOC vessel is regenerated by heat.

For the required temperature increase tail gas, coming from the tail gas system unit DE, is heated up in the electrical heater PU.AE.01.01.01.88. The hot gas transfers the heat to the adsorbent. The VOC-loaded gas is directed via the VOC regeneration gas dust filter U.AE.01.01.01.57, where dust and condensate are separated, and valve KP.AE.01.01.01.68 to the Tail gas system unit DE.

If the set point temperature in the TISAHL.AE.01.01.01.50 is measured at the bottom outlet of the VOC vessel, the heating of the gas is stopped.

Desorption takes place gradually during the heating process and is therefore not listed as an individual step.

Step 3 will take approx. 3.5 hours.

Step 4: Cooling
To reestablish the optimal operating temperature, the adsorbent needs to cool down again.

Thus, the electrical heater PU.AE.01.01.01.88 is switched off and the tail gas is cooled via the heat exchanger E.AE.01.01.01.42 with chilled water. During the cooling phase the flow of chilled water through the heat exchanger is enabled by opening HP.EB.01.04.03.34. After achieving the desired temperature at the outlet of the VOC filter, measured with TISAHL.AE.01.01.01.50, the tail gas flow from unit DE is stopped and the valve KP.AE.01.01.01.68 is closed.

Step 4 will take approx. 3.5 hours.

Step 5: Pressure build-up
To rebuild the pressure in the freshly regenerated vessel, open control valve VC.AE.01.01.01.20 gradually. A small stream of the process gas will slowly build up the pressure. To affect the process gas flow as little as possible, the control valve VC.AE.01.01.01.20 is opened over a time control to allow for a uniform side stream. The pressure build-up stops when the regenerated vessel reaches the same pressure as the one being in operation PI.AE.01.01.01.07 = PI.AE.01.01.02.07.

This should take approx. 30 minutes.

The control valve remains open to have both vessels equalizing. This vessel now is in stand-by for approximately 4 hours. The control valve will be closed shortly before activating the vessel.

3.1.5.5 Special situations:

1. In case of an improper pressure drop at the separator U.AE.01.01.01.82 and/or U.AE.01.01.01.57, they can be isolated by the corresponding valves.

   Render the filter inert. Follow OSHA compliant lock out/tag out procedure reducing the likelihood combustable gas will enter the vessel. Open the filter and clean/repair it.

Close the filter. Remove isolation equipment again following lock out/tag out procedure. Render the filter inert again. Recommission the filter.

2. The gas temperature should not be below the dew point, set in the drying unit AF. In winter times, the temperature of the desulfurization unit AC (checked in TIAHL.AC.01.01.01.20) can be adjusted at the inlet of the VOC vessel via the TSA preheater E.AE.01.01.01.01.
3. In case of a lowered amount of raw gas, the amount of tailgas will be lowered also. In this case there may not be the required amount for regenerating the VOC filter in the planned time.

   Since the VOC filter will not be charged as much in this time as well, the regeneration time can be expanded.
4. In a shut down during wintertime it is possible, that accumulated condensate at KP.DE.01.01.01.73 will freeze. Thus, condensate needs to be drained at the drain point close by the valve.

3.1.6 Subsystem Description Biogas Desulfurization unit AC

3.1.6.1 Location of Installation:

Following the gas stream, the H_2S Removal unit AC is installed between the VOC Removal unit AE and the PSA unit AA.

Optionally the order of units can be changed. It is possible to use the Desulfurization unit AC after the drying and before the VOC Removal unit AE. In this case the order would be: Drying unit AF, Desulfurization unit AC, VOC Removal unit AE and PSA unit AA.

3.1.6.2 Function:

The compressed and dried biogas passes through two series-connected adsorber vessels. The vessels are filled with specially impregnated activated carbon for desulfurization. The adsorbers are arranged as lead and lag function

Hydrogen sulfide from the biogas is adsorbed on the inner surface of the activated carbon. In the presence of residual oxygen in the biogas, is converted to elemental sulfur and water, according to the chemical equation:

$$2\ H_2S + O_2 \rightarrow \tfrac{1}{4}\ S_8 + 2\ H_2O.$$

While the water passes into the gas phase, the elemental sulfur remains irreversibly bound on the activated carbon. The impregnation of the activated carbon with potassium iodide <u>and the increased gas temperature</u> support the above reaction.

Downstream the desulfurization vessels, a dust filter, desulfurization dust filter U.AC.01.01.01.27 is installed to remove carried over particles.

It passes analyzing lines for CH_4, H_2S, CO_2 and O_2.

Before the biogas is injected into the PSA system, the desired pressure for adsorption is adjusted via the control valve VC.AC.01.01.01.33. If the system pressure is too high, a partial gas flow is led back to the suction side of the LFG Blowers.

3.1.6.3 Special situations:

1. In case of an improper pressure drop at the separator U.AF.01.01.01.27 it can be isolated by the corresponding valves.

   Render the filter inert. Set blind plates to avoid combustable gas to enter. Open the filter and clean/repair it. Close the filter. Remove/change the blind plate. Render inert again the filter. Recommission the filter.

2. In case of a low pressure in the LFG booster unit AM, some gas can also be injected into that unit.

3.1.6.4 Functional description lead and lag

Following the gas line, the adsorber vessels V.AC.01.01.01.06 and V.AC.01.01.02.06 are installed consecutively in a so called lead and lag function.

Usually the biogas flows through one vessel (lead) and afterwards through the other vessel (lag).

By changing several butterfly valves, further operating modes are possible:

- only one vessel is in use,
- the second vessel becomes the first vessel and vice versa and

- each vessel is used by itself,

In any case, the gas flows through the vessels from top to bottom.

The different modes of operation are used, when one adsorber is loaded with sulfur and the activated carbon has to be changed. Whether the Adsorber is loaded or can be determined by using the corresponding sampling line. The operating mode has to be changed:

- Use the second vessel, that is the lagging vessel until now only. It becomes the leading vessel now,
- Isolate and change the activated carbon of the loaded vessel (that was the leading vessel before).
- Set the freshly refilled vessel as lagging vessel.

The lagging adsorber functions as guard filter.

In the following table the positions of the individual butterfly valves are listed for each case.

Mode of operation Butterfly valve number	**1 V.AC.01.01.01.06 => V.AC.01.01.02.06 (pre set)**	**2 V.AC.01.01.02.06 => V.AC.01.01.01.06**	**3 V.AC.01.01.01.06 in operation V.AC.01.01.02.06 detached**	**4 V.AC.01.01.02.06 in operation V.AC.01.01.01.06 detached**
KH.AC.01.01.01.01	closed	open	open	closed
KH.AC.01.01.01.02	open	open	open	closed
KH.AC.01.01.01.11	open	open	open	closed
KH.AC.01.01.01.13	open	closed	open	closed
KH.AC.01.01.01.14	closed	open	closed	closed
KH:AC.01.01.02.01	open	closed	closed	open
KH.AC.01.01.02.02	open	open	closed	open
KH.AC.01.01.02.11	open	open	closed	open
KH.AC.01.01.02.13	closed	open	closed	open
KH.AC.01.01.02.14	open	closed	closed	closed

Table 3.2 Valve positions for different modes of operation of biogas desulfurization

3.1.7 Subsystem Description PSA unit AA

3.1.7.1 Location of Installation:

Following the gas stream, the PSA unit AA is installed after the H_2S Removal unit AC and the biomethane delivery unit AO.

The controlling valves of this unit are installed in own container. PSA 1-1 is installed in CT.GA.00.01.01.00. The valves for PSA 1-2 and PSA 2 are installed together in two containers, that are combined. They have the numbers CT.GA.00.01.02.00 and CT.GA.00.01.03.00.

The containers are equipped with a gas monitoring device.

In case of reaching 20% of the lower explosion limit of methane, a fan is switch on to ventilate the container.

In case of reaching 40% of the lower explosion limit of methane the entire biogas upgrading plant is shut down. Visual and acoustical alarms are activated.

The temperature of the container is controlled.

- In case of high temperature, a ventilation is switched on
- In case of low temperature, the heater is/are turned on. They are temperature controlled

In case of emergency, one head light is equipped with a battery pack.

The light can be switched on at every door.

At every door an emergency shut-off is installed.

3.1.7.2 Function:

To remove carbon dioxide and other undesirable gas components, the dried desulfurized LFG is passed to two pressure swing adsorption (**PSA**) stages. The first stage includes two parallel-operated PSA assemblies, while the second PSA stage is a single PSA assembly.

The first stage assemblies consists of two lines with six adsorption vessels each. Each vessel is equipped with desiccant beds to remove any residual moisture and carbon molecular sieve (**CMS**) beds for biomethane enrichment.

The pressure in the PSA stage 1 is kept via PIC.AA.01.01.01.44 / VC.AA.01.01.01.45 downstream PSA 1.

To guarantee a steady volume flow of gas from PSA stage 1 to PSA stage 2, an intermediate buffer vessel V.AA.01.01.01.49 is installed between both stages.

The inlet pressure of PSA stage 2 is controlled via PIC.AA.01.01.01.60/ VC.AA.01.01.01.61 upstream PSA stage 2.

The second stage assembly consists of six adsorption vessels, filled only with carbon molecular sieves (**CMS**).

All assemblies are operated cyclically at different pressure levels.

3.1.7.3 *Operating modes occurring cyclic with different pressures*

Adsorption at a high pressure level

The adsorption of undesired components takes place at the higher pressure level. The increased partial pressure of the individual components results in improved loading of the CMS. During the adsorption phase, LFG enters the adsorption vessel at the bottom. As it flows through the adsorbent, the undesired gas components are physically adsorbed on the inner surface of the adsorbents.

Since methane is also partly adsorbed, the gas generated during de-pressurization of the adsorption vessel still contains significant amounts of methane.

Rotating between the different vessels

Before the adsorbents are fully loaded with the undesired gas components, the adsorption phase in this vessel is stopped and the next adsorption vessel, which has previously been regenerated, begins with the adsorption. Thus a continuous gas flow is realized.

1st stage PSA

Typically set up of vessel operation of the 1st stage PSA:

- One vessel is in operation and adsorbing unwanted components in the gas,
- one vessel is in evacuation via vacuum and
- the other vessel are equalizing the pressure towards each other and towards the LFG booster unit AM.

2nd stage PSA

Typically set up of vessel operation of the 2nd stage PSA:

- Two vessels are in operation and adsorbing unwanted components in the gas,
- one vessel is in evacuation via vacuum and
- the other vessels are either pressurized by using biomethane via valve KP.AA.01.02.01.31 or being depressurized to the LFG Booster unit AM or to the recirculate buffer bladder tank unit DD.

Desorption at a low pressure level/vacuum

The regeneration of the adsorbents (CMS), also called desorption, takes place at the lower pressure level. This is due to the lowered adsorption capacity with lower partial pressure.

The regeneration of the loaded adsorbents is achieved by gradually lowering the pressure to near atmospheric pressure with subsequent evacuation.

Only after the completion of the de-pressurization process the gas still present in the adsorbers, is extracted via the vacuum pumps. Through the generated negative pressure (low vacuum), an almost complete regeneration of the adsorbents can be achieved.

PSA 1

The gas extracted by the vacuum pumps of the first PSA stage is called tail gas. It is burnt at a downstream process step. It also is used to regenerate the VOC vessel in unit AE.

PSA 2

The gas extracted by the vacuum pumps of the second PSA stage is called recirculate. It contains a considerable high amount of methane. It is reinjected directly or indirectly back in the biogas upgrade system at the LFG Blower unit AM.

3.1.7.4 Special situations:

1. The first two PSA assemblies PSA1.1 and PSA1.2 can be taken out of operation separately:

   In case of maintenance in PSA 1.1, close the valves KH.AA.01.01.01.31 and -.32

   In case of maintenance in PSA 1.2, close the valves KH.AA.02.01.01.31 and -.32.

   In case of maintenance of one PSA in stage 1, the biogas upgrading plant can continue with 50% of the gas load.

2. To avoid ice building in the vacuum lines, a heat trace is installed. The heat trace will switch on and off automatically, depending on the outside temperature.

3.1.8 Subsystem Description Biomethane Delivery Unit AO

3.1.8.1 Location of Installation:

Following the gas stream, the Biomethane Delivery unit AO is installed between the RNG (Renewable Natural Gas) compressor Unit AN and the RNG compression unit AP.

The container is equipped with a gas monitoring device.

In case of reaching 20% of the lower explosion limit of methane, a fan is switch on to ventilate the container.

In case of reaching 40% of the lower explosion limit of methane the entire biogas upgrading plant is shut down. Visual and acoustical alarms are activated.

The temperature of the container is controlled.

- In case of high temperature, a ventilation is switched on
- In case of low temperature, the temperature controlled heater is turned on.

In case of emergency, one head light is equipped with a battery pack.

The light can be switched on at every door.

At every door an emergency shut-off is installed.

3.1.8.2 Function:

In unit AO the gas coming from the PSA unit AA is pressure controlled, via PIC.AO.01.01.01.04 and VC.AO.01.01.01.06, injected into the biomethane vessel V.AO.01.01.01.13.The vessel acts as an intermediated a mixing vessel.

Downstream the vessel, the gas passes the flow measuring device PU.AO.01.01.01.27 where the gas flow to the RNG compression unit AO is measured.

3.1.8.3 Special situations:

1. It is possible the release manually the gas back to the LFG booster unit AM.

3.1.9 Subsystem Description AP RNG Compression Unit AP

3.1.9.1 Location of Installation:

Following the gas stream, the RNG (Renewable Natural Gas) compressor Unit AN is installed between the Biomethane Delivery unit AO and the tie in point to the client.

The two compressors and the periphery is installed in one container.

The container is equipped with a gas monitoring device.

In case of reaching 20% of the lower explosion limit of methane, a fan is switch on to ventilate the container.

In case of reaching 40% of the lower explosion limit of methane the entire biogas upgrading plant is shut down. Visual and acoustical alarms are activated.

The temperature of the container is controlled.

- In case of high temperature, a ventilation is switched on
- In case of low temperature, the heating of the oil crank is used for heating the container

Three light switches are installed.

Three emergency shut-offs are installed.

3.1.9.2 Functional Description:

Two frequency driven, piston type compressors are installed. One is working and one is in stand-by.

The renewable natural gas, coming from the biomethane delivery unit AO is filtered in F.AP.01.01.01.01. After the filter the gas is directed to the working compressor either C.AP.01.01.01.51 or .02.51.

The gas is directed via a pulsation damper into the compressor stage. Afterwards it is sent via a pulsation damper into a fin fan air cooler and an oil separator. The gas enters then the second stage of the compressor, which is designed identically as the first stage.

Both gas streams of compressor 1 + 2 are united.

The entire compressor container can be cooled with the blower of the fin fan coolers and heated with the heater in the oil tank.

Further details and the oil circuit for these compressors and the safety chain can be found in the supplier documentation.

After leaving the compressors, the gas is cooled indirectly with Chilled water in the shell and tube heat exchanger E.AP.01.01.01.56.

The pneumatic driven ball valve HP.AP.01.01.01.58 isolates the biogas upgrading plant from the network of the client.

This ball valve will shut in case of:

- Unacceptable high temperature after the RNG cooler E.AP.01.01.01.56,
- An unacceptable high pressure in this line and
- Exceeding 40% LEL of Methane in one of the measuring points.

Finally, the RNG passes a non-return valve and is injected into the gas grid.

3.2 Tail Gas Path Subsystems

3.2.1 Subsystem Description Condensate System Unit DA

During the upgrading process the landfill gas undergoes a variety of pressure and temperature changes, which result in formation of condensate at different process steps. The condensate is collected in a condensate shaft V.DA.01.01.01.33, from where it can flow freely to the customer's condensate system. The level of the condensate inside the condensate shaft is monitored by LI.DA.01.01.01.06.

The condensate is drained from the process at the following spots: upstream of the Sulfur Removal Unit (SRU), upstream of the LFG Compressors and Downstream of the Drying. In addition, condensate will also form within the instrument air system. This condensate is also drained to the condensate shaft.

The condensate from the instrument air system passes an oil/ water separator and flows freely from this separator to the condensate shaft.

The condensate upstream of the Sulfur Removal Unit is drained at the lowest point of the piping between the precooler SRU E.AD.01.01.01.07 and the SRU. The drain pipe starts with an expansion where level switches are implemented. The condensate is collected in this pipe expansion V.AD.01.01.01.33. When V.DA.01.01.01.33 is filled LSH.DA.01.01.01.26 opens the drain valve HP.DA.01.01.01.27 and the condensate is drained to the condensate shaft. When the level inside V.DA.01.01.01.33 falls and LSL.DA.01.01.01.25 is triggered, the drain valves closes again. In case of malfunction of LSL.DA.01.01.01.25 or HP.DA.01.01.01.27 process gas can enter the condensate system. To prevent this LZL.DA.01.01.01.24 will close HP.DA.01.01.01.34 as a safeguard.

The condensate upstream of the LFG compressors and downstream of the LFG Dryer is drained from the process via filter/ separators U.AM.01.01.01.39, U.AM.01.01.02.39 and U.AF.01.01.01.39. Each filter/ separator has a lower part, where most of the condensate is collected, and an upper part. For the lower part the condensate level is maintained at 30% by LIC.AM.01.01.01.42, LIC.AM.01.01.02.42 and LIC.AF.01.01.01.42 and control valves VC.DA.01.01.03, VC.DA.01.01.04 and VC.DA.01.01.01.05 respectively. Thus, condensate is drained from the filter/ separator continuously. The upper part of each filter/ separator is equipped with level switches. The condensate is drained from the upper part periodically. If the fluid level rises above a certain level, LSH.AM.01.01.01.53, LSH.AM.01.01.02.53 or LSH.AF.01.01.01.53 open HP.DA.01.01.01.13, HP.DA.01.01.01.14 or HP.DA.01.01.01.15 respectively. Since the drain lines of the upper and the lower part of the filter/ separator are connected to the same pipe, the control valve is closed as long as the upper part of the respective filter/ separator is drained.

In case of malfunction of the described draining process for the filter/ separators, process gas can enter the condensate system. To prevent this the drain pipe of each filter/ separator is equipped with a syphon. If there is no fluid in the syphon, because it was pushed out by process gas, LZL.DA.01.01.01.21, LZL.DA.01.01.01.22 and LZL.DA.01.01.01.23 will close HP.DA.01.01.01.09, HP.DA.01.01.01.10 and HP.DA.01.01.01.11 respectively as a safeguard.

3.2.2 Subsystem Description Vacuum Pumps Unit DD 1-15

3.2.2.1 Location of Installation:

Four vacuum pumps are equipped for each PSA assembly to promote the PSA process. The gas extracted by the vacuum pumps of the first PSA stage is called tail gas and the gas extracted by the vacuum pumps of the second PSA stage is called recirculate. Hence the eight vacuum pumps associated to the first PSA stage provide the link between the first stage PSA adsorbers, and the tail gas system and the four vacuum pumps associated to the second PSA stage provide the link between the second stage PSA adsorbers and the recirculate buffer bladder tank.

3.2.2.2 Functional Description:

To regenerate the carbon molecular sieve (CMS) and the desiccant bed of the PSA adsorber beds, the pressure is reduced to facilitate desorption of the adsorbed gas components and the moisture. Therefore, four vacuum pumps per PSA assembly are constantly running to create a vacuum.

The vacuum pumps are oil-lubricated rotary vane vacuum pumps which are cooled with cooling water. The vacuum valves separating the adsorber vessels from the suction pipe of the vacuum pumps are opened, when the corresponding vessel is in turn for regeneration, so that only one vessel per PSA assembly is connected to the vacuum pumps at a time.

The tail gas contains considerable amounts of moisture. When the vacuum pumps are connected to the adsorber the pressure inside the adsorber drops quickly. Associated with the pressure drop the temperature inside the vacuum line drops as well. To prevent icing of the vacuum lines those pipes are heat traced, if the necessity is indicated by the temperature transmitters TISAHL.DD.01.01.01.01 and TISAHL.DD.01.01.01.02 or TISAHL.DD.02.01.01.01 and TISAHL.DD.02.01.01.02 respectively. The tail gas is transferred to the tail gas bladder tank V.DE.01.01.01.07.

The recirculate contains considerable amounts of methane. To optimize the yield of the overall plant, the recirculate will not be discarded like the tail gas, but will be recycled within the process. The recirculate will be cooled against chilled water in the 1st Recirculate Cooler E.DD.01.02.01.30, before it is transferred to the recirculate buffer bladder tank V.DD.01.02.01.35. To protect the membrane of the buffer tank, a safety-related temperature switch shuts the way to the bladder tank, if the temperature of the gas is still too high downstream of the 1st Recirculate Cooler.

The vacuum pumps can only run against a limited pressure on the pressure side. Therefore a safety-related pressure switch turns off the motors of the vacuum pumps before this limit is reached.

The oil temperature of the vacuum pumps is monitored. If the oil is too cold, the viscosity of the oil is too high to enable sufficient lubrication and thus the pumps are not allowed to start. If the oil temperature is too high, the pumps have to be switched off, because there is a problem with the cooling.

3.2.3 Subsystem Description Recirculate Buffer Tank Unit DD 16

3.2.3.1 Location of Installation:

The Recirculate Buffer Bladder Tank V.DD.01.02.01.35 is used to buffer the gas flows from the second PSA stage that are transferred back to the LFG booster system. Fluctuations of the gas composition and of the volume flow can thus be homogenized.

3.2.3.2 Functional Description:

The Recirculate Buffer Bladder Tank is a double membrane tank. The outer membrane is always kept fully inflated by supporting air. The inner membrane is kept flexible and inflates, if more gas is going into the inner membrane than going out, and deflates, if more gas is taken out of the inner membrane than going in. The space between both membranes is filled with air, which is either let out via a pressure relief valve, when the inner membrane inflates, or it is pumped back via supporting gas blower B.DD.01.02.01.42, when the inner membrane deflates. The level of gas inside the inner membrane is monitored via a level transmitter. The outlet pipe of the inner membrane is equipped with a hydrostatic head to protect the inner membrane against too high pressure.

The buffer tank is fed by two different gas streams. The first stream of gas is fed into the buffer tank during the last depressurizing step of the second PSA stage before the adsorber is connected to the vacuum pumps. In this step the pressure inside the adsorber is decreased to almost ambient pressure. To achieve this pressure reduction the adsorber can either be connected directly to the suction side of the LFG Blowers or to the Recirculate Buffer Bladder Tank, or both, one after the other. The second stream comes from the vacuum pumps that are used to regenerate the second stage PSA adsorbers.

Both streams have a highly fluctuating flowrate, which is buffered by the inflating inner membrane. Thus, a constant volume flow can be taken from the buffer tank and is transferred to the suction side of the LFG Blowers via recirculate blower B.DD.01.02.01.39. The Recirculate blower is speed controlled by the level transmitter of the recirculate buffer bladder tank. As this level fluctuates the mean value over one cycle is calculated and taken as the lead value for the VFD of the blower. To reduce the temperature of the recirculate after the Recirculate Blower, the gas passes the Recirculate Air cooler 1 E.DD.01.02.01.61, where the recirculate is cooled against ambient air.

3.2.4 Subsystem Description Tail Gas System Unit DE

3.2.4.1 Location of Installation:

The tail gas system is the link between the vacuum pumps of the first PSA stage and the tail gas combustion. The main equipment of the tail gas system is the PSA 1 tail gas cooler, the tail gas bladder tank and the tail gas blowers.

3.2.4.2 Functional Description:

The Tail gas Bladder Tank V.DE.01.01.01.07 is used to buffer the gas flows from the vacuum pumps associated with the first PSA stage before it is transferred to the tail gas combustion. Fluctuations of the gas composition and of the volume flow can thus be homogenized. The tail gas leaves the vacuum pumps with a temperature of up to 194°F. As the membrane of the tail gas bladder tank can only withstand temperature of up to 158°F, the tail gas is cooled down against cooling water in the PSA 1 tail gas cooler E.DE.01.01.01.26. If the temperature of the tail gas is still too high after the heat exchanger, the inlet valve to the tail gas bladder tank is closed safety-related to protect the tank.

The Tail gas Bladder Tank is a double membrane tank. The outer membrane is always kept fully inflated by supporting air. The inner membrane is kept flexible and inflates, if more gas is going into the inner membrane than going out, and deflates, if more gas is taken out of the inner membrane than going in. The space between both membranes is filled with air, which is either let out via a pressure relief valve, when the inner membrane inflates, or it is pumped back via supporting gas blower B.DE.01.01.01.28, when the inner membrane deflates. The level of gas inside the inner membrane is monitored via a level transmitter. The outlet pipe of the inner membrane is equipped with a hydrostatic head to protect the inner membrane against too high pressure.

The incoming gas stream has a highly fluctuating flowrate, which is buffered by the inflating inner membrane. Thus a constant volume flow can be taken from the tail gas bladder tank and is transferred to the tail gas combustion via tail gas blowers B.DE.01.01.01.15 and B.DE.01.01.02.15. The tail gas blowers are speed controlled by the level transmitter of the tail gas bladder tank. As this level fluctuates the mean value over one cycle is calculated and taken as the lead value for the VFD of the blowers.

There are two possible ways for the tail gas from the tail gas blowers to the tail gas combustion. If the bed of one of the VOC vessels is being regenerated, a partial stream of the tail gas is used to heat the bed up and cool it down again. After passing the VOC vessel the tail gas is transferred to the tail gas combustion as well. If neither VOC vessel bed is being regenerated, the whole tail gas stream is transferred directly to the tail gas combustion.

Not during VOC regeneration PIC(A).DE.01.01.01.31 controls the control butterfly valve KC.DE.01.01.01.19 to keep the outlet pressure of the tail gas blowers at 2 psig. At this pressure each tail gas blower is capable to convey the maximum flow of tail gas, if the plant is running on full load. This pressure is sufficient to transfer the tail gas to the tail gas combustion. FISAHL .DE.01.01.01.20 monitors the flowrate of the tail gas flowing directly to the tail gas combustion. KC.DE.01.01.01.34 is kept closed.

During VOC regeneration a higher outlet pressure is required to overcome the pressure drop of the heat exchangers and the VOC vessel in the regeneration loop. Then PIC(B).DE.01.01.01.31 controls the control butterfly valve KC.DE.01.01.01.19 to keep the outlet pressure of the tail gas blowers at 8 psig, while FIC.DE.01.01.01.35 controls the control butterfly valve KC.DE.01.01.01.34 to keep a flow of 467 scfm directed to the VOC regeneration loop. At the outlet pressure of 8 psig both tail gas blowers are needed to convey the maximum flow of tail gas. If the plant is running on minimum load, there is less tail gas produced than 467 scfm. In this case all the available tail gas is used for the regeneration. The heating and cooling process takes longer then, which is acceptable, because on minimum load each VOC filter can be kept in operation longer before it is fully loaded and needs to be regenerated. Thus, there is more time available for the regeneration as well.

The tail gas in the VOC regeneration loop is reunited with the tail gas that is transferred directly to the tail gas combustion. If the pressure of the reunited gas stream is higher than acceptable for the inlet of the tail gas combustion, butterfly valve KP.DE.01.01.01.25 is closed safety-related to protect the tail gas combustion.

In emergency and in accordance to legal regulations the tail gas can be vented to atmosphere by opening the manual valve KH.DE.01.01.01.23 to the exhaust instead of feeding the tail gas to the tail gas combustion.

3.2.5 Subsystem Description Tail Gas Combustion Unit DF

3.2.5.1 Location of Installation:

Following the tail gas stream, the Tail Gas Combustion Unit DF is installed downstream of the Tail Gas System unit DE.

In the tail gas combustion unit hydrocarbons are oxidized to carbon dioxide and water, so that the amount of remaining methane and other remaining VOCs in exhaust gas can be lowered to regulatory environmental standards.

3.2.5.2 Functional Description:

In a first step the tail gas is fed into a mix box (V.DF.01.01.01), where it gets mixed with ambient air to achieve an ideal combustion composition and to lower the methane concentration to below 25% of LEL (lower explosion level).

From here system blower B.DF.01.01.01.16 conveys the tail gas/air-mixture into the two tank beds T.DF.01.01.01/02.45, where the oxidization takes place. The two poppet valves VP.DF.01.01.01/02.20 operate cyclically, so that both tank beds are fed in an alternating manner and the oxidized tail gas is led through the corresponding exit valve.

For start-up and if the calorific value of the tail gas is too low, the tank beds are heated up by burner D.DF.01.01.01.78, to always ensure sufficient temperature to thermally destroy all pollutants. The burner is fed with combustion support gas and ambient air. The ambient air is also used to cool down UV sensor QISAHL.DF.01.01.01.79.

The combustion unit is equipped with several safety mechanisms. If sensor QIC.DF.01.01.01.10 detects an explosive mixture, the burner is shut down and valve KH.DF.01.01.01.12 is opened. Purge blower B.DF.01.01.01.08 then purges the gas stream through the vent. Additionally, the poppet valve VP.DF.01.01.01.30 is switched, so that the system blower sucks in ambient air instead of tail gas.

In case of an overheating of the tank beds damper KM.DF.01.01.01.31 can be used to regulate direct discharge of the gas stream into the vent.

3.3 Auxiliary Subsystems

3.3.1 Subsystem Description Cooling Water Unit EA

The cooling water needed for process gas cooling or pre-heating and machine cooling is provided by a closed loop system.

The cooling water is pumped by a centrifugal pump P.EA.01.01.01.38. The cooling water pressure is increased at this point and then fed to the supply header pipe. The individual streams can be adjusted by circuit control valves.

The cooling water in the return pipe is cooled by two air-cooled dry coolers which are equipped with fans and finned tube heat exchangers (PU.EA.01.01.01.52 and PU.EA.01.01.02.52). The fans are switched on or off individually according to the current cooling requirement, which depends on the cooling water return temperature.

At low ambient temperatures or during system start-up, operation of the cooling water dry cooler is not always necessary. Therefore, if the return temperature falls below a defined value, the dry coolers (PU.EA.01.01.01.52 and PU.EA.01.01.02.52) can be bypassed through automated opening of the pneumatic bypass valve KP.EA.01.01.01.33.

The plate heat exchanger E.EA.01.01.01.53 in the cooling water return line from both LFG compressors (PU.AN.01.01.01.38) provides export heat to the biological desulfurization unit (PU.EC.01.01.01.01) via a separate circuit if needed. The heating water flow is generated by several heating pumps which are installed in the biological desulfurization unit's plant container. If no heat is exported, the waste heat is dissipated completely via the dry cooler unit.

The flow indicator switch FSL.EA.01.01.01.44 with low flow limit acts as protection for the equipment of this subsystem. As soon as the flow reaches a defined value the subsystem will be shutdown.

The supply temperature TISAHL.EA.01.01.01.42 and return temperature TIAHL.EA.01.01.01.09 of the cooling water circuit are monitored for control. The supply and return temperatures of the heating water circuit are measured as well.

In order to ensure a minimum pressure and to compensate for variations in volume of the cooling water due to temperature fluctuations, a membrane expansion vessel is installed, which generates the pre-pressure through a gas cushion in the vessel.

A pressure relief valve Y.EA.01.01.01.05 is installed to protect the subsystem from any pressures higher than 88 psig (6 barg) which could occur in the case of a pipe rupture in one of the process gas heat exchangers or in one of the oil coolers of the water cooled machines.

3.3.2 Subsystem Description Chiller 1 & 2, Unit EB

3.3.2.1 Subsystem Description Chiller 1 (EB, page 1)

The chilled water needed for drying the gas stream of process gas through condensation is provided by a closed loop system. The Chiller 1 fluid is used for the third heat exchanger E.AF.01.01.01.06 in the drying unit AF.

The chilled water is pumped by two redundant centrifugal pumps P.EB.01.02.01.23 and P.EB.01.02.02.23. The chilled water pressure is increased at this point and then fed to the plate heat exchanger E.EB.01.01.01.01 for heat transfer with the internal refrigerant loop with R-410a. The flow rate to both chilled water storage tanks V.EB.01.02.01.15 and V.EB.01.02.01.16 can be adjusted with the circuit control valve PCV.EB.01.02.01.06.

The return stream can be adjusted by circuit control valve VH.EB.01.02.01.01.

The chilled water from the return pipe is cooled at the plate heat exchanger E.EB.01.01.01.01, which is connected to the internal coolant loop. In this loop another heat exchanger with finned tube E.EB.01.01.01.21 is used for cooling of refrigerant R-410a and equipped with two air fans. The fans are individually switched on or off according to the current cooling requirement, which depends on the chilled water supply temperature.

The flow indicator switch FSL.EB.01.02.01.05 with low flow limit acts as protection for the equipment of this subsystem. As soon as the flow reaches a defined value, the subsystem will be shutdown.

The supply temperature TIAHL.EB.01.02.01.24 and return temperature TIAHL.EB.01.02.01.10 of the chilled water circuit are monitored for control.

In order to ensure a minimum pressure and to compensate for variations in volume of the chilled water due to temperature fluctuations, a membrane expansion vessel V.EB.01.02.01.04 is installed, which generates the pre-pressure through a gas cushion in the vessel.

A pressure relief valve Y.EB.01.02.01.07 is installed to protect the subsystem from pressures higher than 88 psig (6 barg), which could occur in the case of a pipe rupture in the process gas heat exchanger E.AF.01.01.01.06.

3.3.2.2 Subsystem Description Chiller 2 (EB page 02 and 03)

The chiller 2 fluid, that is needed for process gas cooling at various points within the gas upgrading process, is provided by a closed loop system.

The chilled water is pumped by two redundant centrifugal pumps P.EB.01.04.01.20 and P.EB.01.04.02.20. The chilled water pressure is increased at this point and then fed to the plate heat exchanger E.EB.01.04.01.08 for heat transfer with the internal refrigerant loop with R-410a. The flow rate to the chilled water distribution system can be adjusted with the circuit control valve VC.EB.01.04.01.18.

The chilled water from the return pipe is cooled at the heat exchanger E.EB.01.04.01.08, which is connected to the internal coolant loop. In this loop four other heat exchangers with finned tubes (E.EB.01.03.01.21, E.EB.01.03.02.21, E.EB.01.03.03.21, E.EB.01.03.04.21) are used for cooling of refrigerant R-410a and are each equipped with two air fans. The fans can be switched on or off individually according to the current cooling requirement, which depends on the chilled water supply temperature.

The flow indicator switch FSL.EB.01.04.01.17 with low flow limit acts as protection for the equipment of this subsystem. As soon as the flow reaches a defined value, the subsystem will be shutdown.

The supply temperature TIAHL.EB.01.04.01.24 and return temperature TIAHL.EB.01.04.01.09 of the chilled water circuit are monitored for control.

In order to ensure a minimum pressure and to compensate for variations in volume of the chilled water due to temperature fluctuations, a membrane expansion vessel V.EB.01.04.01.04 is installed, which generates the pre-pressure through a gas cushion in the vessel.

A pressure relief valve Y.EB.01.04.01.05 is installed to protect the subsystem from pressures higher than 88 psig (6 barg) which could occur in the case of a pipe rupture in any of the process gas heat exchangers.

3.3.3 Subsystem Description Instrument Air System EG

The main function of the subsystem is supplying the instrument air for the actuated valves of the landfill gas upgrading plant, which require air for operation.

There are two instrument air compressors PU.EG.01.01.01.75 and PU.EG.01.01.02.75. One is in operation, the other one in stand-by. The compressors take in ambient air, which is then pressurized up to 200 psig and cooled and collected in Compressed Air Wet Tank V.EG.01.01.01.08. Condensate is collected and drained to Oil/water separator V.EG.01.01.01.15. The compressed air is dried in the twin tower desiccant air dryer PU.EG.01.01.01./02.31 before it is collected in the dry air receiver vessel V.EG.01.01.01.40.

Downstream of the dry air receiver vessel, the instrument air is distributed throughout the plant. As the instrument air consumption of the PSA system is significant, there is another compressed air reservoir V.EG.01.01.02./03./04.60 for each PSA to ensure sufficient airflow to the actuated valves. Before the instrument air is led to the individual actuators, the instrument air is depressurized to approx. 80 psig.

3.3.4 Subsystem Description Nitrogen Unit EE

The central nitrogen unit EE provides the connection point for interchangeable nitrogen cylinder packs which meet the local standard regarding pressure and gas quality. Included in this unit are a pressure reducer PCV.EE.01.01.01.04 and two pressure relief valves Y.EE.01.01.01.05 and Y.EE.01.01.01.06 for protection of downstream components for pressures higher than XX psig.

The pressure reducer PCV.EE.01.01.01.04 shall be designed to meet the local standard regarding maximum primary pressure and set to a secondary pressure of 30 psi(g).

The purpose of the nitrogen unit EE is the supply of nitrogen to the plant for inerting tasks during start-up, planned and emergency shutdown procedures.

3.3.5 Subsystem Description Water Softener Unit ED

The fresh water, which is provided by the plant owner as well water, has to meet the specifications for all components of the SRU and effluent treatment parts of the plant.

For this purpose, the water has to be softened by the water softener unit ED. This task will be done inside the PU.ED.01.01.01.18.

As consumable, the NaCl brine has to be mixed by the operator. In addition, the type of regeneration cycle has to be determined during commissioning. The regeneration cycle can either be based on the run time or on the flow of softened water. Additional information is supplied in the manual of PU.ED.01.01.01.18.

3.3.6 Subsystem Description SRU Neutralization Unit EM

In the SRU Neutralization unit EM the pH value of the sulfate suspension, which is discharged from both SRU Vessels, will be adjusted to meet local standards for wastewater.

Inside of the unit EM the sulfate suspension from the SRU unit AD will be mixed with caustic soda solution (50 wt.%) in the Neutralization reactor V.EM.01.01.01.08. The sulfate suspension is discharged from the biological desulfurization and flows through KP.EM.01.01.01.05 into the Neutralization reactor V.EM.01.01.01.08 until LIC.EM.01.01.01.15 reaches the filling level 83.3%. The pH-value will be increased to more than pH 8.3 through dosing of caustic soda solution (50 wt.%) by parallel redundant pumps P.EM.01.01.01.53 and P.EM.01.01.02.53. The caustic soda is taken from the caustic soda storage tank PU.EM.01.01.01.81, which has to be refilled on a regular basis.

The mixture of sulfate suspension and caustic soda solution is mixed with the parallel redundant pumps P.EM.01.01.01.22 and P.EM.01.01.02.22, which circulate the suspension inside the neutralization reactor V.EM.01.01.01.08.

When the required pH-value is reached, the neutralized sulfate suspension is discharged to the customer's wastewater system by opening KP.EM.01.01.01.42 and 5 seconds later closing KP.EM.01.01.01.37.

KP.EM.01.01.01.37 will be opened and KP.EM.01.01.01.42 will be closed 5 seconds later when the filling level inside the Neutralization reactor V.EM.01.01.01.08 falls below 16,3% on LIC.EM.01.01.01.15.

3.3.7 Subsystem Description Tepid Water and Emergency Showers EN

Handling of caustic soda and sulfate suspension with pH-value down to 1 require the installation of emergency showers and an eye wash station. Those are installed inside and outside of the Process room SRU Neutralization. To prevent hypothermia, if the emergency showers have to be used in cold weather, the softened well water for the emergency showers has to be preheated. Therefore, Tepid Water Supply Unit PU.EN.01.01.01.20 is installed inside the Process room SRU Neutralization to provide the required temperature rise.

3.4 Gas Analysis Subsystems

3.4.1 Subsystem Description Gas Analysis Units FA, FB, FC, FF, FL, FM, FN and FO

The Biogas, Biomethane and tail gas stream are monitored by the analysis subsystems. The analysis is performed automatically according to pre-set parameters. For the calibration and adjustment of measuring equipment test gases need to be provided (by others).

3.4.1.1 Biogas Gas Analyzers Units FA, FC and FF

The biogas stream is monitored for methane, hydrogen sulfide, oxygen, and carbon dioxide. The concentration of CH_4, CO_2, O_2 and H_2S measured by gas analyzers is displayed on the user interface and updated regularly. In case of specification violation, alarms are triggered.

Several measuring instruments are arranged in the biogas lines.

- **Unit FA:** CH4, CO2, O2 and H2S analyzer with the diode laser spectrometer

  Different measuring points upstream the PSA can be chosen for the diode laser spectrometer:

  - at the transfer point, after biological desulphurization
  - after each the desulphurization vessels of the second desulphurization
  - after the dust filter in the unit AC.

  The same sample gas taken from biogas streams is partially used for the H_2S sensor. The sensor validates the correct function of the desulfurization process step and sets of an alarm, if the H_2S concentration exceeds its maximum allowable concentration.

  The gas sample and the test gas are vented into the atmosphere via an exhaust.

- **Unit FC:** Oxygen measurement after biological desulphurization

  In the biological desulphurization elemental sulfur and sulfuric acid are formed from H_2S depending on the oxygen available.

  The oxidation of H_2S requires oxygen. The required oxygen is already available in the biogas, so that no additional oxygen has to be added. The target value of the oxygen concentration at the outlet of the biological trickle-bed reactor has been set to about > 0.7-0.8 vol-%.

  The oxygen content of the biogas exiting the biological desulfurization is checked before the gas enters the biogas compressors. If the oxygen content is too high a hazardous explosive atmosphere may form and the process should be stopped before the gas reaches the compressors.

  The sample gas is conveyed via a diaphragm pump to the diode laser spectrometer. It is filtered before reaching the analyzer.

  The gas sample and the test gas are vented into the atmosphere via an exhaust.

- **Unit FF:** H_2S-analyzer after each the desulphurization vessel and after the dust filter in the unit AC

  A sample of the biogas is taken after each the desulphurization vessel and after the dust filter in the unit AC and led to the H_2S-analyzer QI.FF.01.01.01.50 to check, if the biogas meets the required specification concerning H_2S content of 5 ppm H_2S in the gas flow. If the H_2S concentration of the process gas is not according to the biogas/biomethane gas specification, the gas is recycled to the biogas receipt.

The gas sample and the test gas are vented into the atmosphere via an exhaust.

3.4.1.2 Biomethane Gas Analyzer Units FB and FM

The biomethane stream is monitored for methane, oxygen, carbon dioxide and biomethane dew point. The concentration of CH4, CO2, O2 and dew point measured by gas analyzers is displayed on the user interface and updated regularly. In case of specification violation, alarms are triggered. Several measuring instruments are arranged in the biomethane line inside the PSA and downstream of the PSA.

- **Unit FM:** Analysis of biomethane in the PSA

  Biomethane in the PSA is monitored for methane, oxygen, and carbon dioxide by two individual analyzers, which use one shared source of biomethane. The concentrations of CH_4, CO_2, and O_2 measured by the gas analyzers is displayed on the user interface and updated regularly. In case of specification violation, alarms are triggered.

- **Unit FB:** Analysis of biomethane downstream of the PSA

  The biomethane downstream of the PSA is monitored for methane, water, and carbon dioxide by two individual analyzers, which use one shared source of biomethane. The concentrations of CH_4, CO_2, and H_2O measured by the analyzers are displayed on the user interface and updated regularly. In case of specification violation, alarms are triggered.

  The water content of the biomehtane is continuously monitored by a dew point transmitter.

  When the biomethane complies with the specification, it is fed into the biomethane compressor. In case of non-compliance with the specification or non-acceptance of the produced biomethane by downstream systems, the biomethane is fed back into the biogas pressure vessel.

  After passing through the analyzer the gas sample is vented into the atmosphere via an exhaust.

3.4.1.3 Tail Gas Analyzer Units FL and FN

The tail gas line is monitored for methane, oxygen, and carbon dioxide by two individual analyzers, which use one shared source of biomethane. The concentrations of CH_4, CO_2, and O_2 measured by the analyzers are displayed on the user interface and updated regularly. In case of specification violation, alarms are triggered.

After passing through the analyzer the gas sample is vented into the atmosphere via an exhaust.

The sample gas has to be cooled down to be processed in the analysers. For this purpose unit FL consisting of a gas cooler is installed.

3.4.1.4 Calibration Unit FO

1. Calibration gas for PU.FA.01.01.01.70 diode laser spectrometer AP2E ProCeas®

   - <u>Gas mixture in Nitrogen test gas</u>

     45 vol-% Methane
     40 vol-% Carbon dioxide
     5 vol-% Oxygen

2000 ppm Hydrogen sulfide

- Monthly calibration
- Flow rate 1 to 20 L/h

2. Calibration gas for all oxygen analysis systems (PU.FC.01.01.01.80, PU.FM.01.01.01.10, PU.FN.01.01.01.10)
   - <u>Gas mixture in Nitrogen test gas</u>

     5 vol.-% oxygen
   - Calibration every 3 months
   - Flow rate 0.4 to 0.9 NL/min per unit

   The oxygen analyzer is also connected to a gas cylinder with span gas (5 % oxygen balanced with nitrogen) for calibration. Calibration is necessary every 90 days. The calibration procedure has to be performed manually.
   The gas analyzer is calibrated every six hours with nitrogen. Then the zero point is set for the oxygen channel. The calibration for the oxygen is executed automatically with ambient air. The infrared channel has to be calibrated with calibration gases every 90 days by a service technician.

3. Calibration gas for H2S Hydrogen sulfide analysis PU.FF.01.01.01.80
   - <u>Gas mixture in Air mixture</u>

     10 ppm H2S in air.
   - Daily calibration
   - Flow rate 0.3 L/min. to 2.5 NL/min

   The analyzer is also connected to a gas cylinder with test gas of defined H_2S concentration, as well as to the instrument air system for purging. The sensor will be calibrated after start-up. The calibration is then checked at least every 90 days to ensure system integrity.

3.5 Building Technology Equipment Subsystems

3.5.1 Subsystem Description Building Technology Equipment GA

The Building technology equipment sub-system includes HVAC systems of the BUP. It is used for heating and ventilation of the process rooms, i.e. it is a ventilation system with a heating function. A gas warning system monitors the process rooms for the presence of a hazardous explosive atmosphere if necessary. Additionally, other building technology devices and components are shown, e.g., lighting, light switches, etc.

4 Preparing for Operation

The following describes the preparations in order to reset the system after installation work or after assembly into operation.

NOTICE	Tests and work on the electrical and mechanical installation must be performed by qualified personnel.

4.1 Testing of the System Components After Installation or Repairs

The conditions for the inspection of the system after installation or repair, as described in **"Inspection Steps"**, are as follows:

- The main power to the system must be turned off before inspection.
- All resource supply lines are closed.
- The system is completely depressurized.

CAUTION	If the inspection is carried out on a pressurized system, there is a risk of uncontrolled gas release and thus an increased risk of accidents and system damage.

Documents required for inspection of the system:

- P&I Diagrams
- Parts lists
- Wiring diagrams

The inspection must be carried out as described below. Since the system is part of a larger industrial complex, further inspections may be necessary. The execution of the specified steps therefore does not release the employer and operator from the obligation to perform any additional inspections if necessary, resp. required by regulations or authorities.

Inspection Steps

- Review the complete and correct installation of the piping system and of the I&C equipment of the system.
- Check the compliance of the electrical connections with the terminal diagrams.
- Check the safe and tight mounting of the flanged and threaded pipe connections.
- Check the function of the manually operated valves by fully opening and closing them.
- Close and reopen the gauge valves.
- Turn off the power to the system back on at the main switch.
- Turn on the fuses in the control cabinet.
- Turn the controls on and start the operating PC.
- Check the input and output signals of the electrically operated I&C equipment. If you are unsure of the correct signal processing, the respective cable connections should first be checked by applying a test signal.
- Check the functionality of all the pressure and temperature gauges with local displays. In case of doubt, these must be verified on a test stand.
- Manually check the mechanical functionality of the pneumatic valve units.

NOTICE	After testing the pneumatic fittings, all solenoid valves must be switched to **automatic position**. That is, the manual operation has to be released again. **Therefore, also check the position of the manual override on all solenoid valves!**

- The pilot solenoid valves of those actuated valves with a safety-instrumented function do not have a manual switching function. To test the mechanical functionality of the pneumatic actuators, pressurize them with instrument air.
- The initialization and adjustment of all electro-pneumatic positioners must be performed as described in the manufacturer's documentation.
- Check the oil level of all machines according to the manufacturer's documentation.

CAUTION	During pressure or tightness tests, make sure that the maximum allowable working pressure is not exceeded for **ANY** component of the system. Danger to life and risk of destruction of the system may result e.g. by bursting of system parts. The work must be performed by qualified personnel.

4.2 Pressure Testing

Pressure testing of the system is somewhat limited because vessels filled with adsorbent media, such as desulfurization and adsorber vessels, cannot be tested using water as a test medium (hydrostatic pressure test).

The following points must be considered for pneumatic pressure tests:

- An inert gas must be used for pressure testing since the vessels are filled with adsorbents or catalyst, which can be damaged by e.g. moisture.
- Parts of the piping system to be tested must be shut off with line blanks, blind flanges or by closing the appropriate valves.
- When using gas as test medium for testing, the maximum allowed pressure is 1.1 times the design pressure of the piping resp. equipment.

4.3 Leak Testing

After installation or maintenance work, the system must be leak tested. An inert gas, such as nitrogen, must be used as the medium for tightness checks.

After shutting off the respective inlets and outlets with blind flanges or other suitable means, the entire system or parts thereof can be checked for leaks by pressurizing it with test gas and then checking all connections and components for tightness.

The gas pressure must be chosen so that the maximum allowable working pressure is not exceeded for **ANY** component in the tested part of the system. The specifications for the maximum allowable pressure can be found in the system documentation or the equipment labels / plates.

The adsorbents of the PSA must be separated from the rest of the piping system for leak tests since the adsorbent contained in the vessels can bind and release large amounts of gas depending on pressure and temperature and therefore the pressure cannot be maintained within the system.

Please also note:

- Leaks must be located using leak detection spray or equivalent means.
- Insulated pipe parts must be isolated with blind flanges, pressurized, and then checked for leaks by using visualization and the recorded measurement values.

4.4 Resources Supply

The resources required for the continuous operation of the system (e.g. instrument air) must be available in sufficient quantity so that a system shutdown can be executed at any time in the intended manner.

For details please refer to the maintenance plan.

4.4.1 Power Supply

The power to the system is supplied centrally via the main switch located on the switch cabinet.

CAUTION	Before the power is connected to the system, it must be verified that no electrical cables are unsecured or open as a result, for example, of installation or maintenance. All works on the mains voltage must be performed in accordance with the applicable regulations and guidelines.

Starting the Power Supply

When turning on the main switch of the power supply, please note the following:

- The 480V mains supply must be located before the main switch.
- Perform a "reset" of the emergency stop via the button on the switch cabinet.
- Check all fuses by visual inspection, e.g. enamel discs, LED indicators, etc.
- After switching on the main switch, switch on all circuit breakers, motor protection circuit breakers, and fuses in the switch cabinet.

4.4.2 Cooling Water Supply

Depending on the ambient conditions, the cooling water system must be filled with an appropriate mixture of water and antifreeze agent, such as 44% antifreeze and 56% water for frost protection to approx. -22°F.

If a different antifreeze ratio is used, the operating data of the cooling system will change.

Refilling

Procedure:

1. Set the required pressure in the expansion vessel.

   The system-specific pressure values can be found in the Appendix of this description.
2. Open the valves of the cooling water circuit.
3. First pump the required amount of antifreeze, see fill protocol, into the system via the ball valve, using a suitable pump.
4. Close the bleeder.

5. The cooling water system must now be filled with cooling water to operating pressure. The system-specific pressure values can be found in the Appendix of this description.

NOTICE	To fill the cooling water system, it is recommended to use a methyl glycol-water mixture with corrosion inhibitors.

6. Vent cooling water pump and put into operation in manual mode.
   Then allow the pump to work in the circuit for a minimum of 5 min.
   The bypass valve must be opened and closed several times during this process.
7. Bleed the dry cooler by carefully opening the bleed valves vent until cooling water exits.
8. Slowly bleed the pipeline system via the bleed valves until cooling water exits.
9. Close the bleed valves and seal with stopper.

Refilling

Procedure:

1. Stop cooling water circuit according to instructions.
2. Top up with coolant mixture as described in the previous chapter.
3. The refilled glycol must be of the same type as that used in the system.

4.4.3 Chilled Water Supply

The chilled water system must be filled with a mixture of water appropriate for the ambient conditions.

If a different antifreeze ratio is used, the operating data of the chilling system will change.

Refilling

Procedure:

1. The water circuit must be filled to a pressure of 1.6 to 1.7 bar (a) and vented to build up an air or nitrogen reserve in the expansion vessel because the water volume shrinks by cooling after starting up the system.
2. All manual valves of the chilled water system must be opened.
3. First, pump the required amount into the system via the ball valve, using a suitable pump. See fill protocol.
4. Turn on the chilled water system in a de-pressurized state and in manual mode, according to the instructions, and allow it to work in the circuit for some time.
5. Bleed the chilled water expansion vessel by carefully opening the bleed valve.
6. Slowly bleed the piping system via the bleed valves until cooling mixture exits.
7. Close bleed valves tightly.

CAUTION	When refilling the cooling water or chilled water system with antifreeze, the system must be shut off. **Refilling with pure water reduces the cold resistance and is therefore to be avoided.**

4.4.4 N_2 supply

The N_2 supply is mainly required for inerting the system. For this purpose, an N_2 cylinder bundle with appropriate pressure reducer must be provided (by others).

There is a risk of exceeding the permissible pressure in the parts of the system.

For the sake of brevity, the following text will refer to an N_2 cylinder. If using an N_2 cylinder bundle, proceed analogously.

DANGER	There is a risk of exceeding the permissible pressure in the parts of the system. Use of the pressure reducer is required to ensure compliance with the permissible pressure ranges. There is a risk of serious accidents with physical damages, including death if the instructions above are not followed.

For assembly and disassembly of the mobile connection unit, refer to the "Inerting“ section.

NOTICE	Regularly check the fill level of the N_2 cylinder bundle and ensure sufficient reserve. Bear in mind the lead time for replacement of cylinder packs.

4.5 Inerting of the System

4.5.1 Purging/Inerting of the System Dane County WI BUP2500

A mixture of methane/oxygen or methane/air forms an explosive atmosphere. In order to avoid the formation of an explosive gas mixture in the system or in the pipelines, it must be inerted with nitrogen before parts of the system/pipes are opened.

Inert the system:

- Before biogas or methane is supplied again, for example, after prolonged shutdown of the system.
- Before the activated carbon beds in the H_2S stage or in the VOC filter are replaced.
- Inerting is carried out by flushing the system with nitrogen until the residual concentration of oxygen and methane in the piping system and the adsorbers is 1.0 Vol.% respectively.
- In the case of longer downtimes, it is advisable to pressurize the adsorbers with nitrogen to prevent the diffusion of moisture into the adsorbents.
- Before any welding and grinding in the engine rooms, the affected system parts must be inerted.
- Before commissioning and after parts of the system have been opened, for example, for repair or inspection purposes, the system must be inerted with nitrogen.

For inerting, nitrogen must be supplied to the system or system parts via the appropriate valves. When doing so, the valves of the system must be adjusted so that the entire system interior, composed of piping and equipment interior, is flushed.

Pneumatically driven valves in the flushing path must be opened via the OS or via manual overrides of the corresponding pilot valves.

4.5.2 Inerting Sulfur Removal Unit AD (without Biological Desulfurization) and Gas Receipt AM

1. Make sure the following valves are closed: KH.AD.01.01.01.10, KH.AD.01.01.02.10, KH.AD.01.01.01.19, KH.AD.01.01.02.19, KC.AM.01.01.01.33, VC.AM.01.01.01.34 KP.AN.01.01.01.01 and KP.AN.01.01.02.01.
2. Open all internal valves incl. KH.AD.01.01.01.51.
3. Connect Nitrogen to HH.DA.01.01.01.35 and set the pressure regulator to max. 3psi. The pressure in the system should not exceed 3psi.
4. Open now KH.AM.01.01.01.11 and close KH.AM.01.01.02.11.
5. Open HH.DA.01.01.01.35 and purge the system with nitrogen until the pressure in the system reaches 3psi. Now open HH.AM.01.01.01.32 and release the pressure. You can read the pressure on PI.AM.01.01.01.26 and PI.AD.01.01.01.51.
6. Close now KH.AM.01.01.01.11 and open KH.AM.01.01.02.11. and repeat the above mentioned procedure.
7. Repeat steps 4 to 6 appr. 10 times

4.5.3 Inerting Biological Desulfurization AD

1. According to manufacturer TS-Umwelt no need for purging.

4.5.4 Inerting LFG Compressors AN

2. Inerting Compressor 1 :
   i. Connect Nitrogen to HH.AN.01.01.01.02 and set the pressure regulator to max. 7psi. The system pressure should not exceed 7psi.
   ii. Open HH.AN.01.01.01.02 until the pressure in the system reaches 7psi. Now open HH.AN.01.01.01.35 and release the pressure. You can read the pressure on PI.AN.01.01.01.08.
   iii. Repeat steps 2 and 3 for appr. 5 times
3. Inerting Compressor 2 :
   i. Connect Nitrogen to HH.AN.01.01.02.02 and set the pressure regulator to max. 7psi. The system pressure should not exceed 7psi.
   ii. Open HH.AN.01.01.02.02 until the pressure in the system reaches 7psi. Now open HH.AN.01.01.02.35 and release the pressure. You can read the pressure on PI.AN.01.01.02.08.
   iii. Repeat steps 6 and 7 for appr. 5 times

4.5.5 Inerting Drying AF

1. Connect Nitrogen to HH.AE.01.01.01.05 and set the pressure regulator to max. 50psi. The pressure in the system should not exceed 50psi.
2. Close KH.AE.01.01.01.03, KH.AE.01.01.02.03 and KH.AE.01.01.01.71
3. Open HH.AE.01.01.01.05 and purge the system with nitrogen until the pressure in the system reaches 50psi. Now open HH.AF.01.01.01.50 and release the pressure. You can`t read the pressure in the system you must rely on the reading of the pressure reducer.
4. Repeat this procedure 5 times

4.5.6 Inerting VOC Removal AE

1. Connect Nitrogen to HH.AE.01.01.01.05 and set the pressure regulator to max. 50psi. The pressure in the system should not exceed 50psi.
2. Close KH.AE.01.01.01.72, KC.DE.01.01.01.19, KP.DE.01.01.01.25, KH.AE.01.01.01.85, KH.AE.01.01.01.86, KP.AE.01.01.01.68, VC.AE.01.01.01.62, KP.AE.01.01.02.03, KP.AE.01.01.01.04.
3. All remaining internal valves should be open.
4. Open HH.AE.01.01.01.05 until the pressure in the system reaches 50psi. Now open HH.AE.01.01.01.28 and release the pressure. You can read the pressure on PI.AE.01.01.01.07 and PI.AE.01.01.02.07.
5. Repeat this procedure for appr 5 times during the last procedure release the pressure from HH.AE.01.01.01.83

4.5.7 Inerting Desulfurization AC

1. Connect Nitrogen to HH.AC.01.01.01.04 and set the pressure regulator to max. 50psi. The pressure in the system should not exceed 50psi.

2. Close KH.AA.01.01.01.31, KH.AA.02.01.01.31, VC.AC.01.01.01.33, KH.AE.01.01.01.85, KH.AE.01.01.01.86, KH.AE.01.01.01.74, KH.AC.01.01.02.13, KH.AC.01.01.02.14, KH.AC.01.01.01.01.
3. All remaining internal valves should be open.
4. Open HH.AC.01.01.01.04 until the pressure in the system reaches 50psi. Now open HH.AC.01.01.01.28 and release the pressure. You can read the pressure on PI.AC.01.01.01.10 and PI.AC.01.01.02.10.
5. Repeat this procedure for appr 5 times

4.5.8 Inerting PSA – Intermediate buffer vessel AA

1. Connect Nitrogen to HH.AA.01.01.01.42 and set the pressure regulator to max. 50psi. The pressure in the system should not exceed 50psi.
2. Make sure the following valves are closed: KH.AA.01.01.01.32, KH.AA.01.02.01.32 and KP.AA.01.02.01/02/03/04/05/06.01.
3. VC.AA.01.01.01.45 should be open
4. Open HH.AA.01.01.01.42 until the pressure in the system reaches 50psi. Now open HH.AA.01.01.01.57 and release the pressure. You can read the pressure on PI.AA.01.01.01.60 and PI.AA.01.01.01.45.
5. Repeat this procedure for appr 5 times

4.5.9 Inerting Biomethane Vessel AO

1. Connect Nitrogen to HH.AO.01.01.01.02 and set the pressure regulator to max. 50psi. The pressure in the system should not exceed 50psi.
2. Make sure the following valves are closed: KH.AP.01.01.01.34 and KP.AA.01.02.01/02/03/04/05/06.08.
3. VC.AO.01.01.01.06 should be open.
4. Open HH.AO.01.01.01.02 until the pressure in the system reaches 50psi. Now open HH.AO.01.01.01.08 and release the pressure. You can read the pressure on PI.AO.01.01.01.04 and PI.AO.01.01.01.10
5. Repeat this procedure for appr 5 times

4.5.10 Inerting Product Gas Compressors AP

1. Refer to directions in the Cobey manual

5 Operational Check and Maintenance

Although the container system for biogas upgrading is set up for fully automatic operation and can be controlled by remote monitoring, regular checks of system on site are essential for long, trouble-free operation.
In addition to a general inspection of operating values, which can take place via the user interface, an inspection of the facility following the maintenance plan is highly recommended.

Before restarting, particularly after prolonged down times, an inspection of the system is necessary.

In addition, a log book should be kept for the facility to document all checks and maintenance in a calendar log.

This log book should document:

- Operating hours of the facility
- Maintenance and service calls for all machines, including operating times from the operating hours counters
- Calibration data of analysers
- Special events

The log book helps in planning and cost-effective execution of service calls.

Maintenance Plan

The following maintenance plan provides guidance for the planning of maintenance tasks. The maintenance intervals indicated represent only a summary of existing operational experience and the manufacturer's recommendations.

 **NOTICE**	The inspection and maintenance of the system parts should be performed according to the manufacturer's instructions.

The operator must follow the operating and maintenance instructions supplied with the system documentation.

5.1 Maintenance

The staff maintaining the system or parts thereof must read and understand this manual and the corresponding manufacturer's operating instructions; see Appendix System Documentation, of each component in this system and comply with instructions, recommendations, and with the **Chapter "Safety"**.

 **DANGER**	It must be ensured that the system has been shut down, i.e. de-pressurized and disconnected from the power supply, before any work is carried out on the system! The biogas feed must be stopped and all other gas inlet and outlet lines must be closed! The pipes and the vessels must be inerted with nitrogen, especially when welding or carrying out similar work.

5.2 Filling the Adsorbent and the H_2S Stage

Under normal operating conditions, the expected service life is:

- carbon molecular sieve (CMS) in the adsorbents
  ➡ up to ten years.
- the impregnated activated carbon in the H_2S stage for conversion of hydrogen sulfide, depending on the specifications at nominal operating conditions
  ➡ approx. 6 months per bed

The visual impression of the filler material gives no indication of the amount of the load. Even heavily loaded or contaminated filler material looks as good as new.

The intervals for refilling are mandatory.

 **NOTICE**	The carbon molecular sieve and activated carbon are strong adsorbents, which are thus easily contaminated when exposed to the influence of the atmosphere (humidity or other gas components) unprotected. For this reason, the bags or barrels of filler materials should not be opened until immediately before filling to minimize the influence of the atmosphere and keep it as short as possible!

Using the adsorbents in the CMS exchange as an example, the following steps must be considered when changing the filler material:

- The system must be shut down completely via the FGC and secured against restarting.

  All drives that are not required must be secured against start-up by pulling the NH isolators!
- Inerting of all parts of the system, including the biomethane pressure vessel and PSA, as described in the **Chapter "Inerting of the System"**.

DANGER	Residual pressure in the piping system and the pressure vessels and electrical shock can result in serious personnel injury, including death!

- Dismantling the pipes on the vessel head.
- Carefully remove the cover and the gasket on the adsorbent. If the gasket is damaged, a new gasket must be used.
- The flange on the edge of the vessel and cover must be cleaned before filling.

CAUTION	A sieve insert is installed in the adsorbent cover and bottom, which must not be damaged. Otherwise, you must notify **BIOFerm Energy Systems** as the system cannot be operated properly! The sieve insert must be repaired or replaced!

- We recommend emptying the adsorbent with an explosion-proof industrial vacuum cleaner. On the bed, there is a compressed coconut fiber mat to hold the coal bed in place and protect it as carbon abrasion may occur during transport and pressure change. The old coconut mat must be replaced with a new one if the spring action is reduced!
- The filling material is a specially prepared carbon material and can be ordered from **BIOFerm Energy Systems**.
- The new filler material is poured into the empty vessel. Uniform packing in the vessel is very important. It may be necessary to level the surface. The material must be compacted against the vessel casing with light strokes, for example using a plastic hammer. Under certain circumstances, a pneumatically driven vibrator must be used. The vessel is filled until the surface is flush with the edge of the vessel.
- Carefully clean the container rim and add new seal.

NOTICE	It must be ensured that the sealing surfaces are thoroughly cleaned. When closing the container head, no carbon particles or similar objects may be compressed between the sealing surfaces! Leakage would occur at the soiled areas under gas pressure and re-tightening the head bolts will not seal the container! If this happens, the container must again be inerted, opened, cleaned, and re-closed.

DANGER	There must be no carbon particles between the sealing surfaces on the container head! Even the smallest carbon particles or similar objects will cause leaks, which will cause bursting of the seal under gas pressure. Ejected seal parts act as projectiles and can cause serious injury, including death, to personnel!

- Place coconut mat on the smooth surface and add adsorbent cover.
- Make sure that no coal particles are between the sealing surfaces and then install the cover and piping system.
- For inerting the PSA unit, see the **Chapter "Inerting of the System"** and Regenerating of the Adsorbent.

The following applies for the replacement of the activated carbon in the H_2S adsorbents:

- Inert the H_2S stage as described in the **Chapter "Inerting of the System"**.
- Remove insulation, cover and perforated sheet from the adsorbent head.

DANGER	Residual pressure in the piping system may result in serious personnel injury, including death!

CAUTION	Depending on the previous operating mode, there may still be combustible gas in the void volume of the activated carbon bed. After inerting, a gas detector must be used that no more methane is out-gassing! The rules for handling of flammable gases apply when emptying and storing of spent activated carbon!

- Empty the H_2S stage using vacuum trucks.
- Fill the H_2S stage with KI-activated carbon.
- Clean container edge and insert new gasket.

NOTICE	The sealing surfaces must be thoroughly cleaned. When closing the container head, no carbon particles or similar objects may be compressed between the sealing surfaces! Leakage would occur at the soiled areas under gas pressure and re-tightening the head bolts will not seal the container! If this happens, the container must again be inerted, opened, cleaned, and re-closed.

To avoid the risk of leaks, new seals must be used!

DANGER	There must be no carbon particles between the sealing surfaces on the container head! Even the smallest carbon particles or similar objects will cause leaks, which will cause bursting of the seal under gas pressure. Ejected seal parts act as projectiles and can cause serious injury, including death, to personnel!

- Close H_2S stage and reinstall isolation.
- Inert H_2S stage as described in the **Chapter "Inerting of the System".**

5.3 Instruments, Valves, Small Parts

Most parts of the system cannot be repaired by the operator and must be replaced if damaged or not functioning properly.

At the request of the operator, **BIOFerm Energy Systems** will provide suggestions for a spare parts list. Use only the spare parts specified by each subcontractor.

If the system is taken out of service for a longer period of time, all the valves must be carefully operated by hand from time to time to ensure smooth running of the valves.

5.4 Decommissioning and Conservation

If the system is not used for a longer period of time, the adsorbent must be purged with nitrogen and then pressurized with nitrogen. This prevents the diffusion of moisture into the vessel. Water would be absorbed by the activated carbon, thereby deteriorating the efficiency of the separator material.

The procedure of de-pressurizing, purging, and pressurizing the PSA unit is described in the **Chapter "Inerting With Nitrogen".**

See **Chapter "Inerting of the System".**

From time to time, all valves must be opened carefully by hand to ensure the smooth operation of the valves. This applies particularly to the parts of the system that are installed outside the vessel.

6 Measures When System is Out of Operation

In case of prolonged shutdown of the system, various measures must be taken to ensure a problem-free restart of the system after a shutdown and that no system components are damaged during the shutdown.

6.1 Shutdown of the System

The system should be shut down using the FGC mode "Shutdown". This ensures that all necessary shutdown steps are performed. Only the AO instrument air and building technology equipment remain switched on.

If the entire system is not in operation, individual SGCs and AOs can of course be switched off as well via the respective operating modes.

If the power supply is maintained, the AO instrument air and ambient air monitoring should remain on. This allows for monitoring the ambient atmosphere for explosive or toxic gas mixtures and ensures that vessels are kept frost free. Secondly, the instrument air pressure is maintained in order to be able to restart the system quickly. It should however be noted that the control valves have requirements for continuous air even if the system is not operating. The control is not required for mere ambient air monitoring.

If the whole plant is shut down in cold weather, and hot gas is trapped inside the biological desulfurization scrubbers, the pressure might gradually fall below the ambient pressure, when the gas inside cools down. The biological desulfurization scrubbers cannot withstand negative pressure. Therefore the local pressure gauges have to be monitored regularly during a shut down in cold weather. If the pressure is falling too much, the manual valve HH00.31.02 or HH00.41.02 respectively has to be opened shortly to aerate the system and equalize the pressure inside and outside the scrubber towers.

6.2 Conservation for Prolonged Shutdown

In case of prolonged system shutdown, further measures are also necessary:

- De-pressurize the complete system using appropriate manual operations.
- Purge complete system with nitrogen using appropriate manual operations.
- Empty any existing condensate from the gas conditioning and the condensate collection vessel using the manual locks.
- If frost protection cannot be ensured inside the vessel during the system shutdown, the entire condensate system must be emptied.
- The cooling water and chilled water system does not have to be emptied provided that adequate frost protection is ensured. The glycol content should be measured if necessary.
- Close shut-off valves at the transfer points for biogas and biomethane.
- Pressurize system with nitrogen at low pressure, 2 bar, from the inlet of the gas conditioning to the exit of the PSA system.
- Pressurize desulfurization vessel with nitrogen at low pressure, 2 bar.
- Check nitrogen pressure in the system from time to time and restore original pressure if the pressure drops.

NOTICE	Control valves may have minor leaks. In order to ensure ongoing nitrogen pressure, it may be necessary to install line blanks.

7 Operating and Monitoring

The WinCC User Interface by Siemens is used for operation and monitoring of the system. The HMI allows the process operator to interact with the control system for the plant using a graphical interface (screens). This chapter will describe the basic principles for using the system. Further information on the visualization system "WinCC" can be found in the WinCC documentation that is installed on the operation and monitoring computer (operator station).

The user interface is installed on a PC and communicates with the system controller via an Ethernet interface. This PC is called operator station.

The remote maintenance is performed via the Internet to which the PC is connected via an Ethernet connection. The VMware software is installed for remote maintenance and is started only for the purpose of remote maintenance.

The installation of additional software, in particular updates and security updates, is not permitted, because they can jeopardize the stability of the control system and can shut the plant down.

The PC is to be used solely for the operation of the system. Any other use of this PC can violate the plant warranty.

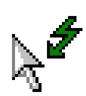
7.1 User Interface

The user interface is divided into several screens. The headers and footers of all screens are identical. The header includes, among other things, a navigation bar, which can be used to switch between screens, and a message bar, which displays the most recent message.

The Piping and Instrumentation Drawings are the basis of the process screens.

The system is operated using a keyboard and mouse. Individual system components are operated via standardized faceplates. These can be accessed by clicking the corresponding icon, tag, or value.

If something on the screen can be interacted with, it is indicated by a green lightning bolt on the mouse pointer. Most icons, measurements, and some equipment can be interacted with. These interactions can include: opening trends, opening more detailed screens, opening the next screen for the process, and opening faceplates for equipment that offer control options.



Greyed-out control buttons cannot be used. This is mostly due to the restrictions of user privileges and meant for the protection of the operator and the system.

Changeable values are indicated by white letters on a blue background.

The pipes are shown in different colors, depending on the medium in them.

7.1.1 The Header

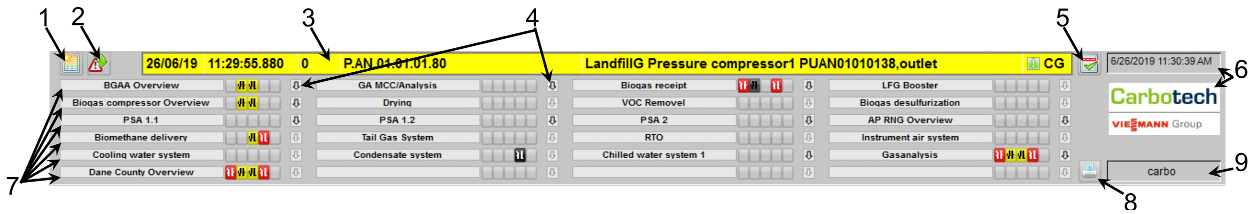


Figure 7.1: **Header**

No.	Function	Description
1	Alarm List	Displays the last 1000 unacknowledged messages/alarms
2	Loop in Alarm	Left click jumps to the page of the displayed message/alarm
3	Display of the last incoming message/alarm	Double-click on the message bar causes the screen to display the corresponding screen. The exception are system-generated messages. They will only appear in the alarm list.
4	Screen Tree Navigator	The "Screen Tree Navigator" (Fig. 7.3) is accessed by mouse-click and can be used to display and select the operating screens of the associated assemblies. Likewise, alarms, warnings, faults, and errors are displayed above. By clicking the corresponding assembly or an icon of an active event, the corresponding page is opened.
5	Acknowledge	Acknowledges the displayed message
6	Company Logo, Date and Time of the Operator Station	The time and date is taken from the operating system on the PC.
7	Parent Screens	Change to the selected screen: • (Overview screen of the associated units)
8	Printer	Prints the current page to the default printer
9	Current User	Displays the current logged in user. The login window can be opened with a click in order to switch user by entering a new username and password.

Table 7.1 **Overview - Header**

The buttons of the header can be used to switch between the screens of the system. The notification system displays alarms, warnings, faults, errors, and their statuses by color change.

For a single event (alarm, warning, fault, and/or error), clicking on the notification takes the user to the corresponding screen. In case of multiple events, the parent screen is automatically selected.

7.1.2 Screen Selection

Figure 7.2: Page Selection

The main button "02 Biogas Compressor" will open the main screen for the biogas compressor when clicked. The5 boxes to right of the button show if any of the equipment, loops, or sequences in the main screen or the sub assemblies screen are in an alarm, warning or error state:

- **AH** Alarm High - Violation of upper alarm limit (UL2)
- **WH** Warning High - Violation of upper warning limit (UL1)
- **WL** Warning Low - Violation of lower warning limit (LL1)
- **AL** Alarm Low - Violation of lower alarm limit (LL2)
- **F** Measurement error, measurement error (see description in Chapter 7.5)
- **S** Loop communication error, measurement error (see description in Chapter 7.5)

7.1.3 Screen Tree Navigator

Under the image of the "Screen Tree Navigator," all sub-assembly screens of the BUP are listed with the symbols of the current events, limit violations, incidents, according to the tool bar "Page Selection," Figure 7.2. By clicking the down arrow button with a screen name, e.g., "BGAA Overview" the Screen Tree Navigation window is opened.

Figure 7.3: BGAA Overview Screen Tree Navigator

7.1.4 The Footer

The footer contains 2 rows of buttons:

Button Set 1

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Figure 7.4: Footer - Button Set 1

No.	Function	Description
1	Button Set Change	Change the footer to Button Set 2
2	Login	Logon/logoff user
3	Alarm List	(See alarm lists and functions WinCC)

No.	Function	Description
4	Protocols	Print system data
5	Operating hours counters	Use this function to display the operating hours of motors on the corresponding pages. The monthly operating hours screen is shown under the parent screen "Parameters BUP" and displays the operating hours for all rotating equipment.
6	Screen via Name	Screens can be accessed directly via their name
7	Screen left	Select the previous screen from the parent screen
8	Screen above	Select the parent screen
9	Screen below	Select the first screen below the parent screen in the tree
10	Screen right	Select the following screen from the parent screen
11	Previous screen	Select the previously opened screen
12	Next screen	Back to previous screen
13	Save screen	Saves the current screen
14	Show screen	Access the last saved screen
15	Access compilation screen	Saved screen compilations can be accessed here
16	Save screen compilation	Screen compilations can be saved here
17	Delete screen compilation	Saved screen compilations can be deleted here
18	System configuration	Access the screen with the hardware configuration of the process control system
19	Screen information	System information for the user interface
20	Acknowledge error	This button acknowledges all events on the current page.

Table 7.2: Description Footer - Button Set 1

Button Set 2

1 2 3 4 5 6 20

Figure 7.5: Footer - Button Set 2

No.	Function	Description
1	Button Set Change	Change the Footer to Button Set 1
2	Switch language	Used to switch between the configured languages. English and German are configured
3	Lock message	Not used.
4	Unlock messages	Not used.
5	User Administrator	Opens the User Administrator
6	Close WinCC	Closes the User Interface
20	Acknowledge error	This button acknowledges all events on the current page.

Table 7.3: Description Footer - Button Set 2

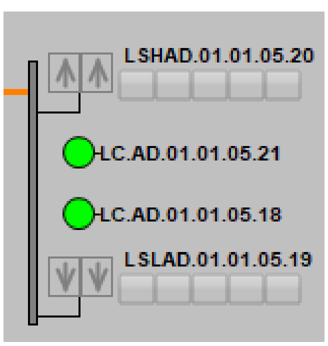
7.1.5 Symbols of Control System User Interface

The user interface of the control system uses symbols commonly used in process engineering.

The color changes of the symbols indicate the different states of the actuators/sensors. A left mouse click on these screen icons will open an operating window, also called faceplate, through which the selected component can be operated.

7.1.5.1 Digital Limit Switch Modules:

Limit switches have only 2 states (on or off). They can show that level is at a certain height or it isn’t, but they can show what percentage full of liquid a vessel is. They can show that there is flow or there isn’t flow, but not how much flow.



Limit Switch

Color change to red = Limit alarm or warning

AH Alarm High - Violation of upper alarm limit (UL2)

WH Warning High - Violation of upper warning limit (UL1)

WL Warning Low - Violation of lower warning limit (LL1)

AL Alarm Low - Violation of lower alarm limit (LL2)

F Measurement error (see description in Chapter 7.7)

S Instrument Communication Error (see description in Chapter 7.7)

Icon with magenta background = Sensor is in simulation mode

Icon with background = Sensor is in service mode

The yellow background of a measuring point name identifies a safety instrumented system (SIS) related instrument.

The dot color to the left of the Tag No.: LC.AD.01.01.05.18 (level switch) changes from green to red when the liquid level falls below this level.

Faceplate for Digital Limit Switch

The Faceplate of the digital inputs is opened by clicking the icon.

In the top row on the left, the tag number is displayed while on the right, the plain text of the measuring point is shown.

The current state of the release function is indicated in the Enable text box (green text = enabled, red text = disabled) and the position of the switch (open = disabled, closed = enabled).

The monitoring of the enable and damping time is shown in the boxes for “Actual Time” and the respective give target times are show in the boxes “Target Time” (set point time) with white text on blue background.

After clicking the release target time window or damping target time window, the time can be changed as desired.

A color change to red in the fields "Contact" (limit switch) indicates that the limit switch tripped.

Simulation switch can be used to simulate the digital release and the digital limit contact.

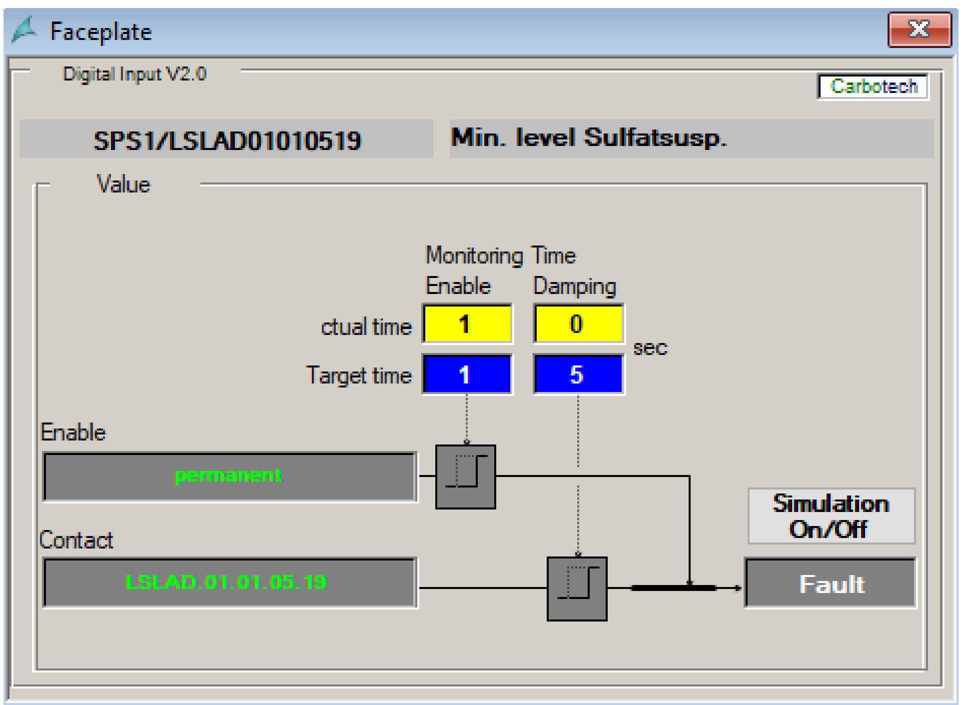
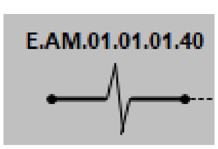


Figure 7.6: Digital Limit Switch Faceplate

7.1.5.2 Heater Modules:

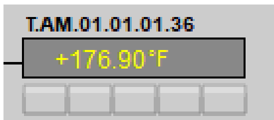


<u>Heater</u>

These indicate an electrical resistance heater, often used for space heating in a container or for heat trace. There is no faceplate for these heaters.

7.1.5.3 Instrument (Analog) Modules:

This section describes the function of independent instrument modules. These instrument modules measure process pressure, temperature, flow, pH, or other process condition. They measure the actual value within their specified range. These modules have alarms and warnings and may be connected to the interlocking logic of other modules. These instruments are standalone though in that they are not part of a PID control loop



Instrument

AH Alarm High - Violation of upper alarm limit (UL2)

WH Warning High - Violation of upper warning limit (UL1)

WL Warning Low - Violation of lower warning limit (LL1)

AL Alarm Low - Violation of lower alarm limit (LL2)

F Measurement error (see description in Chapter 7.7)

S Instrument Communication Error (see description in Chapter 7.7)

Right-clicking on measured value opens the trend.

Icon with magenta background: Sensor is in simulation mode. In simulation mode, the measured value display and processing is decoupled from the hardware. Any measured value can be entered in the Faceplate, which will be processed instead of the actual measured value. This does not apply to any SIS interlocks programs. For instrument modules in the SIS, while the simulated measured value is displayed in the visualization and is changeable, the measured value is still used for any SIS related interlocks.

The yellow background of an instrument PID tag identifies a safety instrumented system (SIS) related instrument. If an SIS interlock is triggered, it must be acknowledged in the SIS system.

Faceplate Overview for Instrument Modules

The Instrument Module Faceplate displays the current measured values of the instrument.

For instruments that are part of PID Control Loops, see Section XXX

The Instrument faceplate is divided into two sections:

- Value – displays current value, alarm and warning set points, Hysteresis and a bar graph showing the current instrument reading
- Operation – has 3 buttons “Value”, “Limits”, and “Diagnostic” by clicking on these buttons different operational functionality is available. By default, clicking on the instrument opens to the Value Faceplate.

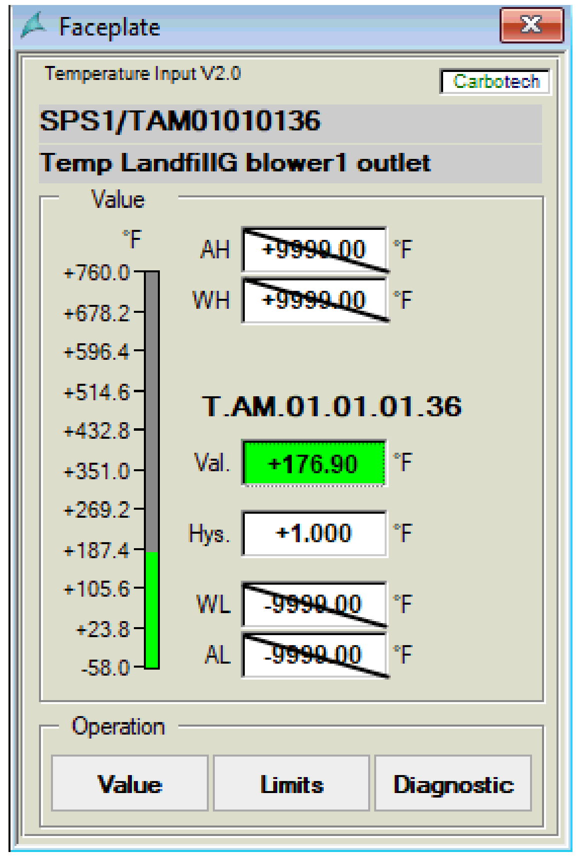


Figure 7.7: Instrument Faceplate

Measured Value Faceplate for Instrument Modules

The first measured faceplate is shown in Figure 7.8: Measured Value Faceplate 1. This figure shows a faceplate that is in normal operation. The second measured faceplate shown in Figure 7.9: Measured Value Faceplate 2 is in alarm.

For Measured Value Faceplate 1, the alarm and warning points are set at ±9999.0 and crossed out this indicates that for this instrument the alarms and warnings are deactivated. For Faceplate 1, since it is not in an alarm or warning state, both the measured value and the bar graph are shown in green.

For Measured Value Faceplate 2 there are a couple items of note that make this faceplate different than Measured Value Faceplate 1. First, the header line “SPS1/PAP01010160” and the “AH psig” are highlighted yellow indicating that this instrument is part of the Safety Instrumented System (SIS). This yellow highlight also indicates that the High Alarm set point will trip an SIS interlock. Second, the value (+242.80) box and the AL box are red, and the WL box is yellow. The color change in these boxes indicates that the current value is below both the lower limit warning and alarm set points. Additionally, the bar graph is also red again indicating that the instrument reading is in an alarm state.

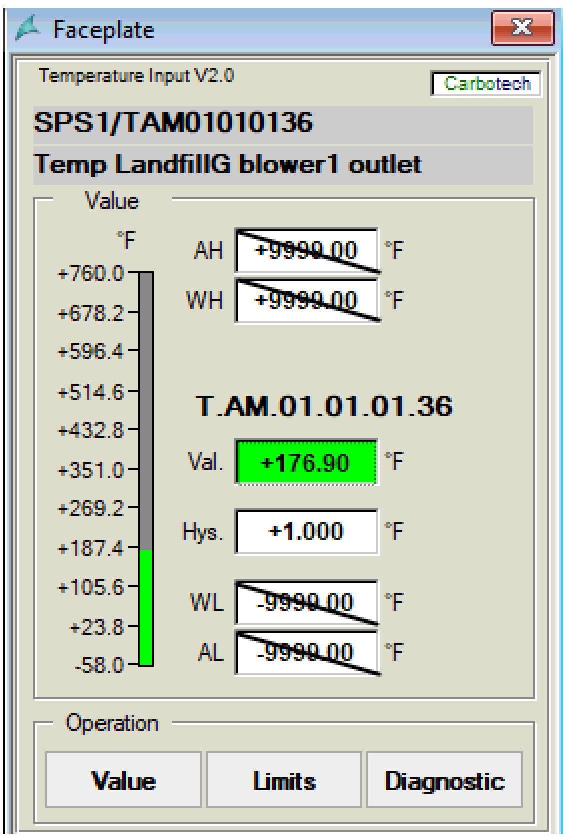


Figure 7.8: Measured Value Faceplate 1

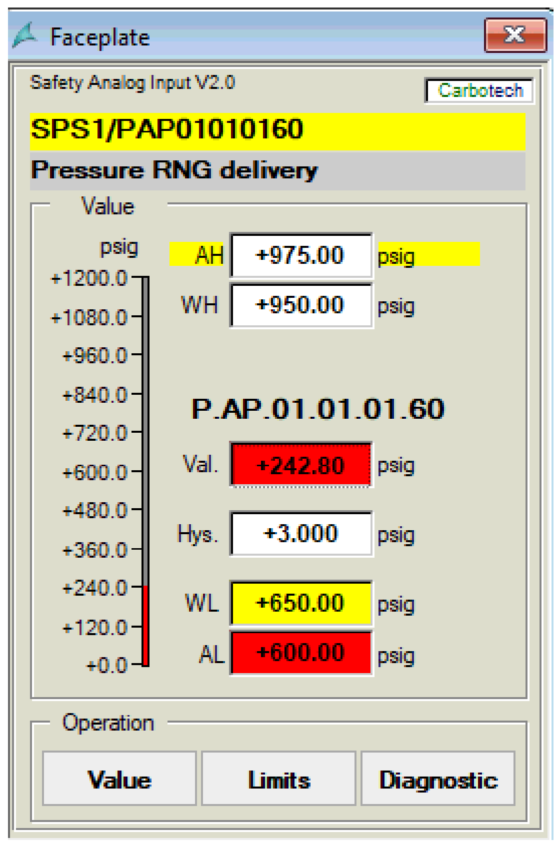


Figure 7.9: Measured Value Faceplate 2

Measured values

Tag No.	
Measuring points short text	Display with magenta background when sensor is in simulation mode

Measurement Scale

Measurement Scale	Scale for displaying the current measured value
Color change of the scale bar	
Depending on the limit violation, the scale bar is colored as follows:	AH / AL = red WH / WL = yellow
WH / WL AH / AL	**W**arning **H**igh / **L**ow limit: triggers a warning **A**larm **H**igh/**L**ow limit: triggers an alarm

Limits

Color change for limit values	Yellow= high or low warning limit violated Red = high or low alarm limit violated
Actual value display:	Current measured value The background color matches the bar graph color.
If the limit is exceeded by the current process value the field color changes according to the limit severity:	AH / AL = red WH / WL = yellow
Hysteresis:	Hysteresis of the limit values defined in Section 7.2

Operation

Button set for switching the faceplate:	• Measured values • Limits • Diagnostics

Limits Faceplate for Instrument Modules

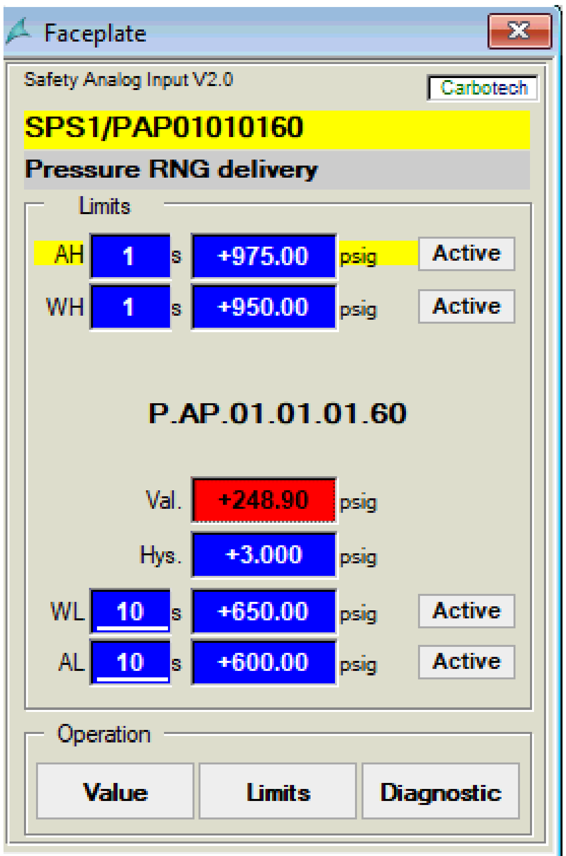


Figure 7.10: Example Limit Value Faceplate Instrument Module

Selecting the “Limit” button on the operation section of the main instrument module faceplate opens the Limit Faceplate. This faceplate is used to enter or change the limits, damping times, and hysteresis.

The limits, dampening times, and hysteresis are changed by overwriting the values. When the text is shown as white on a blue background this indicates that the user can change the values, unless they are set by the SIS system.

The limits can be activated or deactivated via the active/inactive buttons next to the limit set points.

For dynamically deactivated/activated limit values, an initial delay time is also available. This cannot be observed or changed via the HMI but must be modified directly in the programming logic. Limits might be dynamically activated/deactivated by automated sequences or other logic and interlocks that are variable depending on process conditions. They are also crossed out in the deactivated state and will be accepted by the program this state.

Limits

Dampening times	The first box next to the limit labels (AH, WH, WL, AL) is the dampening times, since these boxes are with white text, they can be changed
Limit & hysteresis values	The second box next to the limit labels (AH, WH, WL, AL) is the limit values. These limit values and the Hysteresis set point are with white text and they can be changed Hysteresis of the limit values defined in Section 7.2
Color change for limit text	Yellow= high or low warning limit violated Red = high or low alarm limit violated
Actual value display:	Current measured value The background color is Green if no limits are violated; otherwise it becomes Yellow or Red depending on the severity of the limit violation.

Operation

Button set for switching the faceplate:	• Measured values • Limits • Diagnostics

Diagnostics Faceplate for Instrument Modules

The Diagnostics Faceplate is used for troubleshooting or loop logic fault correction. To this end, this faceplate offers the possibility to simulate the actual value of the measuring point, i.e., manually enter any value.

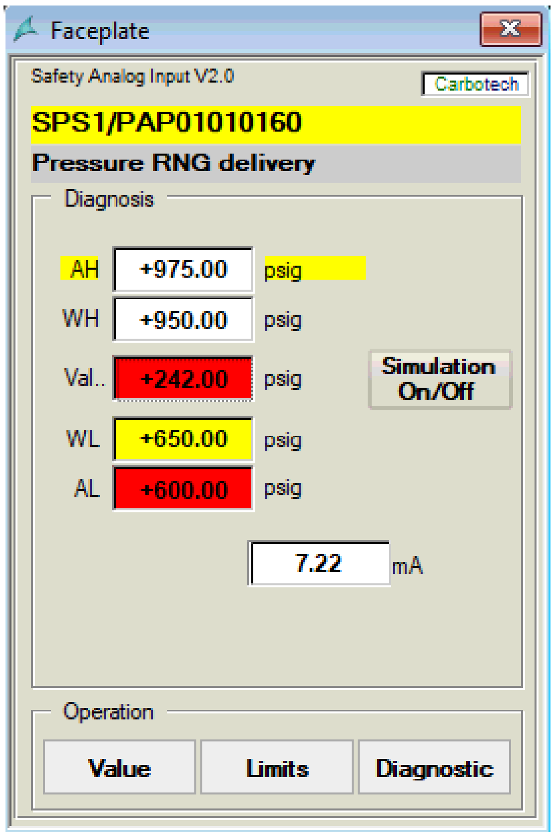


Figure 7.11: Example Diagnostic Faceplate Instrument Module

Tag No. and measuring point short text:	Display with magenta background:	Sensor is in simulation mode
Values can be changed with mouse click and administrator privileges		

Diagnosis

Input / Output Fields	
Output fields for displaying and changing the limit values	Alarm Limits AH, AL and Warning Limits WH, WL of the measured value
Actual value display:	Current measured value The background color is Green if no limits are violated; otherwise it becomes Yellow or Red depending on the severity of the limit violation. When simulated, the user can enter the simulated value here. Otherwise, this will display the current measured Value.
Current Instrument Signal (mA)	Regardless of if the instrument is simulated or not, this will display the current signal coming from the field instrument. Usually this is in mA.
Simulation On/Off Button	
With the button Simulation On/Off the input signal of the measuring point [mA] is decoupled from the value shown in the Val. box. Using the Val. Input-field an arbitrary value can now be entered to simulate a new measured value. This function is not available for SIS functions, so that a SIS shutdown cannot be deactivated or simulated with this function. Safety-related circuits can never be simulated.	
The measured value is decoupled from the process and can be entered via the Val. field.	
The simulation is not available for SIS parts of the program. That means the shutdowns in the SIS program are not affected by the simulation and will always cause a shutdown.	
Input/output field of the analogue input value in mA	Output field of the analogue input value of the measured value in mA or, in case of a simulation, input field for the simulation value

Operation

Button set for switching the faceplate:	• Measured values • Limits • Diagnostics

CAUTION	A change in the limit values can cause unstable operation of the system. The same applies to accidental activation/deactivation of limit values. Special caution is required for simulations, since the entry of unfavorable simulation input values can actually cause an alarm with a resultant system shutdown. Since the measured value is simulated, no shutdown can be caused by the measured value.

Locking interlock component, only sub-assemblies and functional group control:

All listed interlocking conditions are released only by activating the start-up or operating step sequence of the corresponding sub-group/functional group.

The interlock component contains "or" operations, i.e., as soon as one of the interlocking conditions listed is violated, the functional group or sub-group is switched off. In case of a violation of any conditions contained herein, the color of the tag no. field changes from grey to red, or from green to red for the prepended OR operation and the subsequent main OR operation.

Force: The button "Force" can be used to deactivate any individual condition (but requires corresponding rights).

A violation of one of the interlocking conditions is saved and released only after pressing the "Quit" (acknowledge) button.

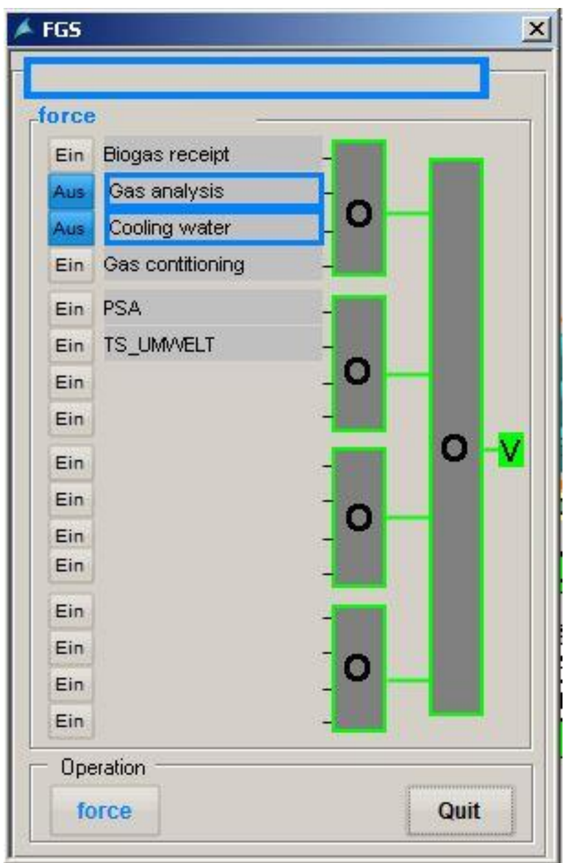
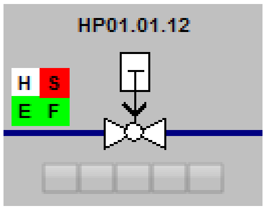


Figure 7.12: Interlocks

Coaxial valve/ball valve/valve

Coaxial valve/ball valve with pneumatic drive



The ball valve/valve shown is in the safety position "Closed".

The sign above the ball valve/valve indicates that the ball valve is electrically/ pneumatically controlled.

A color change displays the ball valve/valve graphically in green (feedback).

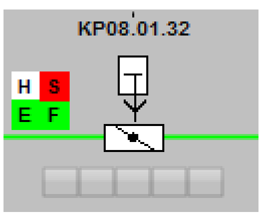
If the icon is shown in magenta, the ball valve/valve is in simulation mode.

If the icon is displayed in red **and** flashing, there is an error or a fault at the ball valve/valve.

Display to left of the ball valve:

A/M	green	automatic/manual mode activated
R/R	green	release granted
O/O	green	switch-on release granted
S	red	STOP

Valve with Pneumatic Operation



The valve shown is designed in the safety position "Closed".

The sign above the valve indicates that the door is electrically/pneumatically controlled.

A color change displays the valve graphically in green (feedback).

If the icon is shown in magenta, the valve is in simulation mode.

If the icon is displayed in red **and** flashing, there is an error or a fault at the valve.

Indicator to the left of the valve:

A/M	green	automatic/manual mode activated
R/R	green	release granted
O/O	green	switch-on release granted
S	red	STOP

Valve Faceplate

The Valve Faceplate controls the valves/valves of the system.

For control valves, see Chapter "Control Valves".

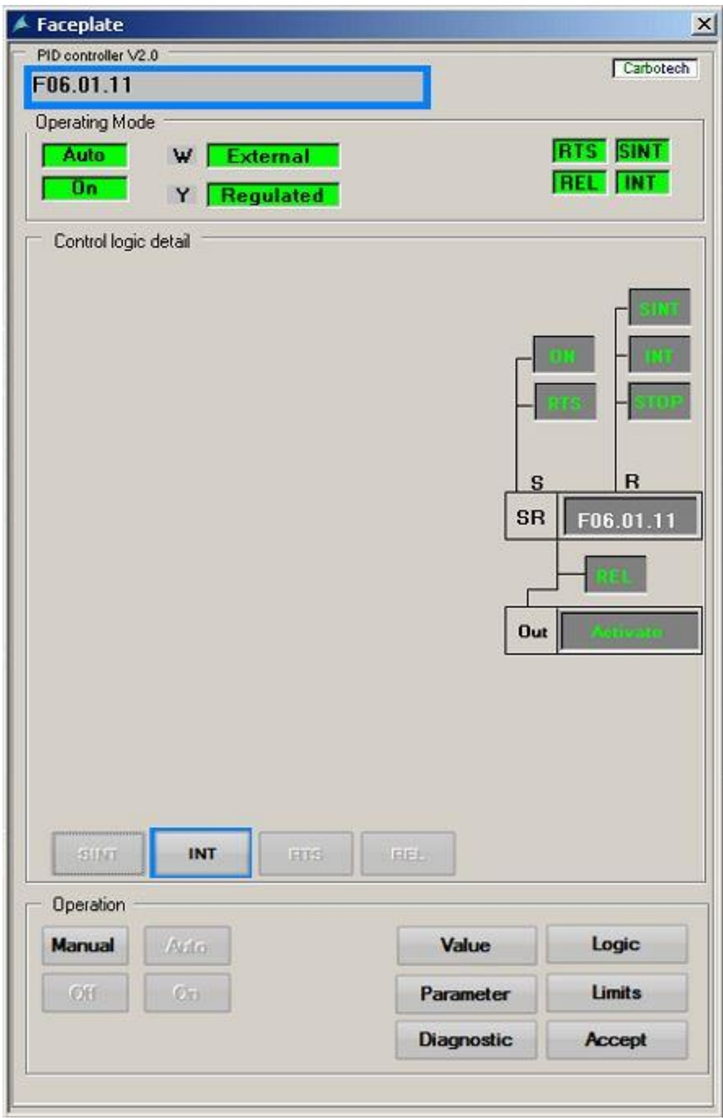


Figure 7.13: Valve Faceplate

The **"Valve" (Ventil) Faceplate** is divided into "Operating State" (Betriebszustand), "Control Logic" (Steuerlogik), and "Operation" (Bedienung).

Tag No. and measuring point short text:	Display with magenta background: Display with background:	Actuator in Simulation Mode Actuator in Service Mode

In the operating state section, the following is displayed:

"Hand/Auto" (Manual/Auto)	Manual/automatic mode selected
Automatic **active**	**Green**
"Ein/Aus" (On/Off)	Turned **On**/turned **Off**
HDE	Status manual input (0/1)
ACE	Status Forced Automatic (0/1)
AW	Status automatic input (0/1)
FF Feedback Fault	Possible causes: - Drive is switched on and but does not returns drive feedback - Drive is switched off and returns drive feedback
IF Interlock Fault	If VS (IF) is shown, there is an interlock fault, which can be seen in the "Steuerlogik" (Control Logic) under "VERR" (LOCK) or "ZVERR" (ZLOCK).
Stop Emergency stop is triggered (flashing)	If Stop is displayed, the emergency stop of the system has been triggered.

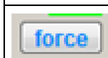
In the **"Control Logic" (Steuerungslogik)** section, the following is displayed:

Graphical representation of the control logic with display of the input and output signals

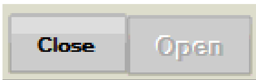
In the control logic, the conditions required to switch on the drive are visualized

Green font: Condition is satisfied

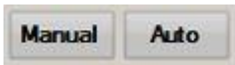
font: Condition is not satisfied

Z-LOCK	The controller is locked for safety-related reasons
LOCK	The drive can be locked for several conditions. An interlock fault has to be acknowledged!
RTS	The release to start does only need to be existent once when turning on the valve. Thereafter, the flip-flop is set and the valve stays ON until it is switched OFF by an **OFF** command or the **"LOCK"** or **"STOP"** conditions. The conditions **"ON"** and **"RTS"** are linked by a logical **"AND"** condition, which means that both conditions must be met (font color green) in order for the flip-flop to be set and the drive to be switched on.
CLEAR	The **"CLEAR"** condition between the RS-FF and the drive is an additional condition that must be met in order to control the valve.
	The "**Service**" switch can be used to show additional buttons that can be used to force, bridge or **"set"** individual conditions. Service operation: **In service mode, individual locks, releases, and switch-on releases can be forced. The service mode is an unsecured system operation to be used only for special service calls. Z locks cannot be forced.** **The service operation can only be activated by granting the appropriate rights.**
Monitoring of operating hours: If the switch of the operating mode in the control is not confirmed within the operating hours monitoring, a feedback fault is triggered	**Set time** Time limit for switching the operating state
	Actual time Current time since switching the operating state from **On** to **Off** or from **Off** to **On**.
Switching the interlocking logic:	Shift key to display the detailed conditions of the switching logic. The arrow above a button indicates the active logic

In the **"Operation" (Bedienung)** section, the following is operated:



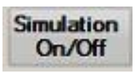
Open/**close** valve in manual mode



Manual-Operation for manual control of the valve

Automatic operation

The valve is switched on or off by the controller.

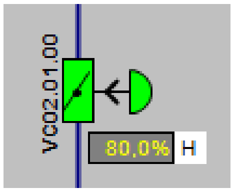


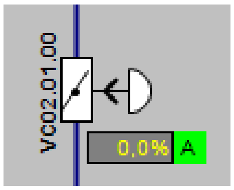
Simulation mode **On/Off** - Release for setting the input signal for the measuring point.

In simulation mode, the valve can be opened/closed and the controller returns the corresponding drive feedback without the output being set/reset. This mode is useful for testing the automatic operation.

ACKnowledgment of alarm and warning messages

Control valve





Information on the control valve shown:

Icon green:	Valve > 2% open
Icon with magenta background:	Actuator in Simulation Mode
Icon with blue background:	Actuator in Service Mode
Aggregate purple / red	error or fault
A/M	automatic/manual mode activated

In the field to the bottom and on the side with the message "80.0%" or "0.0%," the ACTUAL value of the actuator is displayed.

Click the window of the displayed ACTUAL value of the actuator to open the Faceplate of the set point adjuster.

For more information on the set point controller, see under Set-point Controller Faceplate

Symbol Controller

Controller

Yellow font:	Actual value
Blue font:	Set point
Brown font:	Control variable

AH	Alarm High - Violation of upper alarm limit (UL2)
WH	Warning High - Violation of upper warning limit (UL1)
WL	Warning Low - Violation of lower warning limit (LL1)
AL	Alarm Low - Violation of lower alarm limit (LL2)
F	Measurement error, see description in Chapter 7.7
S	Assembly error (see description in Chapter 7.7
IF	Interlock fault
S	Stop
A/M	green automatic/manual mode activated
R/R	green release granted
O/O	green switch-on release granted
EX/IN	Set point source external/internal
YA/YM	Valve automatic operation/valve manual operation

Icon with magenta background	sensor is in simulation mode
Icon withblue background	sensor is in service mode
1. left mouse click:	Open Analogue Value Faceplate
2. left mouse click:	Open Controller Faceplate

Right mouse click on the set point/control value field:
Open Trending

Right mouse click on the current measurement value:
Open Analogue Faceplate

PID Controller Faceplate

The operation and setting of controllers is done through three operating windows. When accessing the Controller operating window, the operating window "Regulator Values" (Reglerwerte) always appears first. The remaining operating windows, "Control Parameters" (Regelparameter) and "Interlocking" (Verriegelung) can be accessed in the "Operation" (Bedienung) section of the PID Controller Faceplates.

The Controller Faceplates differ in the middle input/output field.

The Actual Values Faceplate is used to display the current controller parameters. For specific parameters, there is an option to simulate these values, for example in diagnostic mode, i.e., manually parameterize them.

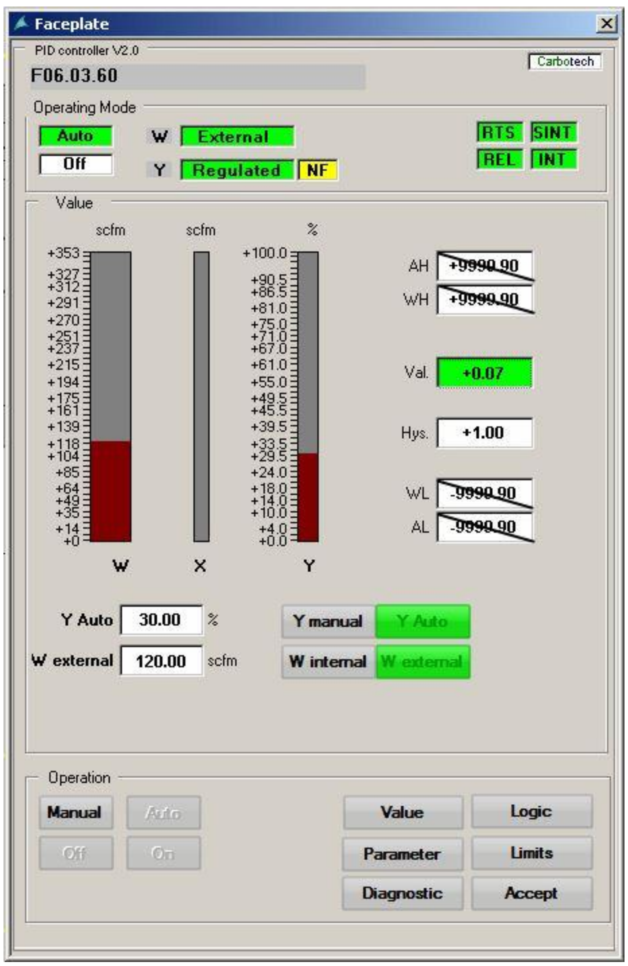


Figure 7.14: PID Controller Faceplate "Actual Values" (Istwerte)

Description of PID Controller Faceplate:

Description	Name of the controller	
Operating state	**Manual** operation/ **automat**ic operation selected Set point Set point entry Operating mode	**MANUAL/AUTO** Set point source **W INTERNAL/EXTERNAL** **"Yman/Yauto"** Control **manual/auto** The active mode is shown in **green**.
Set point W Variable Y Input/output field for set point Y (variable entry) Input/output field for set point Y (set point entry) Bar graph	Input/output field for actual value X and bar graph Input/output field for variable Y and bar graph : Entering the internal set point W_Int is possible White: Display the external set-point W_Ext : Entering the internal set point W_Int is possible White: Display the external set-point W_Ext Bar green Actual value is within the limits Bar yellow Value is above or below inner actual value limit Bar red Value is above outer actual value limit Bar , entry field white	
Limit input for controller	Input/output fields for limit values of the actual value changed by selecting the "Grenzwerte" (Limit Values) button UL1 and UL2 upper limit values LL1 and LL2 lower limit values Actual value Controller hysteresis	
Variable and set-point entry	W_ext/W_int Switching between set-point source between controller (internal) and from peripherals (external set-point is determined by software, e.g., in the case of master controllers) Y_man/Y_auto Switching between manual variable value entry and automatic variable value transfer from controller	

Description	Name of the controller	
Operation	**"Hand" (Manual)**	Choose **manual** operation of the controller
	Auto	Choose **auto**matic operation of the controller
	On	Switching **On** the Controller
	Off	Switching **Off** the Controller
	Diagnostics	Possibility of simulation of the actual value
	ACK	**Ack**nowledge interlock
	Actual value	Displays the associated current actual values
	Interlocks	Displays of the interlocking matrix
	Limits	Display and input window of the limit values
	Parameter	Display of other controller parameters

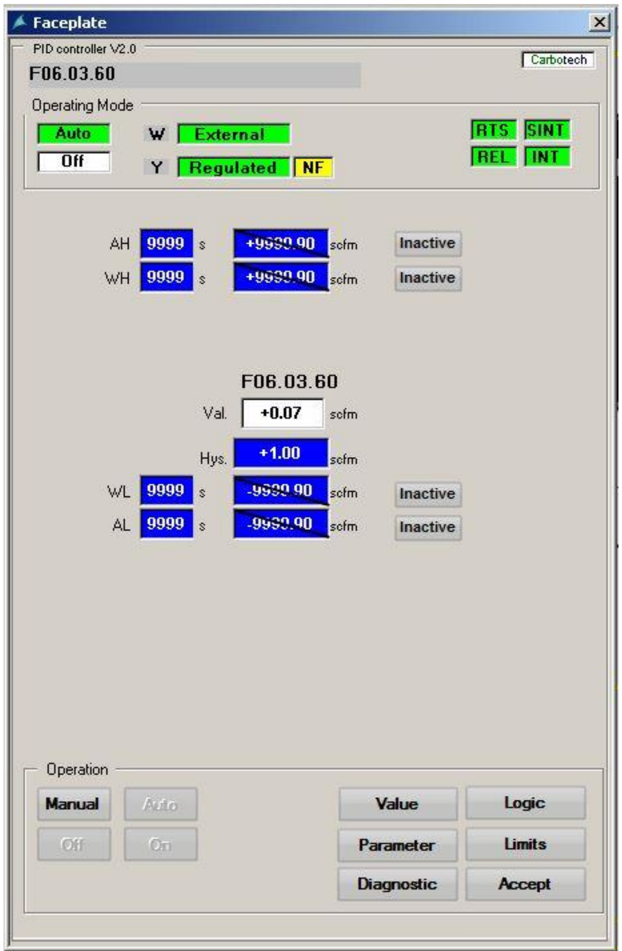


Figure 7.15: PID Controller Faceplate "Limit Values" (Grenzwerte)

The PID Controller Faceplate "Limit Values" (Grenzwerte) is used to enter or change the limit values and damping times of the measured values (X)

UL2, UL1, LL1, and LL2.

The limit value monitoring can be activated or deactivated via the buttons "inactive" (inaktiv) or "active" (aktiv).

If activations/deactivations are set by the program, they cannot be changed here.

For dynamically deactivated or activated limit values, a start-up time is also available.

This cannot be observed or changed via the visualization.

PID Controller Faceplate "Interlocks" (Verriegelungen)

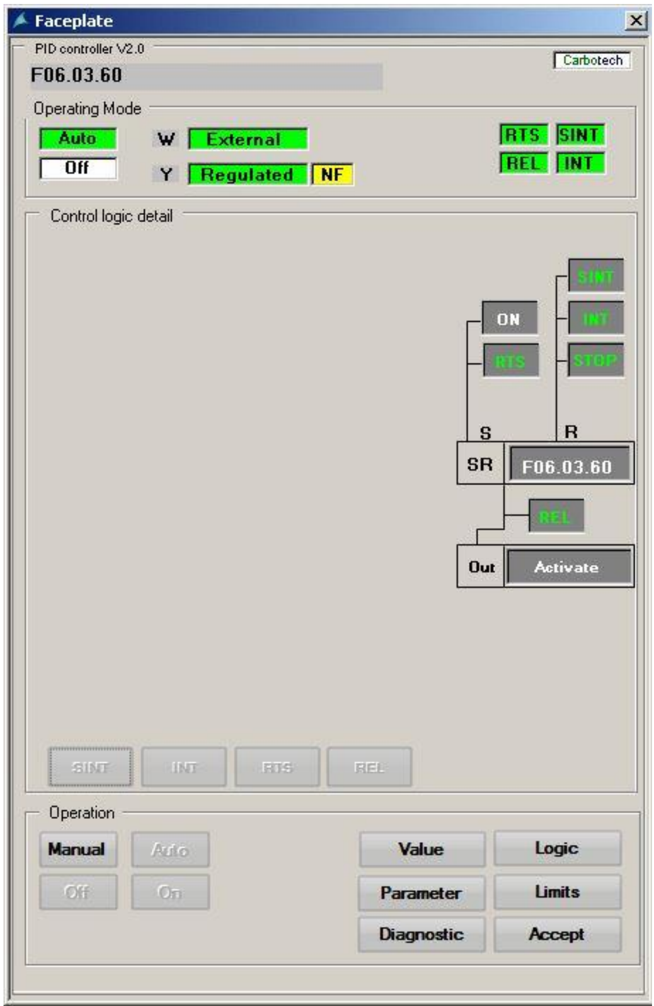


Figure 7.16: PID Controller Faceplate "Interlocks" (Verriegelungen)

Z-LOCK	The controller is locked for safety-related reasons
LOCK	The controller can be locked for several conditions. An interlock fault has to be acknowledged!
RTS	The release to start must be given only once when turning on the controller. Thereafter, the flip-flop is set and the controller stays on until it is switched off by an OFF command or the "LOCK" (VERR) or "STOP" conditions. The conditions "ON" (EIN) and "RTS" (EIFR) linked by a logical "AND" condition, which means that both conditions must be met (font color green) in order for the flip-flop to be set and the drive to be switched on.

REL	The "REL" (FREI) condition between the RS-FF and the drive is an additional condition that must be met in order to control the drive.

PID Controller Faceplate "Parameters"

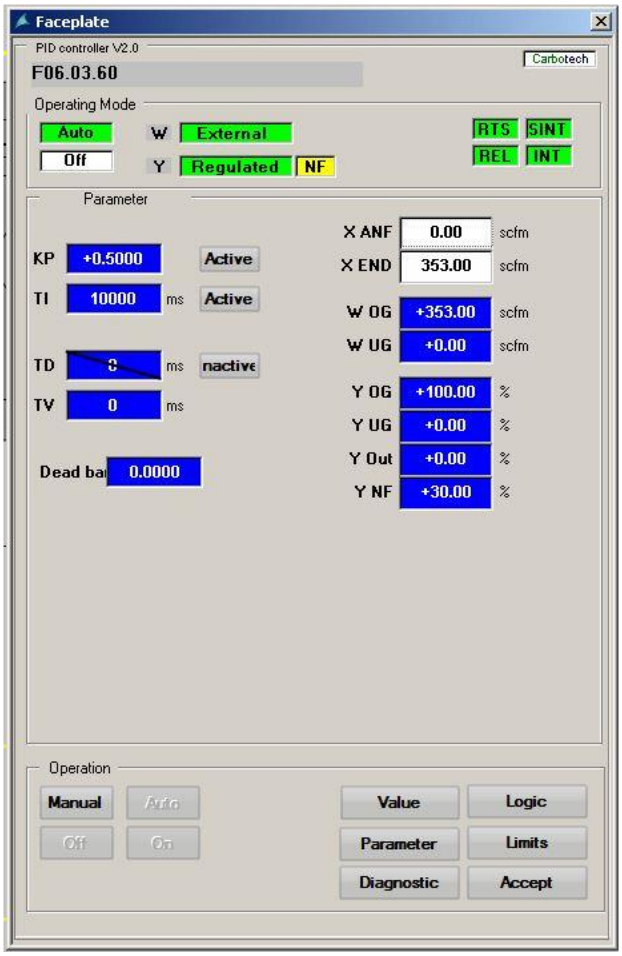


Figure 7.17: PID Controller Faceplate "Parameters"

Input fields for controller parameters	KP	P component of the controller (activated/deactivated)
	TI	I component of the controller (activated/deactivated)
	TD	D component of the controller (activated/deactivated)
	TV	Delay time of the D component
	Dead zone	Interval around the set-point within which the deviation is set to zero
	Possible entries are the of min./max. values for actual value, set-point and variable value, as well as the initial values for variable values.	
	Parameters can be deactivated via a switch.	

Input fields for limit values	Possible entries are the of min./max. values for actual value, set-point and variable value, as well as the initial values for variable values.

PID Controller Faceplate "Diagnostics" (Diagnose)

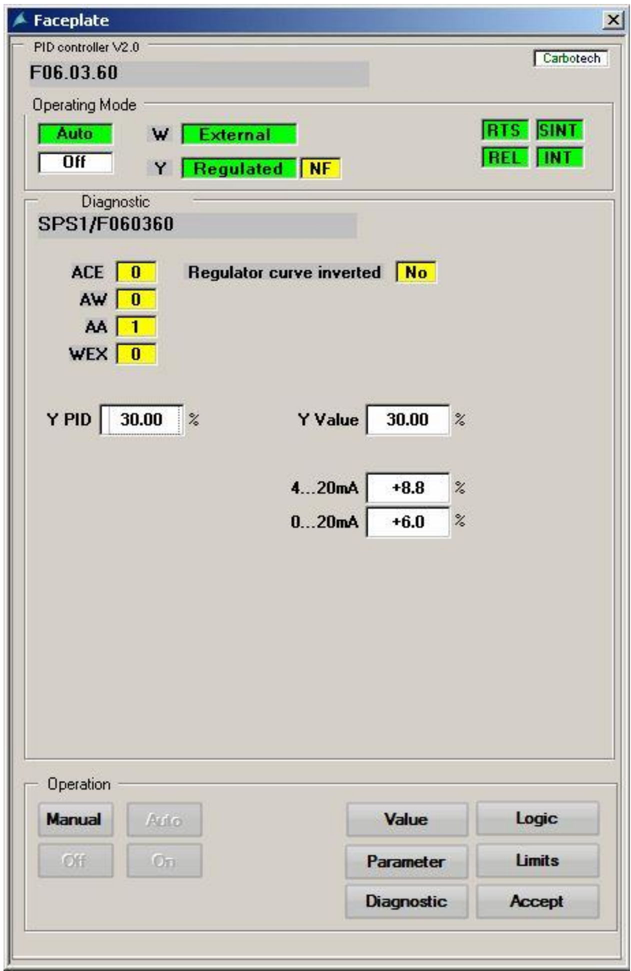


Figure 7.18: PID Controller Faceplate "Diagnostics"

The Faceplate Controller Diagnostics is used to control the current controller settings and functions.

For this purpose, the most important current controller parameters are displayed.

SMA	Currently set manual variable value
AI/AO	Analogue values input/output
WEX	Set point
Y PID	Control variable from the controller
Y valve	Control value from the valve
Analogue Output	Control value with limit intervals 0-20mA and 4-20 mA

NOTICE	If the set-point source is changed from External to Internal while the FGC is activated (reference) and the value is changed, it must be noted that the new value no longer exists after a restart of the FGC. The software of the "BUP Parameters" (BGAA Parameter) once again uses the external set-points, thereby overwriting the last internal set-points.

Set-point Controller Faceplate:

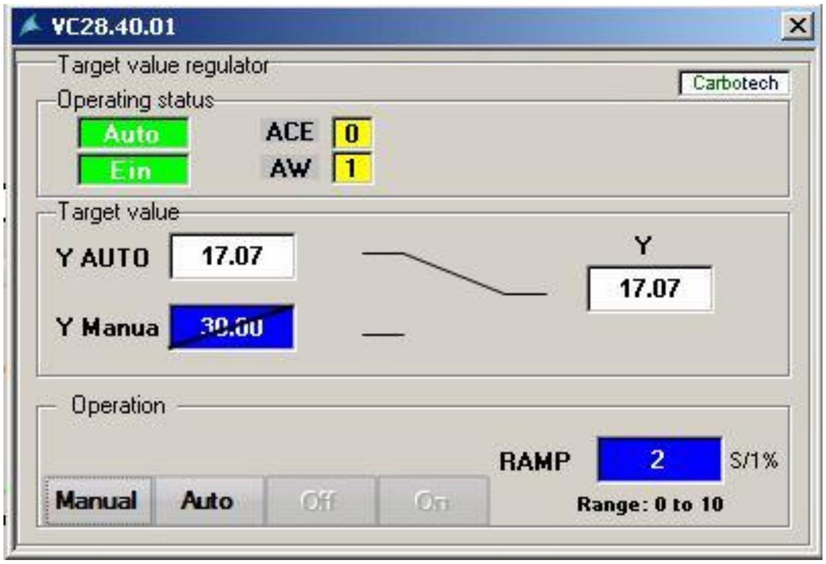


Figure 7.19: Set Point Controller

The Faceplate "Set-point Controller" can be selected in the "Operation" section, using the buttons of the manual/automatic operation.

In addition, the set-point controller can also be switched on and off, using the buttons "On" and "Off" in the "Operation" section.

A control variable change can only be performed in manual mode by a value change in a blue field, e.g. for controlled valves, to adjust the set-point manually or configure the ramp of the drive for start-up and shutdown of the drive.

In the blue box "RAMP" (RAMPE), the ramp function from can be set from 0 to 10 sec./1%.

In the fields "Operating state", the manual/automatic mode and the on/off state of the valve is displayed.

The symbolically shown switch changes according to the operating state.

Motor with a Speed

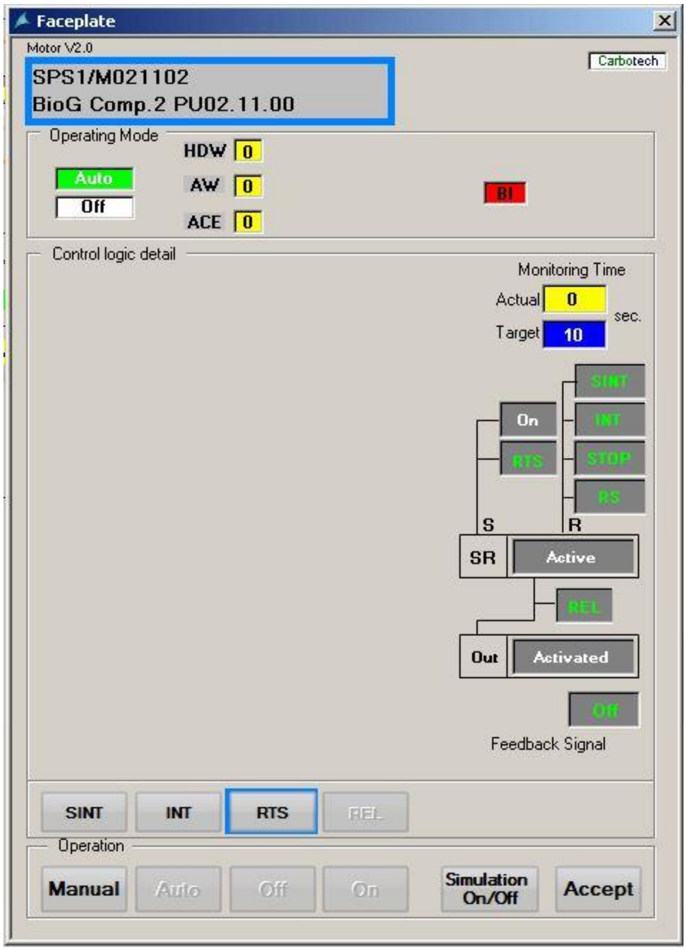


Figure 7.20: Motor with a Speed

The Motor Faceplate controls the drives of the system, such as pumps, fans, and heaters. For variable-speed drives (frequency converter), see under "Set-point Controller Faceplate". For motors with 2 speeds, see "**Motor with Two Speeds**"

The **Motor Faceplate** is divided into the following sections:
"Operating Mode", "Control Logic", and "Operation".

Tag No. and measuring point short text:	Display with magenta background: Display with background:	Actuator in Simulation Mode Actuator in Service Mode

In the "**Betriebszustand**" (Operating State) section, the following is displayed:

"Hand/Auto" (Manual/Auto)	Manual/automatic mode selected
Automatic **active**	Green
"Ein/Aus" (On/Off)	Switched on/off
HDE	Status manual input (0/1)
ACE	Status Forced Automatic (0/1)
AW	Status Automatic Input (0/1)
Frequency Converter Fault	SC
Motor protection switch has tripped	BI
Feedback Fault	RM
PTC thermistor has triggered	TS
Repair switch is on	RS
Interlock fault	VS
Emergency stop is triggered (flashing)	Stop

In the "**Control Logic**" section, the following is displayed:

Graphical representation of the control logic with display of the input and output signals. In the control logic, the conditions required to switch on the drive are visualized.	Green font: Condition is satisfied font Condition is not met

LOCK	Drive is locked. **The interlock fault has to be acknowledged!** **Interlock logic**
STOP	**Drive has received a stop command, e.g. emergency stop**
RM	Drive has a feedback fault Possible causes: Drive is switched on but does not return drive feedback Drive is switched off and returns drive feedback
ON	In the manual mode, **On** command from operator, or in automatic mode, "AW" = 1 from the controller
RTS	The release to start does only need to be existent once when turning on the valve. Thereafter, the flip-flop is set and the drive stays on until it is switched off by an OFF command or the "LOCK" (VERR), "STOP," or "RM" conditions. The conditions "ON" (EIN) and "RTS" (EIFR) are linked by a logical "AND" condition, which means that both conditions must be met (font color green) in order for the flip-flop to be set and the drive to be switched on
REL	The "REL" (FREI) condition between the RS-FF and the drive is an additional condition that must be met in order to control the drive.
Service/Force	"Service" button This button can also be used to display further buttons in order to "force", i.e., bridge or "set" some conditions. Switch Sends an output signal to the line contactor or to the frequency converter in order to switch on the drive Feedback Displays the feedback of the drive: either OFF or ON

Monitoring of operating hours:	• **Set time** Time limit for switching the operating state
	• **Actual time** Current time since switching the operating state from up On to Off or from Off to On.
If the switch of the operating mode in the control is not confirmed within the operating hours monitoring, a feedback fault is triggered	

Switching the interlocking logic:

Operation

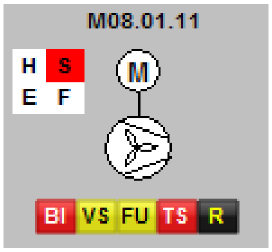
<u>Button set for operating the motor:</u> Shift key to display the detailed conditions of the switching logic. The arrow above a button indicates the active logic	• Selection of **MANUAL** or **AUTO**matic operation • Switch **ON/OFF** in manual mode • **Simulation On/Off** - Release for setting the input signal for the measuring point • **ACK**nowledgment of alarm and warning messages

Simulation mode:

In simulation mode, the drive can be opened/closed and the controller returns the corresponding drive feedback without the output being set/reset. This mode is used for test purposes in automatic mode.

NOTICE	Manual operation of a system component can only be used if the automatic mode is not required by a running operating program (e.g., a SGC). This state is then indicated by the display ACE = 1 (forced automatic). The manual mode maintains the settings from the automatic mode. This means that, if the actuator is switched on in automatic mode, the actuator remains switched on when you switch to manual mode. The same applies if the actuator was switched off in automatic mode. During changeover from manual to automatic mode, the settings are not maintained, which means the actuator is switched on or off after the switch to automatic mode, dependent on the automatic program.

Icon Motor with Fan



Fan with Motor

Actuator H (on white background)	Manual mode
Actuator A (on green background)	Automatic mode
Icon with magenta background	Actuator is in simulation mode
Icon with blue background	Conditions are forced
Icon/unit flashing white / red	Error or fault

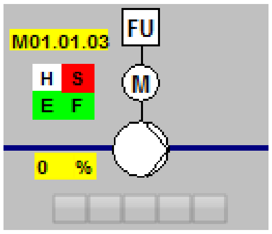
4 fields at the top left of the unit

A/M	automatic/manual mode activated
F/F	release granted / not granted
E/E	Switch-on release granted/not granted
S STOP	

5 fields below the unit

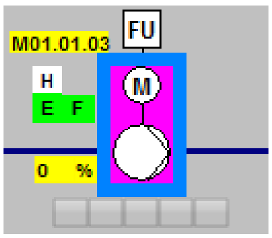
BI	Bimetal fault/motor protection triggered
IF	Interlock Fault
FC	Frequency converter fault
TF	PTC thermistor fault
R	Repair switch fault
FF	Feedback fault

Motor with Frequency Converter Operation



Fields at the top left of the unit

A/M automatic/manual mode activated
F/F release granted / not granted
E/E Switch-on release granted/not granted
S STOP



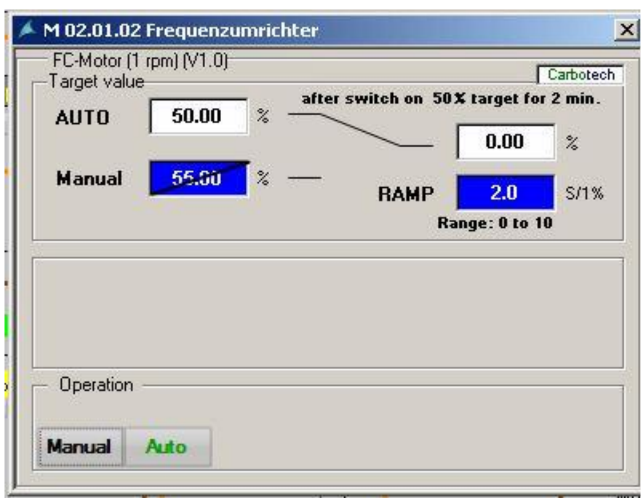
Fields below the unit

BI Bimetal fault/motor protection triggered
IF Interlock Fault
FC Frequency converter fault
TF PTC thermistor fault
R Repair switch fault
FF Feedback fault

The symbol of the motor is framed in if the motor is in service mode.

On the bottom left of the icon, the actual value of the control variable is shown on yellow background

Click the FU icon above the motor to open the FU Motor Faceplate:



In manual mode, the font of the "Hand" (manual) button ("Bedienung" (Operation) section) appears in green and the fields

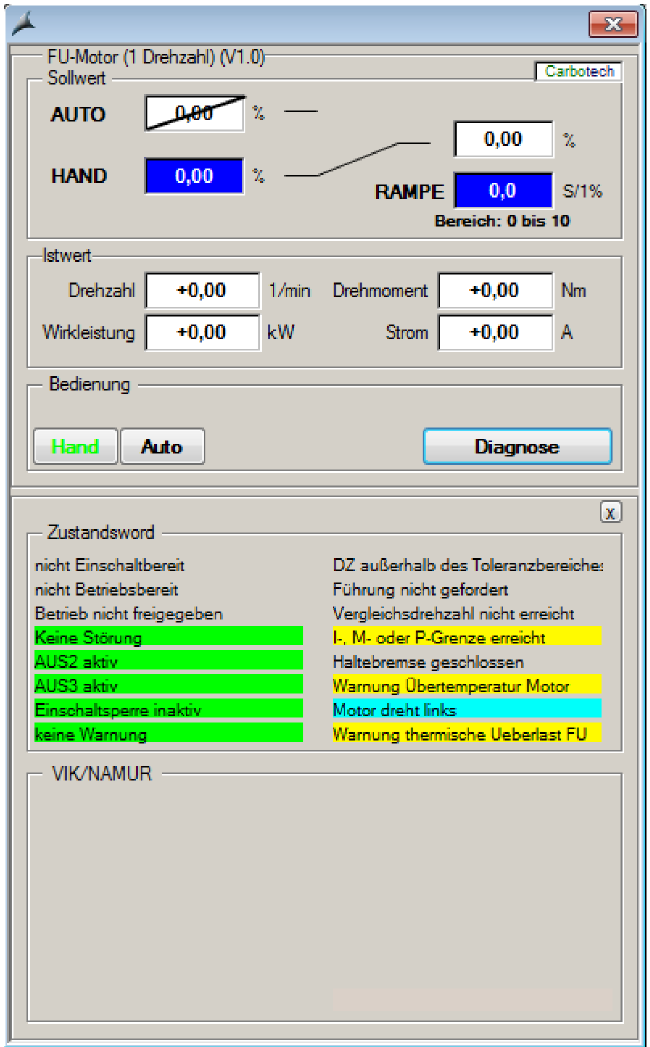
"HAND" (manual) and "RAMPE" (ramp) (Set-point Section) are shown with a blue background.

In these two blue windows, the value can be changed in manual mode by clicking on the corresponding window.

In the section actual value, the speed (1/min), the effective power (kW), the torque (Nm), and the current (A), which are measured by the frequency converter, are displayed.

With another click on the "Diagnose" (Diagnostics) button, this window is expanded according to the Figure "Advanced Motor Frequency Converter Faceplate":

Advanced Motor Drive Faceplate



This shows additional information that is generated by the frequency converter.

The information presented here refers exclusively to a frequency converter by the Siemens company.

Additional or different information can be displayed here.

For the meaning of this information, refer to the manual of the corresponding frequency converter.

Figure 7.1 Advanced Motor Drive Faceplate

Package Unit

The color change from grey to green with a small circle indicates whether the PU is switched on or off.

Switching a Packet Unit, e.g., a Packet Analyser, Water Chiller

Icon with magenta background:
corresponds to sensor in simulation mode

Icon with blue background: corresponds to sensor in service mode

A/H automatic/manual mode activated/deactivated

F/F release granted / not granted

E/E Switch-on release granted/not granted

V Interlocking

R Feedback fault

S STOP

SINT-lock

A measurement point name with yellow background identifies a safety-related measuring point that triggers a hardware shutdown and must be acknowledged separately.

In safety-related controlled actuators, the left interlock icon will be shown in case of violation of these safety-related shutdowns.

- Display "Locked" (Verriegelt) when safety-related interlock is triggered
- Acknowledge the lock by pressing the "Unlock" (Entriegeln) button
- Before this lock is acknowledged, the cause must be investigated.

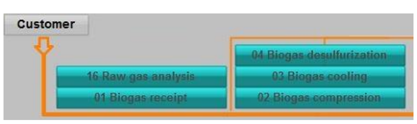
 CAUTION	**Under no circumstances should this interlock be acknowledged multiple times or at short intervals!**

"Selection" (Auswahl) Button

Button to select the Faceplates

arranged according to the process flow/product flow

Line Symbols



Piping with directional arrow

State Symbols

	Color change to green	Good state, ON
	Color change to	Bad state, e.g., fault

7.2 Hysteresis

The hysteresis prevents constant state changes of limits for small changes of measured values. The hysteresis is the same for all limit values of a measuring point. The hysteresis is always a switch-off hysteresis. The following figures show, by example, the influence of the hysteresis on the state of the limit values and messages.

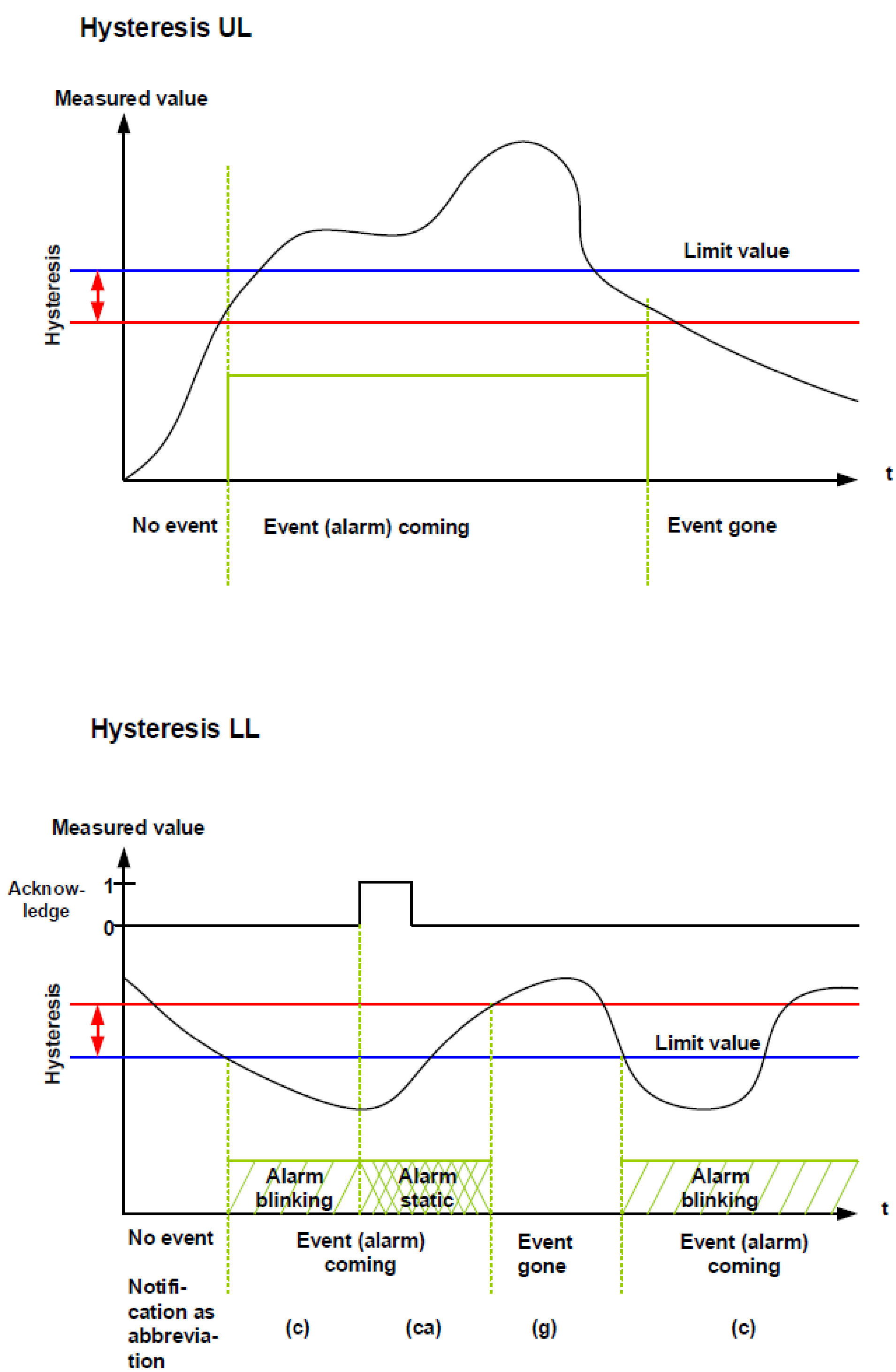


Figure 7.21: Hysteresis

7.3 Operation Modes

Three different operating modes are available for the system operation and system control:

- Manual mode
- Automatic mode
- Semi-automatic mode

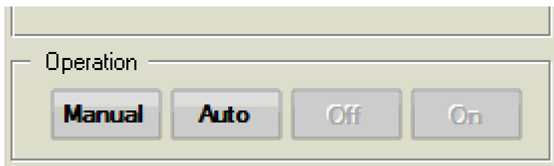


Figure 7.22: Operating panel in faceplates for switching the operating modes

Detailed information about individual functions, step chains, interlocks, etc. can be found in the switch rule matrix (SRM).

7.3.1 Manual mode

In manual mode, the actuators, e.g., valves, drive components, actuators, SGC, etc. are operated directly. The manual mode is mostly unsecured and allows almost any switch states. If the safety or the system protection might be affected by switching errors in manual mode, interlocks are provided to limit the manual mode.

To control switches in manual mode, manual mode must be selected separately in the faceplate of the actuators.

 **CAUTION**	For reasons mentioned above, manual mode of the system may be used only by trained, experienced personnel while taking into account all the system limit conditions.

Manual mode is intended solely for switching valves and drives in a manner not possible in semi-automatic or fully automatic mode.

This mode is intended exclusively for start-up or to correct abnormal operating conditions, such as after a fault shutdown.

The biogas cleaning must not be performed in manual mode.

Continuous switching from manual to semi-automatic or automatic mode is not possible as automatic parameters for valves and drives are set by switching the mode, which usually differ from the current state, e.g., a valve open in manual mode could be closed by switching to the automatic mode before it is opened again by the automatic mode.

If a SGC is to be run in manual mode anyway, please refer to the corresponding processes in semi-automatic mode for the necessary switching operations.

7.3.2 Fully Automatic Operation

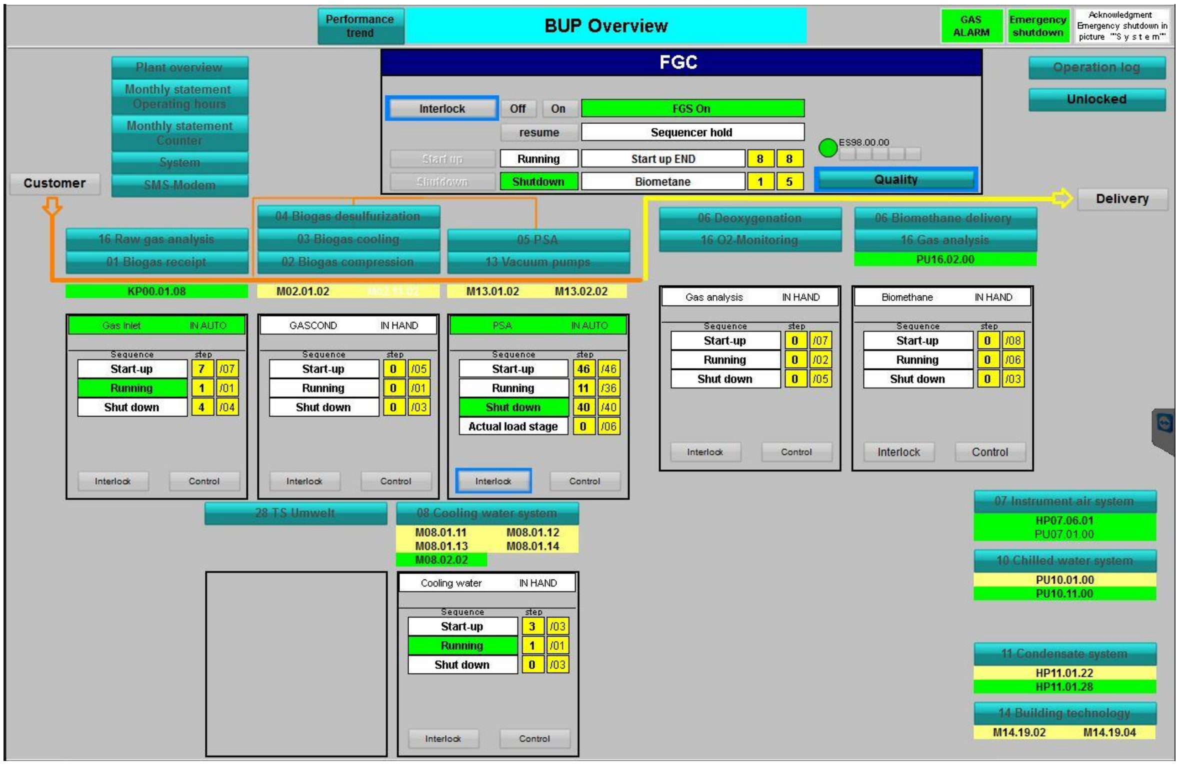


Figure 7.23: Assemblies Screen "BUP – Overview" (BUP – Übersicht)

In the Assemblies Screen "BGAA – Overview" (BGAA – Übersicht), with status SGC (UGS), the process is shown with information fields for the subgroup controls. The fully automatic operation of the system via the so-called functional group control "FGC" is operated through the frame in the top center of **Figure 7.23: Assemblies Screen "BUP – Overview" (BUP – Übersicht)**.

The FGS controls the entire process, i.e., the entire system runs in fully automatic mode. All subgroups are operated automatically. For this purpose, the FGS "Start-up" (Anfahren) must be turned on first to start the process in order to bring all subgroups to the base state for the automatic operation of the system and start the entire process.

NOTICE	In fully automatic mode, the functional group control (FGC) takes control over the subgroup controls (SGC). Safe and complete operation of the system is possible only in this mode of operation. The functions **Start-up (Anfahren)** and **Shut Down (Abfahren)** of the system are available.

After running through the **start-up** sequence, the production process is started automatically and can be terminated by selecting and running the **shutdown** sequence.

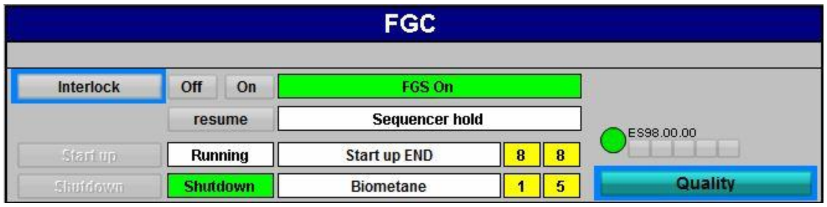


Figure 7.24: Assemblies Screen "BUP – Overview" (BUP - Übersicht") - Frame FGS

During an active sequencer, the button **STOP (HALT)** can be pressed to stop the active sequence. If the step sequence is stopped, **CONTINUE (WEITER)** appears on the same button to continue the active sequence. The step sequence is merely stopped at the current step and does not reset completely. The button "Verriegelung" (Lock) opens another Faceplate containing all conditions that can be used to shut down the functional group control.

Starting the Functional Group Control in Fully Automatic Mode

Procedure:

1. Acknowledge and resolve alarms and warnings in the visualization.
   It is particularly important that all units can be controlled and no fault is present. Locate faults using the screen tree!
2. Unlock safety-related components.
   Check all safety-related components in the visualization!
3. Check whether a lock of a SGC or FGC flashes red.
   Remove the cause and acknowledge the lock!
4. FGC "OFF" (FGS **"Aus")**:
   Select "Aus" (Off) so that the sequence **Shut Down (Abfahren)** is terminated and the sequence "Anfahren" (Start-up) can be selected.
5. Select **"Anfahren"**:
   Anfahren turns green
6. FGS **"Ein"** (FGC on):
   Select **"Ein"** (On), thus starting the fully automatic mode

If the FGC is started, SGC faults can cause an automatic shutdown of the system!

This interlock is documented in the SRM.

 **NOTICE**	It is recommended to always keep the system in fully automatic mode because safe monitoring and, if necessary, shutdown of the system is possible only in this mode. If semi-automatic operation is required, it must be done under constant supervision. Thereafter, the fully automatic mode must be selected again.

The fully automatic operation **"Anfahren"** (Start-up) is possible in any operating mode of the system.

For example, if the semi-automatic mode of the system is active, the FGS **"Anfahren"** (Start-up) can be started to switch all SGCs to automatic operation mode. The FGS can be switched to fully automatic mode even while the system is running in order to start SGCs that have failed or been shut down by faults.

During start-up, switching or shutdown, the status of each SGC is automatically considered, so that, for example, an SGC that is currently running in semi-automatic mode is not first stopped and then restarted.

The **Anfahren** (Start-up) Step Sequence

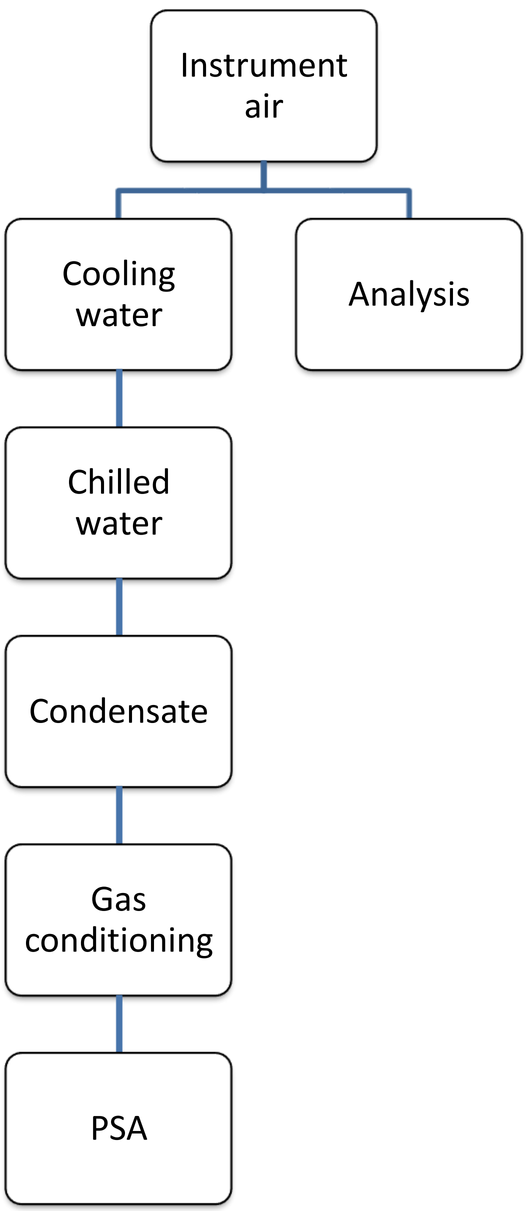


Figure 7.25: Start-up - Step Sequence

After the start of all auxiliary assemblies, such as instrument air, cooling water, chilled water, and condensate system, the step sequence for gas conditioning is started and the desulfurization system is heated. Subsequently, the PSA unit and biomethane delivery are turned on.

The sequence "Anfahren" (Start-up) is turned on by the selection and start of the sequence:

1. Select the **"Overview" Figure 7.23: Assemblies Screen "BUP – Overview" (BUP – Übersicht)** screen
2. **In the "FGC" window, run the "Start-up"** sequence. For this purpose, first press the "Stop" button. The buttons "Start-up" and "Shutdown" are now activated. Now press the "Start-up" button and then, in the new window that opens, confirm with the "Yes" button. C.f. **Figure 7.24: Assemblies Screen "BUP – Overview" (BUP - Übersicht") - Frame FGS**
3. Start sequence

After going through the start-up step sequence, the production process is started automatically at the lowest load level.

For manual intervention, the step sequence must first be terminated or suspended.

The **Abfahren** (Shutdown) Step Sequence

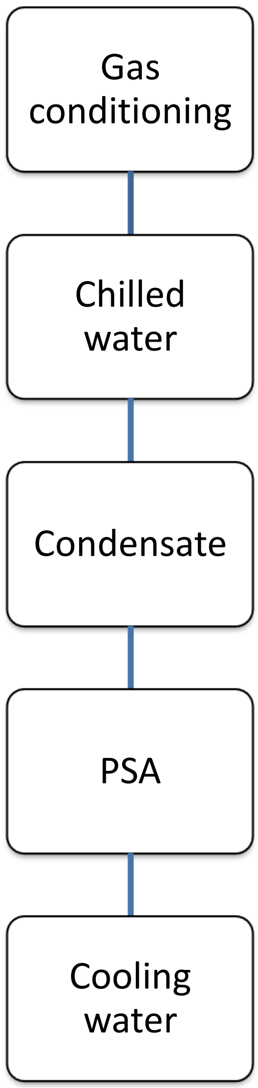


Figure 7.26: Shutdown - Step Sequence

After passing through the shutdown step sequence, the production process is terminated.

In the **"Shutdown"** (Abfahren) sequence, all SGCs are switched so that after passing through the shutdown sequence, all SGCs have passed through the **"Shutdown"** sequence.

When shutting down the system, the **"Shutdown"** step sequence is processed, so that the system is shut down in a controlled manner.

The **"Shutdown"** (Abfahren) sequence is turned on by the selection of **"Shutdown"** and start of the sequence:

1. Select the **"Overview"** **Figure 7.23: Assemblies Screen "BUP – Overview" (BUP – Übersicht)**screen
2. **In the "FGC" window, run the "Shutdown"** sequence. For this purpose, first press the "Stop" button. The buttons "Start-up" and "Shutdown" are now activated. Now press the "Shutdown" button and then, in the new window that opens, confirm with the "Yes" button. C.f. **Figure 7.24: Assemblies Screen "BUP – Overview" (BUP - Übersicht") - Frame FGS**
3. Start sequence

To complete the **"Shutdown"** (Abfahren) step sequence, push the **"OFF"** (Aus) Button of the FGC in the overview screen.

Interrupt Step Sequence

If a start-up sequence is interrupted, for example, due to a fault of the SGC, because manual intervention is required to correct faults, it is not necessary to restart the entire FGC; It is sufficient to shut down and restart the affected SGC.

This requires that the FGC step sequence is stopped, using the **"Stop"** (Halt) button on the overview screen, see **Figure 7.24: Assemblies Screen "BUP – Overview" (BUP - Übersicht") - Frame FGS**.
While the step sequence is stopped, any SGC can be switched to **"Manual"** (Hand) and the faulted SGC can be shut down. Subsequently, the required sequence can be switched on again.

To continue the FGC step sequence, simply push the **"Continue"** (Weiter) button in the window **"Overview FGC"** (Übersicht FGS). The step sequence continues and all SGCs will be switched back to **"Auto".**

For an active sequencer, the button **"STOP"** (HALT) is displayed and for a stopped step sequence, the **"CONTINUE"** (WEITER) button is displayed.
See **Figure 7.24: Assemblies Screen "BUP – Overview" (BUP - Übersicht") - Frame FGS**.

7.3.3 Semi-automatic Mode

In semi-automatic mode, the controls of the individual subgroups (SGC) are operated directly by the operator. After selecting and starting a subgroup, all control elements associated with this subgroup are set to automatic mode. Through the SGC, control elements are equally operated in automatic mode, i.e., they can only be switched on or off, and full manual operation is no longer possible.

The mode must be switched directly by the operator.

The following subgroups are summarized:

- Instrument air system
- Chilled water supply
- Cooling water supply
- PSA, biomethane vacuum
- Condensate system
- Gas analysis
- Gas conditioning
  - Transfer, compressor, drying, desulfurization

 **NOTICE**	Direct activation of the sequence **"Operation"** (Betrieb) is not permitted without completion of the sequence **"Start-Up"** (Anfahren).

To switch a subgroup control from semi-automatic mode to manual operation, the functional group control must be switched off or suspended.

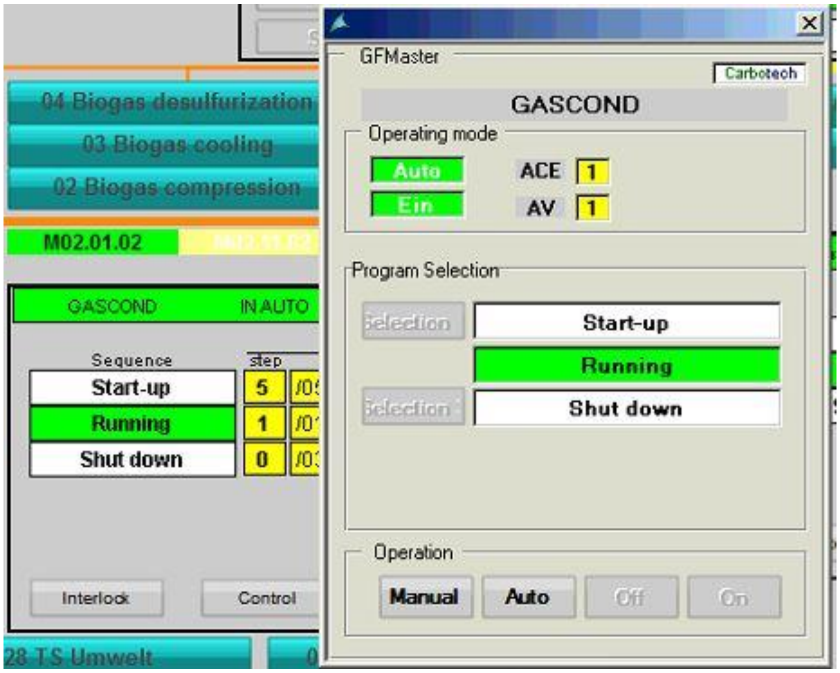


Figure 7.27: Faceplate " Control Semi-automatic Mode Gas Conditioning "

Starting the SGC in Semi-automatic Mode

Procedure:

1. Select “Switching off the FGC” (Ausschalten der FGS) in the screen “Overview BUP” (Übersicht BUP).
2. In the overview window of the respective SGC, select the switch "Control".
3. In the window that opens, select the operating mode "Manual".
   If ACE "1" is also displayed, the FGC is still active and it has to be verified first that it has been turned off or suspended!
4. Choose the desired sequence by clicking the corresponding button.
   However, the selection is possible only when the operating mode "Manual" is selected and no sequence is active. An active sequence must be turned off.
5. Start the sequence with **"On"**

NOTICE	The SGCs, except the SGC Analysis and the Condensate System, are controlled with 3 sequences: First, a process must be started up. A process is then in operation. To finalize, the process must be completed, i.e., shut down. It is therefore necessary in semi-automatic mode to observe the **order of the sequences**! See automatic mode.

By clicking the button "Control" in the subgroup window, the faceplate for the semi-automatic mode is opened.
See **Figure 7.27: Faceplate " Control Semi-automatic Mode Gas Conditioning "**.
The sequences of the process are selected by pressing the button "Select x" and can then be controlled via the faceplate.

Operation of SGC for Semi-automatic Mode

The SGC is in the base state.

- Use the sequence **“Start-up”** (Anfahren) to bring the SGC into the base position for the semi-automatic mode:
  1. Select the sequence **“Start-up”** (Anfahren).
  2. Start the sequence **"Start-up"** with **"On"**(Ein).
  3. Wait for the process sequence **"Start-up"** to complete.
     current step = number target steps
  4. Turn off the processing of the sequence **"Start-up"** with **"Off"** (Aus).

The SGC is now in base position for the semi-automatic mode.

- Activate the SGC with the sequence **"Operation"** (Betrieb) and control the process:
  1. Select the sequence **"Operation"** (Betrieb).
  2. Start the sequence **"Operation"** with **"On"** (Ein) start and control the process.
  3. Stop the sequence **"Operation"** with **"Off"** (Aus) and stop the process.
     To operate the system, the **"Operation"** (Betrieb) sequences of all SGCs must be active.

- Use the sequence **"Shutdown"** (Abfahren) to bring the SGC to base position:
  1. Select sequence **"Shut down".**
  2. Start the sequence **"Shutdown"** with **"On"** (Ein).
     The system is **shut down** and the process is terminated after completing the sequence of the SGC.
     current step = target steps
  3. Confirm the completion of the sequence **"Shutdown"** (Abfahren) with **"Off"** (Aus).

CAUTION	The interlocks of an SGC are not active during automatic mode, i.e., they result in a shutdown of the system only in fully automatic mode. The semi-automatic operation of the system may therefore be used only by trained and experienced personnel taking into account all the system limit conditions.

Example of a subgroup control: "Gas conditioning in automatic mode"

In the SGC **"Gas Conditioning"**, the following assemblies are controlled:

- 01-biogas receipt
- 02-biogas compressor
- 03-drying
- 04-desulfurization

The control of the assemblies is divided into 3 sequences.

See description in **Error! Reference source not found.**.

- Start-up "xx steps"

  The process is started up in several steps until a steady process state is reached and the operator must switch the operating mode to **"Operation"** (Betrieb).

- Operation "xx steps"

  The module runs in normal operating mode from process beginning to process end.

- Shutdown "xx steps"

  The process is shut down in several steps until it is turned off.

"xx steps" = Sequence can consist of one or more steps

After the respective sequence, of the currently active step, which is in the program sequence, is indicated.

"Display step" (Anzeige Schritt): current step or number target steps.

No.	Sequence	Description
1	Gas Conditioning Start-up	01. Determine whether there is at least one compressor without fault activate pre-cooling (optional) 02. Open the receipt valve 03. Wait for the receipt valve feedback 04. The compressor with the least operating hours is turned on. In case of failure, the next compressor is attempted to be switched on 05. PIC controller 04.03.13 is activated 06. *- Reserve -* 07. Wait until the pressure is built up 08. Wait until the heating temperature is reached 09. *- Reserve -* 10. End (gas conditioning is working)
2	Gas Conditioning Operation	01. Gas conditioning is in operation and, in case of failure of a running compressor, the other compressor will be switched on.
3	Gas Conditioning Shutdown	01. The load level 1 is activated and the compressor is turned off 02. The receipt flap closes 03. The PIC controller 4.3.13 is set to the set point 04. *- Reserve -* 05. End (gas conditioning is shut off)

Table 7.4: Description of Gas Conditioning Step Sequence

Steps marked **"- Reserve -"** are activated immediately and serve as a reserve in the planning of the step sequence.

 **NOTICE**	Do not start SGC gas conditioning and PSA without operation of SGC instrument air, cooling water, chilled water, and condensate system. This leads to overheating of the units and can destroy the system in the long run!

7.4 Description Measurement Error and Assembly Error Out of Measuring Range

7.4.1 Measurement Errors in Analogue Value Representation

The analogue values must be processed by the CPU in binary form. Analogue input modules convert the analogue process signal into digital form, 16-bit words.

Five areas must be considered for the conversion of the digital value to analogue value:

Hexadecimal value	Current measuring range	Comment	Meaning
7FFF	22.96 mA	Overflow	For hexadecimal values 16#7F00 and up, the sensor value is above the parametrized measurement range and is invalid.
7F00			
7EFF	22.81 mA	Over-range	This range corresponds to a tolerance band before the overflow is reached. Within this range the resolution is not optimal however.
6C01			
6C00	20 mA	Nominal range	The nominal range is the normal range for the acquisition of the measured values. This range guarantees optimal resolution.
5100	15 mA		
1	4 mA + 578.7 mA		
0	4 mA		
FFFF		Under-range	Area corresponding to the over-range, only for low values.
ED00	1.185 mA		
ECFF		Underflow	For hexadecimal values 16#7F00 and up, the sensor value is below the parametrized measurement range and is invalid.
8000			

Table 7.5: Analogue Value Representation in Current Measuring Range 4 to 20 mA

7.4.2 Unused Inputs

Since configured inputs are unused, the following must be observed for these inputs to activate the diagnostic function for the unused inputs:

- Measuring range 1 - 5 V
- Switch the unused input parallel to a used input of the same channel group.
- Current measurement, 2-wire measuring transducer
- 2 options available for using the channels:
  - Leave the unused input open and do not enable diagnostics for this channel group. With enabled diagnostics, the analogue module triggers a diagnostic alarm once and the SF LED (station fault) of the assembly lights up.
  - Wire the unused input with a resistance from 1.5 to 3.3 Ω to enable diagnostics of this channel.
- Current measurement 4-20mA, 2-wire transmitter:
  - Switch the unused input in series with an input of the same channel group.

7.4.3 View Events

In the summary displayed, there are 5 fields in which alarms, warnings, faults, and errors are displayed. These differ as follows:

- AH Alarm High - Outer limit exceeded - Inner limit (UL2)
- WH Warning High - Inner limit exceeded (UL1)
- WL Warning Low - Lower limit underrun (LL1)
- AL Alarm Low - Outer limit underrun - Lower limit (LL2)
- F Measurement error (see description in Chapter 7.5
- S Assembly error (see description in Chapter 7.5

Event States

The status of a message is displayed in the summary display. There are three states of events, which may also be active simultaneously. Depending on the state of an event, it will also be displayed in the corresponding message list (see Chap. 7.5 Messages).

- Coming Message ➧ Abbreviated "K"
- Gone message ➧ Abbreviated "G"
- Acknowledged message ➧ Abbreviated "Q"

Indicator without colour assignment means:

There is no event. A flashing icon means the message has not been acknowledged, but it does not indicate whether the event is still active. A static symbol indicates that the message has already been acknowledged, but the event is still active.

7.5 Messages

Messages are displayed in message lists in the visualization in order to analyze system faults and to correct any faults in the system. The message lists provide the option to filter messages according to parameters.

The control and monitoring system collects the messages from the automation system or generates messages from message variables and enters these into the message archive in chronological order. In the selected message windows, messages are displayed in message lists.

The messages are archived for a period of 3 months in Alarm Logging. After 3 months, messages of one day are archived externally and must be included manually in the Alarm Logging if needed.

The archive files are located in the folder **"D:\backup\Alarm_Log"**

To ensure that the files can be archived, it must be ensured that there is sufficient space on the hard drive. Regular verification of disk space is recommended.

7.5.1 Types of Messages

- Process messages are process events of the automated process, such as limit violations of measured values or status information.
- Process control messages are error messages caused or detected by SIMATIC PCS7 components. With process control messages, the failure of a component is reported, for example, including a wire break message for a connected I/O signal.
- Operator messages are currently not configured. Only the operator messages from the system are generated.
- System messages are generated by the visualization, WinCC.

7.5.2 Structure of the Message Lists

The current message list in the visualization is displayed by clicking on the header at the number 3 “Meldesystem” (Message System). The following window appears:

Faceplate "Message Lists" (Meldelisten)

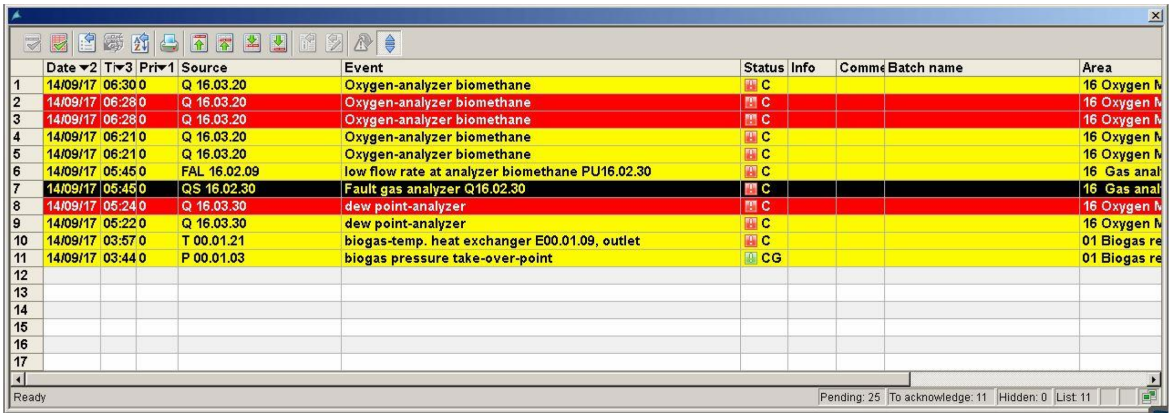


Figure 7.28: Faceplate "Message Lists” (Meldelisten")

Message lists have the following columns:

- "Date of event”: (Datum des Ereignisses) — Date when the event occurred
- "Time of event" (Uhrzeit des Ereignisses): — Time when the event occurred
- "Area of the event": (Bereich des Ereignisses) — Assembly in which the event occurred
- " Origin of the event ": (Herkunft des Ereignisses) — Tag of the event
- "Event": (Ereignis) — Description of the event
- "Type of event": (Art des Ereignisses) — Fault, Alarm High, Warning High,
- "State of events ": (Zustand der Ereignisse) — "Coming gone, acknowledged" (kommend, gegangen, quittiert)

7.6 Trending

For graphical presentation of data WinCC provides the Online Trend Control to present the process data as a graph. The graph type to be used is selectable and offers the option of displaying current or archived values graphically.

Trends are stored for each measured value. Right-clicking on a desired measured value displays the trend, in which the measured value is displayed as well. The measured values, e.g., for pressures, temperatures, and analysis data, are buffered for a period of up to 3 months and can be accessed or displayed via the Online Trend Control.

Figure 7.29: Faceplate "Trend"

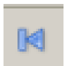
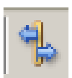
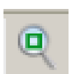
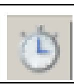
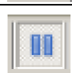
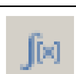
Button	Parameter	Description
	Help	Help with the visualization
	Parametrization	Inserting additional curves, change scaling of the axes, changing trend colors, etc.
	First record	Goes back to the first record in the data set
	Previous record	Go back one record
	Next record	Goes to the next record
	Last record	Moves to the last record in the data set
	Move axis range	Moves the axis range
	Ruler	When accessing the trend, a ruler is displayed while, at the same time, an additional window is opened, in which the values are shown for the time indicated on the ruler. By moving the ruler (hold left mouse button and move the ruler to the desired position), all values for the desired time can be displayed.
	Zoom	By clicking the Zoom button, you can add a zoom rectangle to the trend in order to zoom in on this section
	Original View	The original view is restored, which also happens by closing the trend and changing the page at the same time
	Curve on/off in the foreground	Unnecessary curves can be shown/hidden with this button
	Select time range	Selects the displayed time range
	Start/Stop	Stops recording in the trend; the recording of the trend continues in the background. The recorded values are displayed again with Start
	Print Log	Print Log
	Export Data	Data is exported
	Select statistics field	Displays two rulers in the trend; both rulers can be moved as desired. An additional window with the respective values is opened
	Calculate Statistics	This function is only active if a statistics field is selected. Based on the range, this function determines a mean value, which is displayed in a third window

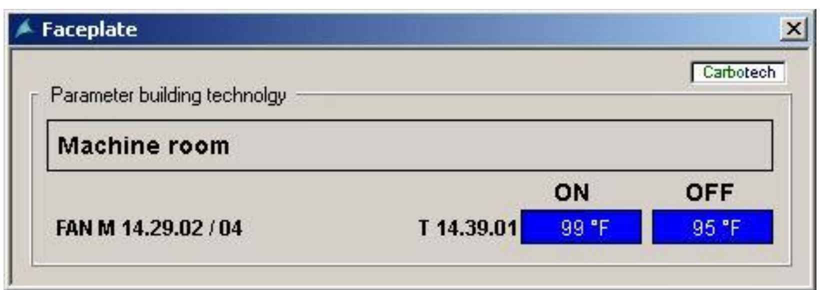
Table 7.6: Operation Trends

7.7 Parameterization

The "Parameter" button is located in the control panel of the assembly screen. After pressing this button, the Parameters window will open
In this **"Parameter Faceplate",** there are different categories corresponding to the assembly, in which parameters can be changed.
Any change of these parameter settings must be coordinated with **BIOFerm Energy Systems** in advance.

"Parameter" Button

"Parameter" Faceplate



7.8 Operating Hierarchies/User Management

User management is set up in the **"User Administrator"** editor. Use the editor to assign and control access rights of users for the individual editors of the configuration system and to the runtime functions. Access rights to WinCC functions, so-called permissions, are assigned in the User Administrator. These permissions can be assigned to individual users or user groups.

Permissions can be assigned in **Runtime**.

When a user logs into the system, the User Administrator verifies whether the user is registered. Non-registered users have no access rights. This means that they cannot retrieve or view any data nor perform any process operations. If registered users access functionality protected by access rights, the User Administrator checks whether this is allowed by the permissions and denies access to the desired functionality in case of missing permissions.

No.	Object	maximum number
1	Permissions	999
2	Users	128
3	User groups	128
4	Areas	256

Table 7.7: Object Management – Maximum Number of Permissions, Users, Areas, Etc.

Three user groups with different rights are set up

- **"Administrator group" (Administrator-Gruppe):**
  Access rights to all parameters; these may only be modified in consultation with **BIOFerm Energy Systems**.
- **"Bediener-Gruppe" (Operator group):**
  Specially designed for the system operator, with this login the system can be started up or shut down; additionally, valves and motors can be operated manually. This should be used only for maintenance purposes.
  There are no rights to modify special system parameters.
- **"Beobachter-Gruppe" (Observer group):**
  Intended for monitoring the system.
  Does not allow for control or parametrization.

When creating a new login, the administrator can copy an existing user.

For this purpose, select a user with the necessary rights with the right mouse button open the window with **"Copy User..."** .

See **Figure 7.30: Creating a User**.

A user can be copied and the administrator has the option of redefining the new user's rights.

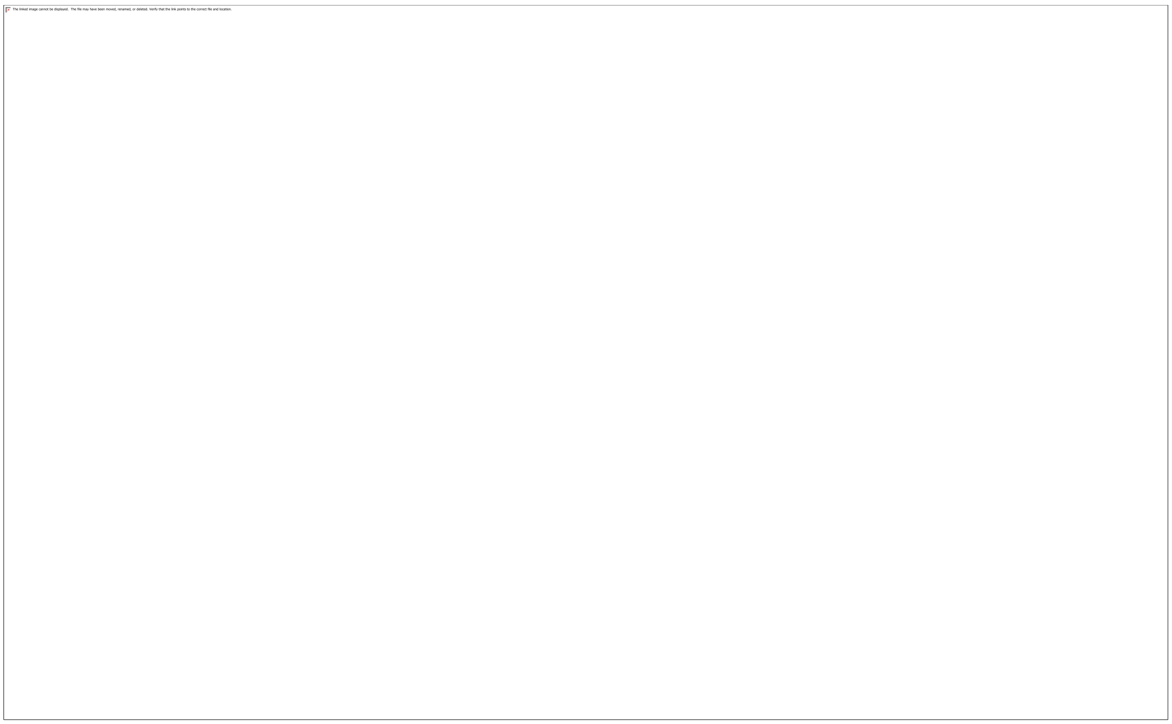


Figure 7.30: Creating a User

7.9 Operation

The user interface screens are designed based on the Piping and Instrumentation Drawings and give an overview of all system and process information.

7.9.1 BUP Overview

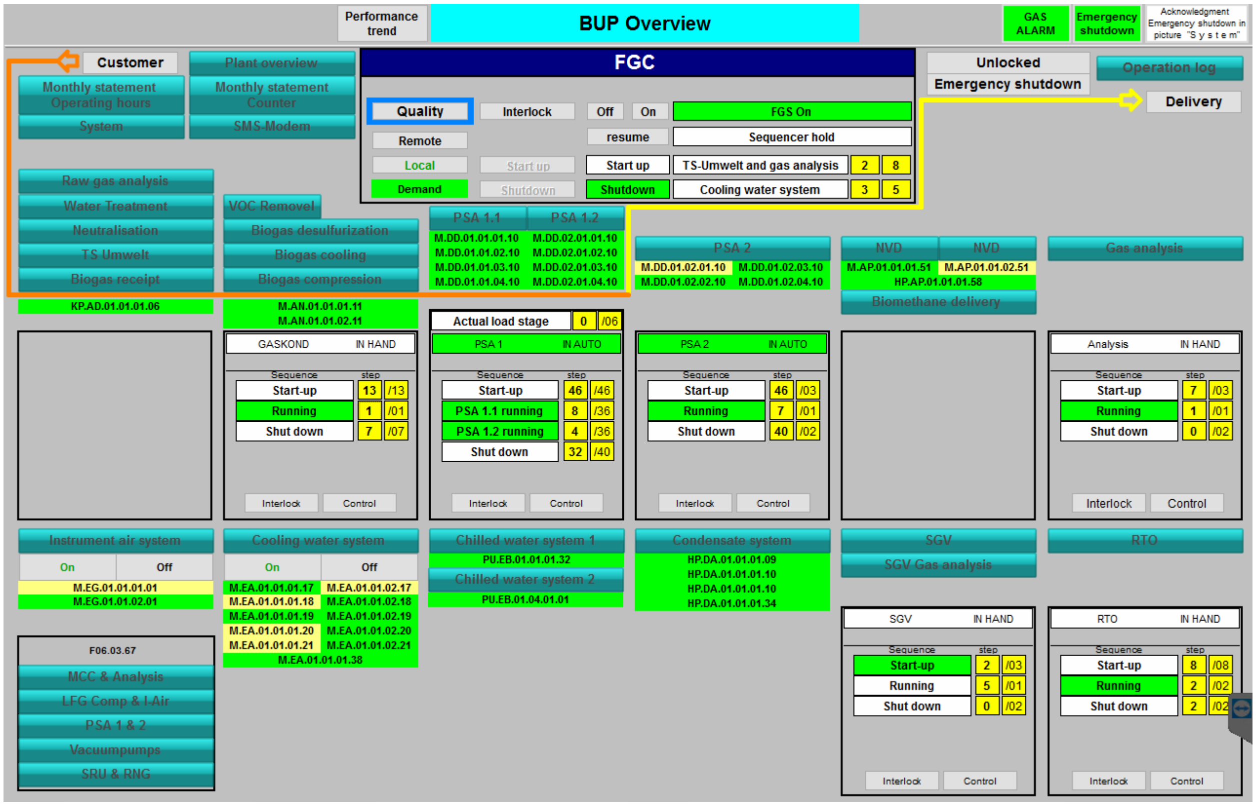


Figure 7.31: Assembly Screen BUP Overview

The assembly screen "BUP Overview" provides an overview of the status of the entire system with the main components, measured values, and states.

The representation corresponds to the production process:

1. Biogas Receipt
2. LFG Booster
3. Biogas Compression
4. Drying
5. VOC Removal
6. H_2S Polishing
7. PSA 1.1, PSA 1.2, and Intermediate Buffer Vessel
8. PSA 2 and Recirculation Bladder Tank
9. Biomethane Delivery
10. RNG Compression
11. Tail Gas System
12. Regenerative Thermal Oxidizer (RTO)
13. Neutralization

14. Fresh Water Supply
15. Instrument Air System
16. Cooling Water a nd Chilled Water Systems
17. Analyzer Room
18. Dane County/BIOFerm Gas Chromatograph (GC)
19. Building Technology/HVAC

<table>
<tr><td rowspan="5">
NOTICE</td><td colspan="3">The background color of a symbol indicates the operating mode of the component:</td></tr>
<tr><td>•</td><td>**Green**</td><td>The component is being driven</td></tr>
<tr><td>•</td><td>White</td><td>the component is turned off</td></tr>
<tr><td>•</td><td>**Red**</td><td>the component has a fault</td></tr>
<tr><td>•</td><td></td><td>the component is forced</td></tr>
</table>

The sub-system "Biogas receipt" is part of SGC "Gas conditioning".

The task and function are described in **Table 7.4**.

In addition to the process overview screen there are several other utility screens that provide different but comprehensive information about the state of the overall plant and equipment.

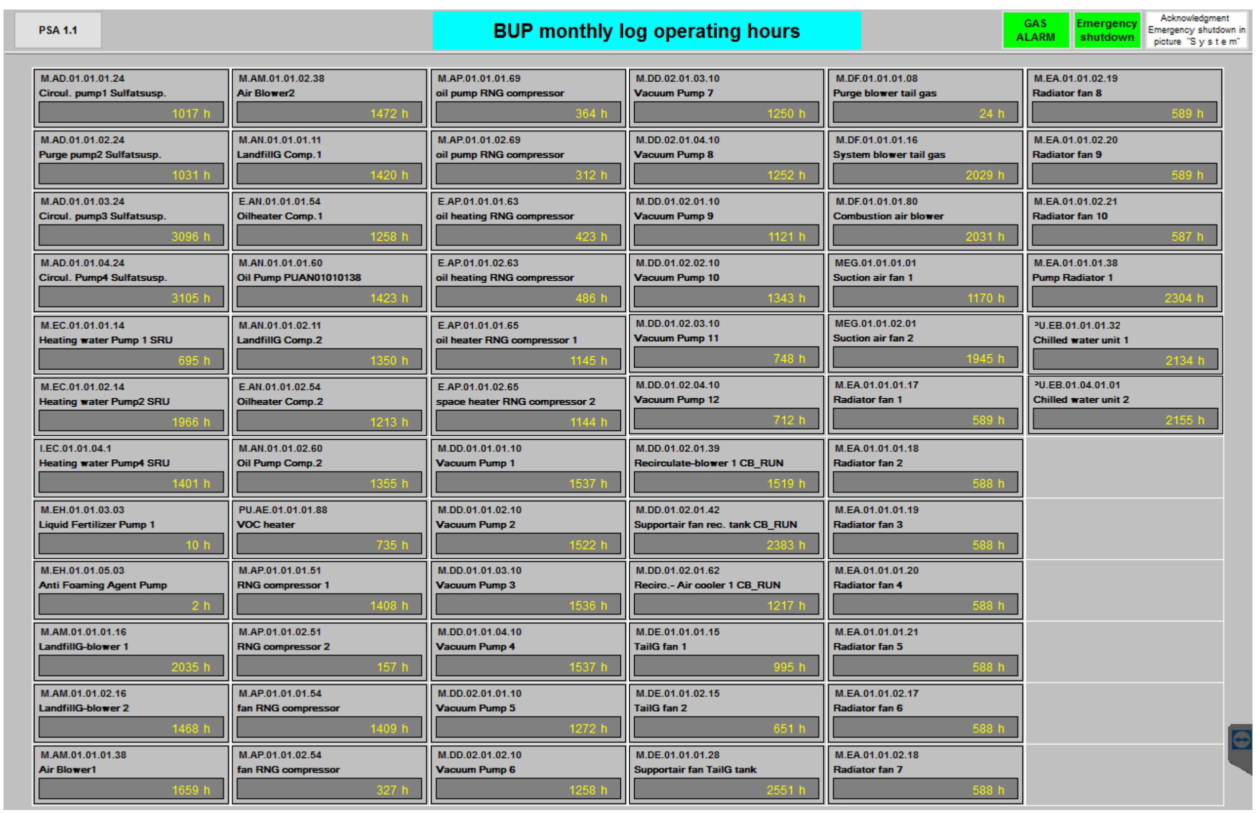


Figure 7.32: Assembly Screen Monthly Log Operating Hours 1

Assembly screen “BUP monthly log operating hours” is the first of two screens that show how many hours most of the rotating equipment and electric heaters have run. This allows the ability to track and schedule preventative maintenance for equipment

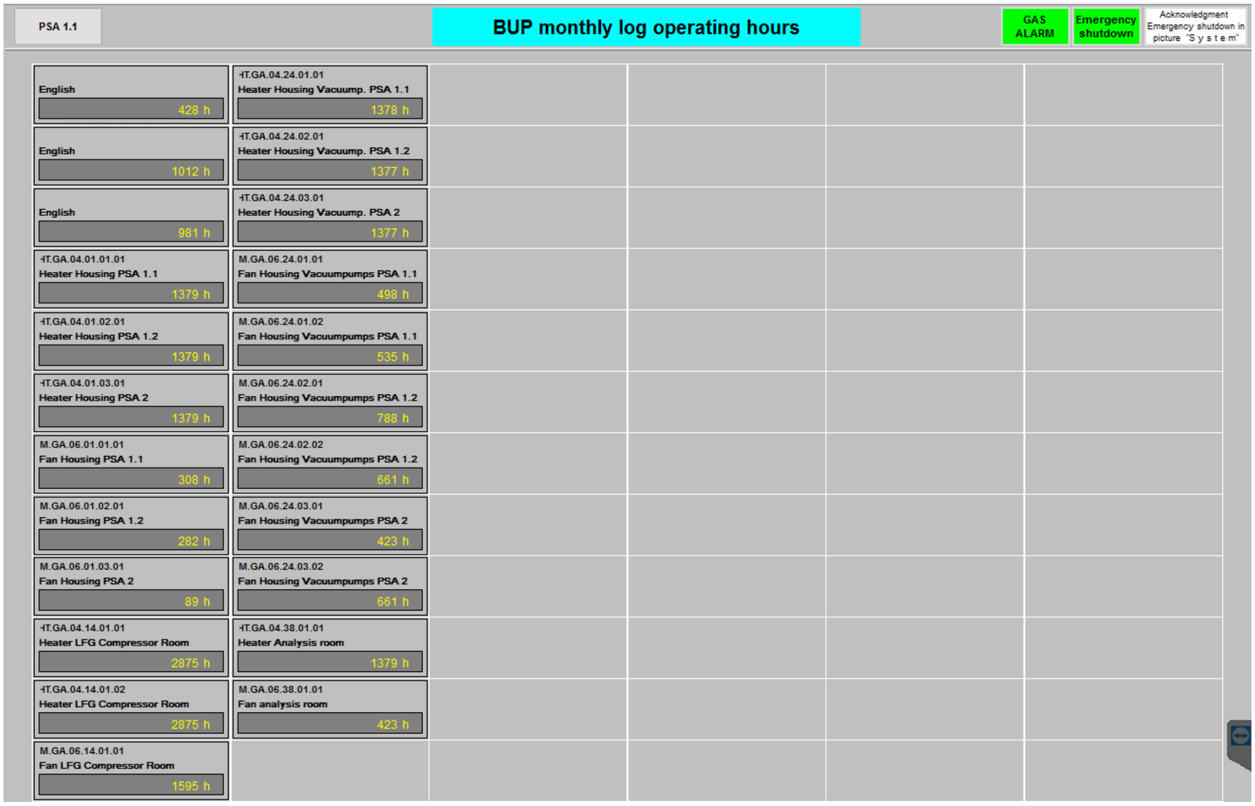


Figure 7.33: Assembly Screen Monthly Log Operating Hours 2

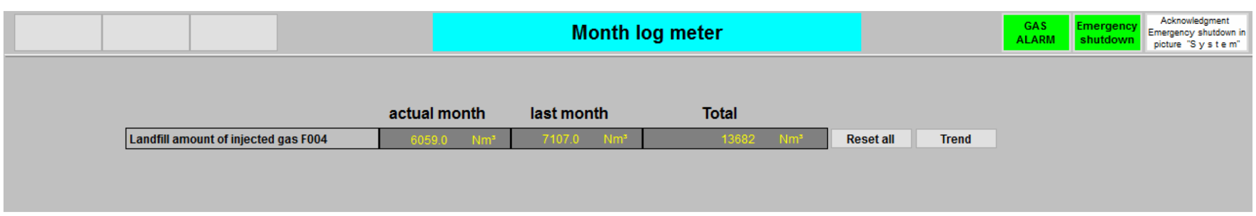


Figure 7.34: Assembly Screen Monthly log meter

Assembly screen "Month log meter" tracks how much gas has been injected into the pipeline. This includes totals for the previous month, the current month, and a running total. There is also reset and trend buttons available to provide additional information and functionality.

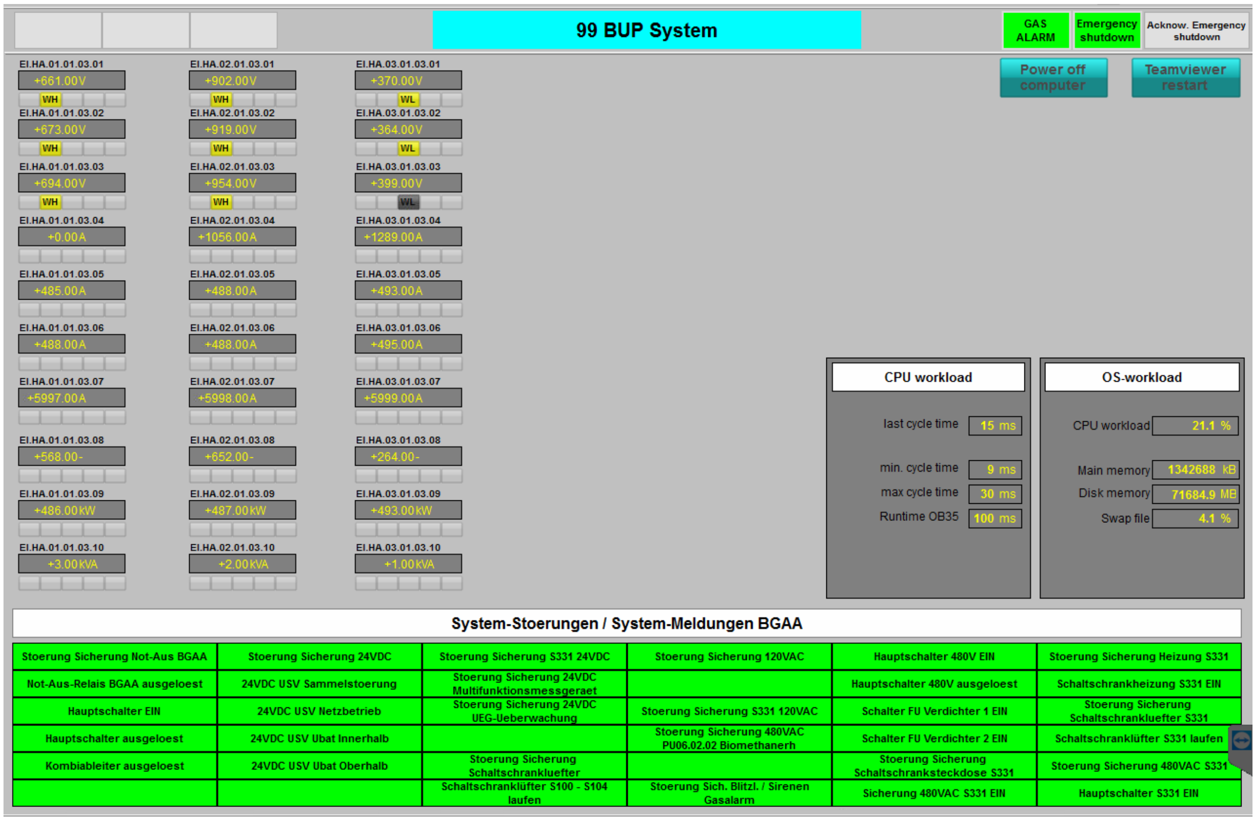


Figure 7.35: Assembly Screen 99 BUP System

Assembly Screen “99 BUP System” tracks the power consumption of rotating equipment at the plant and current PLC processing statistics.

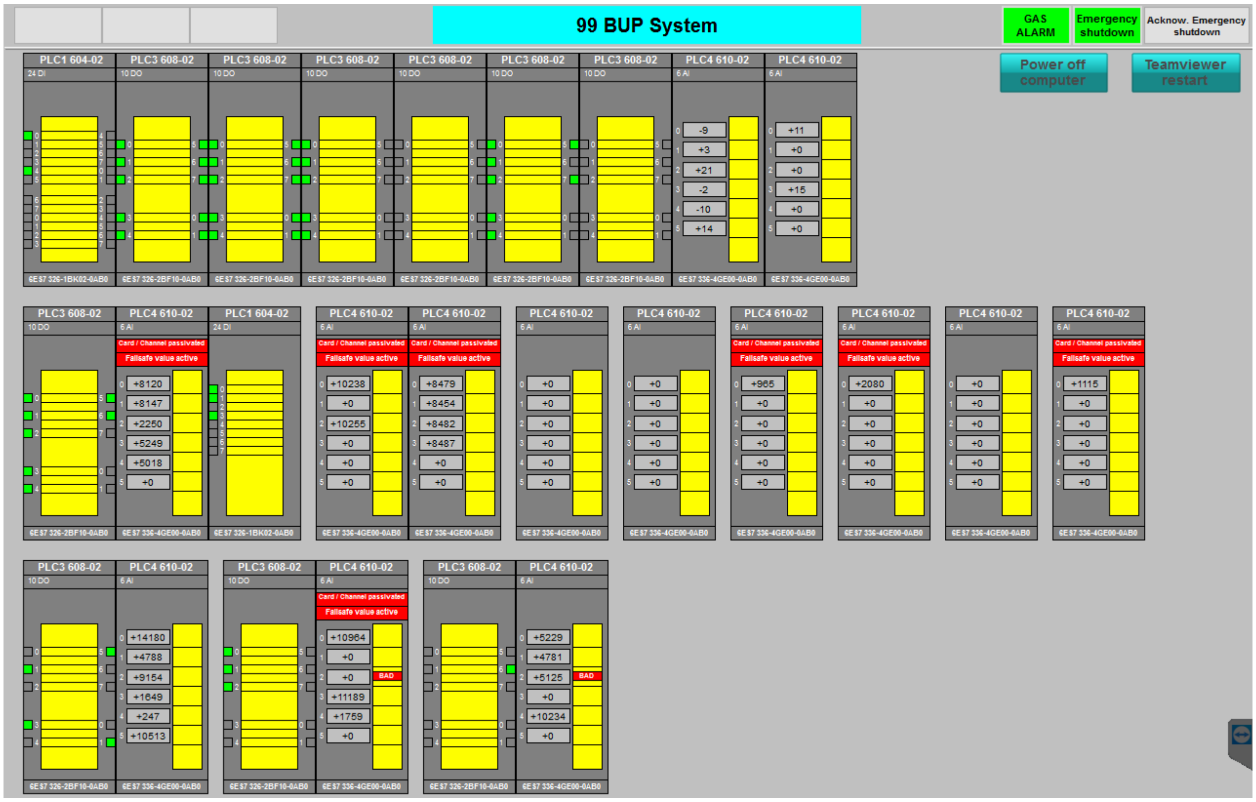


Figure 7.36: Assembly Screen 99 BUP System

The second assembly screen "99 BUP System" shows how the PLC logic and design is operating.

7.9.2 AD Biogas Receipt

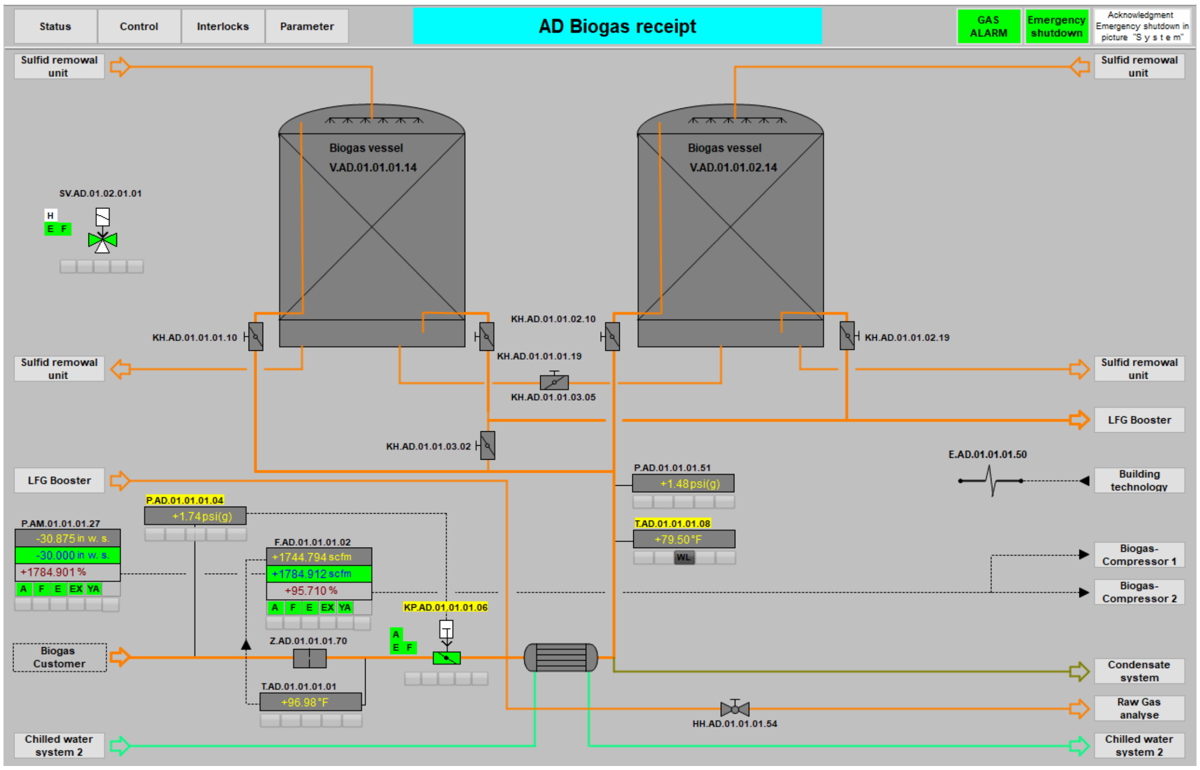


Figure 7.37: Sub-system "AD Biogas Receipt"

The inlet valve (KP.AD.01.01.01.06) is designed as a protective function, indicated by the yellow highlighted tag, i.e. if the limit values are exceeded or values fall below the limit, the valve is closed and safely locked. The valve must then be unlocked in the Safety Instrumented System (SIS) before starting the system.

 **CAUTION**	Before unlocking safety-related actuators or protective devices, the cause of the shutdown must be resolved.

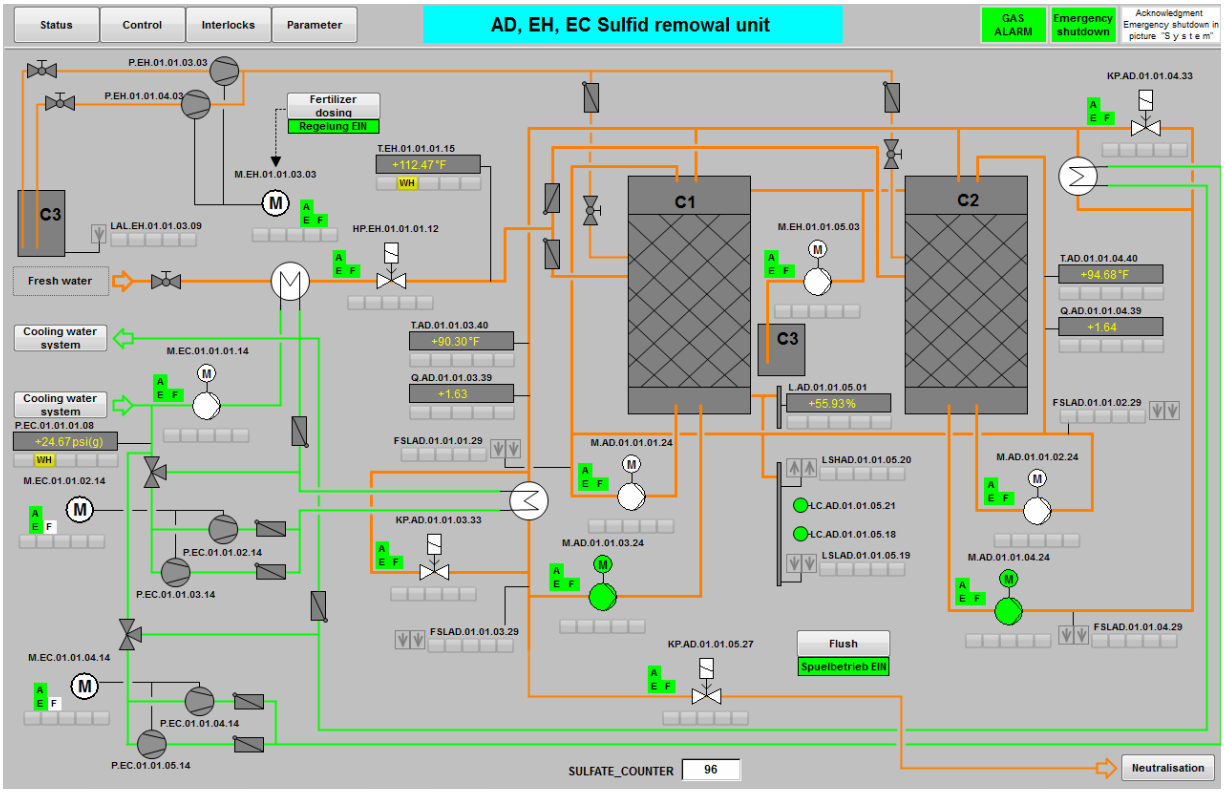


Figure 7.38: Sub-system "AD, EH, EC Sulfur Removal Unit"

All motors of the sub-system Sulfur Removal Unit “TS Umwelt” can be put into manual mode or completely switched off by a switch at each motor. The motors will only respond to signals from the PLC, if the corresponding switch is set to automatic mode. The positions of the switches are indicated at the top of the screen.

For the biological desulfurization to work properly the microorganisms need sufficient amounts of oxygen and fertilizer.

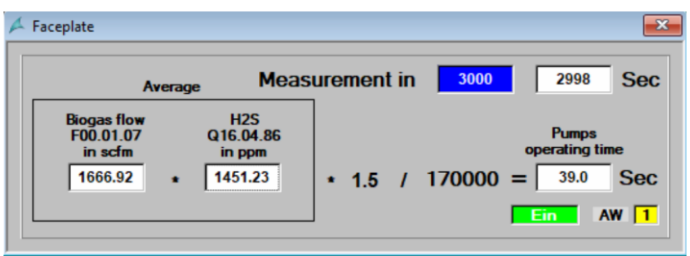


Figure 7.39: Fertilizer Controller

As mentioned above, the microorganisms need nutrients to metabolize hydrogens sulfide. Therefore, fertilizer dosing is necessary. The appropriate amount of fertilizer depends on the amount of hydrogen sulfide, i.e. on the flow of biogas and its H_2S content. The dosing pumps are switched on periodically and then run for a certain time. The time interval can be adjusted manually, if necessary. The calculation of the appropriate dosing time is based on average values for the biogas flow and the H_2S concentration, in which the average is taken over the time span that is equivalent to the chosen time interval.

The microorganisms grow on the surface of the filling material inside the scrubber towers. To keep the biofilm from growing too much and thus end up clogging the towers, the filling material has to be flushed from time to time. The flushing is done by supplementing the flow from the main pumps to the scrubbers. Therefore, pumps or the motors M.AD.01.01.01.24 and

M.AD.01.01.02.24 are switched on periodically. The operation time and the rest time of those pumps can be seen in the “parameter” faceplate. Both pumps should not be started and stopped at the same time. Therefore, a delay time is maintained automatically. This time can also be seen in the faceplate.

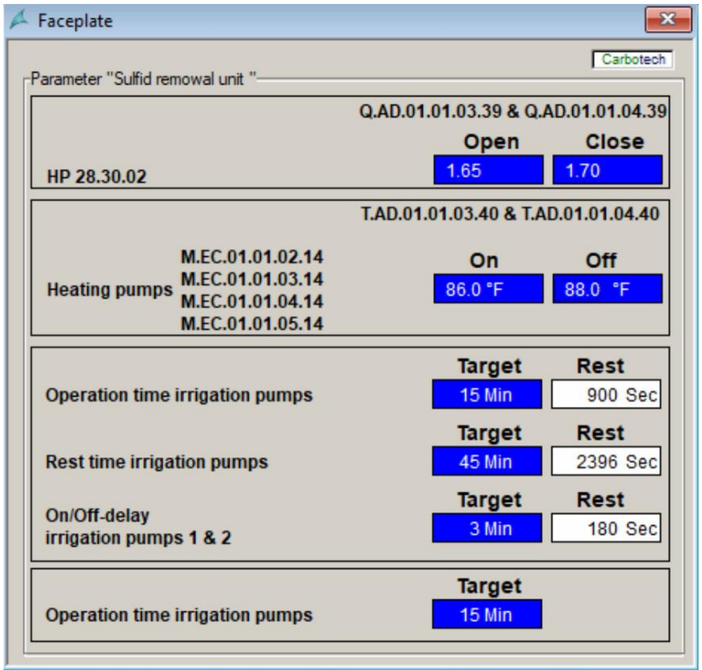


Figure 7.40: Faceplate Flushing of Scrubber Towers

7.9.3 AM LFG Boosters

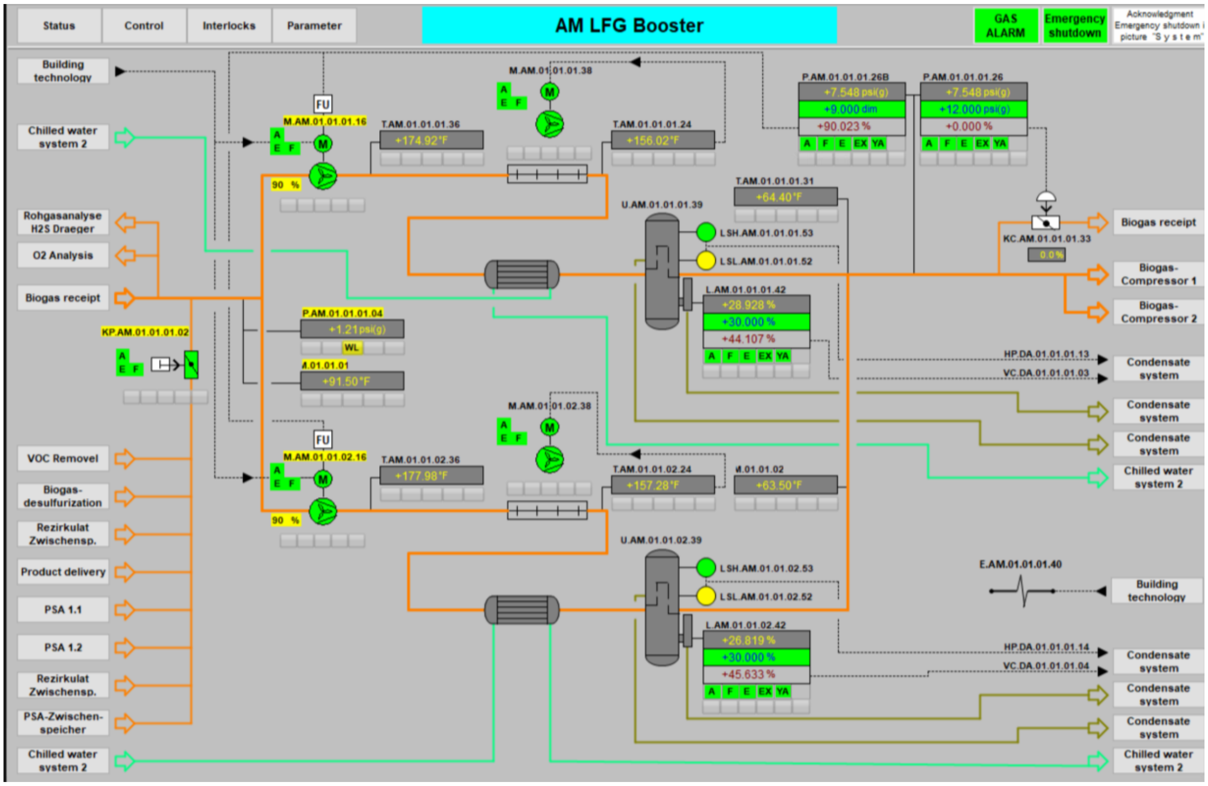


Figure 7.41: Sub-system "AM LFG Booster"

Gas after the biological desulfurization goes to LFG booster, where gas is pressurized up to 10 psig using the LFG blowers. The blower speed is automatically controlled to maintain a downstream pressure of 10 psig. After that the gas passes through a set of heat exchanger to cool down the process stream condensing any water in the gas stream. A filter separator is used to remove water before the gas is sent to LFG compressor. The condensed water is sent to the Condensate Sump.

7.9.4 AN LFG Biogas Compressor

The sub-system "biogas compressor" is part of SGC "gas conditioning". The task and function are described in Table 7.4.

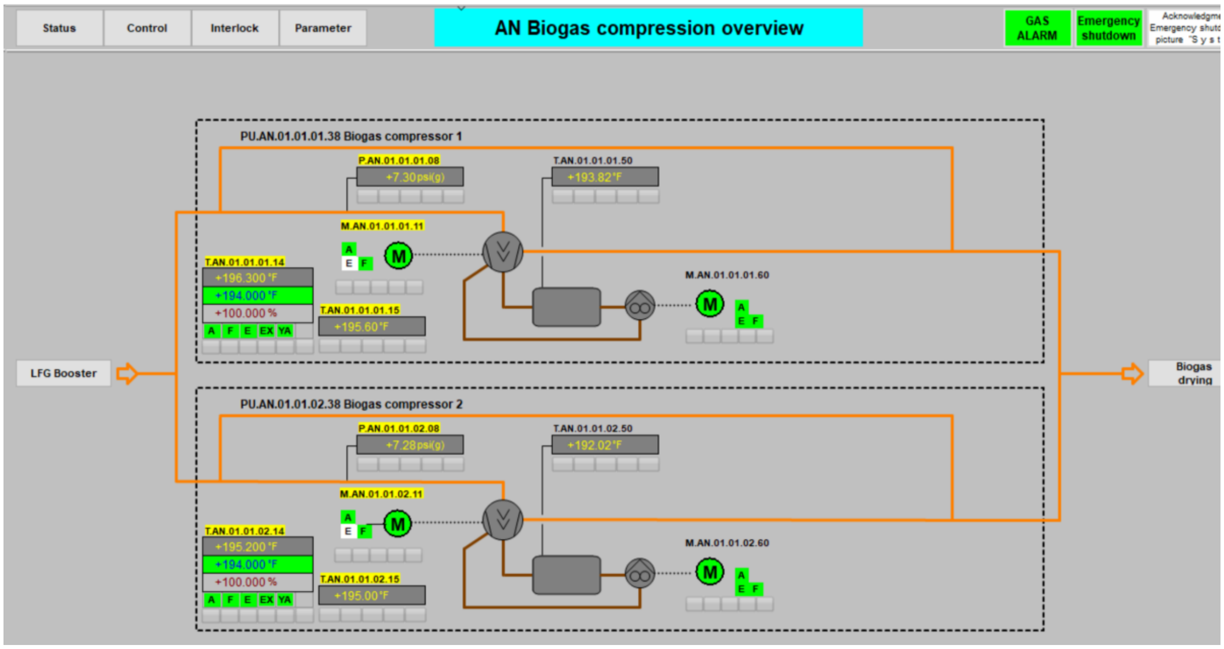


Figure 7.42: AN Biogas Compression Overview

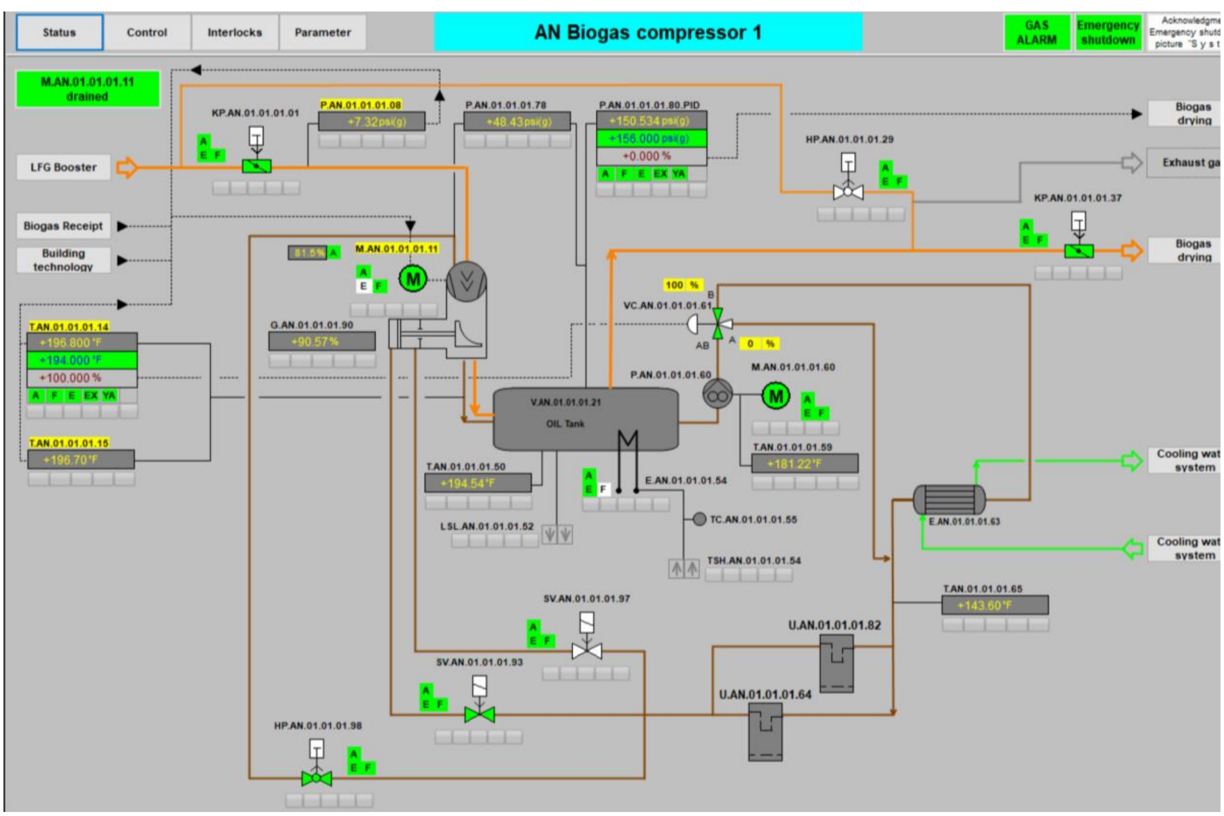


Figure 7.43: Sub-system "AN Biogas Compressor 1"

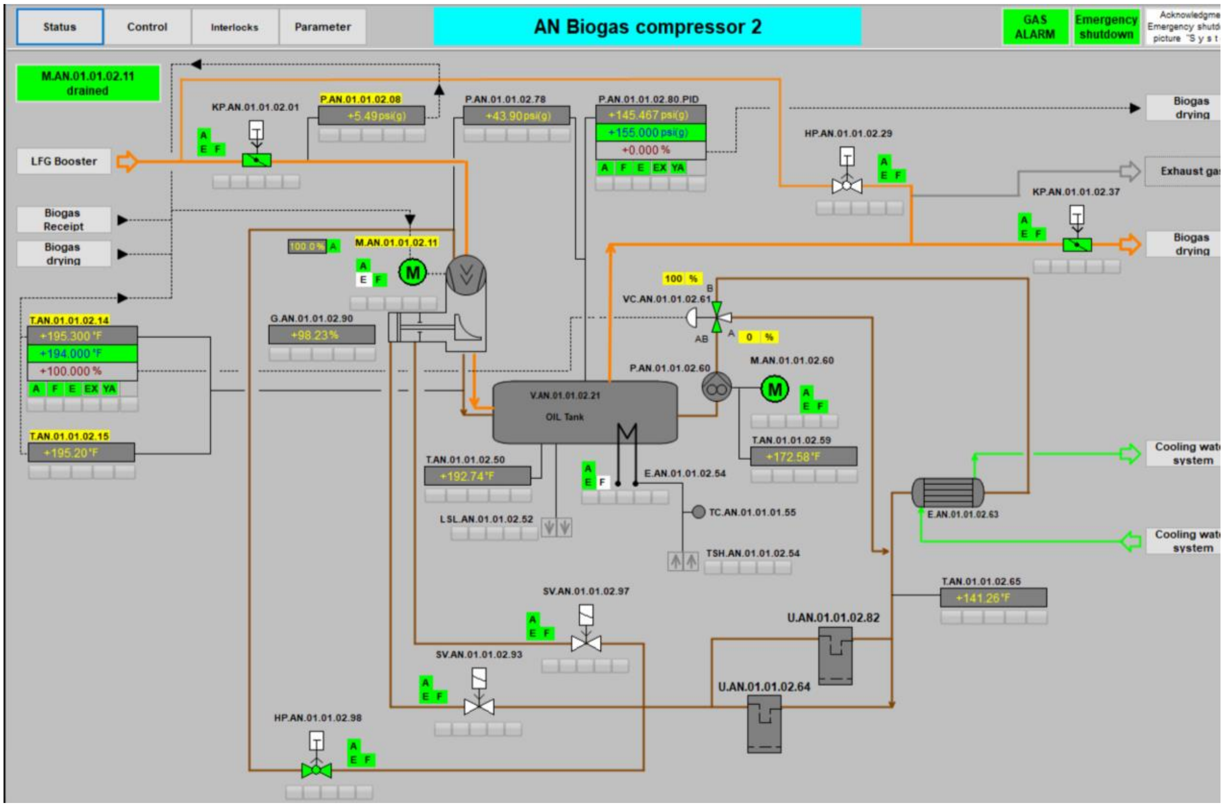


Figure 7.44: Sub-system "AN Biogas Compressor 2"

The inlet valve and the release valve of the compressors are controlled as a function of the compressors. If a compressor is switched on, the release valve is automatically closed and the inlet valve is opened after a time delay. This process is carried out without an SGC or FGC. Detailed information on the process is included in the process description.

To start up the SGC gas conditioning, the following parameters must be considered:

NOTICE	The parameters of the compressor can only be changed in consultation with **BIOFerm Energy Systems** because a change of these parameters may, among others, affect the gas quality.

START of a compressor

Prerequisites:

- Recirculating ball valve HP.AN.01.01.01.29/02.29 in automatic mode
- Inlet valve KP.AN.01.01.01.01/02.01 in automatic mode
- Compressor drive M.AN.01.01.01.11/02.11 unlocked
- Oil pump M.AN.01.01.01.60/02.60 in automatic mode

Process of the start-up sequence:

- Compressor motor can be started only via the function groups control "Gas Conditioning" and, in fully automatic mode, via the functional group control, and the drive is powered up to the appropriate power level high by controlling the slider.
- Oil pump M.AN.01.01.01.60/02.60 is started
- Recirculating ball valve HP.AN.01.01.01.29/02.29 closes
- Inlet valve opens with a time delay

NOTICE	In order to prevent the overheating of a compressor drive, the number of motor starts is limited to max. 4 times per hour.

TURNING OFF a biogas compressor

Process of the shutdown sequence:

- Compressor motor switches off
- Oil pump M.AN.01.01.01.60/02.60 is switched off with a time delay
- Recirculating ball valve HP.AN.01.01.01.29/02.29 opens
- Inlet valve closes

Biogas compression

The biogas is drawn in at pressure supplied by the LFG Blowers and compressed via single-stage screw compressors. The oil injected for cooling is separated via separators (for further details, please refer to the manufacturer documentation of the compressors).

The compressor drives are designed as a protective device. Missing monitoring will lead to a safety shutdown.

- Low suction pressure
- High compressor discharge temperature
- High compressor discharge pressure
- Emergency shutdown
- Container LEL Gas Alarm

The flow rate (setpoint) for controller F.AF.01.01.01.35 is controlled by the load stage control of the PSA. The load stage control for the PSA can be found in the PSA Parameter Performance Adjustment Faceplate.

A compressor discharge pressure of about 145 psig should be reached for the biogas to ensure that the PSAs have adequate pressure.

The cooling water system must be operational before the compressor is switched on because the compressors are water cooled. Without cooling, the max. compressor discharge temperature will be exceeded.

7.9.5 AF Biogas Drain

The sub-system "Biogas Drain" or "Drying" is the next step in the gas conditioning. The task and function are described in the Chapter 3.1.3.

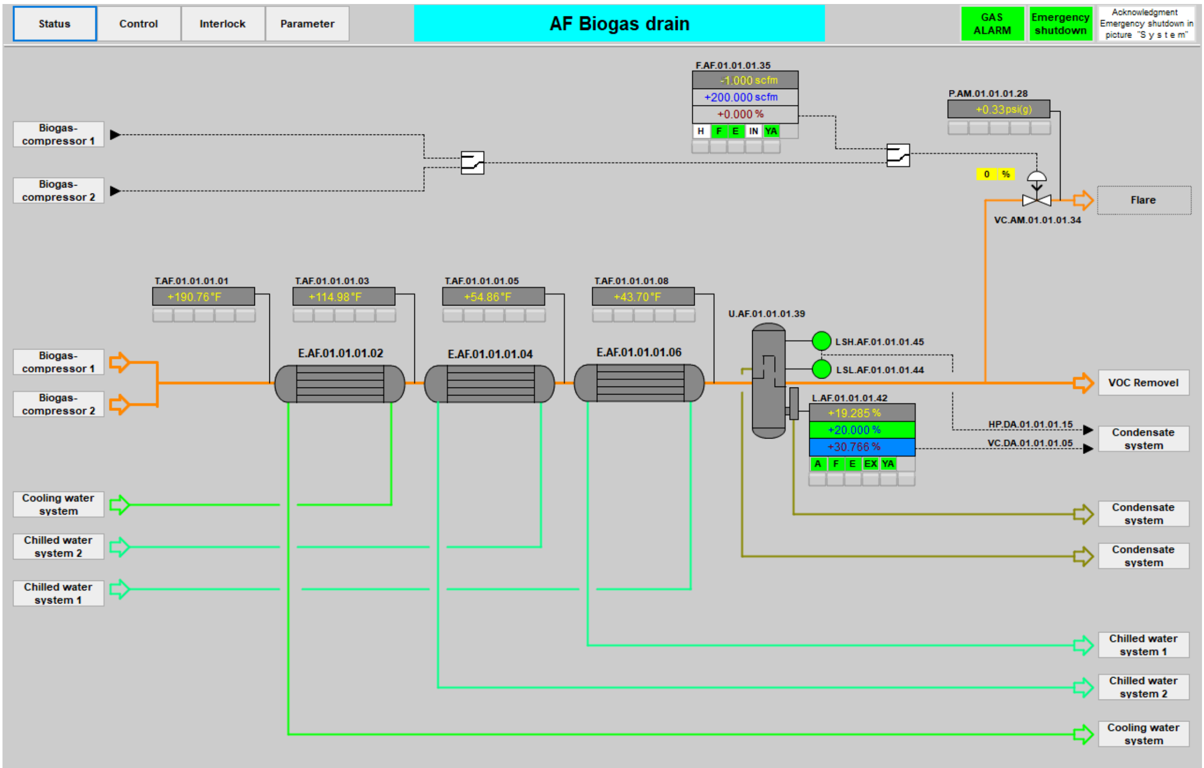


Figure 7.45: Sub-system "AF Biogas Drain"

"AF Biogas Drain" is used for monitoring the biogas drying process. The condensate is separated by staged cooling through 3 heat exchangers. A filter separator is then used to ensure all condensate including any remaining oil from the LFG Compressors are removed before the gas is processed further. The gas is normally moved to the VOC removal process for the next purification step. While the condensate is moved to the Condensate Sump.

7.9.6 AE VOC Removal

The sub-system "VOC Removal" is next step in the gas conditioning. The task and function are described in the Chapter 3.1.5.

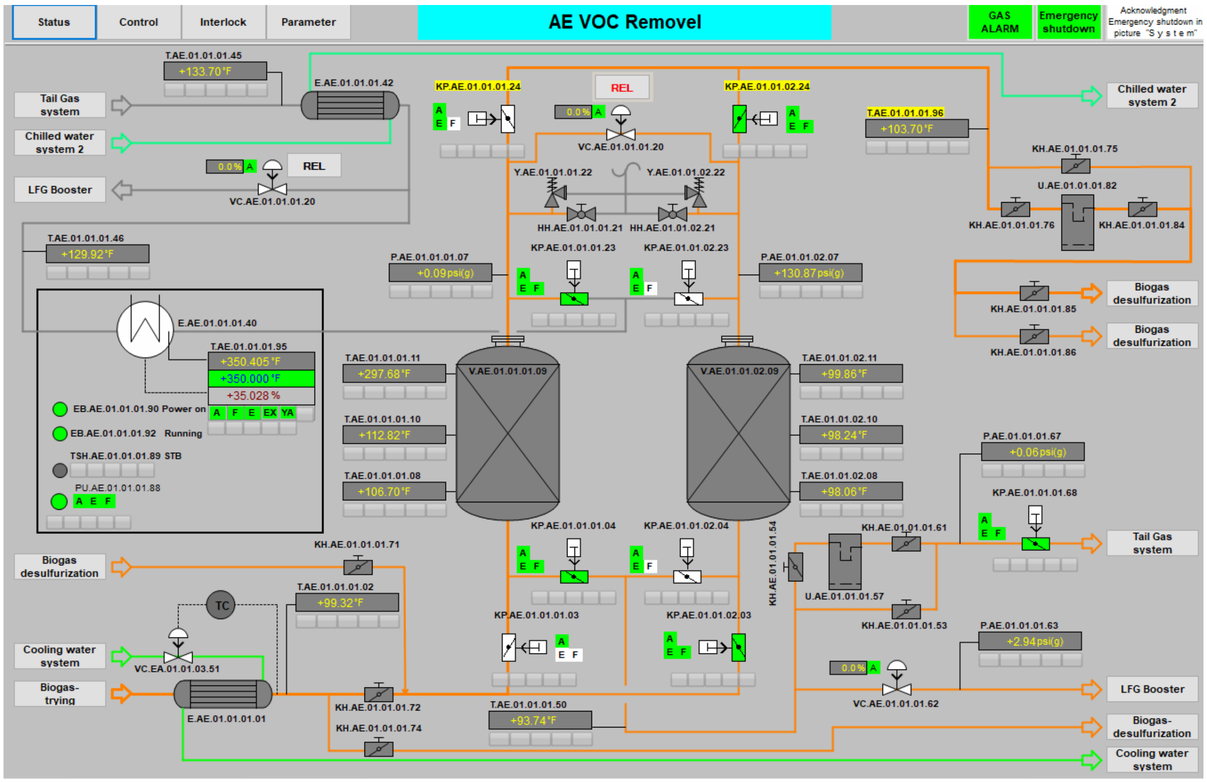


Figure 7.46: Sub-system "AE VOC Removal"

After "AF Biogas Drain" the gas is heated to roughly 110°F before entering the VOC Removal vessels. VOC removal system utilizes a temperature swing adsorption (TSA) process which consists of two vessels filled with adsorbent to remove VOC and siloxanes. While one vessel is in operation the second adsorbent bed is regenerated at elevated temperatures by purging with heated off-gas from the first stage PSA unit. At higher temperatures most of the adsorbed components will desorb and diffuse into the gas phase again. The VOC-laden off-gas from the regeneration process will be destroyed in the thermal oxidizer. The gas subjected to the operational vessel will remove 99.99% of all VOC and siloxanes and will proceed to the Polish Desulfurization system. The VOC removal system operates automatically with vessel regeneration occurring every 24 hours. VOC removal is part of PSA operation mode, so when system is running on Bio-D mode, VOC removal process will be on hold.

7.9.7 AC Biogas Desulfurization

The subsystem Biogas Desulfurization or Polish Desulfurization is part of SGC Gas conditioning. The task and function are described in Chapter 3.1.6 and Table 7.4.

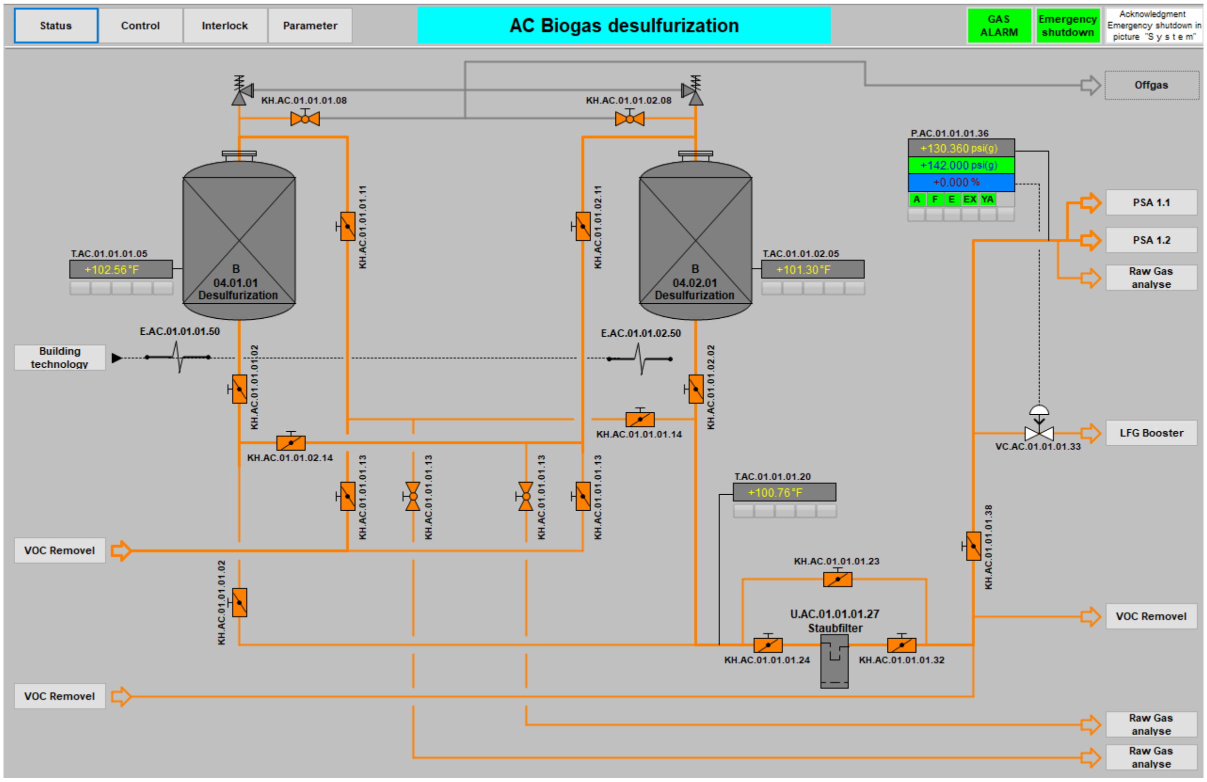


Figure 7.47: Subsystem AC Biogas Desulfurization

Desulfurization system consists of two vessels connected in a lead-lag circuit which directs the flow of biogas through the desulfurization vessels in series, one after the other. By adjusting the valves going into the system, the flow of gas can be changed so that the vessels can be run in reverse order or so that each vessel can be used separately

These adjustments are used in cases where a desulfurization vessel is loaded with elemental sulfur and the activated carbon media must be replaced. The Desulfurization system runs manually at 140 psig and 100°F and removes 100% of remaining hydrogen sulfide (H_2S) and elemental sulfur.

A continuous sample line is monitored at two points in this sub system. The first is between the two vessels and the second is after the vessel. These two sample points allow for the continuous gas analysis during the process ensuring no hydrogen sulfide is passed to downstream units.

Polish Desulfurization is part of PSA operation mode, so, when system is running on Bio-D mode, the polish desulfurization vessel will be on hold.

CAUTION	Since the H_2S removal causes elemental sulfur to remain irreversibly on the activated carbon, the activated carbon filling in the desulfurization vessel must be changed in certain intervals to safely avoid any possible damage and loss of efficiency of downstream equipment by remaining H_2S.
NOTICE	If the H_2S concentration is > 0 ppm after the first vessel, the activated carbon filling needs to be replaced. After the change, the order of the vessels is reversed, and the renewed vessel acts as a "police filter". The filtering works only at low oxygen concentration in the gas.
CAUTION	This interval depends on the sulfur content of the biogas and the size of the desulfurization vessels. In order to test the sulfur load of the activated carbon, gas samples must be taken from the gas stream after each desulfurization stage and the H_2S load must be analyzed. These tests need to be performed on a frequent basis according to the experience of the system operator. Any long-chain hydrocarbons (e.g. VOC's) or siloxanes present can reduce the load time of the activated carbon.

7.9.8 AA PSA 1.1, PSA 1.2 and PSA 2

The subsystems **AA PSA 1.1**, **AA PSA 1.2**, and **AA PSA 2** are part of the SGC PSA. The task and function are described in the Chapter 3.1.7

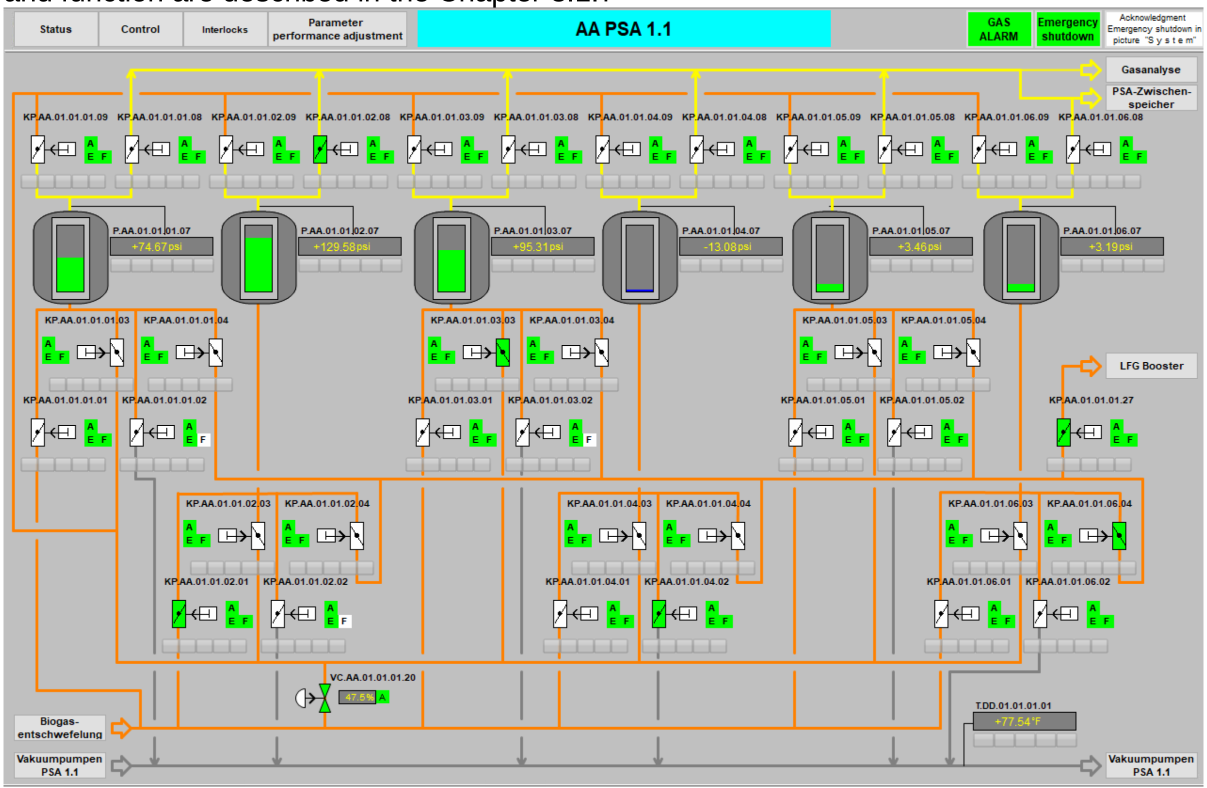


Figure 7.48: Sub-system AA PSA 1.1

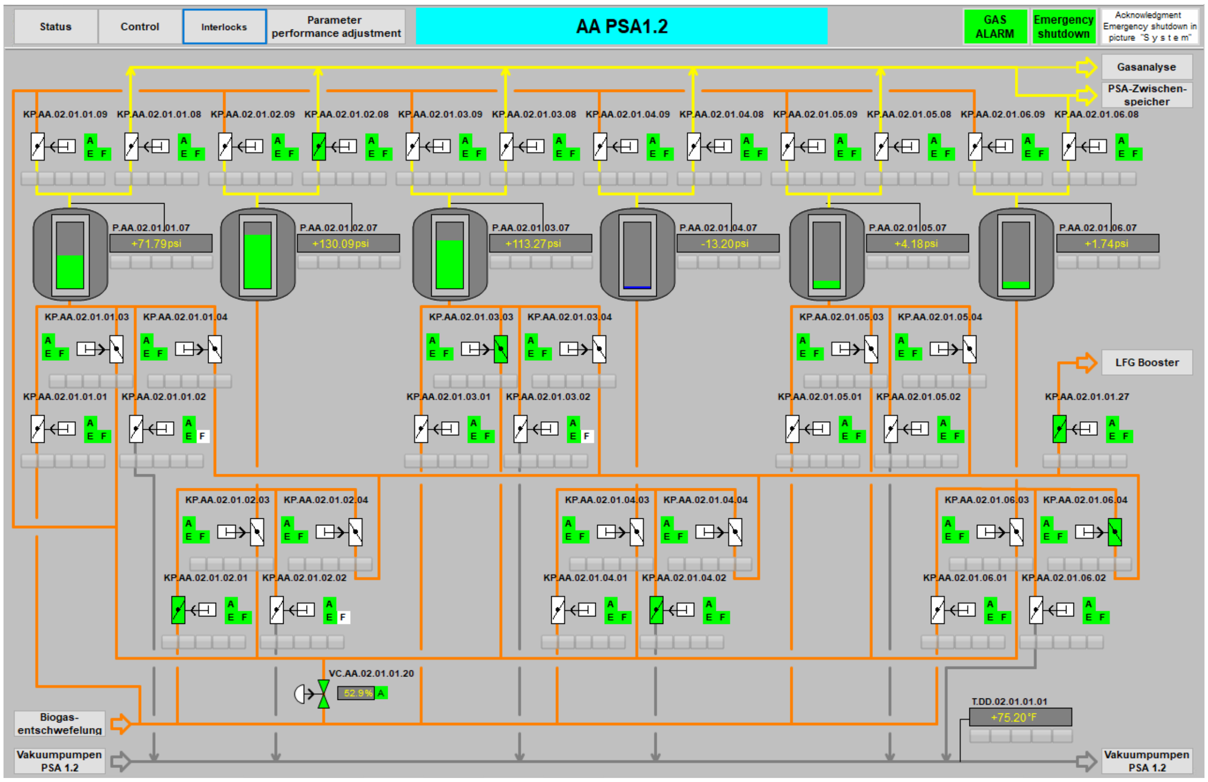


Figure 7.49: Subsystem AA PSA 1.2

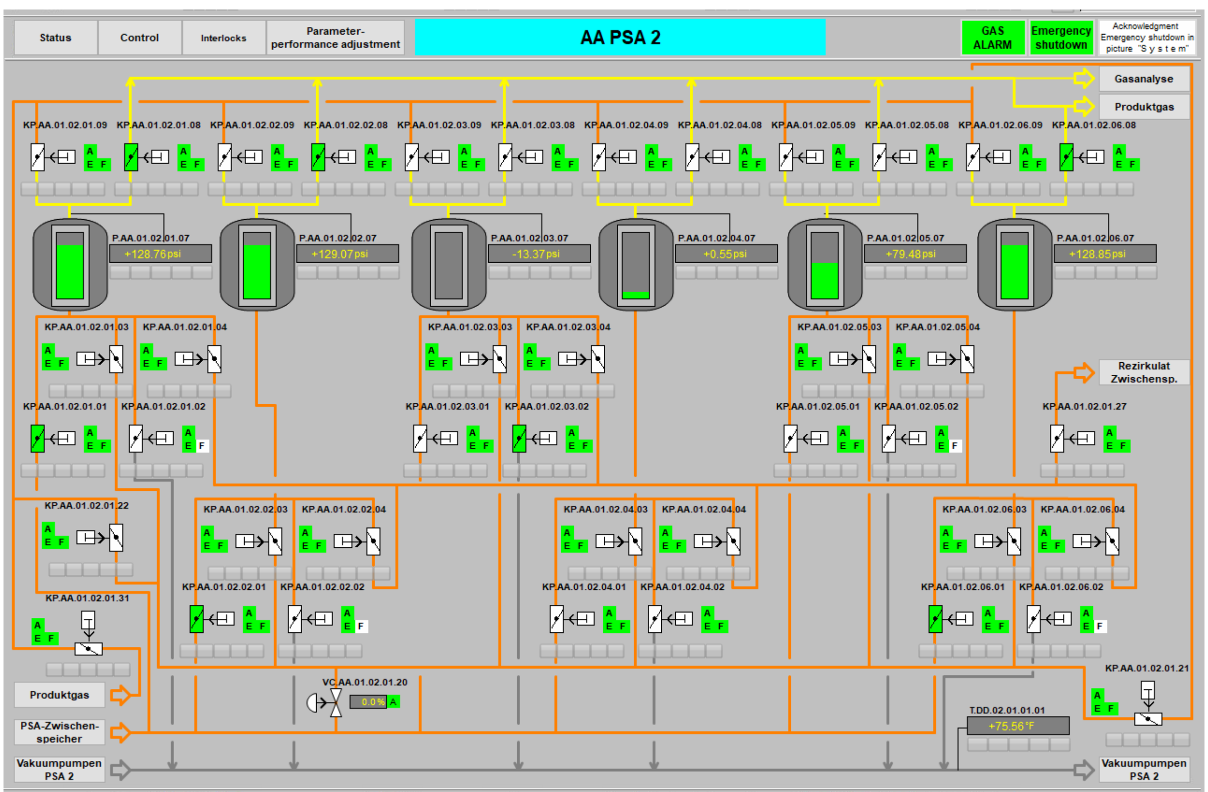


Figure 7.50: Subsystem AA PSA 2

To start up the PSA system, the following parameters must be considered:

No.	Parameter	Description
1	Vacuum pump	Make sure all vacuum pumps are ON and running
2	Alarms High or Low	Make sure there is no alarms
3	Set the P.AA.01.01.01.44 in ON	Make sure P.AA.01.01.01.44 is ON and correct pressure is set

Table 7.8: Parameters to Start PSA System

Preparation for starting up the PSA system in fully automatic mode

Procedure:

1. Automatic power adjustment depending on the landfill pressure.
2. In the "Automatic" operating mode, the different load levels of the PSA are run depending on the flowrate from landfill. The flow from the landfill is a displayed in both in inches of Water Column for the landfill pressure and from the inlet flow meter.
3. Operating Mode Change of Power Adjustment
4. The operating modes of the power adjustment of the PSA are changed via the two buttons "Manual" and "Automatic". The current mode is always highlighted green. The last mode is always stored, i.e., the FGC and the SGC has no influence on the operating mode of the power adjustment.
5. Parameter Setting of the PSA Load Levels
6. This setting may be changed only in consultation with **BIOFerm Energy System.**
7. In the first column, the current load level is displayed. In the remaining columns, the times, the maximum and minimum variable values of VC.AA.01.01.01.20
8. Delay Time Automatic Load Level Change
9. This function may be used to enter a delay of an automatic load level change. After each load level change, the remaining time until the next allowable load degree change is shown in the display field below. This is not relevant in "manual" operating mode and is not considered. This delay is used to protect the compressor against overheating due to frequent compressor starts.

Parameter Faceplates "PSA System"

The faceplate **"Parameter Performance Adjustment"** is used to modify the PSA timing based on load levels, by adjusting the times T1-T6. Each load level has specific PSA timing.

NOTICE	The parameters in the faceplate "Parameter Performance Adjustment" affect the product and tail gas quality. These parameters may only be changed after consultation with **BIOFerm Energy Systems**.

Step no. of the SGC	Corresponding PSA times	PSA cycle
Step number 1	PSA time T1	1. PSA cycle
Step number 2	PSA time T2	
Step number 3	PSA time T3	
Step number 4	PSA time T4	
Step number 5	PSA time T5	
Step number 6	PSA time T6	
Step number 7	PSA time T1	2. PSA cycle
Step number 8	PSA time T2	
Step number 9	PSA time T3	
Step number 10	PSA time T4	
Step number 11	PSA time T5	
Step number 12	PSA time T6	
Step number 13	PSA time T1	3. PSA cycle
…..	…..	
…	…	

Table 7.9: PSA Operating Process with the Current Step of SGC, PSA Timing

7.9.9 AO Product Delivery

The sub-system AO Product Delivery is independent and not associated with any SGC. The task and function are described in the Chapter 3.1.8

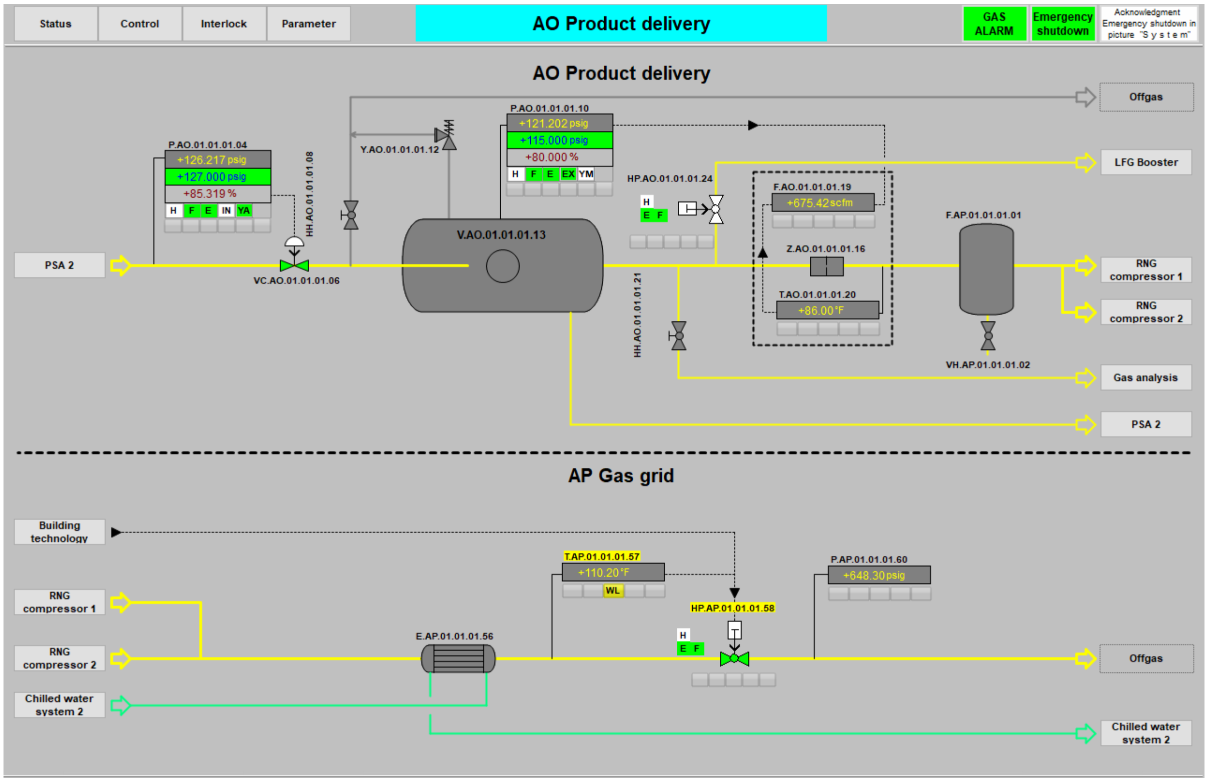


Figure 7.51: Subsystem Screen AO Product Delivery

The control valve VC.AO.01.01.01.06 maintains backpressure on the PSA systems. The Biomethane Vessel V.AO.01.01.01.13 acts to dampen the pressure swings off of the PSA 2 system before the gas is fed into the RNG Compressors.

In normal operation, the control valve HP.AO.01.01.24 is closed and will only be used if there is a need to recirculate gas to the inlet of the LFG Blowers. This might be necessary for plant start up, shutdown, or if there are final gas quality concerns.

The lower section of this screen show the final treatment of the Renewable Natural Gas (RNG) before it is injected into the pipeline. The gas is cooled in a final heat exchanger before being released to the pipeline.

7.9.10 AP RNG Compressors

The subsystem AP RNG Compressors is independent and not associated with any SGC. The task and function are described in the Chapter 3.1.9

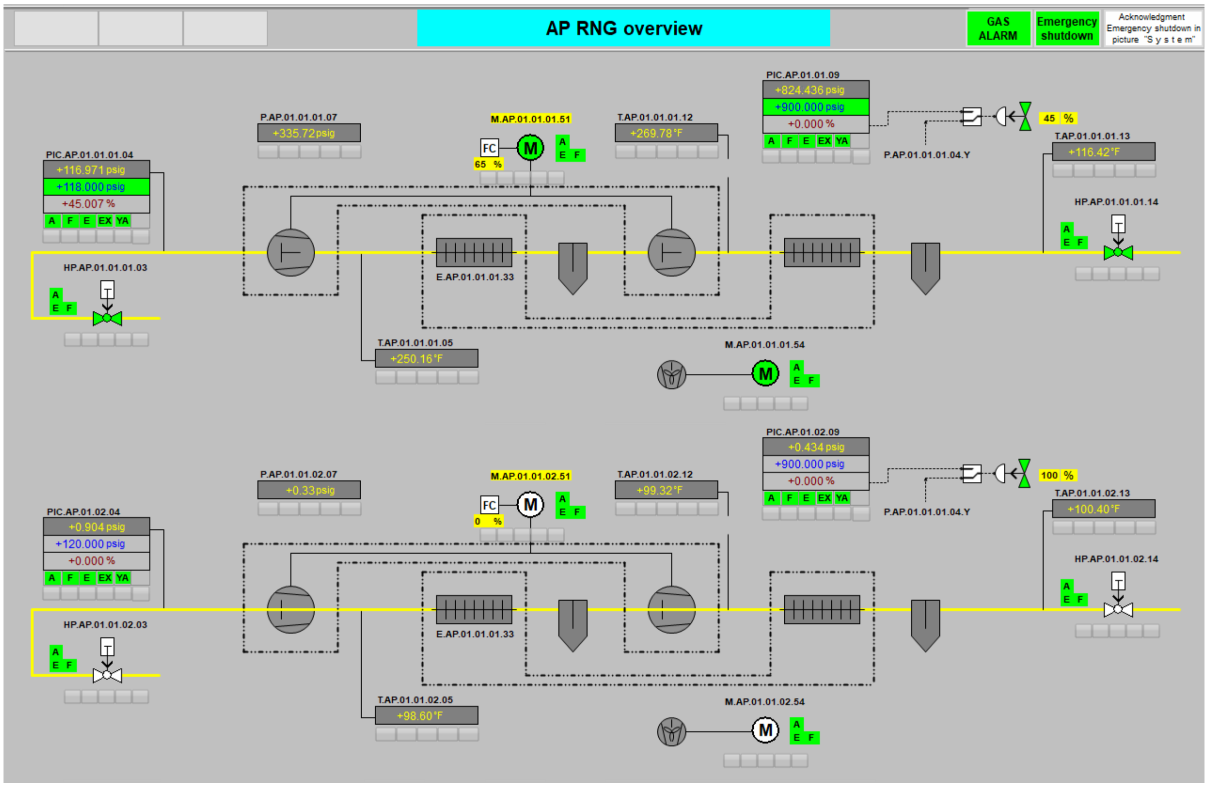


Figure 7.52: Subsystem Screen AP RNG Overview

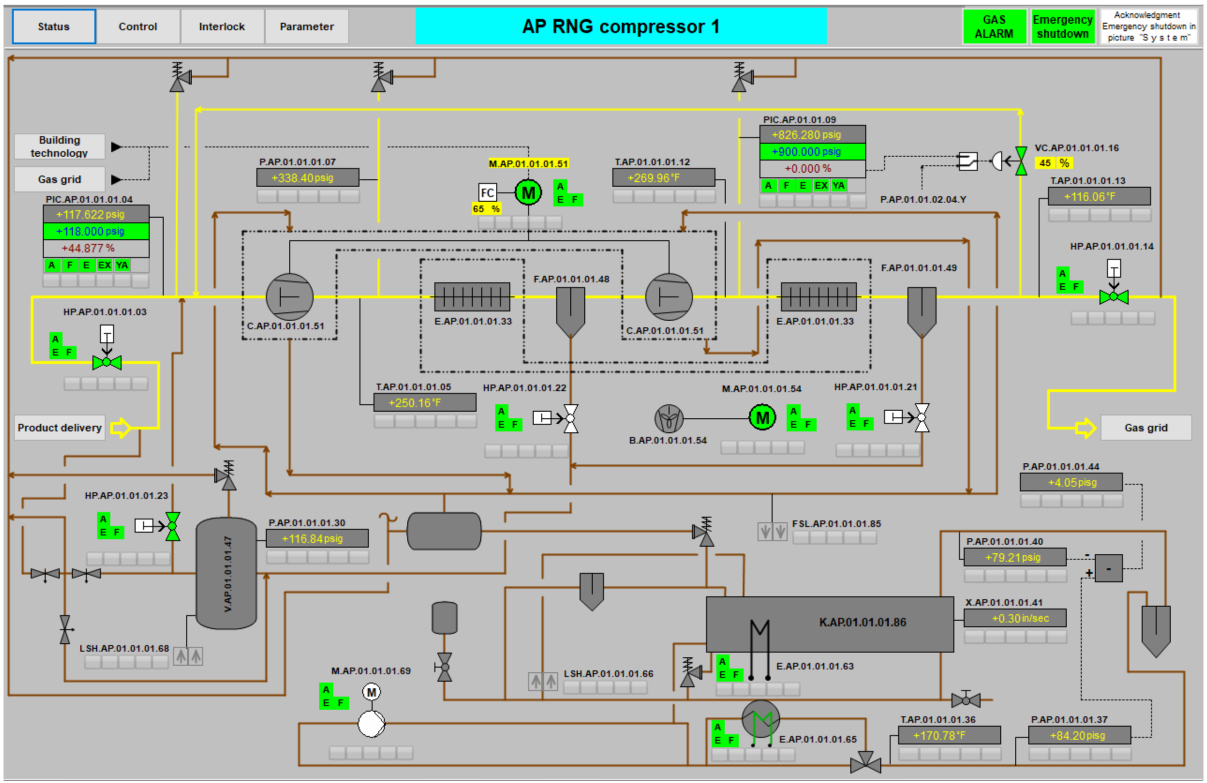


Figure 7.53: Subsystem Screen AP RNG Compressor 1

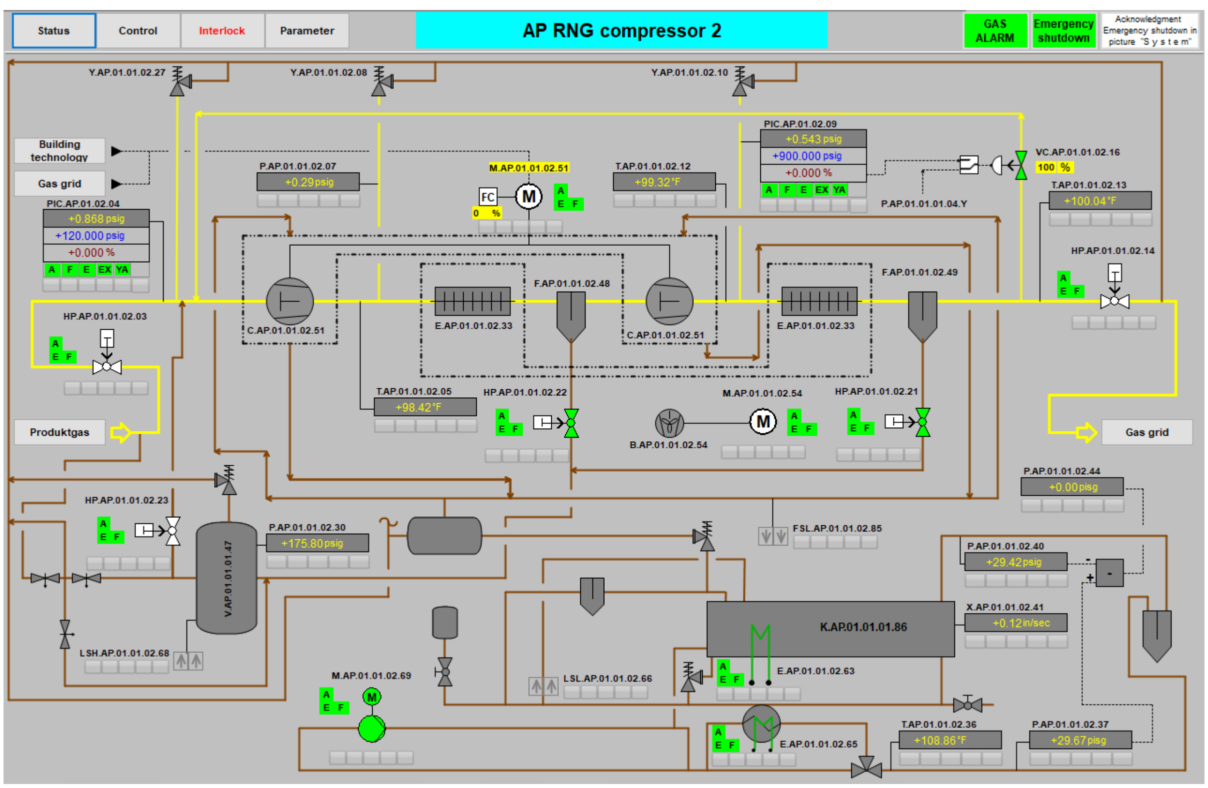


Figure 7.54: Subsystem Screen AP RNG Compressor 2

The product gas leaves the Biomethane vessel and pressurized in the reciprocating piston compressors. There are two compressor trains each can process 100% of the product gas independently. Each compressor train has two stages with cooling down stream of each stage. The dual stage compression allows the process to bring the gas from roughly 120 psig up to pipeline injection pressure of 650-975 psig.

Oil is used to lubricated and cool the compressors. The oil has its own recirculation system with each compressor where it is separated out of the compressor and from the gas stream, collected, cooled, and recirculated back into the compressors. For further details on this operation, please refer to the compressor manufacturer documentation.

Because the tolerances on the compressors are so tight, and they rotate so quickly, they are highly susceptible to damage from several sources. To prevent this damage there are several situations that would interlock the compressor drives to shutdown. These interlocks include:

- Low suction pressure
- High discharge temperature
- High discharge pressure
- Any E-Stop trips or other universal system trips
- Housing gas monitor (LEL) alarm

The air cooler fans must be on before starting the RNG compressors to ensure that the maximum discharge temperature is not exceeded.

7.9.11 DE Tail Gas System

The subsystem DE Tail Gas System has its own independent SGC. The task and function are described in the Chapter 3.2.4

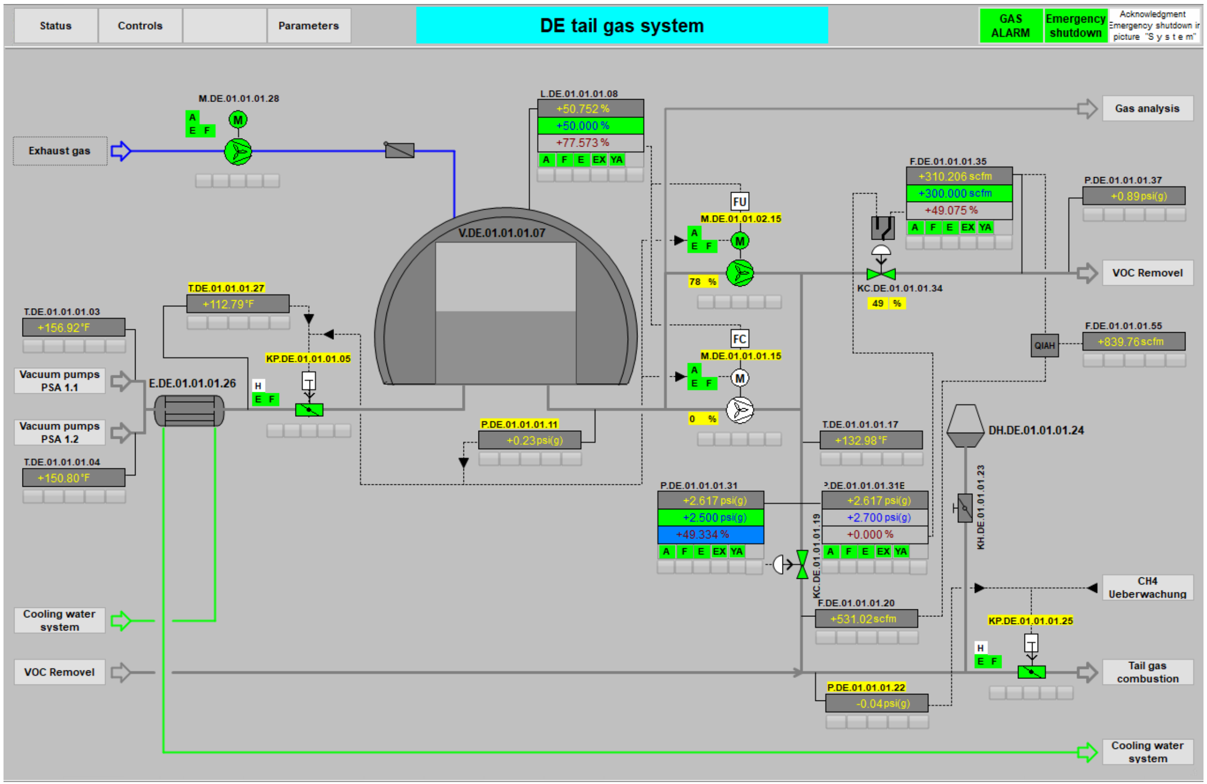


Figure 7.55: Subsystem Screen DE Tail Gas System

The Tail Gas System consists of a bladder tank which stores the tail gas from the PSA 1.1 and 1.2 systems. The level of off gas inside the bladder tanks is maintained by a blower located after the bladder tank. After the blower, the gas from the Tail Gas system is sent two ways: the Regenerative Thermal Oxidizer (RTO) and the VOC system.

The flow of gas to each system is dictated by the VOC's need for gas. Based on which step of the regeneration process the VOC system is in, the need for gas will increase or decrease. The remaining gas not needed for the VOC system will proceed to the RTO.

For control purposes, the system automatically attempts to maintain a level of 50% in the bladder tanks. However, the volume can fluctuate depending on varying system processes. If the tank level gets below 10% tail gas, the blower will shut down until the volume gets back up to 15%. If the tank level reaches 95% tail gas, the inlet valve KP.DE.01.01.01.05 of the bladder tank will close which will put the PSA in a hold state.

7.9.12 DF Tail Gas Combustion

The subsystem DF Tail Gas Combustion/RTO (Regenerative Thermal Oxidizer) has its own independent SGC. The task and function are described in the Chapter 3.2.5

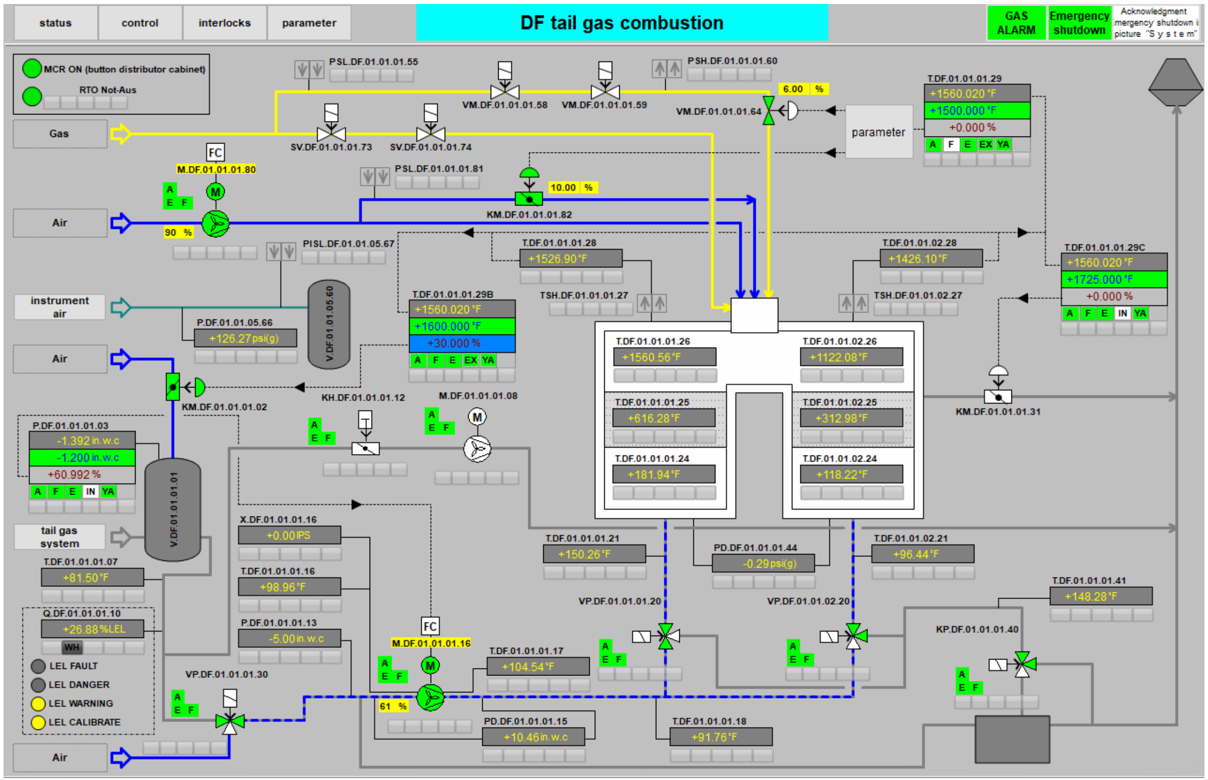


Figure 7.56: Subsystem Screen DE Tail Gas Combustion

The Tail Gas Combustion System uses a Regenerate Thermal Oxidizer (RTO) to fully combust the tail gas before it is released to atmosphere. After the Tail Gas system, the tail gas enters the RTO system where it is first mixed with fresh air to obtain a Lower Explosive Limit (LEL) of below 30%. A sensor placed after the mixing tank measures the LEL levels of the gas, if it is below 30% the gas can proceed to the next step.

If the gas is 50% or higher, the system takes a series of steps to purge the gas directly to the stack bypassing the combustion chambers. First, the inlet valve KP.DE.01.01.01.25 to the RTO is closed. Then the three-way valve VP.DF.01.01.01.30 opens to allow fresh air to flush out all gas contained in the system. The gas is directly vented out through the stack.

For normal operations (<30% LEL) the next step for the gas is to proceeds to the first combustion chamber. Inside the combustion chamber is filled with ceramic media. This ceramic media has stored thermal energy from the last cycle. The stored thermal energy in the ceramic media is used to increase temperature of the gas. As the temperature of the gas increases, the remaining Methane and other VOCs is combusted. While carrying the thermal energy from the exothermic combustion reaction the gas moves into the second combustion chamber. In the second chamber the gas' stored thermal energy is used to heat the ceramic media. This continues until the end of the cycle time and then the lead/lag operation of the chambers is swapped.

If there is not enough energy from the combustion reaction of the gas, supplemental heat can be added to the system using the natural gas burner. The burner turns on if the bed temperature gets below ~1400°F.

The cycle timing for the RTO operation can be adjusted for stream concentration and flow rates. The final gas is released to the atmosphere at ~160°F.

The RTO can operate in any of three modes: fully automatic, semi-automatic, and fully manual.

NOTICE	The RTO parameters may only be changed after consultation with **BIOFerm Energy Systems**. Changing these parameters may affect gas quality, emissions, and could cause unintentional plant shutdowns.

7.9.13 EM Neutralization

The subsystem EM Neutralization has its own independent SGC. The task and function are described in the Chapter 3.3.6

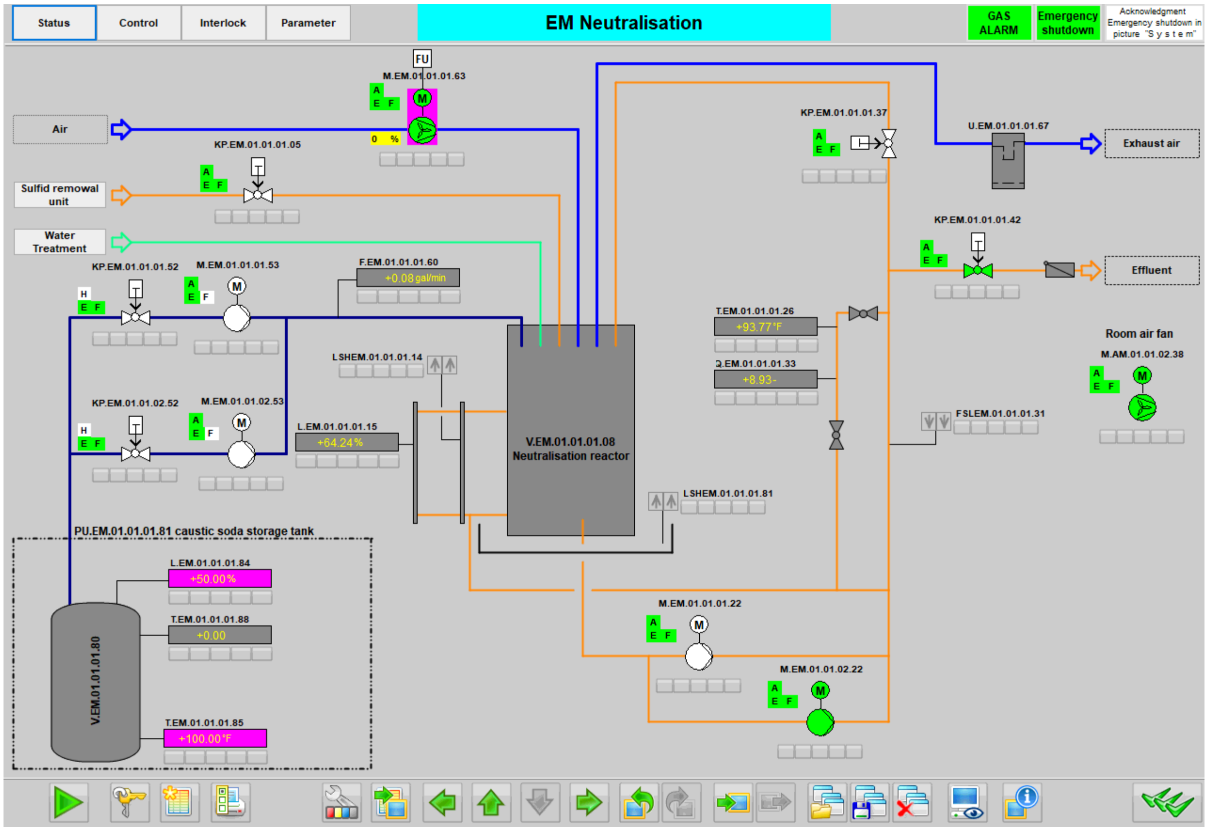


Figure 7.57: Subsystem Screen EM Neutralization

The effluent discharged from the Biological Desulfurization system is sent to the Neutralization system for treatment before being discharged to the municipal sewer system. The effluent with a pH 1.5 is neutralized with 50% caustic (sodium hydroxide) to a pH between 8-11. Once the pH is between 8-11 the effluent is discharged to the sewer system.

7.9.14 ED Water Treatment

The subsystem ED Water Treatment has its own independent SGC. The task and function are described in the Chapter 3.3.7

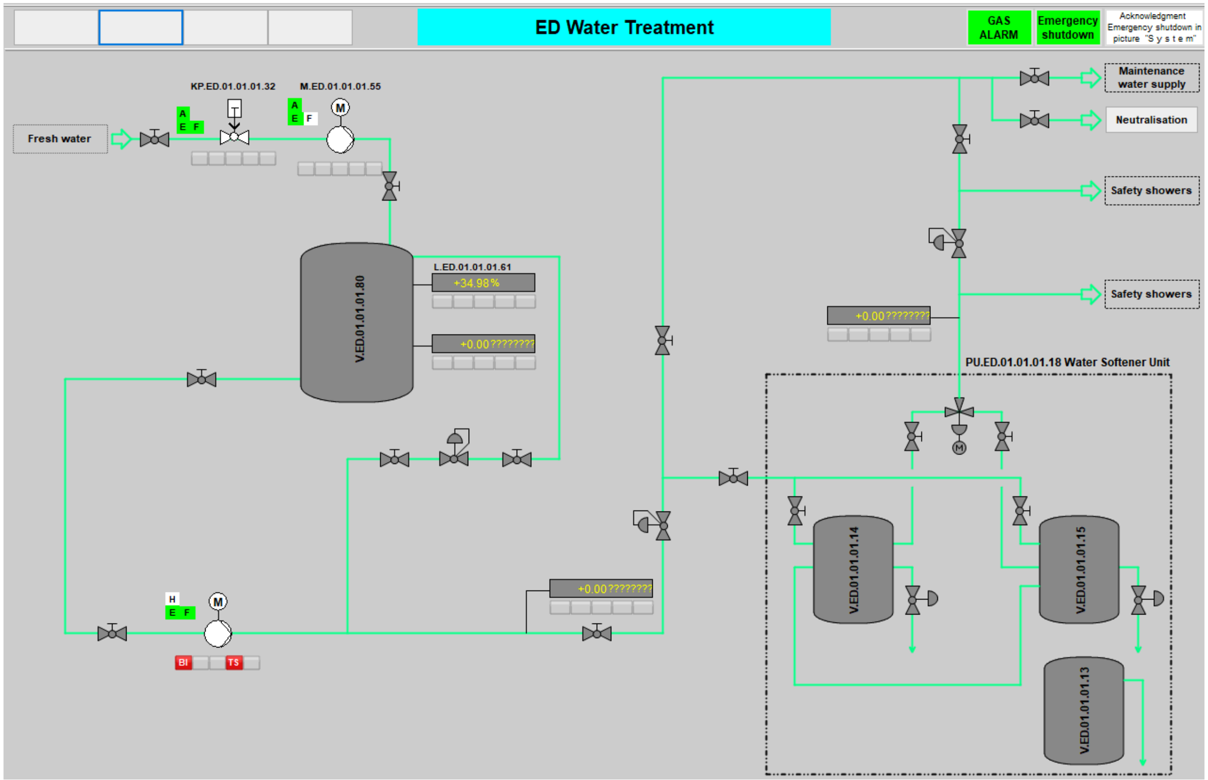


Figure 7.58: Subsystem Screen ED Water Treatment

Fresh water from the tie in point is pumped into the water tank V.ED.01.01.01.80. This tank acts as a surge tank to ensure a constant water supply is available to the water softeners, the water heater, and the safety showers and eyewash stations. The softened water also supplies the biological desulfurization system with make up water.

7.9.15 EG Instrument Air System

The subsystem AP RNG Compressors is independent and not associated with any SGC. The task and function are described in the Chapter 3.3.3

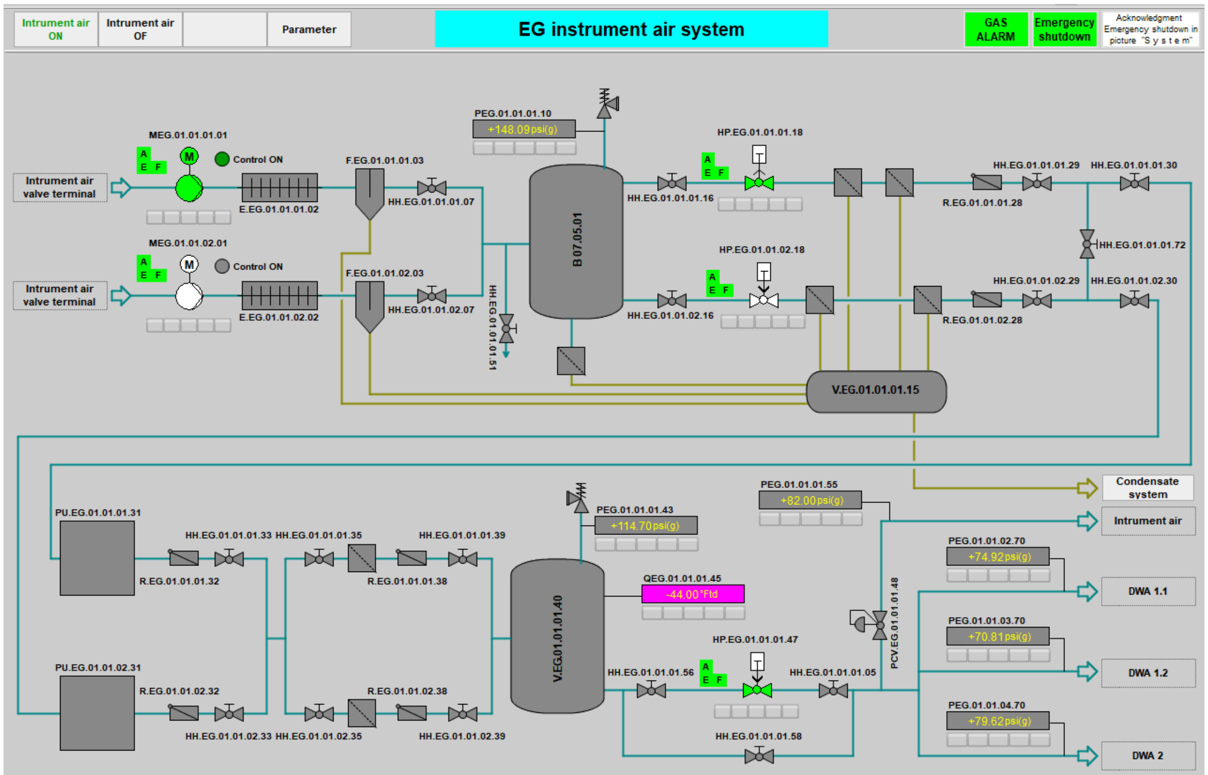


Figure 7.59: Subsystem Screen EG Instrument air system

The instrument air compressor is used to supply the instrument air required for the system operation. To ensure maximum availability of instrument air, the system has a redundant compressor. The programming logic for the instrument air system switches automatically between compressors if one is shut down, maintaining a continuous air supply to the plant.

To control the air compressor in the HMI, the compressor must be in remote mode and switched on.

The operating parameters of the compressor required for pressure control can be read and re-parametrized according to the manufacturer's documentation.

There are remote receivers at each of the PSA valve enclosures. These remote air receivers store air to ensure that it is available locally for PSA valve actuation.

The instrument air system includes a small condensate collection vessel for any water that is condensed out of the compressors or removed in the air dryers. The dew point is continuously monitored to ensure that only dry air is distributed to the pneumatic valves.

7.9.16 EA Cooling Water System

The subsystem EA Cooling Water is independent and not associated with any SGC. The task and function are described in the Chapter 3.3.1

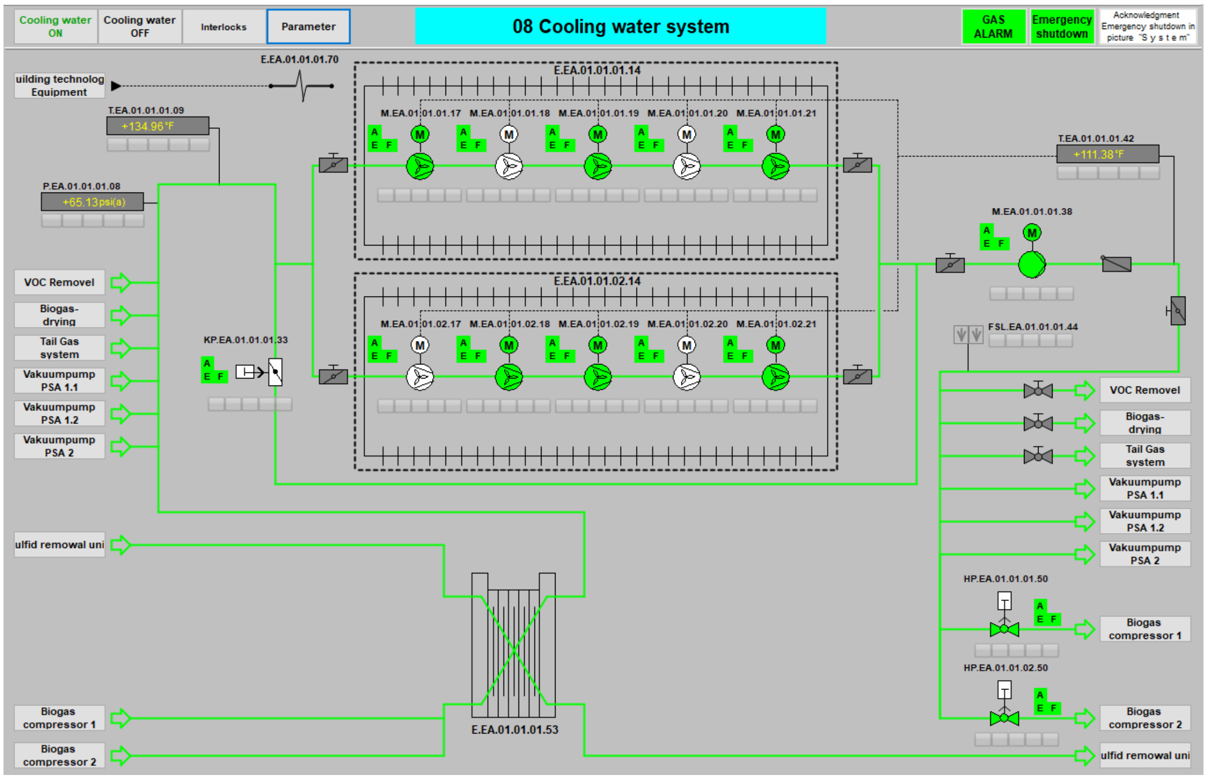


Figure 7.60: Subsystem Screen EA Cooling Water System

The operating parameters for controlling the fans are located in the Parameter Faceplate. The operating parameters refer to the temperature of the cooling circuit supply header. The fans are switched on based on the shortest total running time and switched off based on the longest total running time.

The switching thresholds determines on the number of fans that are running.

No.	Parameter	Description
1	Threshold Level 1: 95 °F	Switching fan on and off
2	Threshold Level 2: 98 °F	Switching fan on and off
3	Threshold Level 3: 101 °F	Switching fan on and off
4	Threshold Level 4: 104 °F	Switching fan on and off
5	Threshold Level 5: 107 °F	Switching fan on and off
6	Threshold Level 6: 110 °F	Switching fan on and off
7	Threshold Level 7: 113 °F	Switching fan on and off
8	Threshold Level 8: 116 °F	Switching fan on and off
9	Threshold Level 9: 119 °F	Switching fan on and off
10	Threshold Level 10: 122 °F	Switching fan on and off

Table 7.10: Cooling Water Fan Parameter Thresholds

In order to achieve the desired cooling water temperature in case of freezing ambient conditions, the bypass is opened.

Cooling water supplies cooling and in some cases heating to the following exchangers:

- E.AF.01.01.01.02
- E.AE.01.01.01.01
- E.DD.01.01.01-04.19
- E.DD.02.01.01-04.19
- E.DD.01.02.01-04.19
- E.DE.01.01.01.26
- E.AN.01.01.01.63
- E.AN.01.01.02.63

7.9.17 EB Chilled Water System 1 & EB Chilled Water System 2

The subsystems EB Chiller 1 & Chiller 2 have independent PLCs and not associated with any SGC. The task and function are described in the Chapter 3.3.2

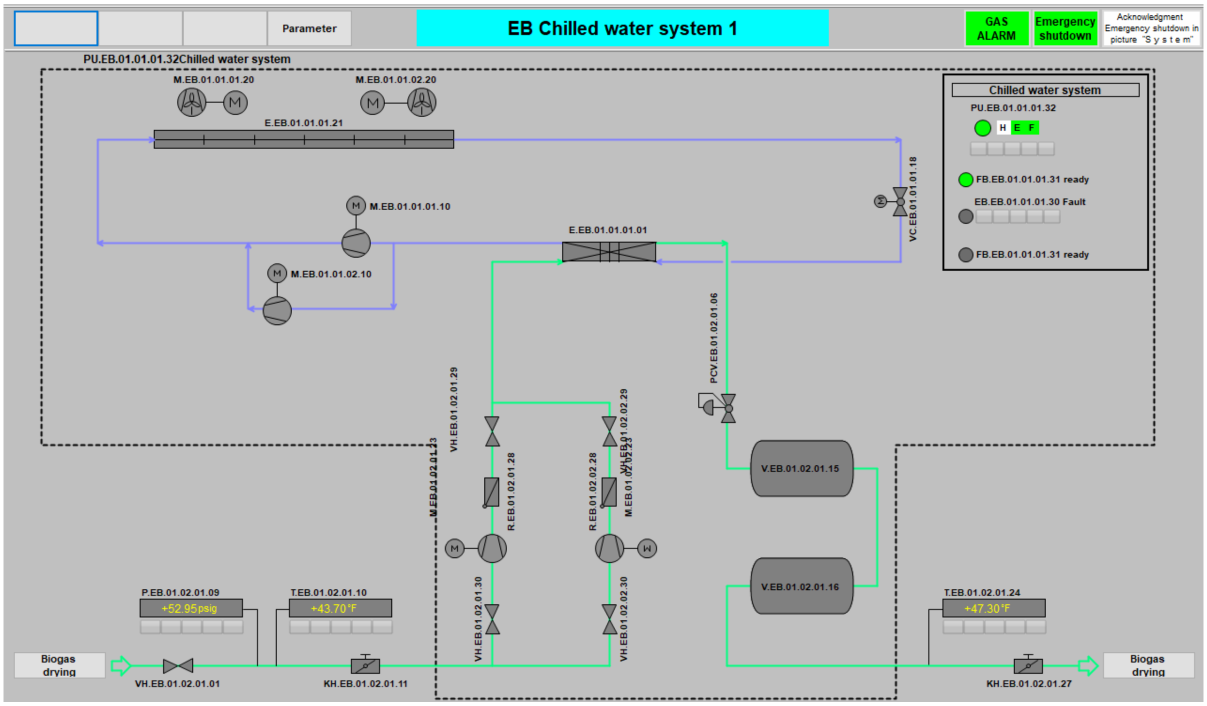


Figure 7.61: **Subsystem Screen EB Chilled Water System 1**

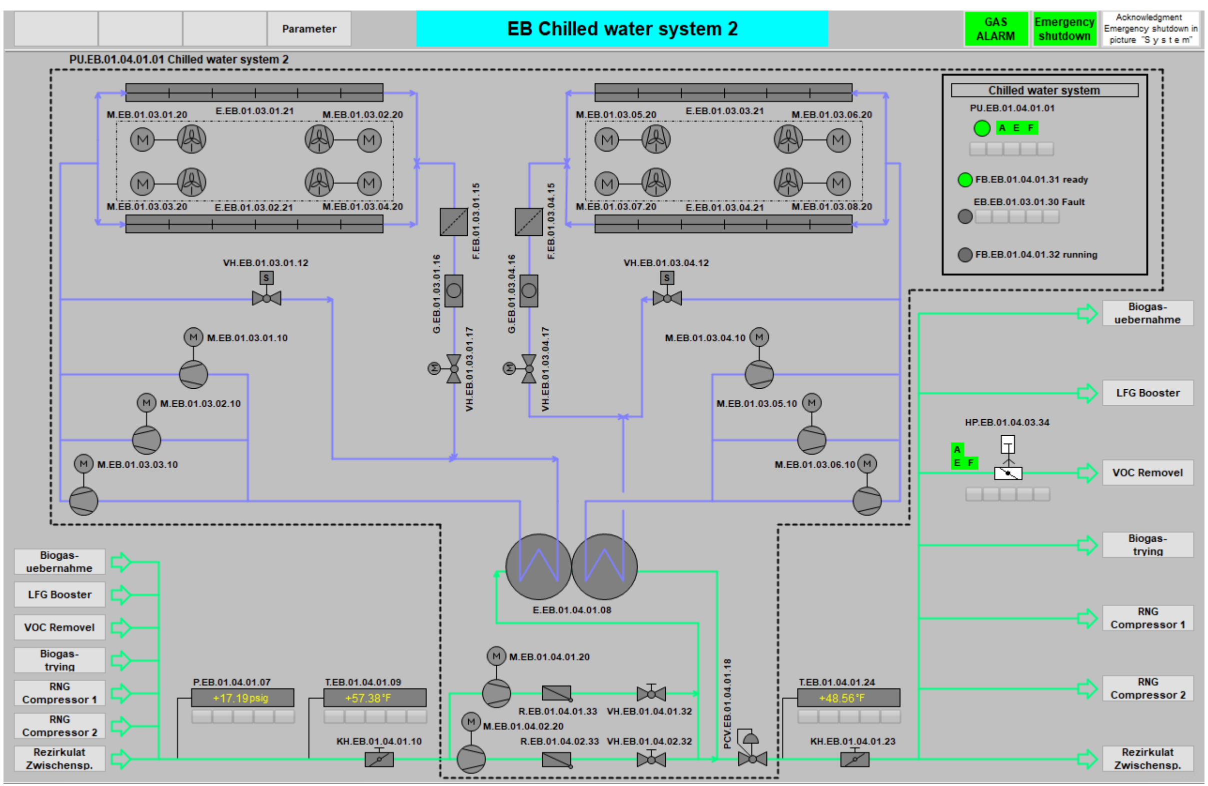


Figure 7.62: **Subsystem Screen EB Chilled Water System 2**

The chillers have their own controls which switch the compressors on automatically depending on the temperature setpoint. The HMI can set the chiller setpoint remotely, but otherwise, the chillers can not be controlled by the HMI.

The chillers control their own water pumps via the local PLC. Feedback from the water pumps and compressors are not displayed in this unit. The pump switching occurs via the local PLC.

Chiller 2 supplies chilled water (~60°F) to the following exchangers:

- E.AD.01.01.01.07
- E.AM.01.01.02.30
- E.AM.01.01.01.30
- E.AF.01.01.01.04
- E.AE.01.01.01.42
- E.AP.01.01.01.56
- E.DD.01.02.01.30

Chiller 1 supplies chilled water (~43°F) to the following exchangers:

- E.AF.01.01.01.06

7.9.18 BUP Condensate System

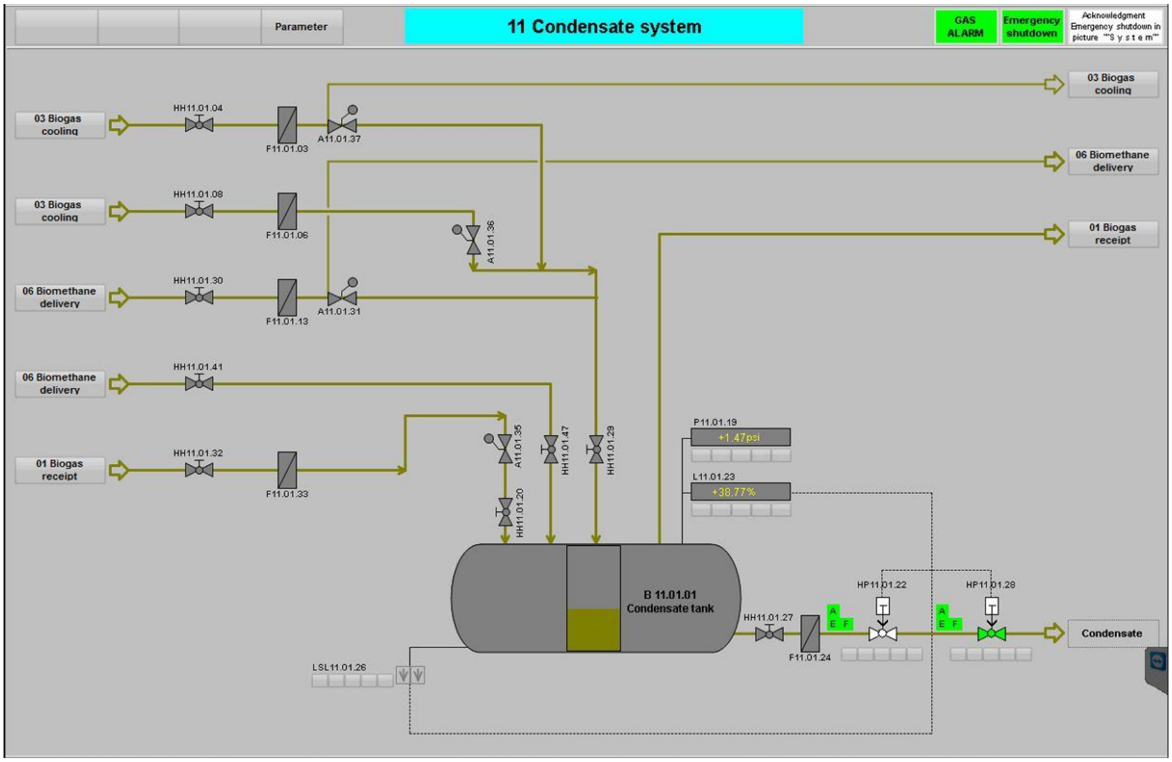


Figure 7.63: Sub-system Screen "BUP Condensate System"

The SGC condensate system controls the cyclic condensate discharge of the system. The valve HP 11.01.28 is permanently open and closes if the min. level monitoring of the container is triggered in order to prevent gas infiltration into the downstream condensate system.

No.	Parameter	Description
1	Time emptying condensate system	The condensate vessel is emptied within this specified time
2	Level draining start	If the level exceeds this value, the condensate vessel is emptied
3	Level draining stop	If the level is below this value, the draining is stopped
4	Relaxation pressure	If the vessel pressure falls below this value, the SGC condensate system goes to the next step since the condensate vessel is considered to be de-pressurized.
5	Pause time until next cycle	Sets the cycle time of the SGC.

Table 7.11: Condensate System Parameters

7.9.19 BUP Vacuum Pump

The vacuum pumps are used to suck the CO_2, adhering to the activated carbon in the PSA, into the atmosphere.

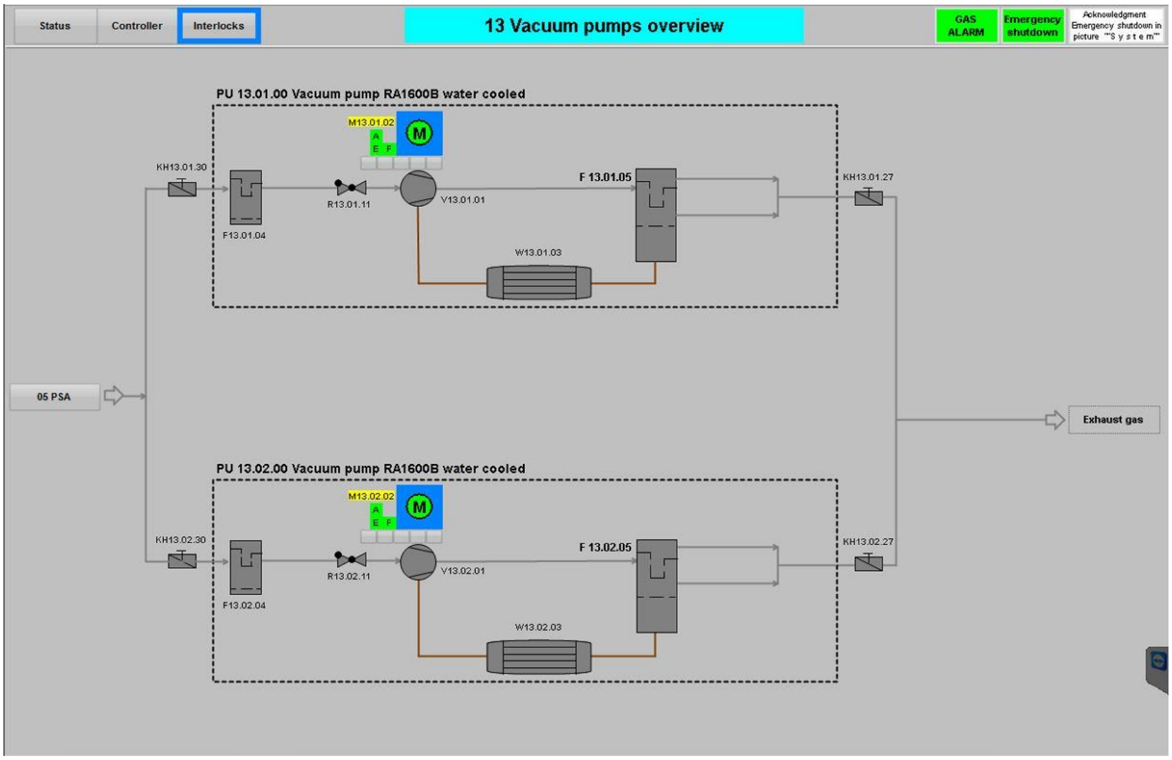


Figure 7.64: Sub-system Screen "BUP Vacuum Pump"

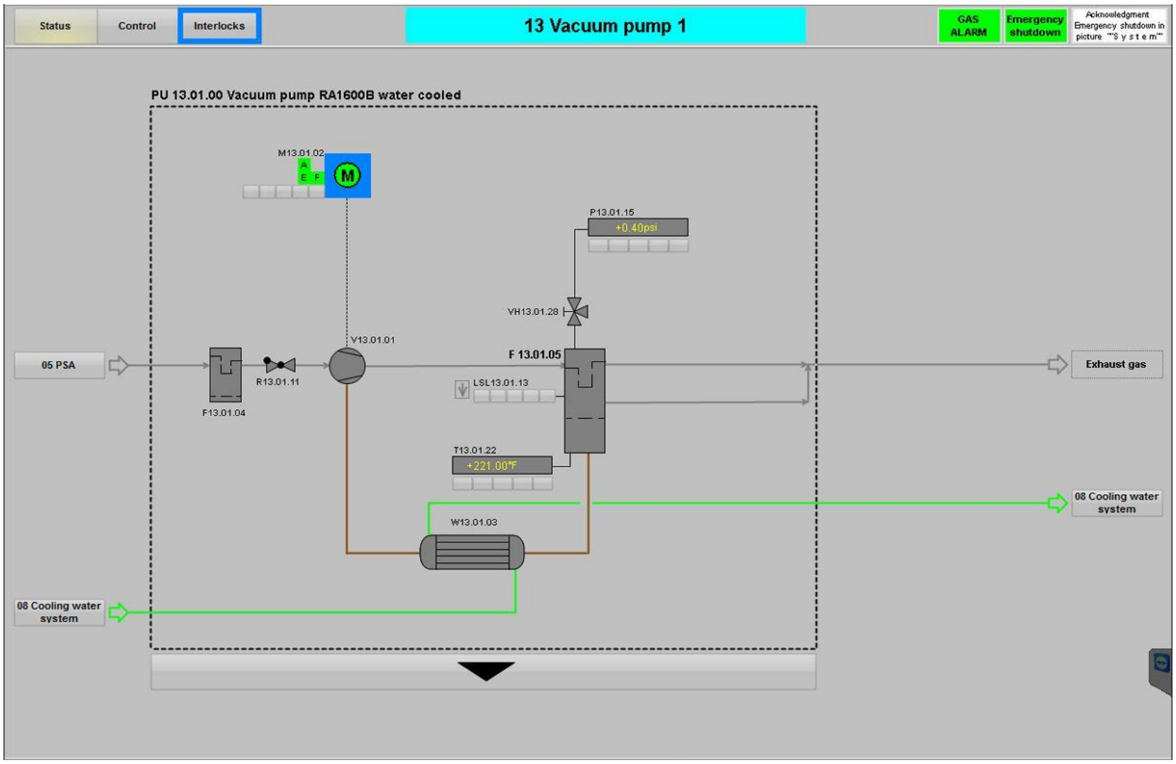


Figure 7.65: Sub-system screen "BUP Vacuum Pump 1"

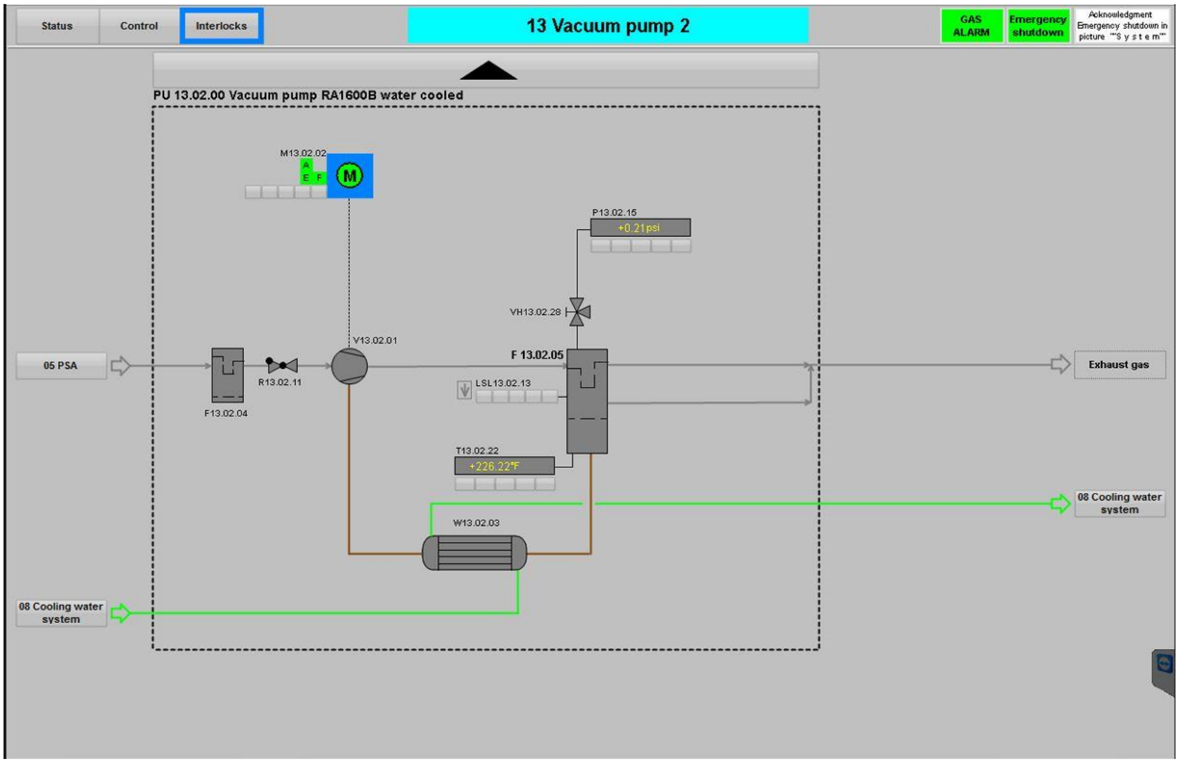


Figure 7.66: Sub-system screen "BUP Vacuum Pump 2"

Depending on the system size, this ASSY may have several vacuum pumps. In some systems, they can also be controlled with frequency converters or soft starters.

7.9.20 BUP Building Technology Equipment

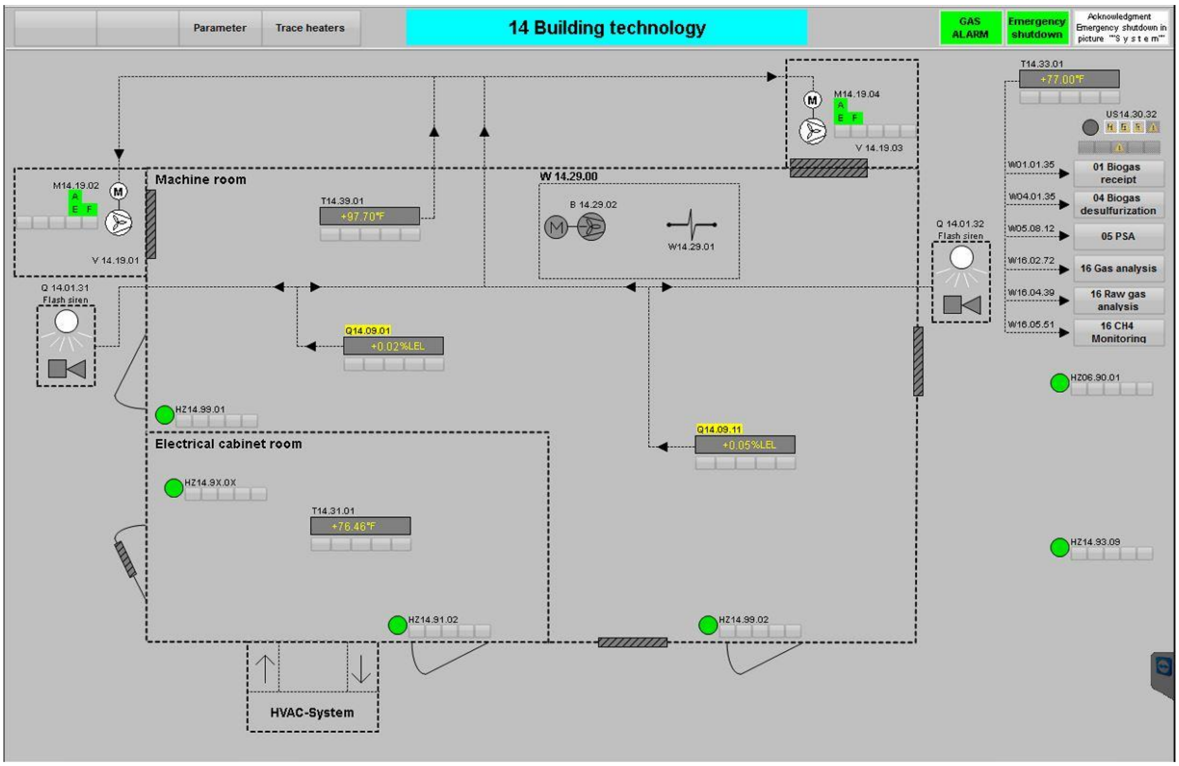


Figure 7.67: Sub-system Screen "Building technology"

Description of Functions

The building technology equipment is used for air conditioning of the system and the e-room by heating and ventilation.

The process room is monitored for potentially explosive atmospheres.

Room Temperature Control in the Process room and E-room

The temperature is measured independently in the process room and the e-room using a resistance thermometer.
If the set-point temperature specified in the parameters is exceeded, the respective wall fan in the process room or the e-room is switched on and turned off again when the temperature falls below the switch-off set-point temperature.

Similarly, the heater is turned on if the temperature falls below the set-point temperature specified in the parameters, and is switched off again once the switch-off set-point temperature is exceeded.

Room Temperature Control in the Process room and E-room with Additional Auxiliary Heating

For the purpose of controlling the auxiliary heating, the temperature limits refer to outside temperature measured with a resistance thermometer.

If the set-point temperature specified in the parameters is exceeded, the wall fan is switched on and turned off again when the temperature falls below the switch-off set-point temperature.

The heater is turned on if the temperature falls below the set-point temperature specified in the parameters, and is switched off again once the switch-off set-point temperature is exceeded.

NOTICE	Observe the switching thresholds and coordinate the two fans so that heater and fan do not run simultaneously.

7.9.21 LEL Monitoring

The process room is monitored for potentially explosive atmospheres. For this purpose, the methane content is measured by two sensors on the ceiling in the area of the compressor and the lower explosion limit (LEL) in the ambient air is monitored. The measured values are evaluated in e-room by an evaluation unit, which can also be used to read the actual measured values. For details on the operation, please refer to the manufacturer's instructions.

If the methane concentration in the process room reaches the fixed limit of 20% LEL at one of the measuring points, the room is force ventilated by the fans and a message is sent to the OS. The alarm is self-resetting, i.e., if the concentration falls below the limit, the alarm is cancelled and the fans are switched off again.

When 40% LEL is exceeded, a safety shutdown of all gas transfer actuators is triggered and the entire biogas upgrading plant is subsequently shutdown. The shutdown does not include the wall fan and the drives and motors outside the system vessel. In addition, a visual/audible warning signal is triggered using a flash siren alarm.

This alarm is not self-resetting. To acknowledge it, the window "Gebäudetechnik" (Building Technology Equipment) must be selected on the OS and the evaluation must be unlocked (RESET). However, this is possible only after the concentration falls below 40% LEL again. In addition, the alarm must be acknowledged in the message list and the panel on-site.

CAUTION	The only way a level of 40% LEL can be reached in the process room is by accidentally opening a valve or by a larger leak. In this case, the process room should not be entered at all or only under extreme caution. Even if no gas alarm is triggered, there is still a risk that 40% LEL is already reached or exceeded in the process room. The container must be entered only with personal protective equipment, i.e., a portable gas detector.

The setting and calibration of the gas detection systems must be performed regularly and documented in writing is by qualified personnel of the manufacturer.

NOTICE	Operating settings: The gas detection system is always active and can neither be turned on nor off. There is no separate SGC for the sub-system Ambient Air!

7.9.22 BUP Biogas Analysis

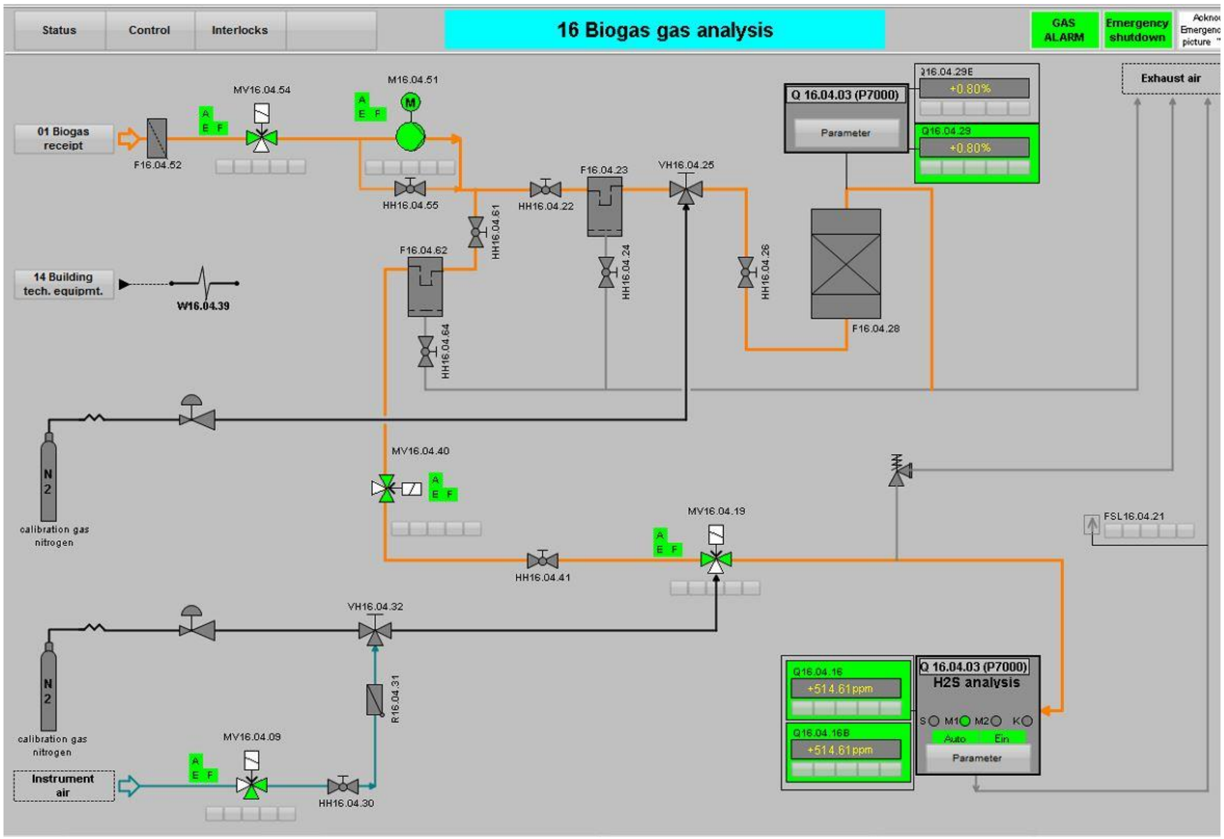


Figure 7.68: Sub-system Screen "BUP Biogas Analysis"

The sub-system screen "Rohgasanalyse" (raw gas analysis) shows the analyzer units and sampling points in the BUP. The biogas analysis consists of two sensors for measuring H_2S and O_2.

The analyzer units are visualized in the sub-system screen. The calibration of the sensors must be carried out manually by the operator.

7.9.23 BUP GasAnalysis

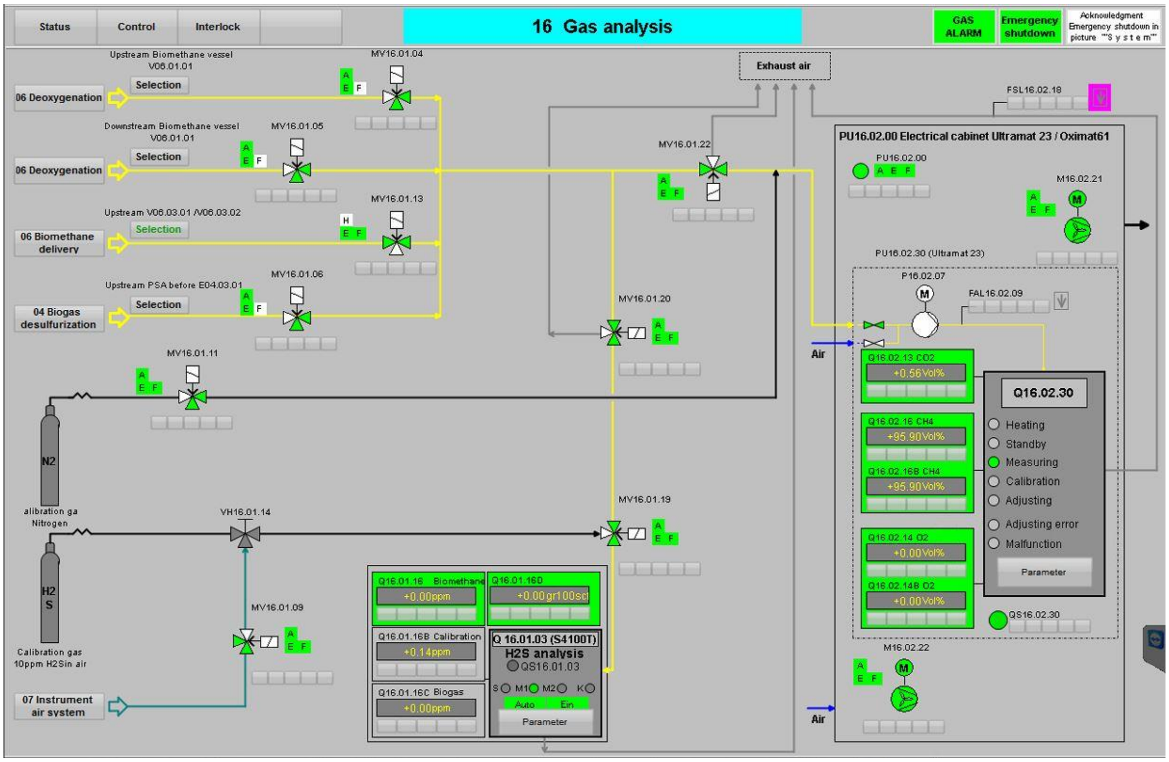


Figure 7.69: **Sub-system Screen "Gas Analysis"**

In the biomethane analysis, the biomethane quality is determined by different measurement instruments. For this purpose, different measuring options can be selected.

The sub-system screen "Gas Analysis" shows the analysis units and sampling sites in the BUP. The biomethane analysis consists of an H_2S meter and an Ultramat for the gas components CH_4, CO_2, and O_2.

The analysis units are visualized in the sub-system screen. The calibration of the H_2S measurement must be carried out manually by the operator on site, using the analysis device.

NOTICE	In normal operation, the sample gas must be taken after the biomethane pressure vessel as an automatic shutdown of the system may result otherwise due to insufficient gas quality at the biomethane output (see switching control matrix). Exceeding of the CO_2 upper limit is displayed with a message and the gas is then automatically returned to the biogas receipt for re-treatment.
CAUTION	Before the valve MV 16:01:22 of the gas supply is opened to the Ultramat, the fans V 16.02.2x must be running to avoid the formation of an explosive atmosphere. The power supply of the switch cabinet of the biomethane analysis can only be switched on after a pre-running interval of the two switch cabinet fans.
NOTICE	Upon shutting down the system, the Ultramat is switched to standby. Only the ambient air is measured then because switching the Ultramat on again requires a warm-up of 30 minutes. In case of an extended shutdown of the system, the Ultramat can be switched off manually.

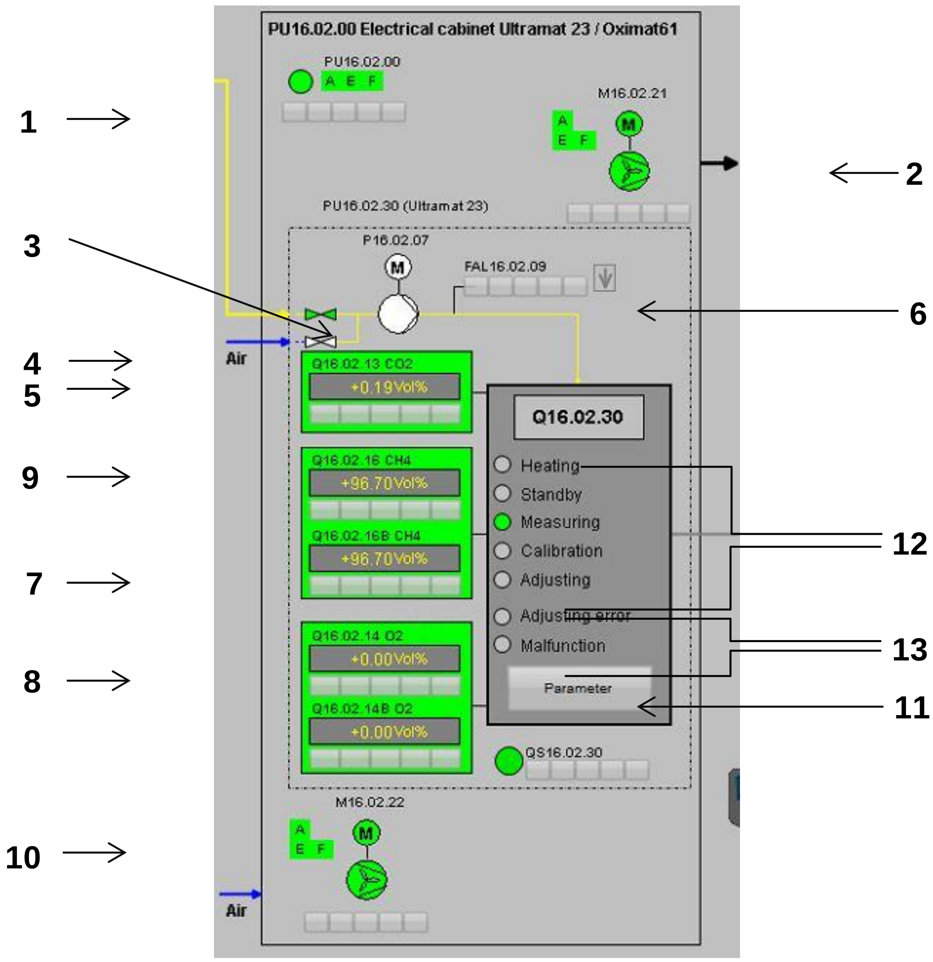
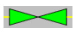


Figure 7.70: **Operation Ultramat in the Sub-system Screen "Biomethane Analysis"**

No.	Parameter/Symbol	Description	
1	PU16.02.00	Package Unit Ultramat	
2	V16.02.22	Switch cabinet fan exhaust	
3	M16.02.07	Internal pump for the autocal	
4		"Messgasventil" (sample gas valve)	
5		"Nullgasventil" (zero gas valve)	
6	FISAL16.02.09 FISAL16.02.69	Internal flow measurement	
7	Q16.02.16 Q16.02.66	Measurement vol.-% methane	
8	Q16.02.14 Q16.02.64	Measurement vol.-% oxygen	
9	Q16.02.13 Q16.02.63	Measurement vol.-% carbon dioxide	
10	V16.02.21	Switch cabinet fan air intake	
11	Parameter	selected = opens faceplate for the operating parameters	
12	Modes of Operation	"Anwaermen" (Pre-Heating)	Warm-up period after device re-start
		Standby	When shutting down the system, the Ultramat system is only switched to standby mode, as it requires approx. 30 minutes from switch-on to be ready to operate. The internal pump is switched on. The zero gas valve is opened and the sample gas valve is closed. Therefore, the meter remains in measurement mode and measures the ambient air.
		"Messen" (Measuring)	normal measuring mode
		"Kalibrieren" (Calibration)	During Autocal, the infrared channels of the Ultramat are set to 0%. Then, outside air is drawn in and measured through the internal pump instead. During this calibration, the measuring cell is calibrated to 21.9 vol.-%.
		"Justieren" (Adjust)	Zero-point adjustment of the Ultramat with nitrogen.
13	Fault message	"Justierfehler" (Adjustment error)	

No.	Parameter/Symbol	Description	
		"Störung" (Fault)	Fault present at Ultramat. See Chapter "Ultramat Diagnostic Mode"

Ultramat - autocal, automatic calibration

The calibration should be performed in automatic mode.

During Autocal, the infrared channels of the Ultramat are set to 0%.

Then, outside air is drawn in and measured through the internal pump instead of the sample gas. During this calibration, the measuring cell is calibrated to 21.9 vol.-%.

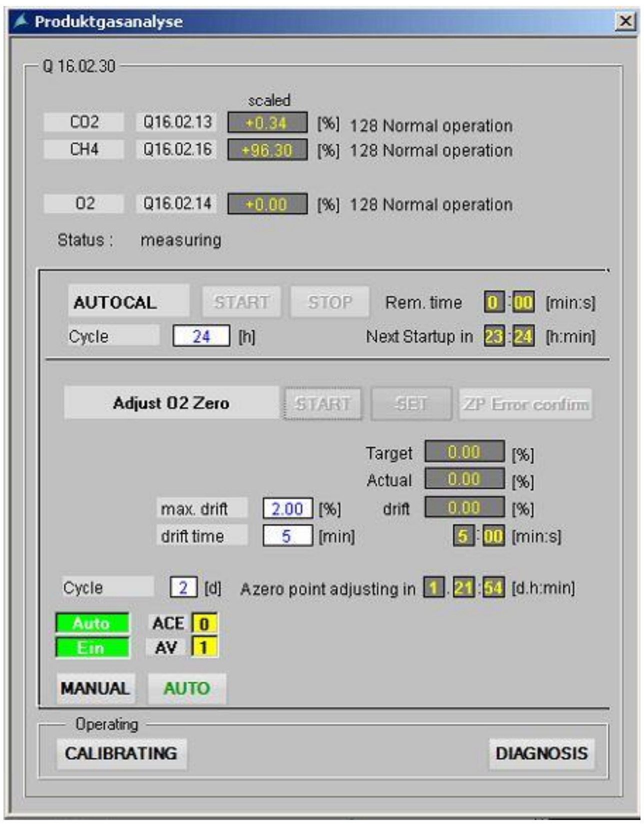


Figure 7.71: **Ultramat – autocal**

<table>
<tr><th>No.</th><th colspan="3">Description</th></tr>
<tr><td>1</td><td colspan="3">Measurement vol.-% carbon dioxide</td></tr>
<tr><td>2</td><td colspan="3">Measurement vol.-% methane</td></tr>
<tr><td>3</td><td colspan="3">Measurement vol.-% oxygen</td></tr>
<tr><td>4</td><td colspan="3">Status Ultramat</td></tr>
<tr><td>5</td><td colspan="3">Manual start **"AutoCal"**</td></tr>
<tr><td>6</td><td colspan="3">Set time **"AutoCal"**</td></tr>
<tr><td>7</td><td colspan="3">Time remaining to end **"AutoCal"**</td></tr>
<tr><td>8</td><td colspan="3">Time to start next **"AutoCal"**</td></tr>
<tr><td>9</td><td colspan="3"><u>Adjust zero:</u>
START — Start manually
SET — Set current O_2 value as new zero point
Acknowledge ZP error — Acknowledge zero point error during current operation</td></tr>
<tr><td>10</td><td colspan="3">Max. Permissible deviation actual value - set-point.
If the value is not reached within the so-called drift time, a zero point error fault occurs</td></tr>
<tr><td>11</td><td colspan="3">"Drift-Zeit" (drift time)</td></tr>
<tr><td>12</td><td colspan="3">Set/actual — calibration gas values
Drift — deviation actual value/set point</td></tr>
<tr><td>13</td><td colspan="3">Target cycle time for zero point adjustment</td></tr>
<tr><td>14</td><td colspan="3">Remaining time to start of next zero-point adjustment</td></tr>
<tr><td rowspan="2">15</td><td rowspan="2">Operation Modes</td><td>"Hand" (Manual)</td><td>In the "Manual" mode, **AutoCal** and **zero point adjustment** must be started manually.</td></tr>
<tr><td>Auto</td><td>In "Auto" mode, the **AutoCal**, followed by **zero point adjustment** is started automatically according to the set point time in no. 7.</td></tr>
</table>

Ultramat Diagnostics Mode

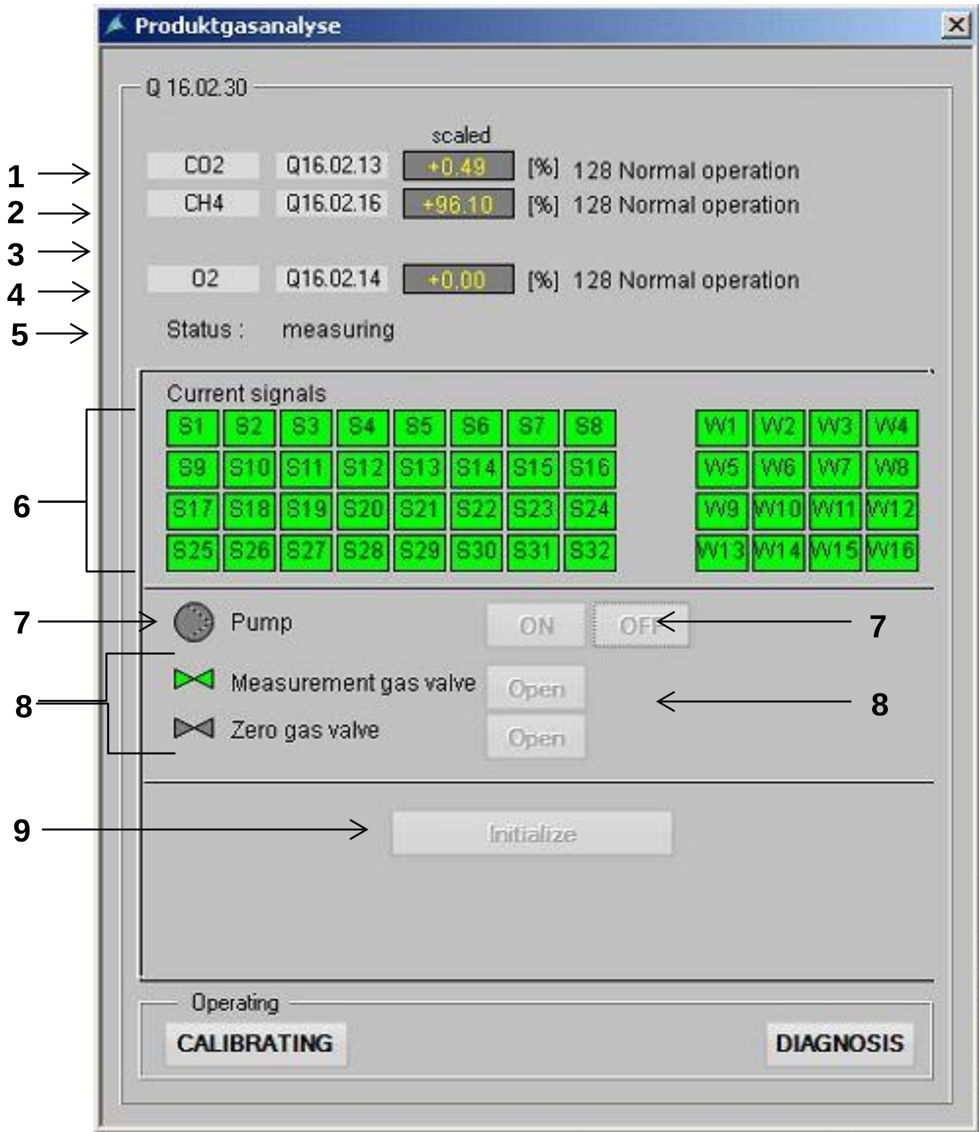
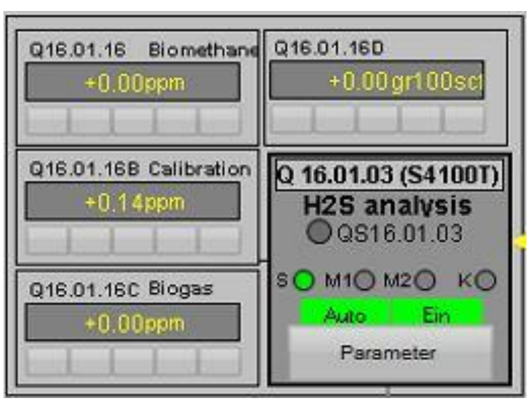


Figure 7.72: Ultramat Diagnostics Mode

No.	Description	
1	Measurement vol.-% methane	
2	Measurement vol.-% carbon dioxide	
3	n/a	
4	Measurement vol.-% oxygen	
5	Operating state Ultramat	
6	Current messages. If the mouse pointer is hovered over a message, the message is displayed in plain text. If the background color of the rectangle is green, it means that the message is in GOOD state. If the rectangle is shown with a red background, the message indicates a FAIL state. The messages are described in the Ultramat manual.	
7	Status and switching of the internal pump A green background of the icon of the internal pump indicates the pump is working. If the pump is turned off, the icon is displayed in grey/white. The buttons "ON" (EIN) and "OFF" (AUS) can be used to switch the pump on or off manually.	
8		"sample gas valve" (Messgasventil)
		"zero gas valve" (Nullgasventil)
	The buttons "ON" (EIN) and "OFF" (AUS) can be used to switch the zero gas valve of the Ultramat on or off.	
9	"Initialize" (Initialisieren)	Action that gets the PLC Ultramat program ready for operation.

H_2S Measurement in the Biomethane Analysis

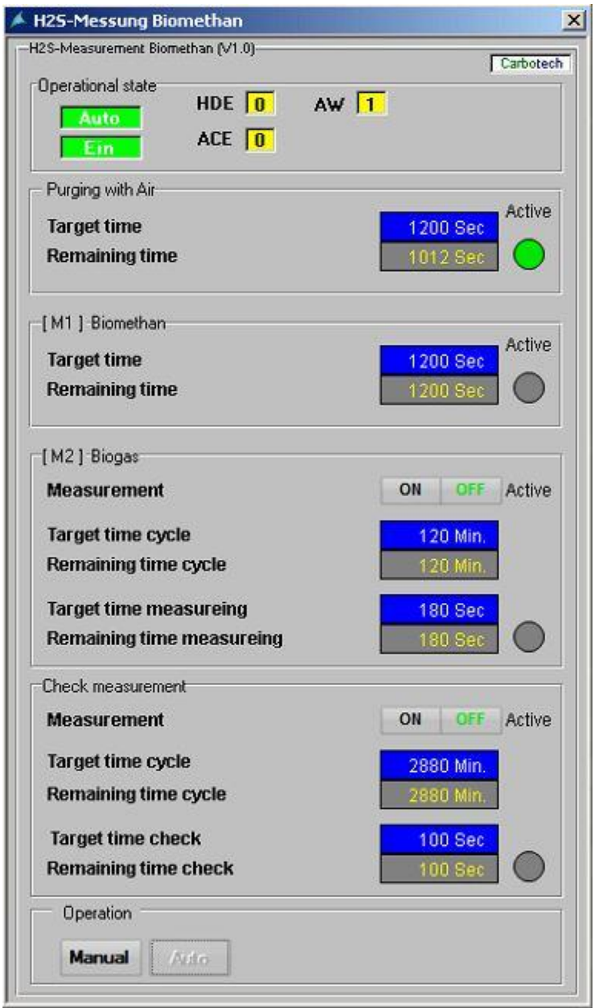


The H_2S measurement Q16.01.00 analyzes the gas path in the biogas cooling as well as the biomethane gas path before and after the biomethane gas pressure vessel.

The analogue measured value is displayed on the left in the window.

Any fault in the measuring instrument will be displayed in red with the tag number. QS 01.16.03. If the dot next to the tag no. QS16.01.03 is shown in green, there is no fault present in the device.

Clicking the "Parameter" button opens the Faceplate below, where parameters can be changed.



The faceplate "H_2S- Measurement Biomethane" is divided into

“operating state” (Betriebszustand),

“measured value” (Messwert),

“measured operating parameters” (Messbetriebsparameter),

“control and measuring parameters” (Kontrollmessparameter)

and

"**Operation**".

In the **“Operating State”** (Betriebszustand) section, the following is displayed:

"Hand/Auto" (Manual/Auto) Automatic **active**	Manual/automatic mode selected **Green**
"Ein/Aus" (On/Off)	Measuring is switched **ON/OFF**
HDE	Status manual input (0/1)
ACE	Status Forced Automatic (0/1)
AW	Status automatic input (0/1)

In the "**Measured value**" section, the following is displayed:

"Luftbespuelung u. Kontrollmessung" (air ventilation and control measurement)	The current measured value during the air ventilation and the control measurement is shown in the display window.

"**Measured Operating Parameters**":

"set time biomethane measurement" (Sollzeit Biomethanmessung)	The time shown in blue font here indicates the duration of the biomethane measurement.
"time remaining biomethane measurement" (Restzeit Biomethanmessung)	The time shown in yellow font here indicates the duration to completion of the biomethane measurement.
Activity indicator	The activity indicator shows on green background whether the biomethane measurement is active.

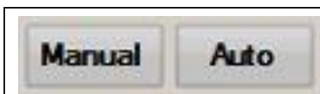
"set time air ventilation" (Sollzeit Luft-Bespuelung)	The time shown in blue font here indicates the duration of the air ventilation.
"time remaining air ventilation" (Restzeit Luft-Bespuelung)	The time shown in yellow font here indicates the duration to completion of the air ventilation.
Activity indicator	The activity indicator shows on green background whether the air ventilation is active.

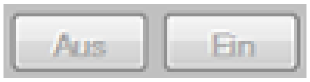
"**Control Measuring Parameters**" section:

"On/Off" (Ein/Aus)	The H_2S control measurement can be switched **On** or **Off**.
"set time control cycle" (Sollzeit Kontrollzyklus)	The time shown in blue font here indicates the duration of the control cycle.
"time remaining control cycle" (Restzeit Kontrollzyklus)	The time shown in yellow font here indicates the duration to completion of the control cycle.
Activity indicator	The activity indicator shows on green background whether the control measurement is active.

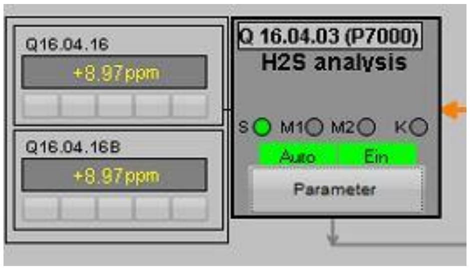
"set time control measurement" (Sollzeit Kontrollmessung")	The time shown in blue font here indicates the duration of the control measurement.
"time remaining air ventilation" (Restzeit Luft-Bespuelung)	The time shown in yellow font here indicates the duration to completion of the control measurement.

"Operation" (Bedienung) section:

	**Manual** mode for manual control of the H_2S measurement **Auto**matic mode The H_2S measurement is controlled by the program.

	Switching the H_2S measurement **On**/**Off** (Only available in manual mode)

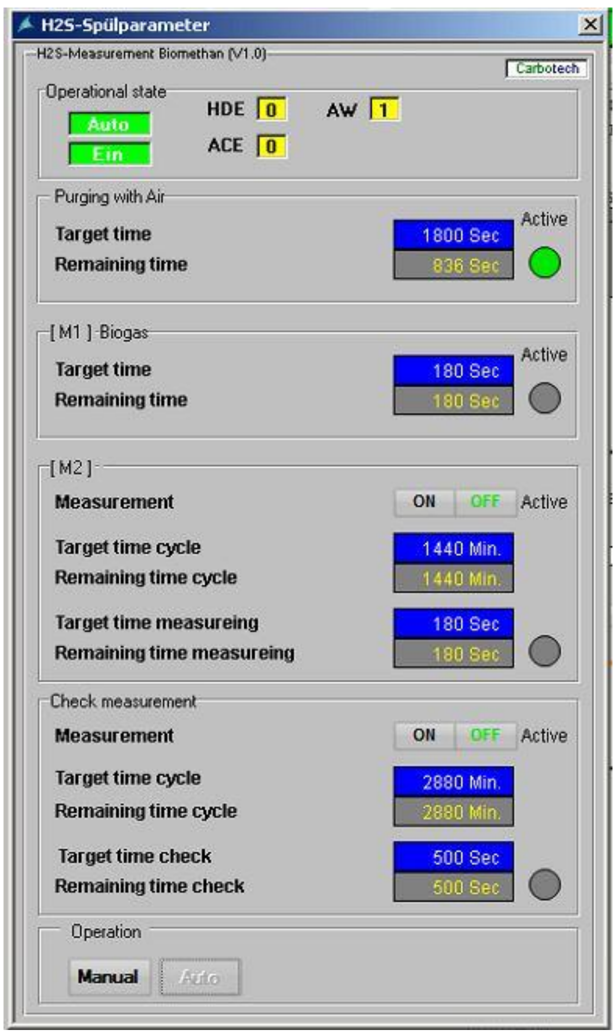
H_2S Measurement in the Biogas Analysis



If desired, the H_2S measurement Q16.04.03 analyzes the gas path in the biogas input after the first or the second filter element in the desulfurization.

The analogue measured value is displayed on the left in the window.

Clicking the "Parameter" button opens the Faceplate below, where parameters can be changed.



The faceplate "H_2S- Measurement Biomethane" is divided into:

"**Betriebszustand**" (operating state),

"**Messwert**" (measured value),

"**Messbetriebsparameter**" (measured operating parameters),

"**Kontrollmessparameter**" (control and measuring parameters)

and

"**Operation**".

In the **"Operating State"** section, the following is displayed:

"Hand/Auto" (Manual/Auto) Automatic **active**	Manual/automatic mode selected **Green**
"Ein/Aus" (On/Off)	Measuring is switched **ON/OFF**
HDE	Status manual input (0/1)
ACE	Status Forced Automatic (0/1)
AW	Status automatic input (0/1)

In the "**Measured value**" section, the following is displayed:

"air ventilation and control measurement" (Luftbespuelung u. Kontrollmessung)	The current measured value during the air ventilation and the control measurement is shown in the display window.

"**Measured Operating Parameters**":

"set time biogas measurement" (Sollzeit Biogasmessung)	The time shown in blue font here indicates the duration of the biogas measurement.
"time remaining biogas measurement" (Restzeit Biogasmessung)	The time shown in yellow font here indicates the duration to completion of the biogas measurement.
Activity indicator	The activity indicator shows on green background whether the biogas measurement is active.

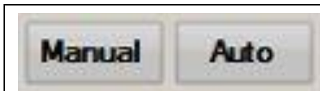
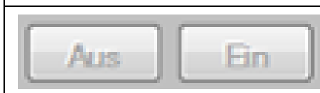
"set time air ventilation" (Sollzeit Luft-Bespuelung)	The time shown in blue font here indicates the duration of the air ventilation.
"time remaining air ventilation" (Restzeit Luft-Bespuelung)	The time shown in yellow font here indicates the duration to completion of the air ventilation.
Activity indicator	The activity indicator shows on green background whether the air ventilation is active.

"**Control Measuring Parameters**" section:

"On/Off" (Ein/Aus)	The H_2S control measurement can be switched **On** or **Off**.
"set time control cycle" (Sollzeit Kontrollzyklus)	The time shown in blue font here indicates the duration of the control cycle.
"time remaining control cycle" (Restzeit Kontrollzyklus)	The time shown in yellow font here indicates the duration to completion of the control cycle.
Activity indicator	The activity indicator shows a green background if the control measurement is active.

"set time control measurement" (Sollzeit Kontrollmessung)	The time shown in blue font here indicates the duration of the control measurement.
"time remaining air ventilation" (Restzeit Luft-Bespuelung)	The time shown in yellow font here indicates the duration to completion of the control measurement.

"Operation" section:

	**Hand** (manual) operation Release to use the button **"Off" (Aus)** and **"On" (Ein).** **Auto**matic operation The H_2S air purge is controlled by the program.
	Switching the H_2S air purge **On**/**Off** (Only available in manual mode)

8 Appendix

8.1 Control Documentation

Inspection Tour Protocol

Maintenance Schedule

Recurrent Checks

8.2 Data Sheet

data sheet for project-specific parameters

8.3 Cause & Effect Matrix for PCS Safety-instrumented Equipment

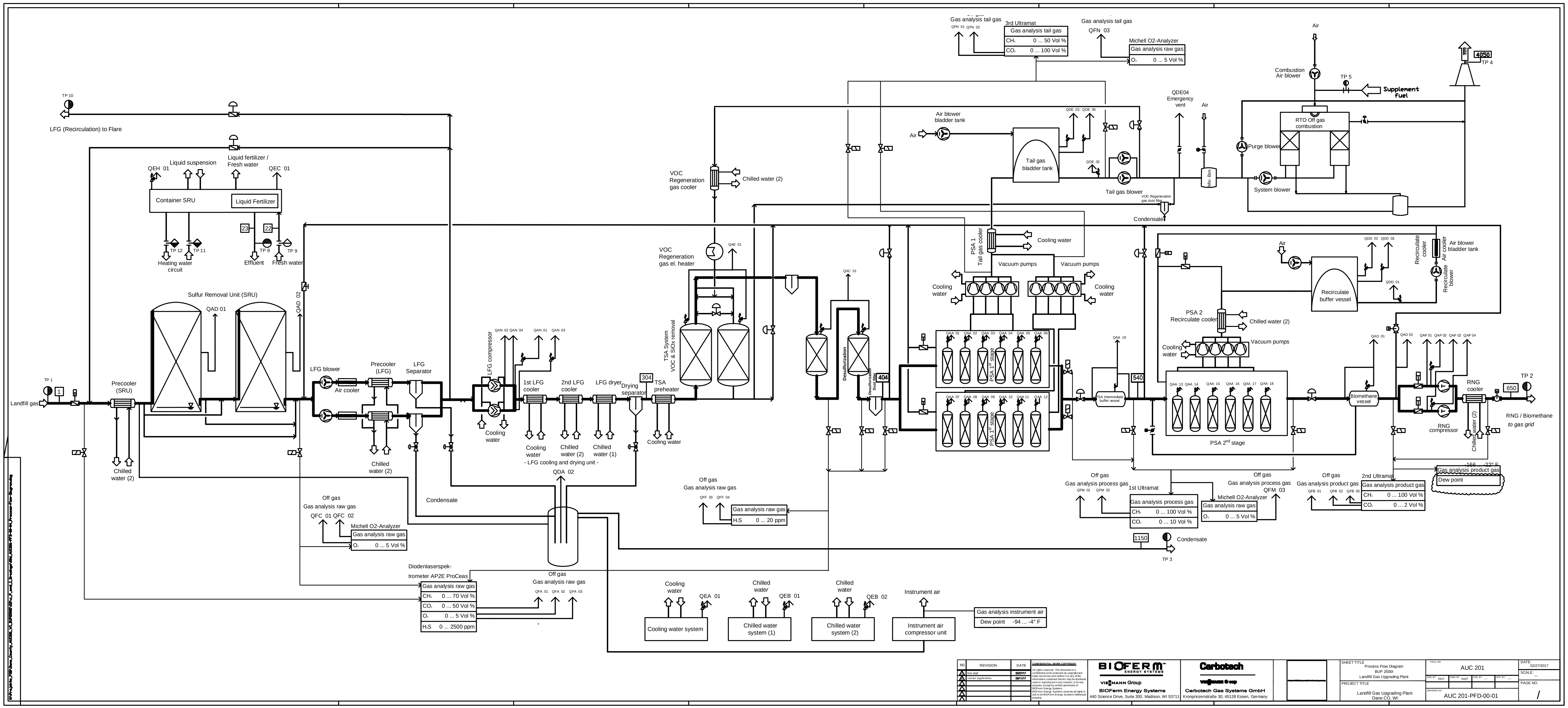
see system documentation

8.4 Step Sequences

see system documentation

8.5 P&I Diagrams

see system documentation


Landfill gas
TP 1
Precooler (SRU)
Chilled water (2)
Sulfur Removal Unit (SRU)
QAD 01
QAD 02
Container SRU
Liquid Fertilizer
Liquid suspension
Liquid fertilizer / Fresh water
QEH 01
QEC 01
Heating water circuit
Effluent
Fresh water
TP 8
TP 9
TP 11
TP 12
TP 10
LFG (Recirculation) to Flare
LFG blower
Air cooler
Precooler (LFG)
LFG Separator
Chilled water (2)
Condensate
Off gas
Gas analysis raw gas
QFC 01 QFC 02
Michell O2-Analyzer
Gas analysis raw gas
O_2 0 ... 5 Vol %
Diodenlaserspektrometer AP2E ProCeas
Gas analysis raw gas
CH_4 0 ... 70 Vol %
CO_2 0 ... 50 Vol %
O_2 0 ... 5 Vol %
H_2S 0 ... 2500 ppm
LFG compressor
Cooling water
1st LFG cooler
2nd LFG cooler
LFG dryer
Drying separator
Chilled water (2)
Chilled water (1)
- LFG cooling and drying unit -
QDA 02
TSA preheater
Cooling water
TSA System
VOC & SiOx removal
VOC Regeneration gas el. heater
VOC Regeneration gas cooler
Chilled water (2)
Gas analysis raw gas
H_2S 0 ... 20 ppm
Desulfurization
Desulfurization Dust filter
Cooling water system
QEA 01
Chilled water system (1)
QEB 01
Chilled water system (2)
QEB 02
Instrument air
Instrument air compressor unit
Gas analysis instrument air
Dew point -94 ... -4° F
PSA 1st stage
PSA 1 Tail gas cooler
Vacuum pumps
Cooling water
Air blower bladder tank
Tail gas bladder tank
Tail gas blower
3rd Ultramat
Gas analysis tail gas
CH_4 0 ... 50 Vol %
CO_2 0 ... 100 Vol %
QFN 03
Michell O2-Analyzer
Gas analysis raw gas
O_2 0 ... 5 Vol %
QDE04 Emergency vent
Mix-Box
Purge blower
System blower
RTO Off gas combustion
Combustion Air blower
Supplement fuel
TP 4
TP 5
PSA 2nd stage
PSA 2 Recirculate cooler
Vacuum pumps
Recirculate buffer vessel
Recirculate cooler
Air cooler
Air blower bladder tank
Recirculate blower
1st Ultramat
Gas analysis process gas
CH_4 0 ... 100 Vol %
CO_2 0 ... 10 Vol %
Michell O2-Analyzer
QFM 03
Condensate
TP 3
Biomethane vessel
RNG compressor
RNG cooler
Chilled water (2)
2nd Ultramat
Gas analysis product gas
CH_4 0 ... 100 Vol %
CO_2 0 ... 2 Vol %
Dew point
RNG / Biomethane to gas grid
TP 2
BIOFERM ENERGY SYSTEMS
VIESSMANN Group
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711
Carbotech
Carbotech Gas Systems GmbH
Kronprinzenstraße 30, 45128 Essen, Germany
Process Flow Diagram
BUP 2500I
Landfill Gas Upgrading Plant
Landfill Gas Upgrading Plant
Dane CO, WI
AUC 201
02/27/2017
AUC 201-PFD-00-01

Graphical symbols for valves and controls according to ANSI/ISA-5.1-2009

	Example
Valve, general	
3-way-valve, manually operated	VH.AA.01.01.01.01
4-way-valve, manually operated	VH.AA.01.01.01.01
Ball valve	HH.AA.01.01.01.01
Ball valve, manually operated	HH.AA.01.01.01.01
Globe valve	VH.AA.01.01.01.01
Globe valve, manually operated	VH.AA.01.01.01.01
Needle valve, manually operated	VH.AA.01.01.01.01
Butterfly valve	KH.AA.01.01.01.01
Butterfly valve, manually operated	KH.AA.01.01.01.01
3-way-valve, manually operated	VH.AA.01.01.01.01
Check valve, general	R.AA.01.01.01.01
Swing check valve	R.AA.01.01.01.01
Balancing valve	VH.AA.01.01.01.01
Angled safety valve, spring loaded	Y.AA.01.01.01.01
Safety valve, spring loaded	Y.AA.01.01.01.01
Bursting Disc	Y.AA.01.01.01.01
Breather valve	Y.AA.01.01.01.01
Valve, diaphragm actuator	VC.AA.01.01.01.01
Valve ,Solenoid valve	SV.AA.01.01.01.01
Valve, pneumatic actuator	VP.AA.01.01.01.01
Valve, pneumatic actuator close, fast purge	VP.AA.01.01.01.01
Motor actuator	VM.AA.01.01.01.01
Electrical hydraulic actuator	VE.AA.01.01.01.01
Pressure controller	PCV.AA.01.01.01.01
Pressure reducer	PCV.AA.01.01.01.01
Temperature controller	TCV.AA.01.01.01.01
Slide valve	SH.AA.01.01.01.01
Filter , Y-Type	F.AA.01.01.01.01
Filter , Inline-Type	F.AA.01.01.01.01
Gas / Liquid Separator	U.AA.01.01.01.01
Sight glas	G.AA.01.01.01.01
Restriction Orifice	Z.AA.01.01.01.01
Open Figure 8 Blind	Z.AA.01.01.01.01
Closed Figure 8 Blind	Z.AA.01.01.01.01
Condensate drain	A.AA.01.01.01.01
Gas cylinder	

Graphical symbols for safety positions according to ANSI/ISA-5.1-2009

Example

- Fail to closed position, spring operated
- Fail to opened position, spring operated
- Position locked in operation
  LO = locked open
  LC = locked closed
- Safety position:
  filled end normally closed

P: Port inlet
R: Port outlet
A: Port exhaust / ventilation

Graphical symbols for piping parts according to ANSI/ISA-5.1-2009

Reducer concentric	
Reducer excentric	
Expansion joint	KO.AA.01.01.01.01
Hose	S.AA.01.01.01.01
Flange connection	

Pipe ends - from left to right
- Blind flange
- Flange
- Cap
- Plug
- Hose Connector

Pipe boundaries - from left to right
- CT-Pipe Boundary
- CT-Supplier Boundary
- Supplier-CT Boundary
- Customer-CT Boundary
- CT-Customer Boundary
- Supplier Customer Boundary
- Customer Supplier Boundary
- Supplier Supplier Boundary

CT-Pipe Boundary CTOP
CTOP: connection Take-over point)

Deflector hood	DH.AA.01.01.01.01
Vent	X.AA.01.01.01.01
Lambda blow out	X.AA.01.01.01.01
Vent	X.AA.01.01.01.01
NNxxxxxx Inlet / Outlet Flow arrow	
CT Instrument Flow arrow	
Flow arrow	
Pipe Insulation	
Pipe Insulation trace heating	
Blind flange	
Detonation Arrestor	Y.AA.01.01.01.01
Explosion Proof Flame Arrestor	Y.AA.01.01.01.01
Silencer Inline	X.AA.01.01.01.01
Silencer	X.AA.01.01.01.01
Air Distribution Manifold (here 6-way)	D.AA.01.01.01.01

Graphical symbols for equipment according to ANSI/ISA-5.1-2009

	Example
General pump	P.AA.01.01.01.01
Diaphragm pump	P.AA.01.01.01.01
Gear pump	P.AA.01.01.01.01
General compressor	C.AA.01.01.01.01
General blower	B.AA.01.01.01.01
Axial blower	B.AA.01.01.01.01
Radial blower	B.AA.01.01.01.01
Reciprocating compressor	C.AA.01.01.01.01
Roller vane compressor	C.AA.01.01.01.01
Srew compressor	C.AA.01.01.01.01
Liquid ring compressor	C.AA.01.01.01.01
SS Soft starter	SS.AA.01.01.01.01
Frequency Inverter	SC.AA.01.01.01.01
M Motor	M.AA.01.01.01.01
Exchanger	E.AA.01.01.01.01
Exchanger	E.AA.01.01.01.01
Exchanger	E.AA.01.01.01.01
Exchanger	E.AA.01.01.01.01
Vessel	V.AA.01.01.01.01
Expansions Vessel Diaphragm Type	V.AA.01.01.01.01
Dust filter	U.AA.01.01.01.01
Fluid filter	U.AA.01.01.01.01
Separator	U.AA.01.01.01.01
Cyclone Separator	U.AA.01.01.01.01
Demister	U.AA.01.01.01.01
Heater electrical	E.AA.01.01.01.01
Heater electrical	E.AA.01.01.01.01

Graphical symbols for diverse accessories according to ANSI/ISA-5.1-2009

Electrical light	
ES Emergency Shut down Switch TG Toggle Light On/Off Switch RC Receptacle	
Annunciator	
Motion Detector	
Emergency Shower	Y.AA.01.01.01.01
Air distributor	

Group of equipment sub-system

GA Reference Number ----vv

AA	PSA	01
AB	Membrane	02
AC	Desulfurization	03
AD	Sulfur Removal Unit	04
AE	VOC Removal	05
AF	Drying	06
AG	Deoxygenation	07
AH	Adsorption Dryer	08
AI	Blending	09
AJ	Odorizing	10
AK	Biological Methanation	11
AL	PSA air	12
AM	Gas Receipt	13
AN	Compressors	14
AO	Product Delivery	15
AP	Product Gas Compressors	16
AQ	Electrolyzer stack	17
AR	Oxygen Separator	18
AS	Hydrogen Separator	19
AT	Hydrogen Storage	20
AU	Raw gas cooling	52
AV	Pressurized rawgas vessel	53
DA	Condensate System	21
DB	Waste Water System	22
DC	Off-gas system	23
DD	Vacuum Pumps	24
DE	Tail Gas System	25
DF	Tail Gas Combustion	26
DG	CO2 Liquefaction	27
DH	Liq. CO2 Storage and Loading Station	28
DI	Flare	54
EA	Cooling Water System	29
EB	Chilled Water System	30
EC	Export Heat	31
ED	Demineralized Water System	32
EE	Nitrogen System	33
EF	Oxygen System	34
EG	Instrument Air	35
EH	Liquid Additives	36
EI	Purging Water	37
EM	Neutralization	55
EN	Safety shower	56
EJ	Demineralized Water Cooling	57
FA	Raw Gas Analysis CH4, CO2, (O2)	38
FB	Product Gas Analysis CH4, CO2, (O2)	39
FC	Raw Gas Analysis oxygen monitoring	40
FD	Product Gas Analysis Oxygen Concentration	41
FE	Product Gas Analysis Hydrogen Concentration	42
FF	Raw Gas Analysis H2S	43
FG	Product Gas Analysis H2S	44
FH	Dew Point Monitoring	45
FI	Gas Analysis Oxygen in Hydrogen	46
FJ	Gas Analysis Hydrogen in Oxygen	47
FL	Gas cooling Analysis	58
FM	Gas Analysis after PSA	59
FN	Tail gas Analysis	60
GA	Building Technology Equipment	48
HA	Electric technology	49
IA	Signal Exchange with Upstream Plant	50
IB	Signal Exchange with Downstream Plant	51
IC	Signal Exchange with parallel working Plant	52

P&ID Revision

RED = add
BLUE = remove
GREEN = comment
YELLOW = accepted
All changes have to be signed and dated

Graphical symbols for instrument functions

Pressure

1. PI — Local pressure control gauge
2. PC — Local automatic pressure control (self adjusting)
3. a) PI b) PI — Displayed only a) in central PLC b) in other PLC
4. PISAHL — Display of alarm (A) in PLC, switching (S) function in PLC (for lower/upper limit)
5. PSAL — Local swich (Alarm and switching function)
6. PIC — Controlling function in PLC
7. PIZAH — 29 psi(g) 2.0 bar(g) — Safety instrumented system / Safety instrumented function in PLC

Common combinations

8. PISAHL / PI
9. PIC / PISAHL / PI
10. PIZAH / PISAL / PI — 29 psi(g) 2.0 bar(g)

Combination 1 + 4
Combination 1 + 4 + 6
Combination 1 + 4 + 7 — L alarm and switching normal, H switching safety related
Safety instrumented system / Safety instrumented function

Temperature

1. TI — Local temperature gauge
2. TC — Local temperature control (eg. capillary tube)
3. a) TI b) TI — Displayed only a) in central PLC b) in other PLC
4. TISAHL — Display of alarm (A) in PLC, switching (S) function in PLC (for lower/upper limit)
5. TSAL — Local swich (Alarm and switching function)
6. TIC — Controlling function in PLC
7. TIZAH — 194°F 90°C — Safety instrumented system / safety instrumented function in PLC

TAG numbering of equipment

BUP1 VH.AA.01.01.01.01

Plant identification — Table 1 Table 2 Table 3 — Group of Equipment — Train number — Stage number — Parallel Equipment Index — Counting Number

(Only used if supplying more than 1 plant)

Table 1

Identification letters for equipment	
A	Stack
B	Blower, Fan
C	Compressor
D	Burner
DH	Deflector hood
E	Heat Exchanger
F	Filter inline , Strainer
G	Air distributor
K	Crankcase
M	Motor, Drive
P	Pump
Q	Blow out spot
R	Reactor
U	Filter, Sieve, Separator
V	Vessel
T	Tank, Tower
X	Lambda blow out

Table 2

Identification letters for valves and controls

	1st letter	Appended letter
A	Drain	
C		Controlled (e.g. Positioner)
D	Air Distribution Manifold	
F	Filter, sieve, strainer	
G	Sight glass	
H	Ball valve	Manually / Hand operated
K	Butterfly valve	
M	Motor	Motor actuator
P		Pneumatic actuator (Piston)
R	Check valve	
S	Solenoid valve	
V	Valve	
Y	Safety valve	
Z	Plate	

Table 3

Identification letters for measuring and control devices

ID	Group 1; variables: 1st letter	Additional letter (1)	Group 2: processing: Appended letter (11) I, R, C
A			Alarm
C			Controlling function
D	Density	Difference	
E	All electrical variables		Sensing element
F	Flow rate	Ratio	
FB	Feedback		
G	Gauging, length, position		
H	Hand operated		Upper limit (High)
I			Indication
J	Power	Scan	
K	Time		
L	Level		Lower limit (Low)
M	Moisture, humidity		
O			Visual signal
P	Pressure		
Q	Quality e.g. analysis, concentration, conductivity	Integrate or totalise	
R	Nuclear radiation		Recording function, Registration
S	Speed, frequency		Switching function
T	Temperature		Transmitter, Transducer function
U	Multi-variable		Multifunction unit, Combined function
V	Viscosity		Actuator function
W	Weight or force		
X	Unclassified variables		
Y			Computational function
Z			Safety instrumented system / function

Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

NO.	REVISION	DATE
	first Draft	11/22/17
	change from 4 to 6 vessels	03/14/18
	generally revised	04/23/18
	Revision 3	12/01/18
	Issue for construction / IFC	01/31/19
	--- AS BUILT ---	07/25/19

BIOFERM ENERGY SYSTEMS
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

COUNTY of DANE WISCONSIN

SHEET TITLE: P&ID Typical Equipment	PROJ. NO.: AUC201		DATE: 2019-01-31
	DSN. BY:	DWN. BY: SctP 2019-01-31	CHK. BY: ZimT 2019-01-31	APP. BY: ----
PROJECT TITLE: Dane County WI BUP2500I Dane County	DRAWING NO.: AUC201-TPC-00-01		PAGE NO.: 0a / 72

Equipment	Sub-System designation	Rating	Material number	Material marking	designation				
AA	PSA	300#	A333	-	Corrugated metallic g.	SPWG	300CS-650-212 (*)		
AA	PSA	150#	A333	-	Corrugated metallic g.	SPWG	150CS-165-212	13591/1023	
AC	Desulfurization	150#	304L	-	Corrugated metallic g.	SPWG	150SS-165-250 (**)	13591/1023	
AD	Sulfur Removal Unit	150#	304L	-	Corrugated metallic g.	SPWG	150SS-22-176	13591/1023	Biogas w/ H2S
AE	VOC Removal	150#	304L	-	Corrugated metallic g.	SPWG	150SS-165-250 (**,*4)	13591/1023	Biogas w/ H2S
AF	Drying	150#	304L	-	Corrugated metallic g.	SPWG	150SS-165-250 (**)	13591/1023	Biogas w/ H2S
AM	Gas Receipt	150#	304L	-	Corrugated metallic g.	SPWG	150SS-22-176	13591/1023	Biogas w/ H2S
AN	Compressors	150#	304L	-	Corrugated metallic g.	SPWG	150SS-165-250 (**)	13591/1023	Biogas w/ H2S
AO	Product Delivery	150#	A333	-	Corrugated metallic g.	SPWG	150CS-165-212	13591/1023	Biomethane
AP	Product Gas Compressors	1000#	A333	-	Corrugated metallic g.	SPWG	1000CS-1250-220	13591/1023	RNG
DA	Condensate System	150#	304L	-	Corrugated metallic g.	SPWG	150SS-165-250 (*)	Grey/7005	Condensate
DB	Waste Water System								
DC	Off-gas system	150#	A333	-	Corrugated metallic g.	SPWG	150CS-30-180	13591/1023	Off gas
DD	Vacuum Pumps	150#	A333	-	Corrugated metallic g.	SPWG	150CS-30-180	13591/1023	Tail gas
DE	Tail Gas System	150#	A333	-	Corrugated metallic g.	SPWG	150CS-30-180	13591/1023	Tail gas
DF	Tail Gas Combustion	150#	A333	-	Corrugated metallic g.	SPWG	150CS-30-180	13591/1023	Tail gas
DI	Flare								
EA	Cooling Water System	150#	A53 Gr.B	-	Centellen	NBR	150CS-100-212	Grey/7005	Cooling water
EB	Chilled Water System	150#	A53 Gr.B	-	Centellen	NBR	150CS-100-212	Grey/7005	Chilled water
EC	Export Heat	150#	A53 Gr.B	-	Centellen	NBR	150CS-100-212	Grey/7005	Hot water
ED	Demineralized Water System								
EE	Nitrogen System	150#	-	-	-	-	-	Grey/7005	Nitrogen
EF	Oxygen System								
EG	Instrument Air	150#	304	-	HNBR	NBR	150SS-150-180 (***)		Instrument air
EH	Liquid Additives								
EM	Neutralisation								
EN	Safety Showers								
FA	Raw Gas Analysis CH4, CO2, (O2)	300#	316	-	Swagelok or eq.		Swagelok or eq.		
FB	Product Gas Analysis CH4, CO2, (O2)	300#	316	-	Swagelok or eq.		Swagelok or eq.		
FC	Raw Gas Analysis oxygen monitoring	300#	316	-	Swagelok or eq.		Swagelok or eq.		
FD	Product Gas Analysis Oxygen Concentration	300#	316	-	Swagelok or eq.		Swagelok or eq.		
FF	Raw Gas Analysis H2S	300#	316	-	Swagelok or eq.		Swagelok or eq.		
FG	Product Gas Analysis H2S	300#	316	-	Swagelok or eq.		Swagelok or eq.		
FH	Dew Point Monitoring	300#	316	-	Swagelok or eq.		Swagelok or eq.		
FI	Gas Analysis Oxygen in Hydrogen	300#	316	-	Swagelok or eq.		Swagelok or eq.		
FJ	Gas Analysis Hydrogen in Oxygen	300#	316	-	Swagelok or eq.		Swagelok or eq.		
FL	Gas cooling Analysis	300#	316	-	Swagelok or eq.		Swagelok or eq.		
FM	Gas Analysis after PSA	300#	316	-	Swagelok or eq.		Swagelok or eq.		
FN	Tail gas Analysis	300#	316	-	Swagelok or eq.		Swagelok or eq.		
FO	Test gas	n.a.							
GA	Building Technology Equipment	n.a.							
HA	Electric technology	n.a.							
IA	Signal Exchange with Upstream Plant	n.a.							
IB	Signal Exchange with Downstream Plant	n.a.							
IC	Signal Exchange with parallel working Plant								

(*) Severe cyclic conditions may apply for individual pipe spools within specified assembly.
(**) Change of material from Stainless to Carbon steel may apply for individual pipe spools within specified assembly.
(***) Oxygen Service may apply for individual pipe spools within specified assembly.
(*4) May apply for 30psi(2bar+) and 550°F(288°C).
WD10 Corrugated metallic w/ graphite layer
WD20 Corrugated metallic w/ graphite layer + inner eyelet
(*5) Biogas: Landfill gas (LFG) in different states

Display format of lines

- Primary Flow
- Functional unit
- Secondary Flow
- Dotted function line
- Package unit boundary
- + XY ft Reference (above mean plant level)
- Slope

Battery limits

Customer | CT — Supplier | CT — Customer | Supplier — Supplier | Supplier

TP = Tie-in point / Transfer point (Piping)
PU = Package unit

All pressures given as gauge pressure

Insulation and heating key

- CC - xx: CC = Insulation for Cold / Heat Conservation (multipurpose)
- HC - xx: HC = Insulation for Heat conservation
- ET - xx: ET = Electrical Trace Heating
- PP - xx: PP = Personnel Protection

xx = Thickness of insulation in inch

P&ID Revision

RED = add
BLUE = remove
GREEN = comment
YELLOW = accepted
All changes have to be signed and dated

Pressure test circuit boundary

PK01 (P) PK02

Pressure test circuit PK01
Pressure test circuit PK02
Pressure test circuit PK03
Pressure test circuit PK04
Pressure test circuit PK05

Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFERM™ ENERGY SYSTEMS
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID Typical - Pipes
PROJ. NO.: AUC201
DATE: 2019-01-31
SCALE:
DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----
PROJECT TITLE: Dane County WI BUP2500I Dane County
DRAWING NO: AUC201-TPC-00-02
PAGE NO. 0b / 72

Identification letter(s) for Building technology equipment	Unit	Number for Building technology **function**	Number for equipment **location** sub-system	**Parallel Equipment**	**Counter**
CT/AC/ES/F/HT/LT/M/MD/O/PB/QF/QG/RC/SV/T/TG/PU/B	GA	01..99	01..99	01..99	01..99
CT = container	GA	00 = container	01 = PSA [AA]		
AC = air conditioners		01 = air conditioners	02 = Membrane [AB]		
ES = emergency stop buttons		02 = emergency stop buttons	03 = Desulfurization [AC]		
F = airflow monitoring		03 = airflow monitoring	04 = SulfurRemovalUnit [AD]		
HT = heaters		04 = heaters	05 = VOCRemoval [AE]		
LT = luminaires		05 = luminaires	06 = Drying [AF]		
M = fan motors		06 = fan motors	07 = Deoxygenation [AG]		
MD = motion detectors		07 = motion detectors	08 = AdsorptionDryer [AH]		
O = flash/sounders		08 = flash/sounders	09 = Blending [AI]		
PB = push buttons		09 = push buttons	10 = Odorizing [AJ]		
QF = fire detectors		10 = fire detectors	11 = BiologicalMethanation [AK]		
QG = gas sensors		11 = gas sensors	12 = PSAair [AL]		
RC = receptacles		12 = receptacles	13 = GasReceipt [AM]		
SV = solenoid valves		13 = solenoid valves	14 = Compressors [AN]		
T = temperatures		14 = temperatures	15 = ProductDelivery [AO]		
TG = light switches		15 = light switches	16 = ProductGasCompressors [AP]		
PU = Package units		16 = Package units	17 = Electrolyzerstack [AQ]		
B = blowers		17 = Trace heatiing	18 = OxygenSeparator [AR]		
			19 = HydrogenSeparator [AS]		
			20 = HydrogenStorage [AT]		
			21 = CondensateSystem [DA]		
			22 = WasteWaterSystem [DB]		
			23 = Off-gassystem [DC]		
			24 = VacuumPumps [DD]		
			25 = TailGasSystem [DE]		
			26 = TailGasCombustion [DF]		
			27 = CO2Liquefaction [DG]		
			28 = Liq.CO2StorageandLoadingStation [DH]		
			29 = CoolingWaterSystem [EA]		
			30 = ChilledWaterSystem [EB]		
			31 = ExportHeat [EC]		
			32 = DemineralizedWaterSystem [ED]		
			33 = NitrogenSystem [EE]		
			34 = OxygenSystem [EF]		
			35 = InstrumentAir [EG]		
			36 = LiquidAdditives [EH]		
			37 = PurgingWater [EI]		
			38 = RawGasAnalysisCH4,CO2,(O2) [FA]		
			39 = ProductGasAnalysisCH4,CO2,(O2) [FB]		
			40 = RawGasAnalysisoxygenmonitoring [FC]		
			41 = ProductGasAnalysisOxygenConcentration [FD]		
			42 = ProductGasAnalysisHydrogenConcentration [FE]		
			43 = RawGasAnalysisH2S [FF]		
			44 = ProductGasAnalysisH2S [FG]		
			45 = DewPointMonitoring [FH]		
			46 = GasAnalysisOxygeninHydrogen [FI]		
			47 = GasAnalysisHydrogeninOxygen [FJ]		
			48 = BuildingTechnologyEquipment [GA]		
			49 = Electrictechnology [HA]		
			50 = SignalExchangewithUpstreamPlant [IA]		
			51 = SignalExchangewithDownstreamPlant [IB]		
			52 = Rawgascooling [AU]		
			52 = SignalExchangewithparallelworkingPlant [IC]		
			53 = Pressurizedrawgasvessel [AV]		
			54 = Flare [DI]		
			55 = Neutralization [EM]		
			56 = Safetyshower [EN]		
			57 = DemineralizedWaterCooling [EJ]		
			58 = GascoolingAnalysis [FL]		
			59 = GasAnalysisafterPSA [FM]		
			60 = TailgasAnalysis [FN]		

TAG numbering of building technology equipment

BUP1 AC.GA.01.01.01.01

Plant identification — Identification Letter(s) — Fix = GA — Function number — Location number — Parallel Equipment Index — Counting Number

(Only used if supplying more than 1 plant)

Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

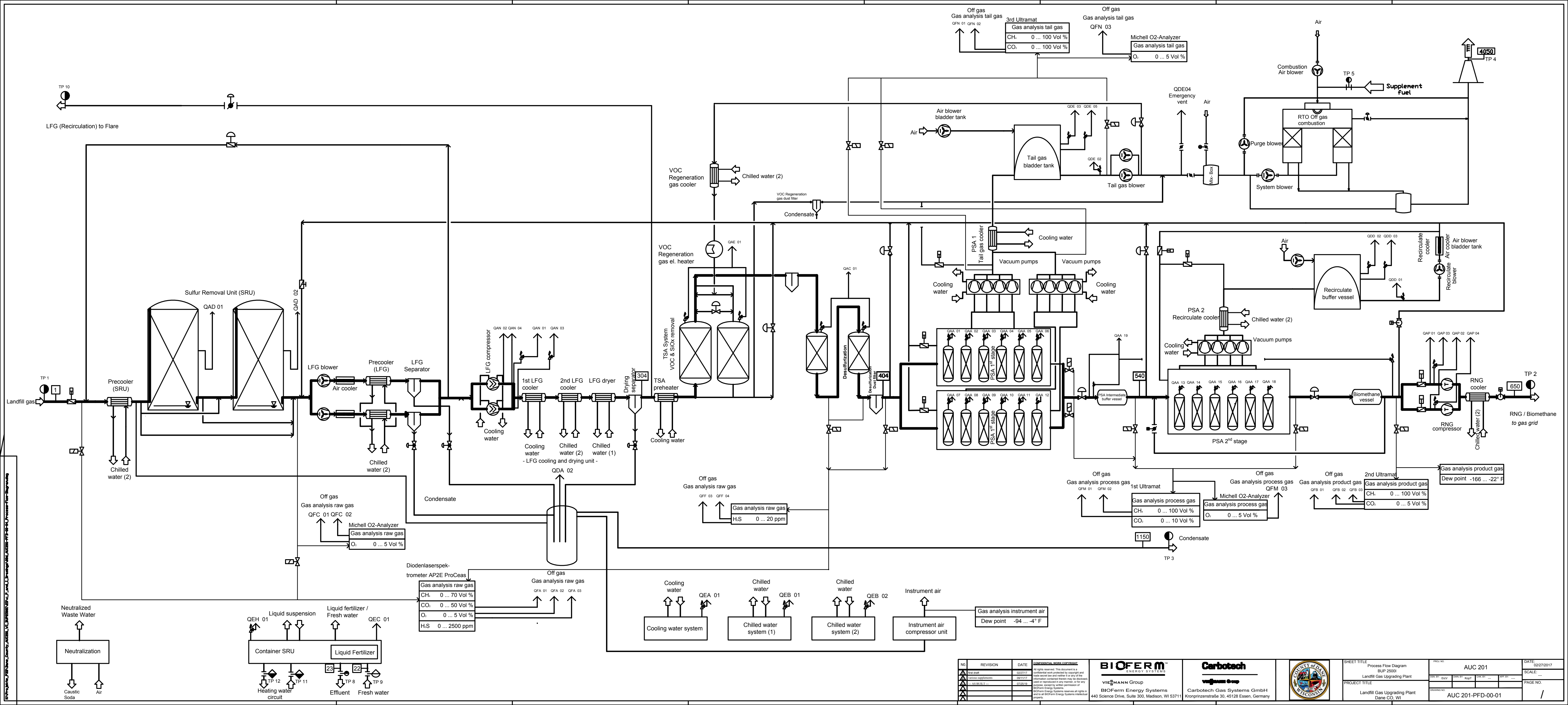
N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

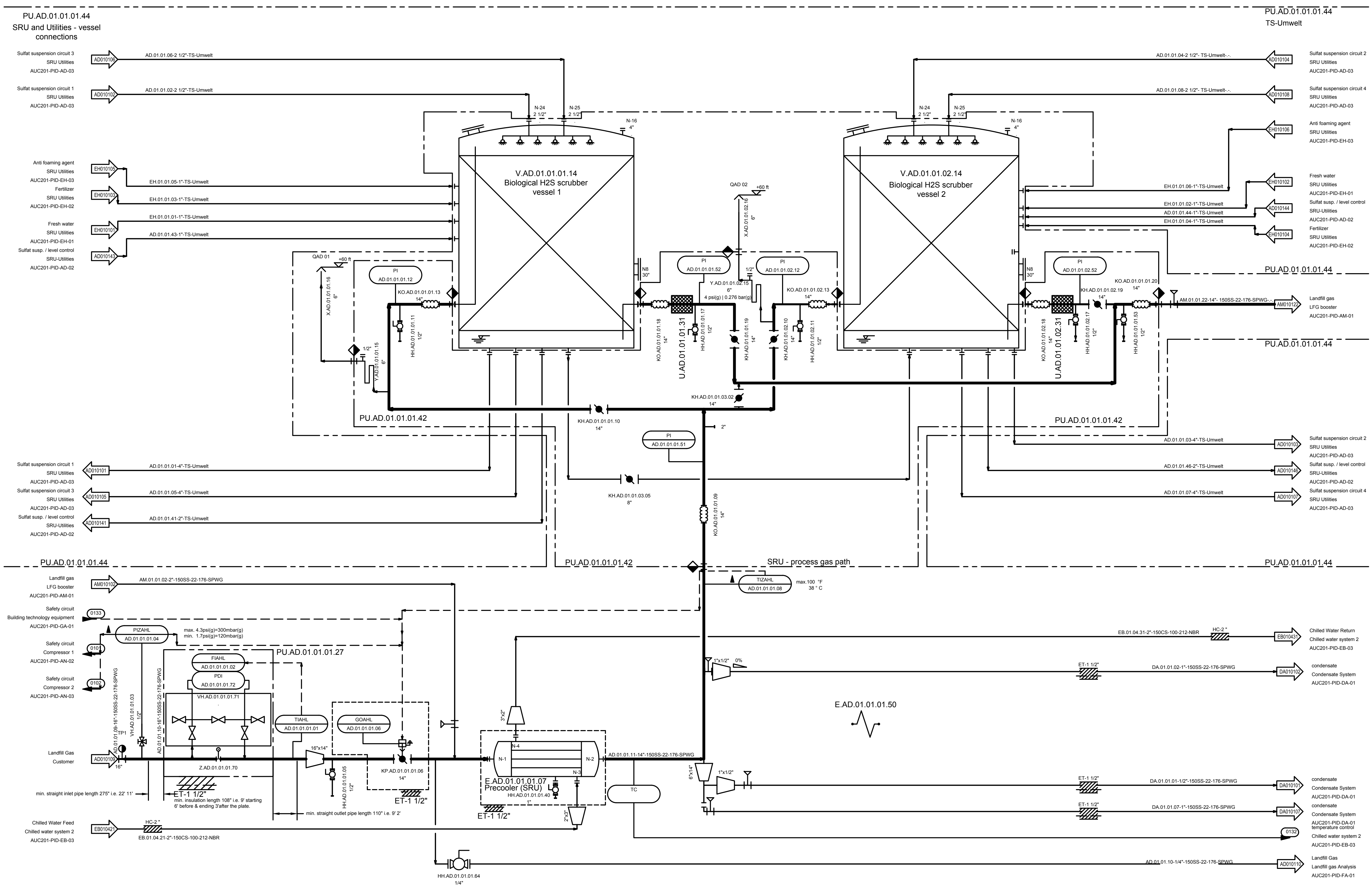
BIOFERM™ ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID Typical Building-technology-equipment	PROJ. NO. AUC201			DATE: 2019-01-31
	DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----
		2019-01-31	2019-01-31	SCALE:
PROJECT TITLE: Dane County WI BUP2500I Dane County	DRAWING NO: AUC201-TPC-00-03			PAGE NO. 0c / 72


Landfill gas
TP 1
Precooler (SRU)
Chilled water (2)
Sulfur Removal Unit (SRU)
QAD 01
QAD 02
LFG (Recirculation) to Flare
TP 10
LFG blower
Air cooler
Precooler (LFG)
LFG Separator
Chilled water (2)
Condensate
LFG compressor
Cooling water
1st LFG cooler
2nd LFG cooler
LFG dryer
Drying separator
304
TSA preheater
Cooling water
Chilled water (2)
Chilled water (1)
- LFG cooling and drying unit -
QDA 02
VOC Regeneration gas cooler
Chilled water (2)
VOC Regeneration gas dust filter
Condensate
VOC Regeneration gas el. heater
QAE 01
TSA System VOC & SiOx removal
Desulfurization
Desulfurization Dust filter
404
QAC 01
PSA 1 Tail gas cooler
Cooling water
Vacuum pumps
PSA 1st stage
QAA 01 QAA 02 QAA 03 QAA 04 QAA 05 QAA 06
QAA 07 QAA 08 QAA 09 QAA 10 QAA 11 QAA 12
QAA 19
PSA Intermediate buffer vessel
540
PSA 2 Recirculate cooler
Chilled water (2)
Vacuum pumps
QAA 13 QAA 14 QAA 15 QAA 16 QAA 17 QAA 18
PSA 2nd stage
Biomethane vessel
Recirculate buffer vessel
Recirculate cooler
Recirculate blower
Air cooler
Air blower bladder tank
QDD 01 QDD 02 QDD 03
QAP 01 QAP 03 QAP 02 QAP 04
RNG cooler
RNG compressor
650
TP 2
RNG / Biomethane to gas grid
Chilled water (2)
3rd Ultramat
Off gas
Gas analysis tail gas
QFN 01 QFN 02
CH₄ 0 ... 100 Vol %
CO₂ 0 ... 100 Vol %
QFN 03
Michell O2-Analyzer
O₂ 0 ... 5 Vol %
Air blower bladder tank
Tail gas bladder tank
Tail gas blower
QDE 02 QDE 03 QDE 05
QDE04 Emergency vent
Air
Mix. Box
Combustion Air blower
TP 5
Supplement fuel
4050
TP 4
RTO Off gas combustion
Purge blower
System blower
Off gas
Gas analysis raw gas
QFC 01 QFC 02
Michell O2-Analyzer
O₂ 0 ... 5 Vol %
QFF 03 QFF 04
H₂S 0 ... 20 ppm
Diodenlaserspek-trometer AP2E ProCeas
CH₄ 0 ... 70 Vol %
CO₂ 0 ... 50 Vol %
O₂ 0 ... 5 Vol %
H₂S 0 ... 2500 ppm
QFA 01 QFA 02 QFA 03
Off gas
Gas analysis process gas
QFM 01 QFM 02
1st Ultramat
CH₄ 0 ... 100 Vol %
CO₂ 0 ... 10 Vol %
QFM 03
Michell O2-Analyzer
O₂ 0 ... 5 Vol %
Gas analysis product gas
QFB 01 QFB 02 QFB 03
2nd Ultramat
CH₄ 0 ... 100 Vol %
CO₂ 0 ... 5 Vol %
Dew point -166 ... -22° F
1150
TP 3
Condensate
Cooling water
QEA 01
Cooling water system
Chilled water
QEB 01
Chilled water system (1)
QEB 02
Chilled water system (2)
Instrument air
Gas analysis instrument air
Dew point -94 ... -4° F
Instrument air compressor unit
Neutralized Waste Water
Neutralization
Caustic Soda
Air
Liquid suspension
Liquid fertilizer / Fresh water
QEH 01
QEC 01
Container SRU
Liquid Fertilizer
23
22
TP 12
TP 11
TP 8
TP 9
Heating water circuit
Effluent
Fresh water
BIOFERM ENERGY SYSTEMS
VIESSMANN Group
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711
Carbotech
Carbotech Gas Systems GmbH
Kronprinzenstraße 30, 45128 Essen, Germany
COUNTY of DANE WISCONSIN
Process Flow Diagram
BUP 2500l
Landfill Gas Upgrading Plant
AUC 201
02/27/2017
PROJECT TITLE
Landfill Gas Upgrading Plant
Dane CO, WI
AUC 201-PFD-00-01



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID
Sulfur removal unit - SRU

PROJECT TITLE
Dane County WI BUP2500I
Dane County

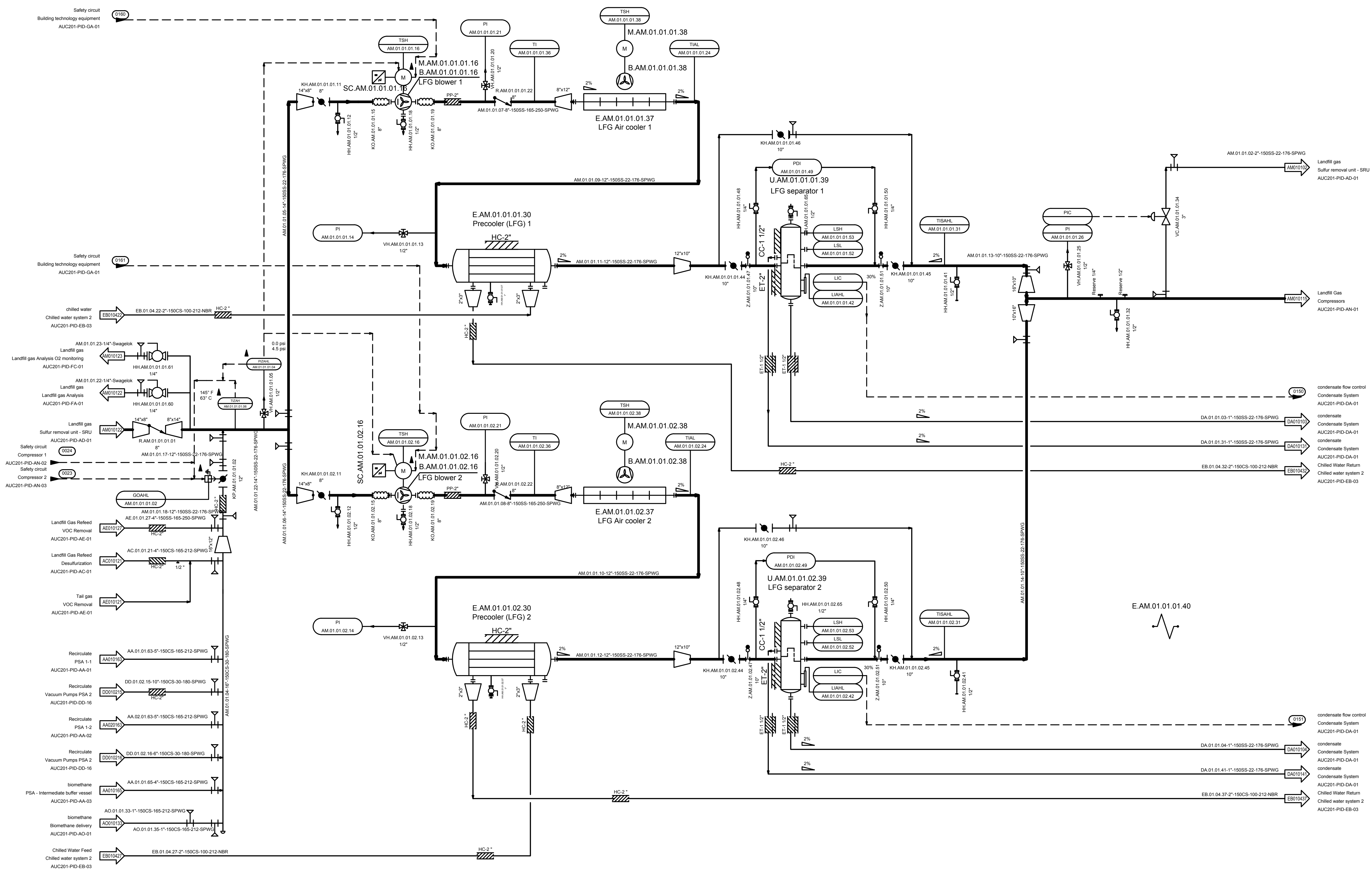
PROJ. NO. AUC201

DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----
	2019-01-31	2019-01-31	

DRAWING NO: AUC201-PID-AD-01

DATE: 2019-01-31

SCALE:



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

NO.	REVISION	DATE
	first Draft	11/22/17
	change from 4 to 6 vessels	03/14/18
	generally revised	04/23/18
	Revision 3	12/01/18
	Issue for construction / IFC	01/31/19
	--- AS BUILT ---	07/25/19

BIOFERM™ ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID
LFG booster

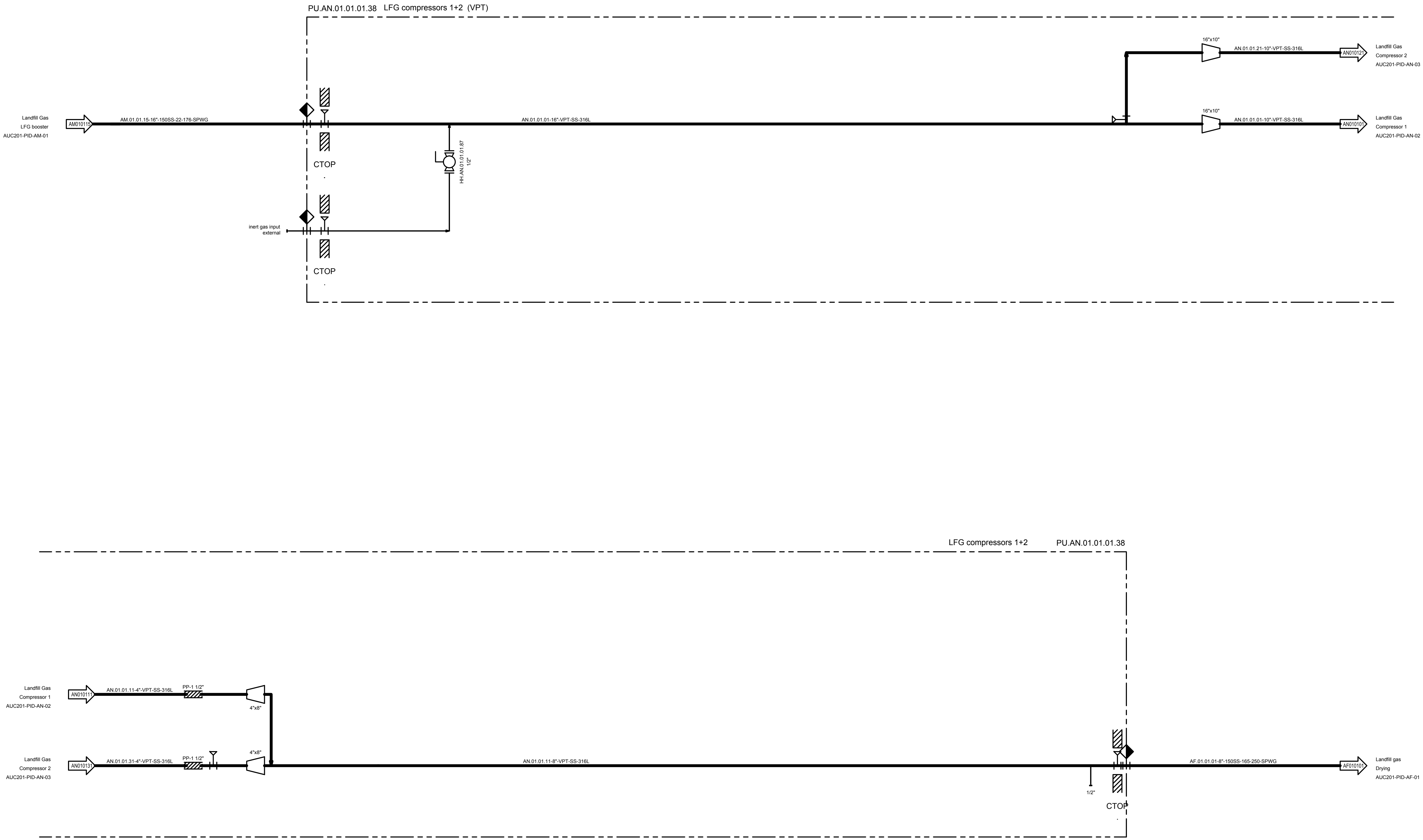
PROJ. NO. AUC201

DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

PROJECT TITLE
Dane County WI BUP2500I
Dane County

DRAWING NO: AUC201-PID-AM-01

DATE: 2019-01-31
SCALE:
PAGE NO. 02 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID Compressors manifolds

PROJECT TITLE: Dane County WI BUP2500I Dane County

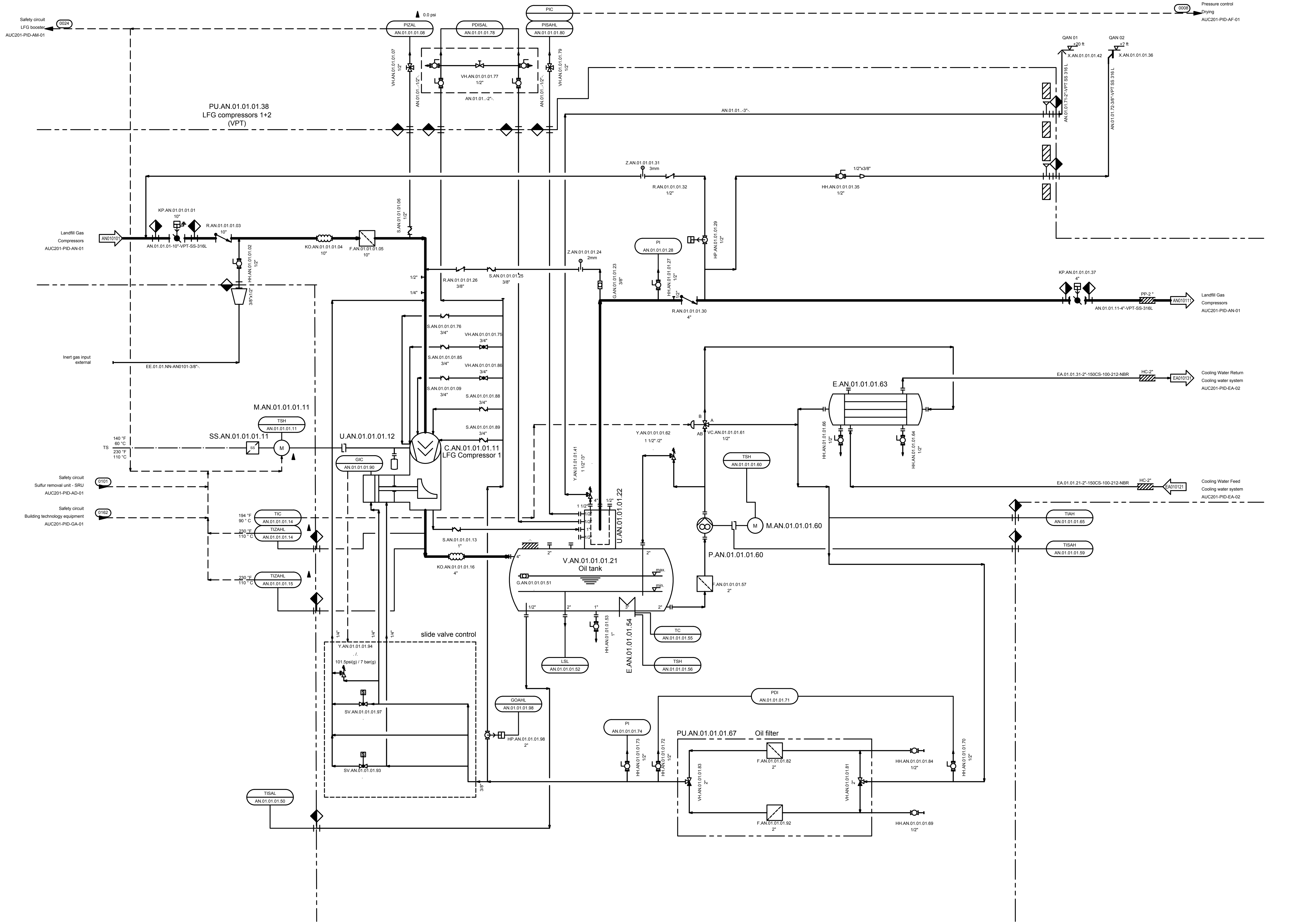
PROJ. NO.: AUC201

DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

DRAWING NO: AUC201-PID-AN-01

DATE: 2019-01-31

SCALE:



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID Compressor 1

PROJECT TITLE: Dane County WI BUP2500I Dane County

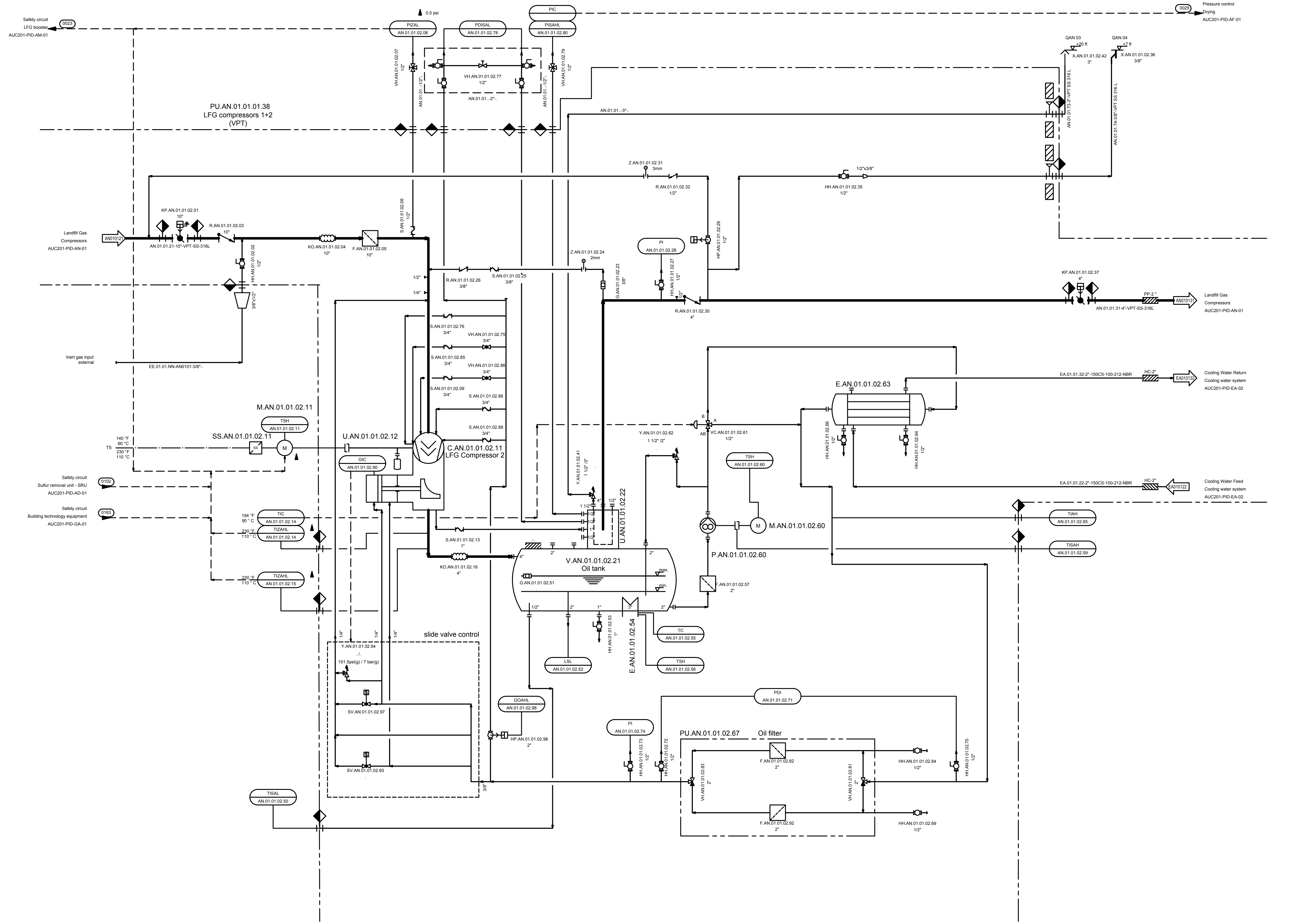
PROJ. NO.: AUC201

DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

DRAWING NO: AUC201-PID-AN-02

DATE: 2019-01-31

SCALE:



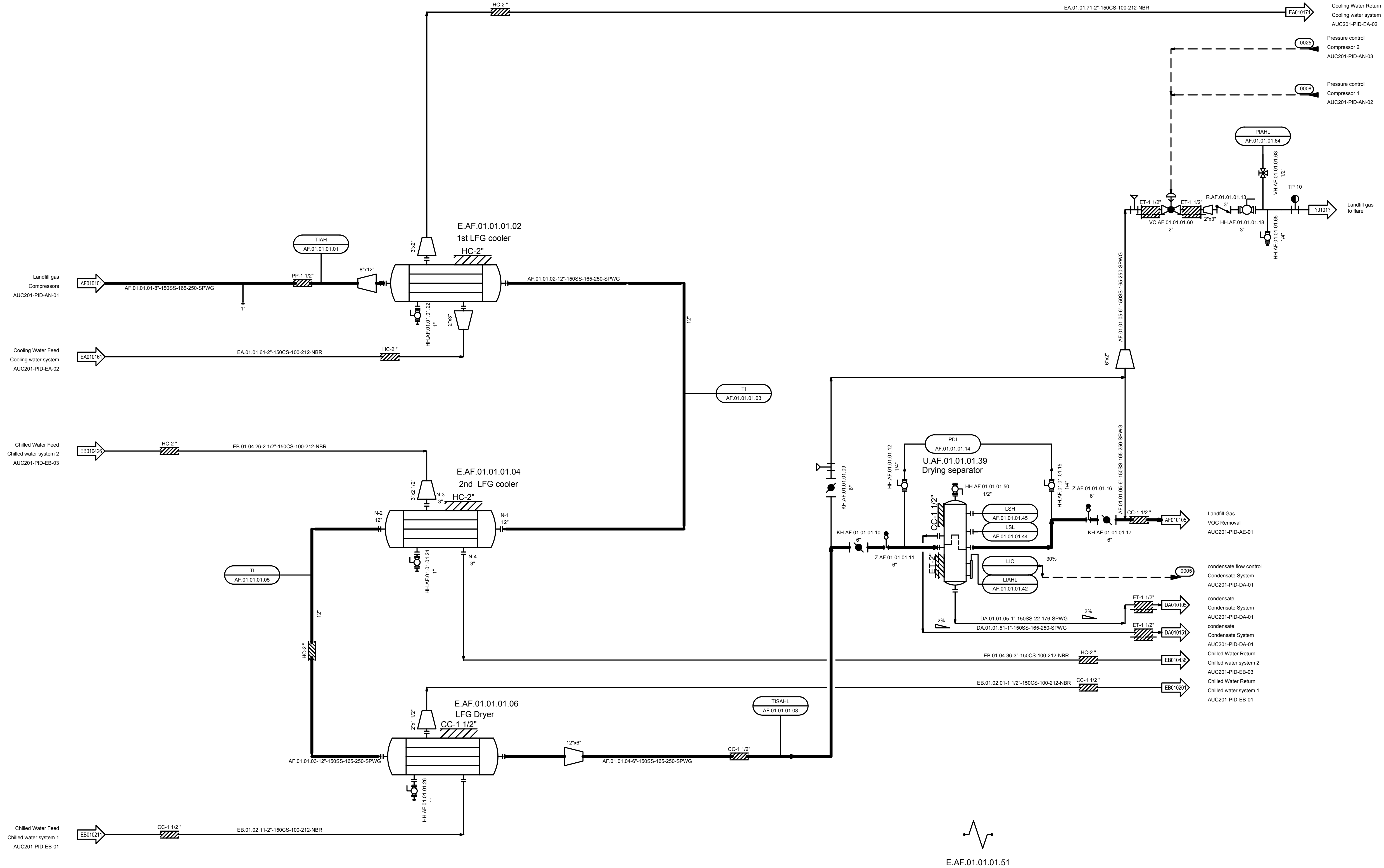
Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

NO.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFERM ENERGY SYSTEMS
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID Compressor 2
PROJ. NO.: AUC201
DATE: 2019-01-31
SCALE:
DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----
PROJECT TITLE: Dane County WI BUP2500I Dane County
DRAWING NO: AUC201-PID-AN-03
PAGE NO. 05 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

NO.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID Drying

PROJECT TITLE: Dane County WI BUP2500I Dane County

PROJ. NO.: AUC201

DSN. BY: | DWN. BY: SctP | CHK. BY: ZimT | APP. BY: ----

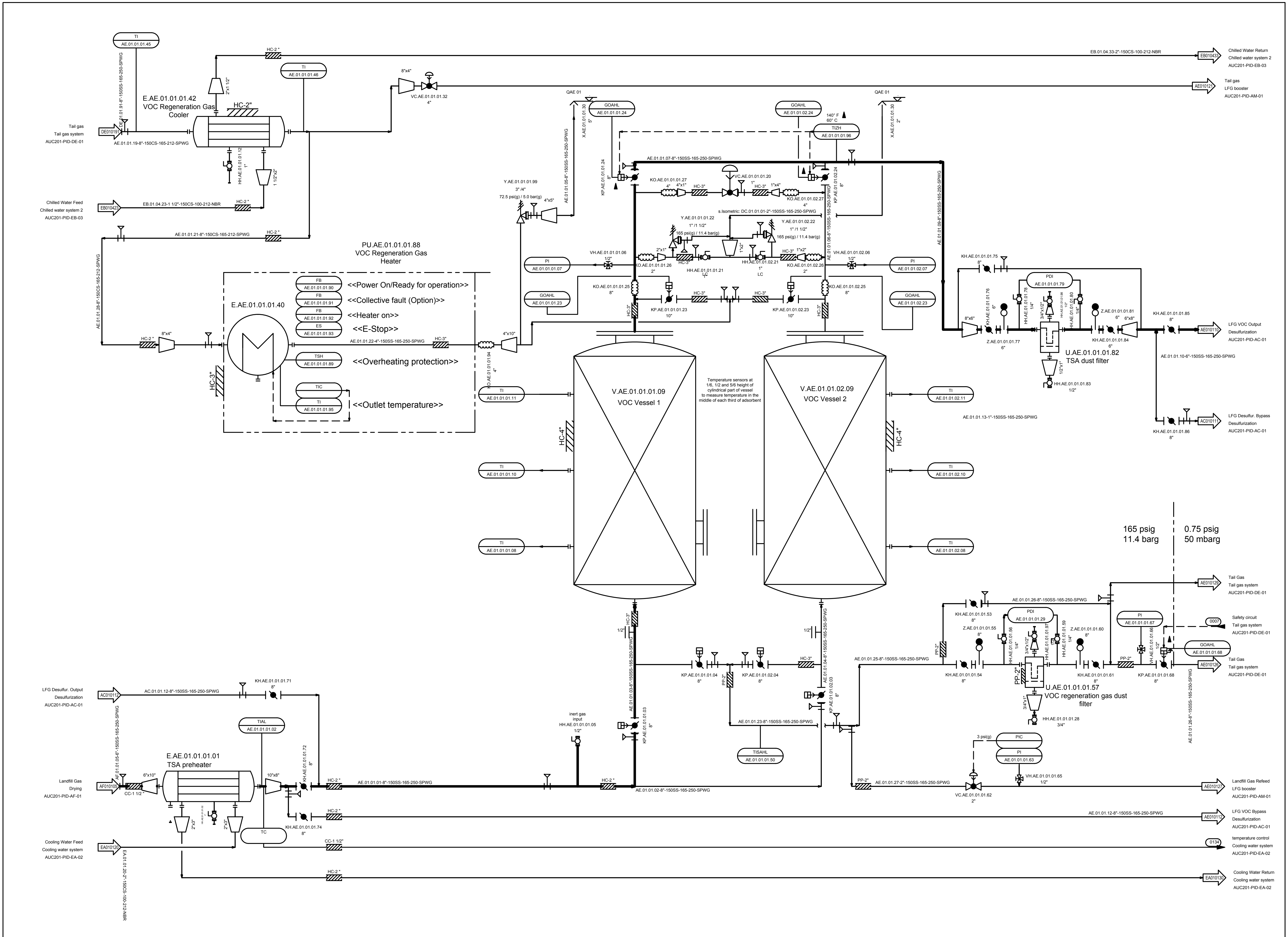
2019-01-31 | 2019-01-31

DRAWING NO.: AUC201-PID-AF-01

DATE: 2019-01-31

SCALE:

PAGE NO. 06 / 72



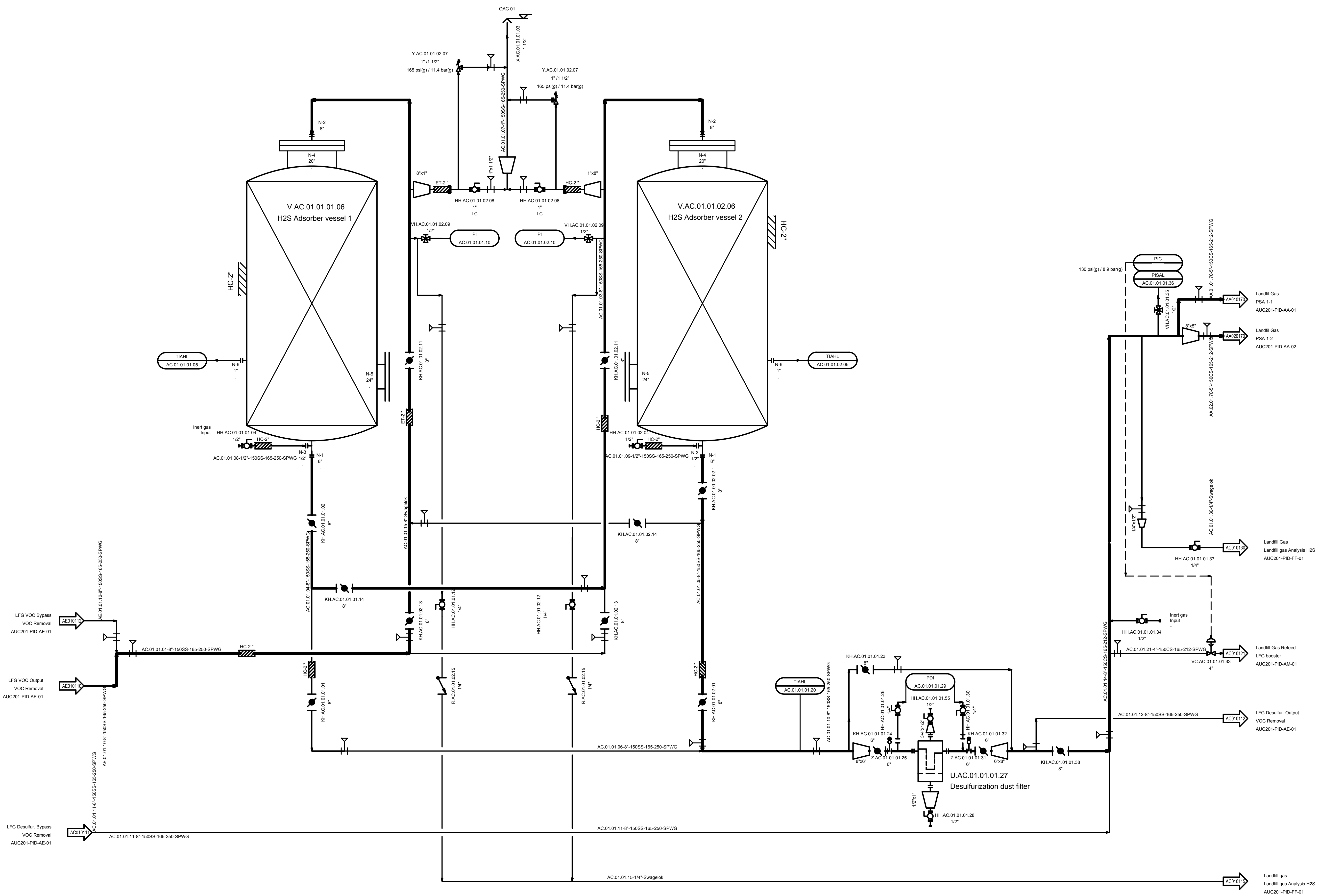
Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

NO.	REVISION	DATE
	first Draft	11/22/17
	change from 4 to 6 vessels	03/14/18
	generally revised	04/23/18
	Revision 3	12/01/18
	Issue for construction / IFC	01/31/19
	— AS BUILT —	07/25/19

BIOFERM ENERGY SYSTEMS
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE	P&ID VOC Removal
PROJ. NO.	AUC201
DSN. BY:	
DWN. BY:	SctP 2019-01-31
CHK. BY:	ZimT 2019-01-31
APP. BY:	----
PROJECT TITLE	Dane County WI BUP2500I Dane County
DRAWING NO.	AUC201-PID-AE-01
DATE	2019-01-31
SCALE:	
PAGE NO.	07 / 72



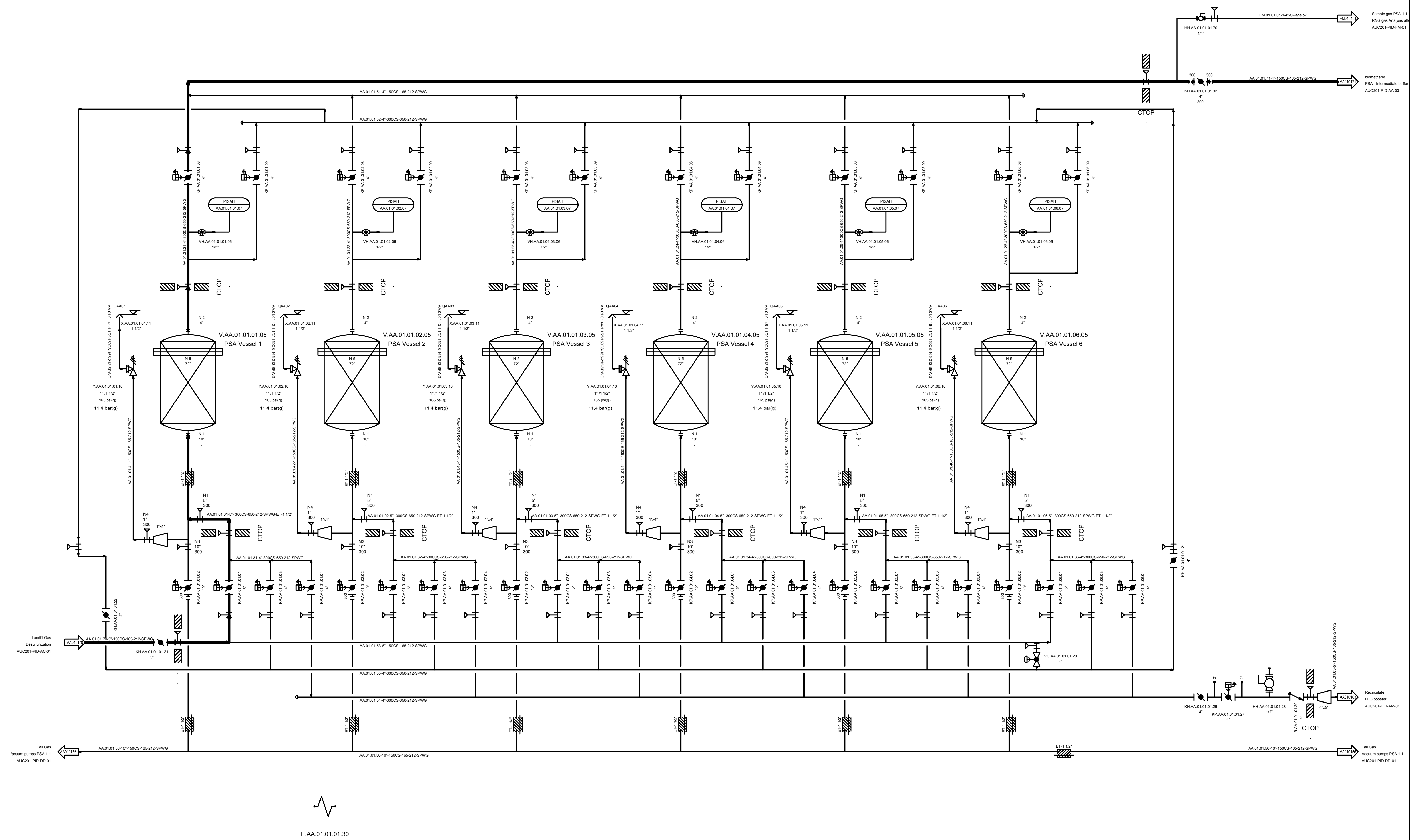
Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID Desulfurization	PROJ. NO. AUC201			DATE: 2019-01-31
	DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----
		2019-01-31	2019-01-31	SCALE:
PROJECT TITLE Dane County WI BUP2500I Dane County	DRAWING NO: AUC201-PID-AC-01			PAGE NO. 08 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFERM™ ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID PSA 1-1

PROJECT TITLE Dane County WI BUP2500I Dane County

PROJ. NO. AUC201

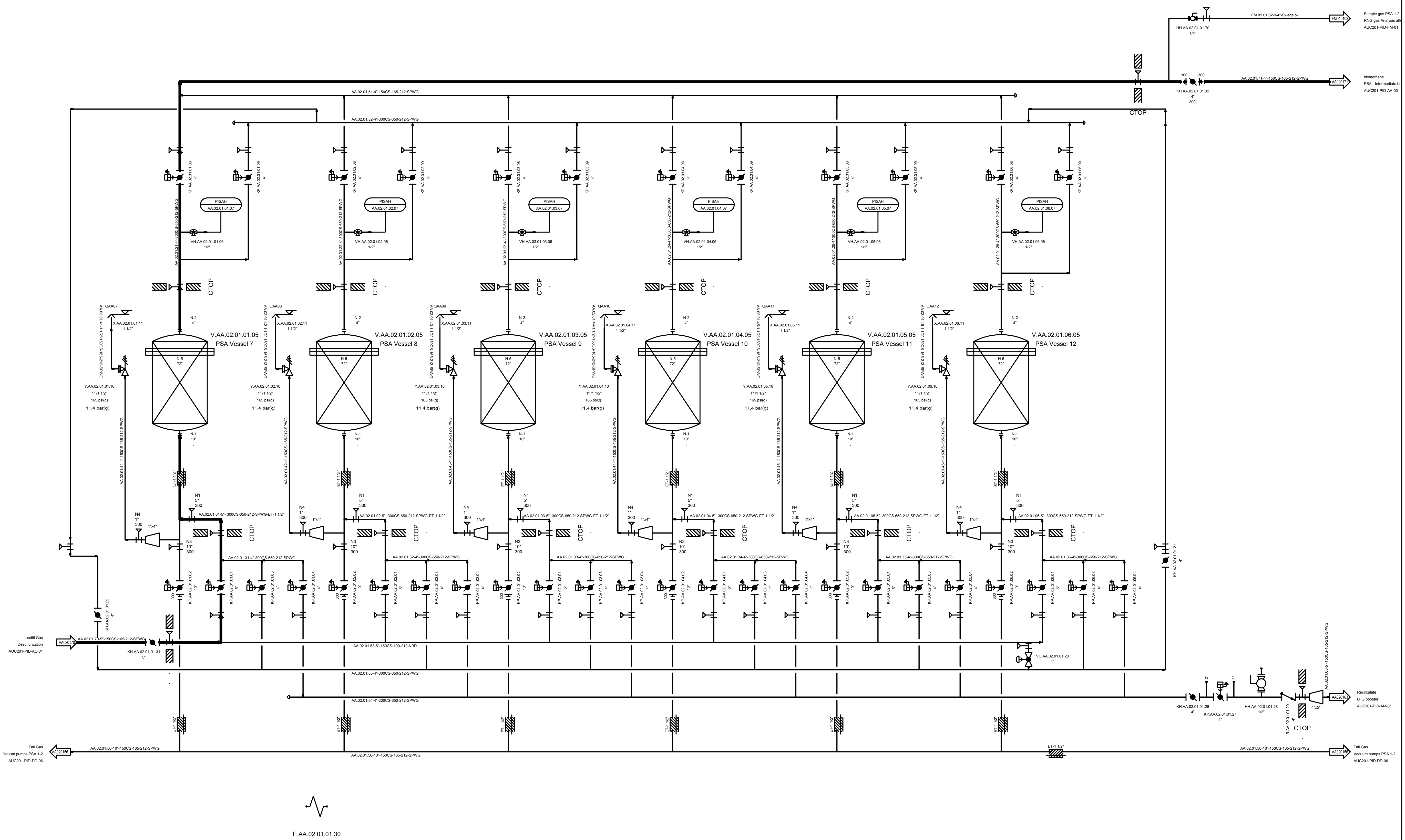
DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

DRAWING NO: AUC201-PID-AA-01

DATE: 2019-01-31

SCALE:

PAGE NO. 09 / 72



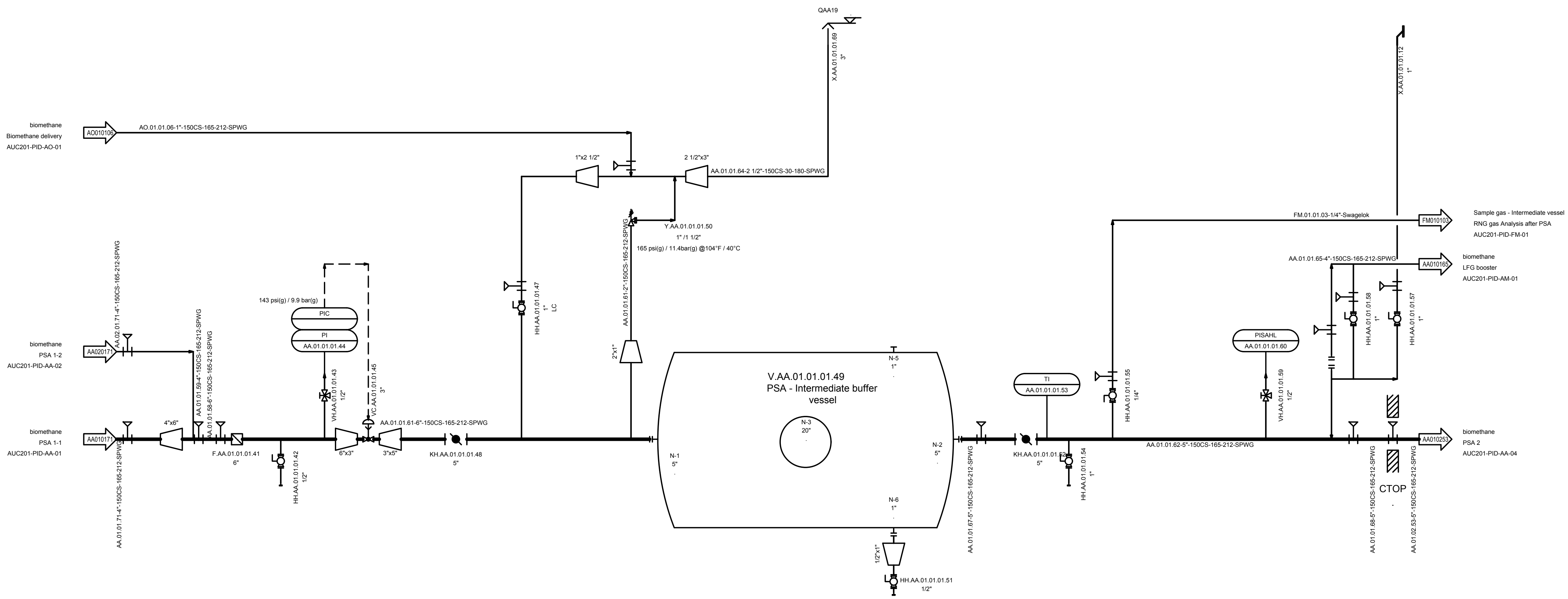
Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID PSA 1-2	PROJ. NO. AUC201				DATE: 2019-01-31
	DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----	SCALE:
PROJECT TITLE Dane County WI BUP2500I Dane County		2019-01-31	2019-01-31		PAGE NO. 10 / 72
	DRAWING NO: AUC201-PID-AA-02				



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

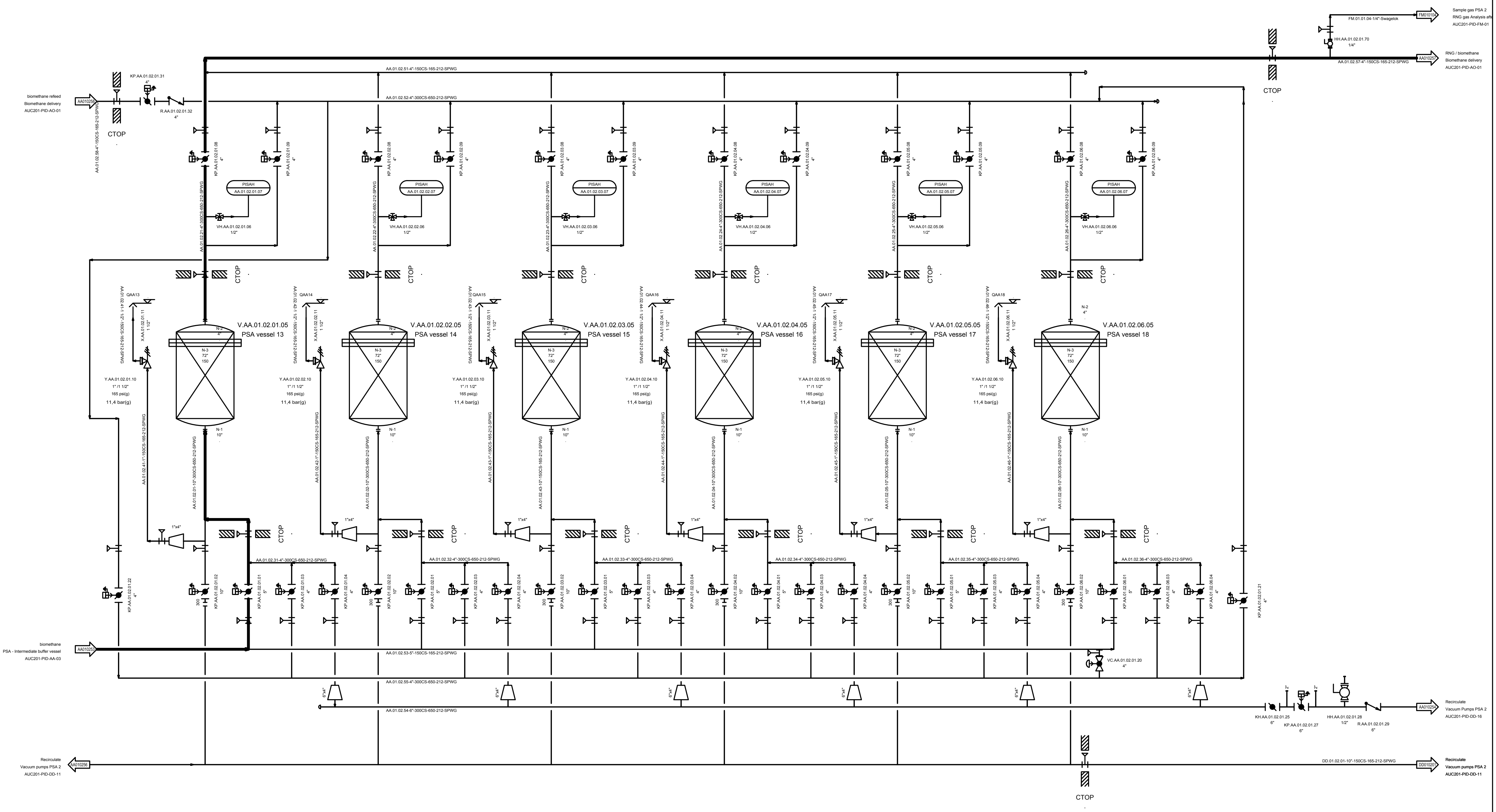
BIOFERM™ ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

COUNTY of DANE · WISCONSIN · 1839

SHEET TITLE P&ID PSA - Intermediate buffer vessel	PROJ. NO. AUC201				DATE: 2019-01-31
	DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----	SCALE:
PROJECT TITLE Dane County WI BUP2500I Dane County		2019-01-31	2019-01-31		PAGE NO.
	DRAWING NO: AUC201-PID-AA-03				11 / 72



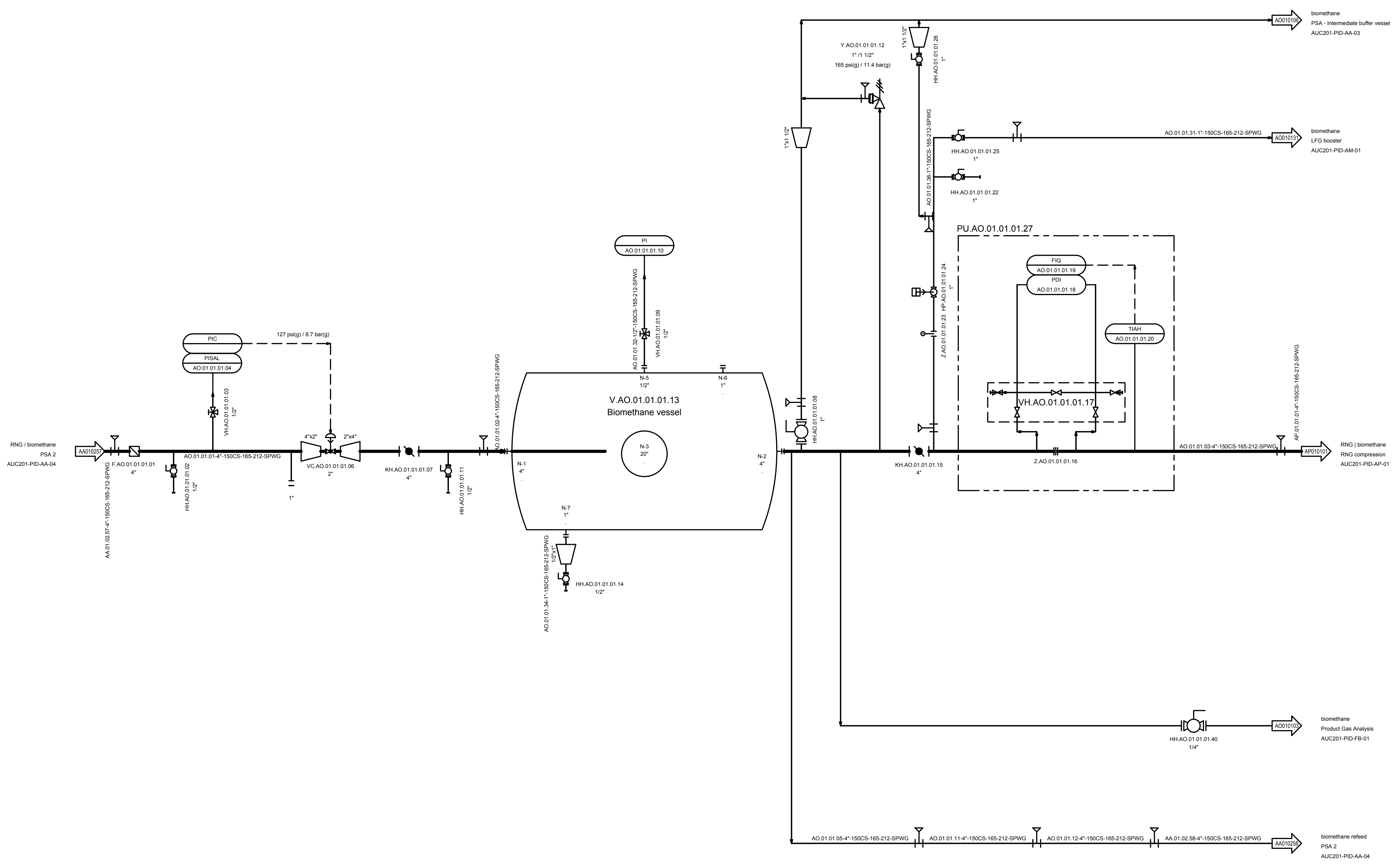
Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID PSA 2	PROJ. NO. AUC201	DATE: 2019-01-31	SCALE:
PROJECT TITLE Dane County WI BUP2500I Dane County	DSN. BY: / DWN. BY: SctP 2019-01-31 / CHK. BY: ZimT 2019-01-31 / APP. BY: ----		PAGE NO.
	DRAWING NO: AUC201-PID-AA-04		12 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

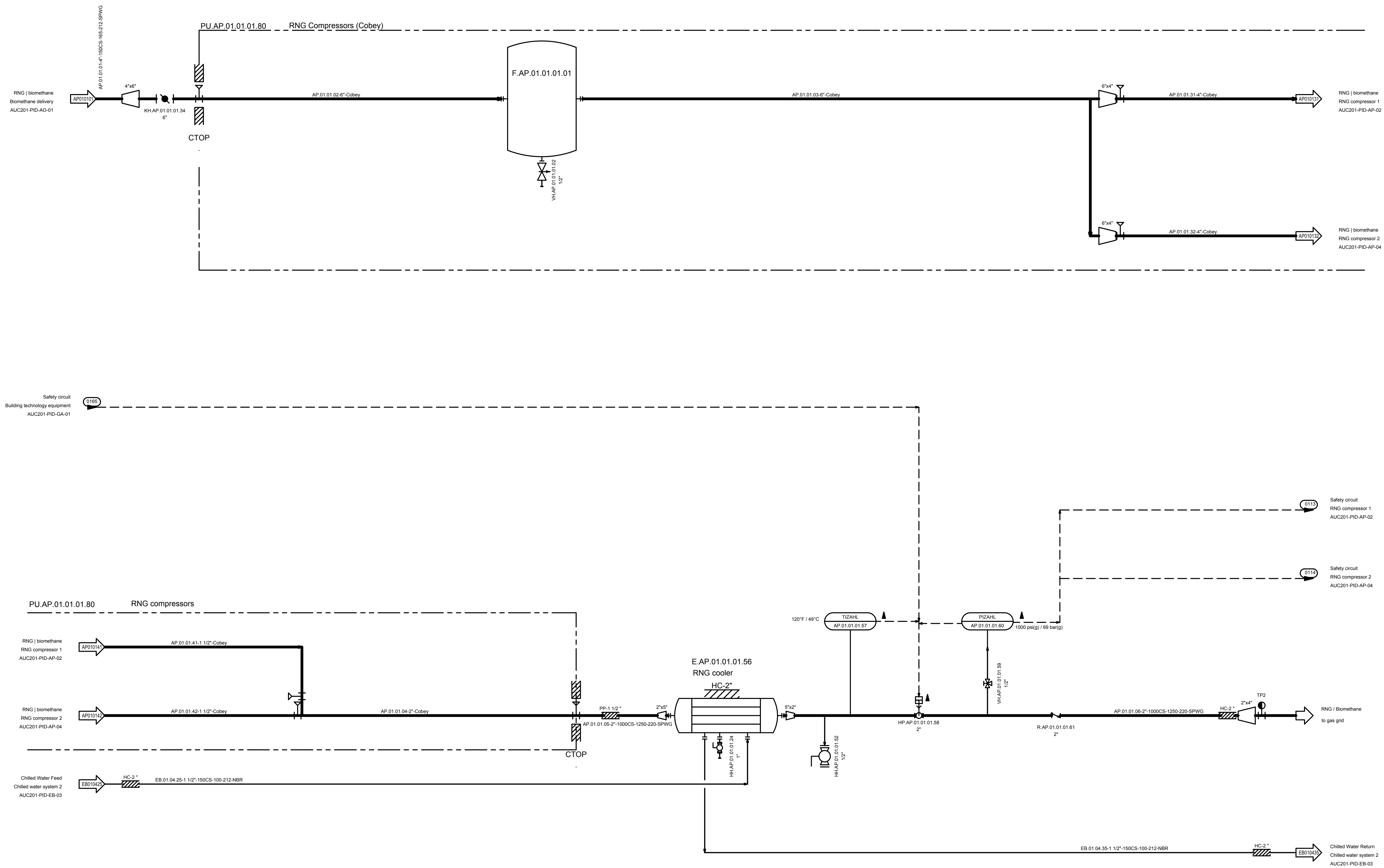
N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFERM™ ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID Biomethane delivery	PROJ. NO.: AUC201		DATE: 2019-01-31
	DSN. BY:	DWN. BY: SctP 2019-01-31 / CHK. BY: ZimT 2019-01-31 / APP. BY: ----	SCALE:
PROJECT TITLE: Dane County WI BUP2500I Dane County	DRAWING NO.: AUC201-PID-AO-01		PAGE NO.: 13 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID
RNG compression
Manifolds

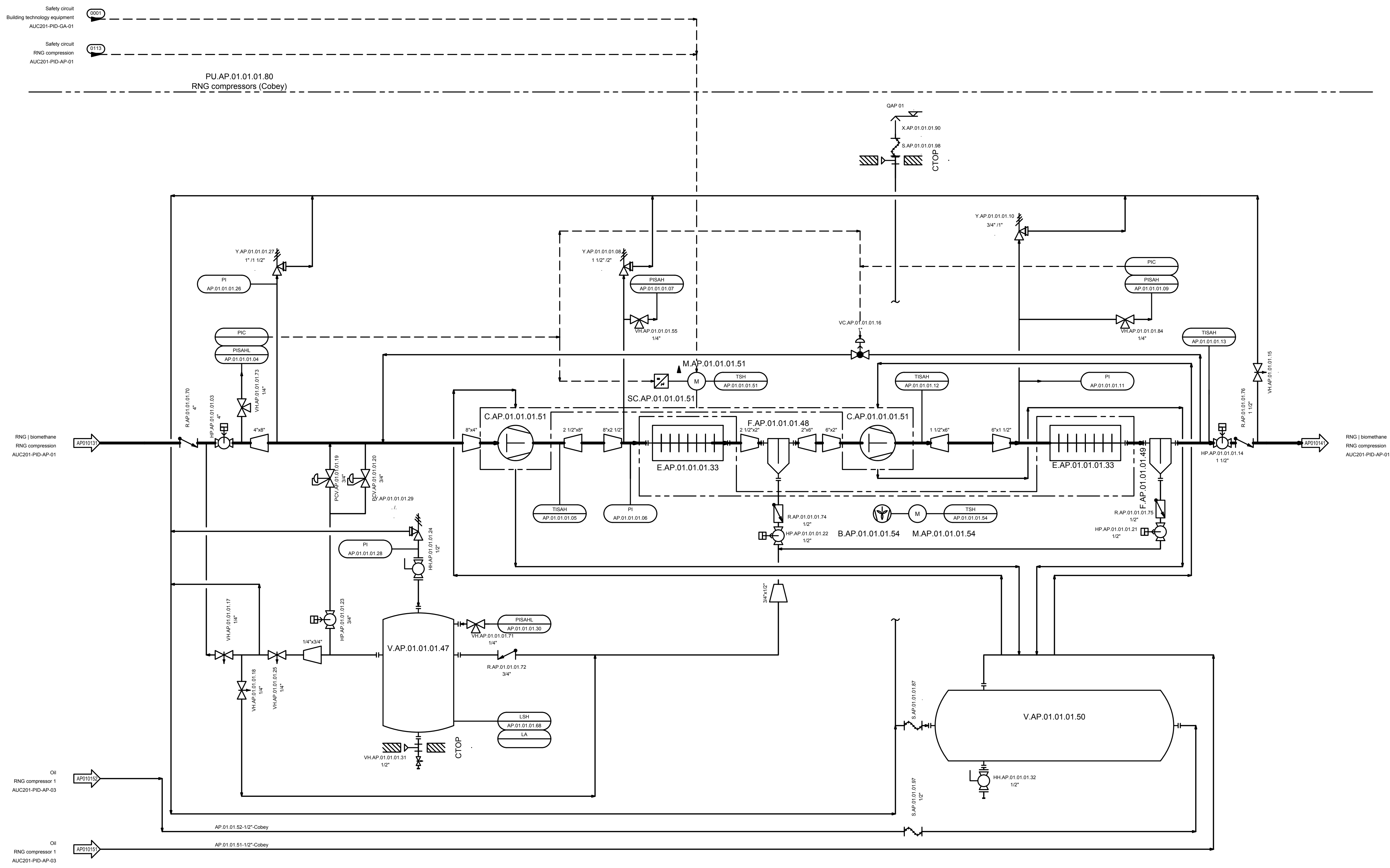
PROJECT TITLE
Dane County WI BUP2500I
Dane County

PROJ. NO. AUC201

DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----
	2019-01-31	2019-01-31	

DRAWING NO: AUC201-PID-AP-01

DATE: 2019-01-31
SCALE:



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

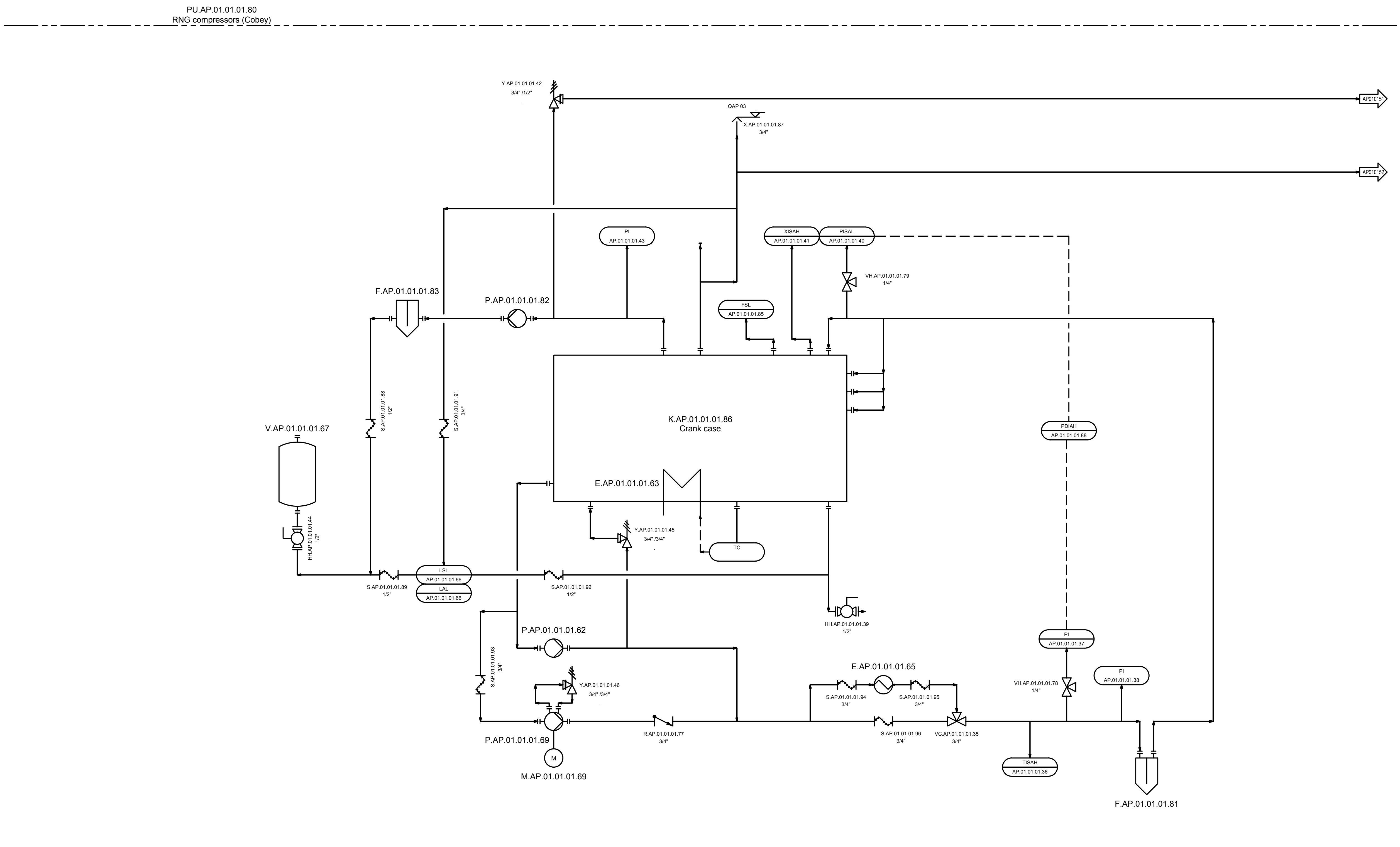
SHEET TITLE: P&ID
RNG compressor 1
Gas path

PROJECT TITLE: Dane County WI BUP2500I
Dane County

PROJ. NO.	AUC201			
DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----	
	2019-01-31	2019-01-31		
DRAWING NO:	AUC201-PID-AP-02			

DATE: 2019-01-31

SCALE:



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

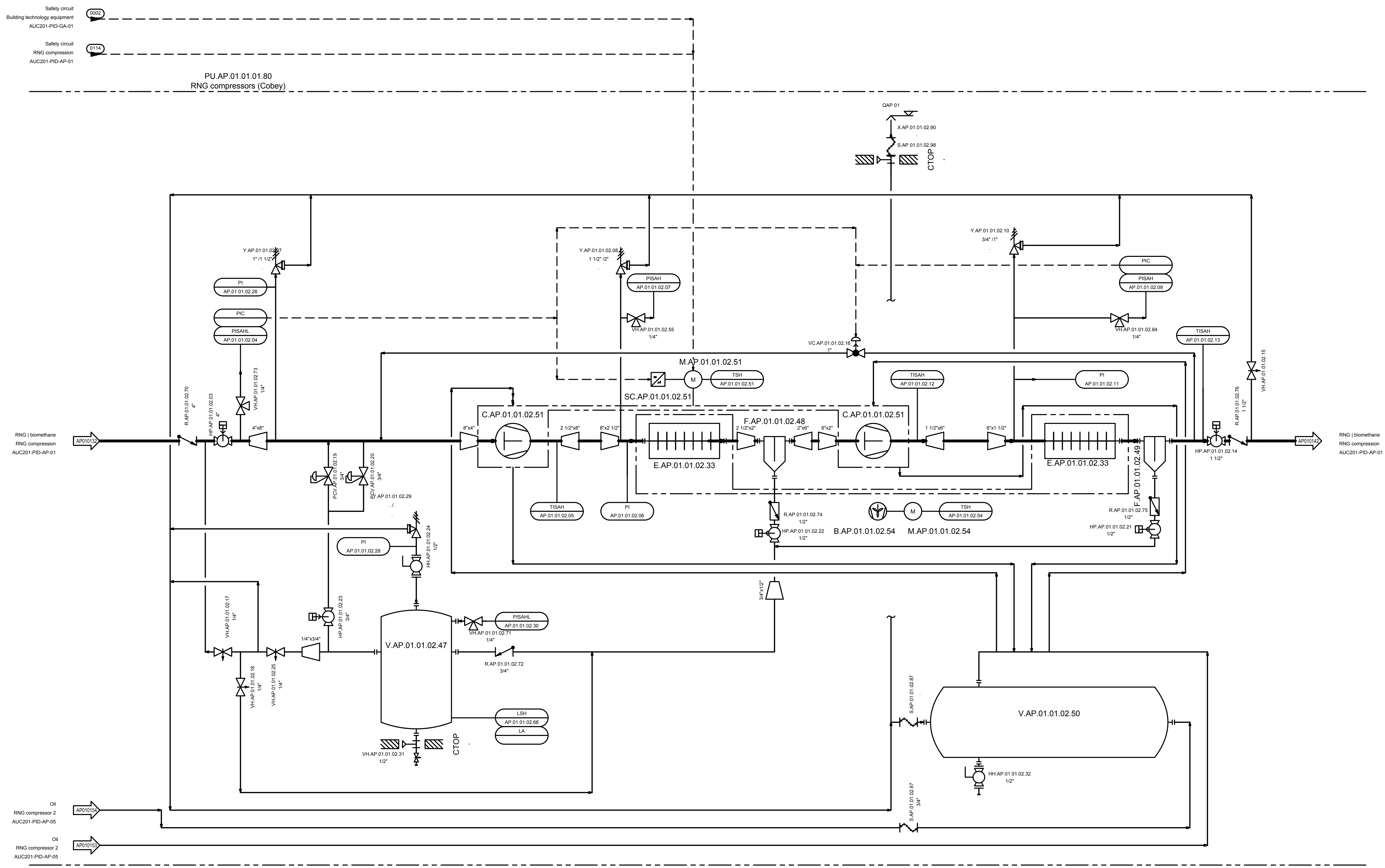
SHEET TITLE: P&ID
RNG compressor 1
Oil circuit

PROJECT TITLE: Dane County WI BUP2500I
Dane County

PROJ. NO.	AUC201		
DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----
	2019-01-31	2019-01-31	
DRAWING NO:	AUC201-PID-AP-03		

DATE: 2019-01-31
SCALE:
PAGE NO. 16 / 72

K:\Projekte_P3D\Dane_County_AUC201_WI_BUP2500I\2Dc_P_and_I_Drawings\16_AUC201-PID-AP-03_RNG-compressor-1-oil-circuit.dwg



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID
RNG compressor 2
Gas path

PROJECT TITLE: Dane County WI BUP2500I
Dane County

PROJ. NO.: AUC201

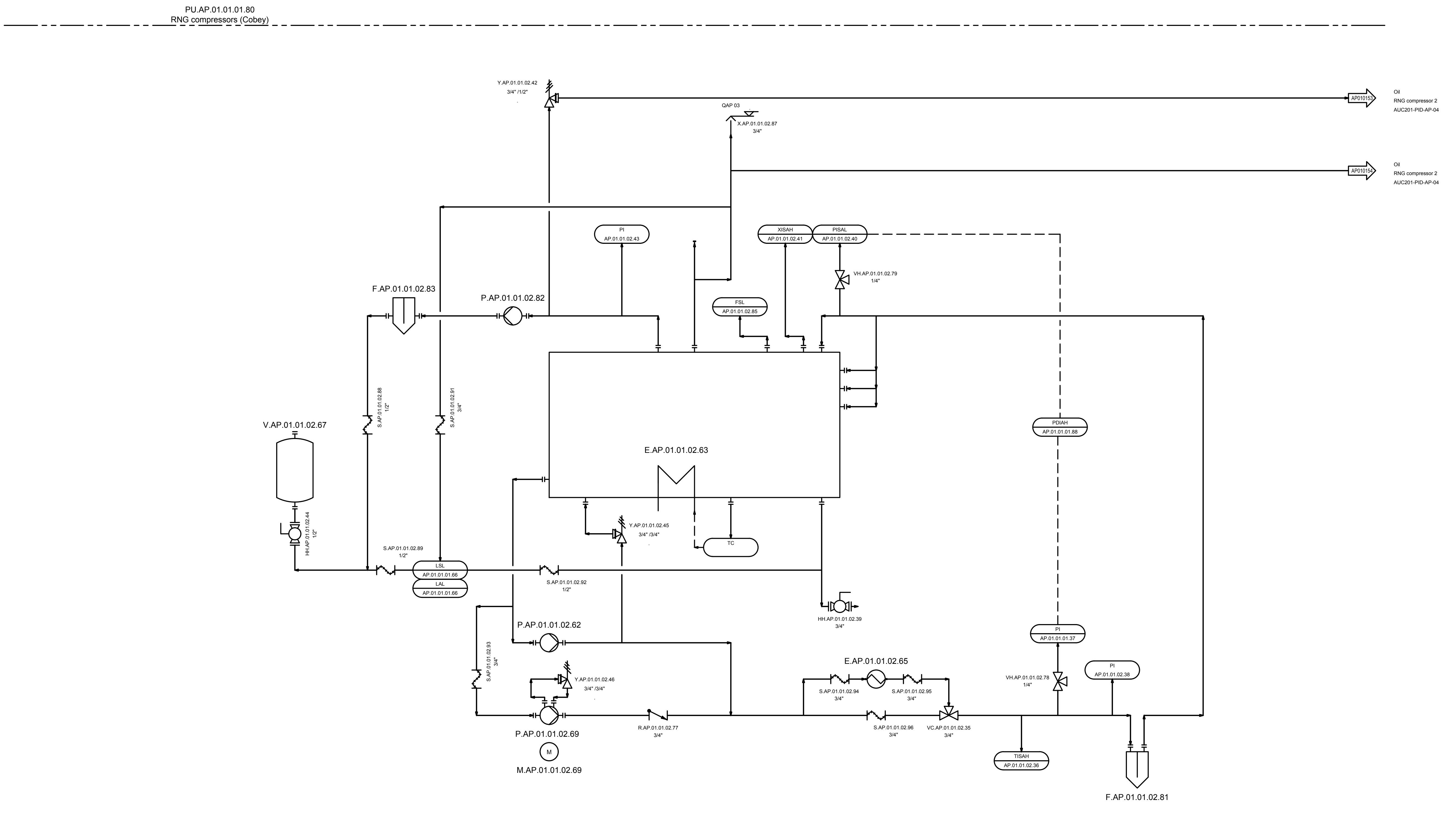
DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

DRAWING NO: AUC201-PID-AP-04

DATE: 2019-01-31

SCALE:

PAGE NO. 17 / 72



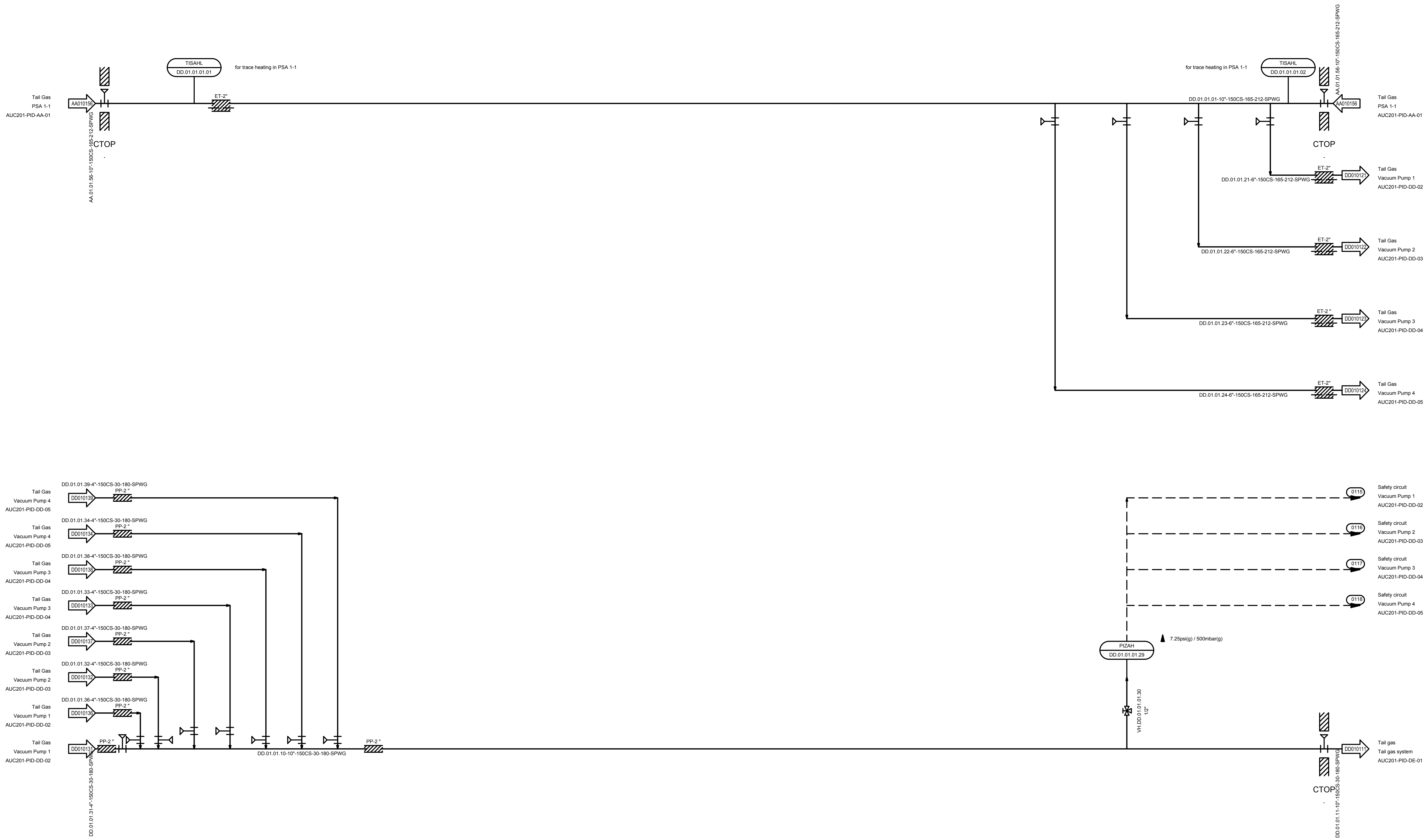
Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE	P&ID RNG compressor 2 Oil circuit
PROJECT TITLE	Dane County WI BUP2500I Dane County
PROJ. NO.	AUC201
DSN. BY:	
DWN. BY:	SctP 2019-01-31
CHK. BY:	ZimT 2019-01-31
APP. BY:	----
DRAWING NO:	AUC201-PID-AP-05
DATE:	2019-01-31
SCALE:	
PAGE NO.	18 / 72



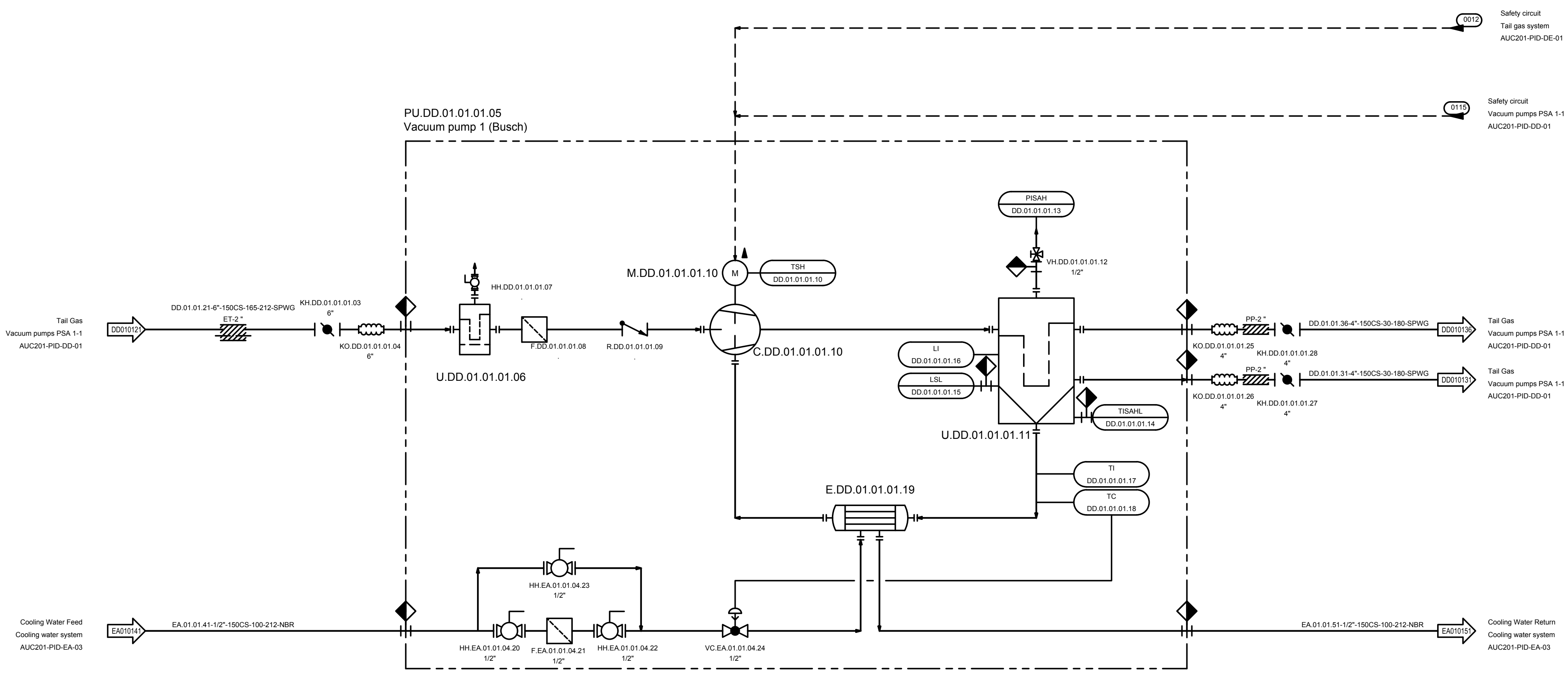
Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE	P&ID Vacuum pumps PSA 1-1 manifolds	PROJ. NO. AUC201			DATE: 2019-01-31
		DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----
			2019-01-31	2019-01-31	SCALE:
PROJECT TITLE	Dane County WI BUP2500I Dane County	DRAWING NO: AUC201-PID-DD-01			PAGE NO. 19 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFERM™ ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

COUNTY of DANE WISCONSIN 1839

SHEET TITLE P&ID
Vacuum Pump 1

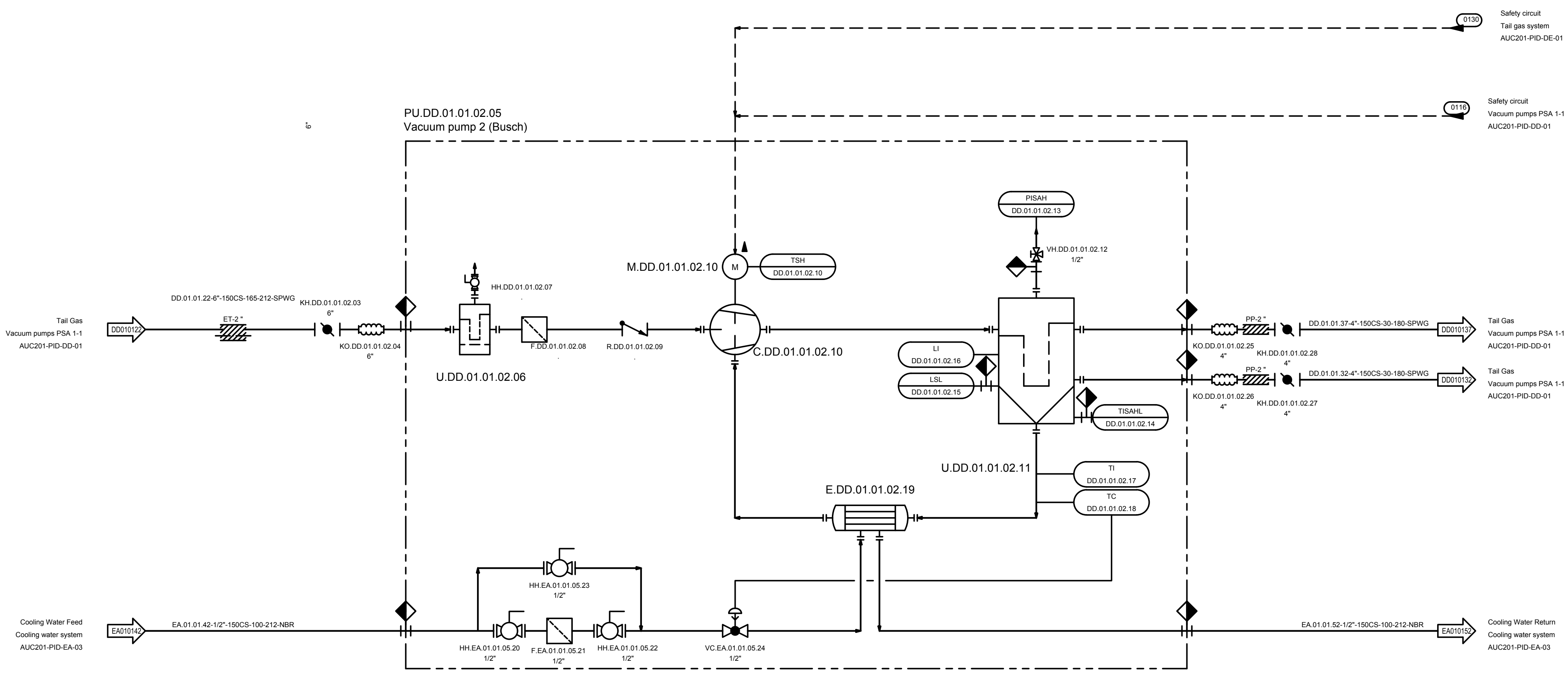
PROJECT TITLE
Dane County WI BUP2500I
Dane County

PROJ. NO. AUC201

DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

DRAWING NO: AUC201-PID-DD-02

DATE: 2019-01-31
SCALE:



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

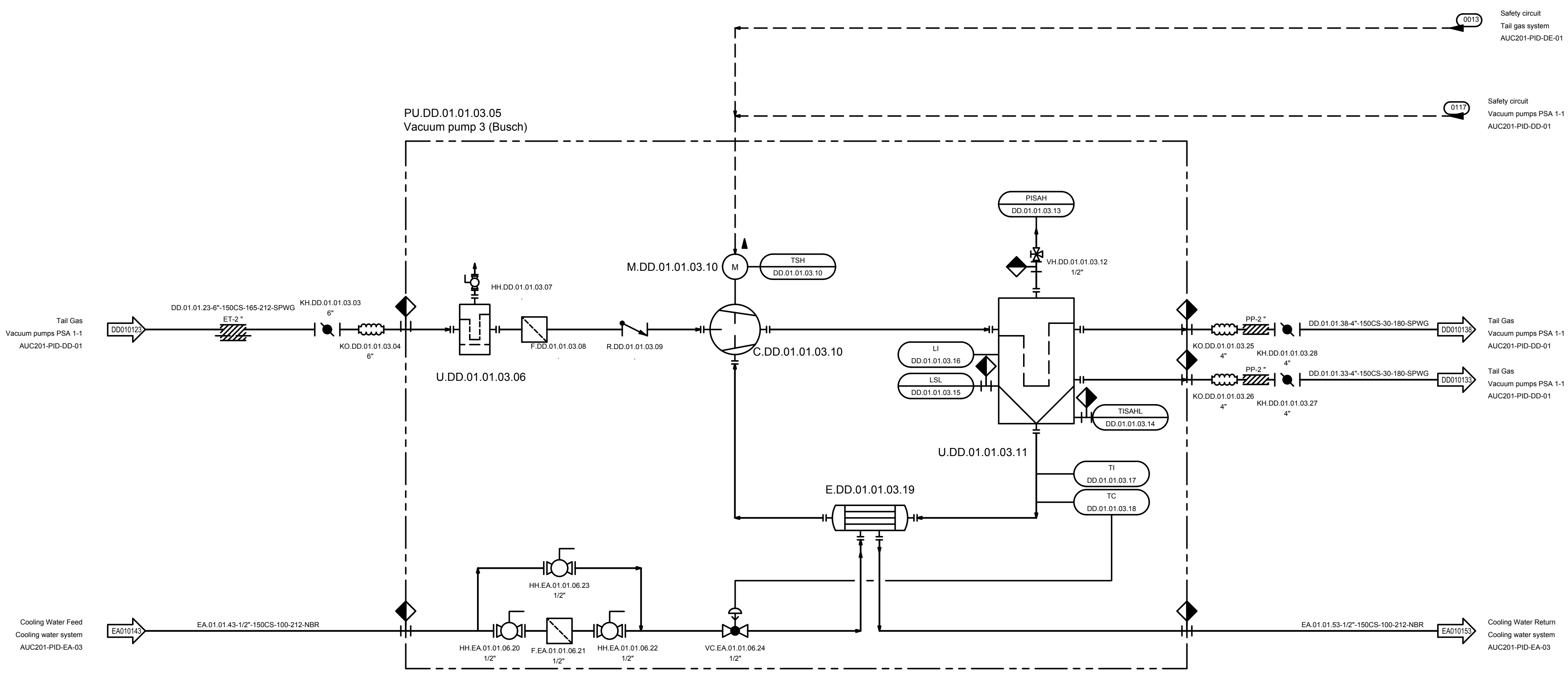
N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFERM ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID Vacuum Pump 2	PROJ. NO. AUC201				DATE: 2019-01-31
	DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----	SCALE:
PROJECT TITLE Dane County WI BUP2500I Dane County		2019-01-31	2019-01-31		
	DRAWING NO: AUC201-PID-DD-03				PAGE NO. 21 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

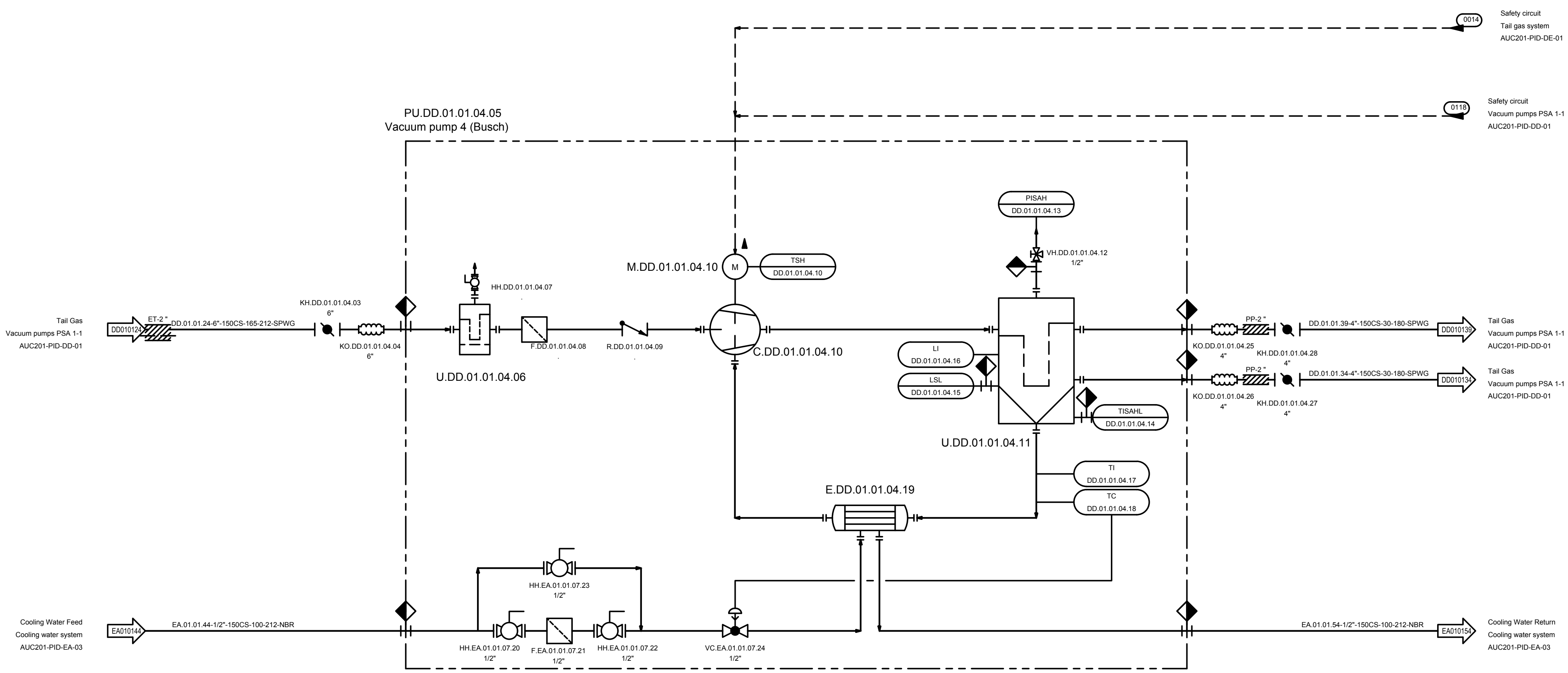
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID Vacuum Pump 3

PROJECT TITLE Dane County WI BUP2500I Dane County

PROJ. NO.				DATE: 2019-01-31
AUC201				SCALE:
DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----	PAGE NO.
	2019-01-31	2019-01-31		22 / 72
DRAWING NO: AUC201-PID-DD-04				



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

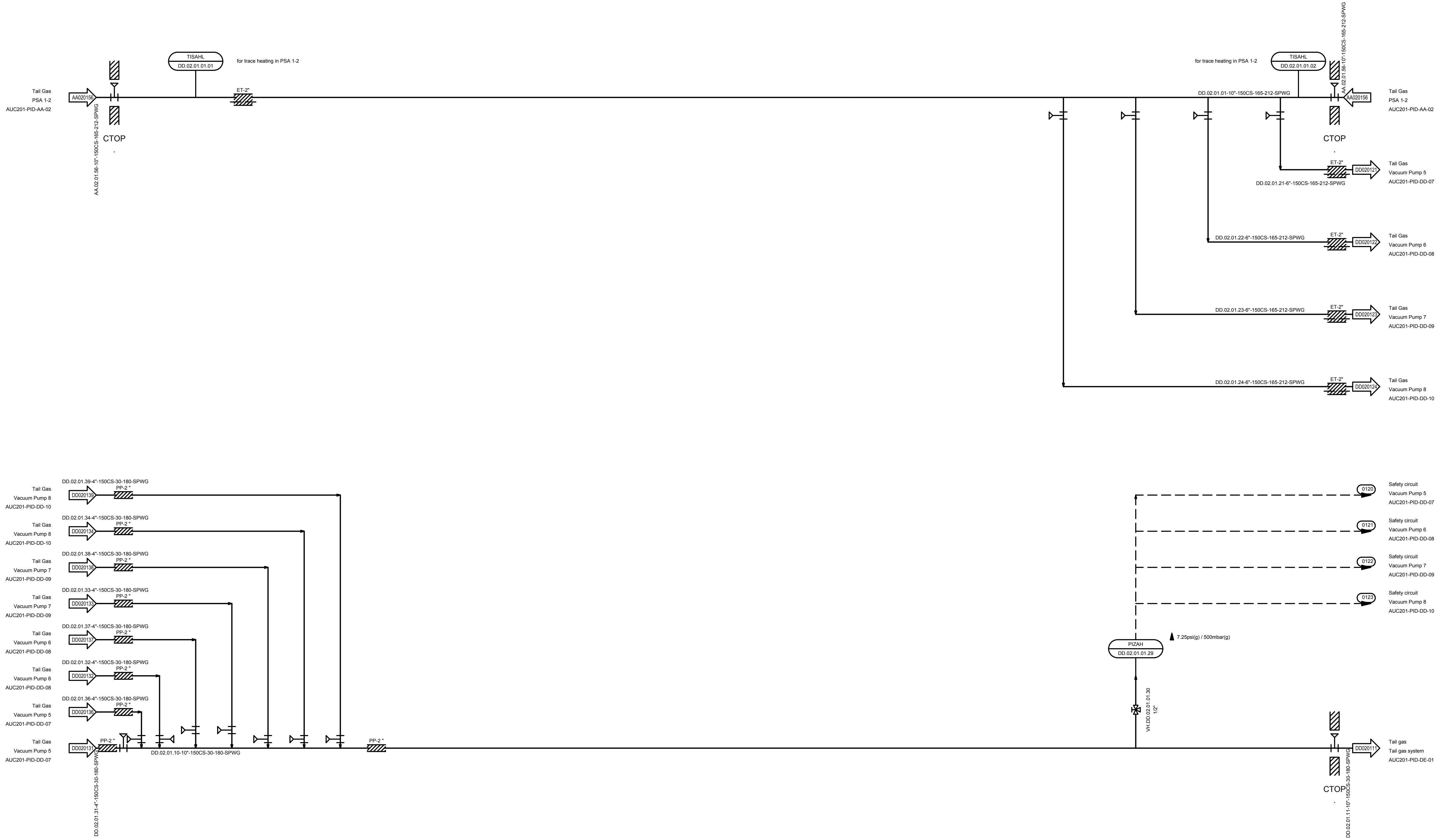
BIOFERM™ ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

COUNTY of DANE WISCONSIN 1839

SHEET TITLE P&ID Vacuum Pump 4	PROJ. NO. AUC201				DATE: 2019-01-31
	DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----	SCALE:
PROJECT TITLE Dane County WI BUP2500I Dane County		2019-01-31	2019-01-31		PAGE NO.
	DRAWING NO: AUC201-PID-DD-05				23 / 72



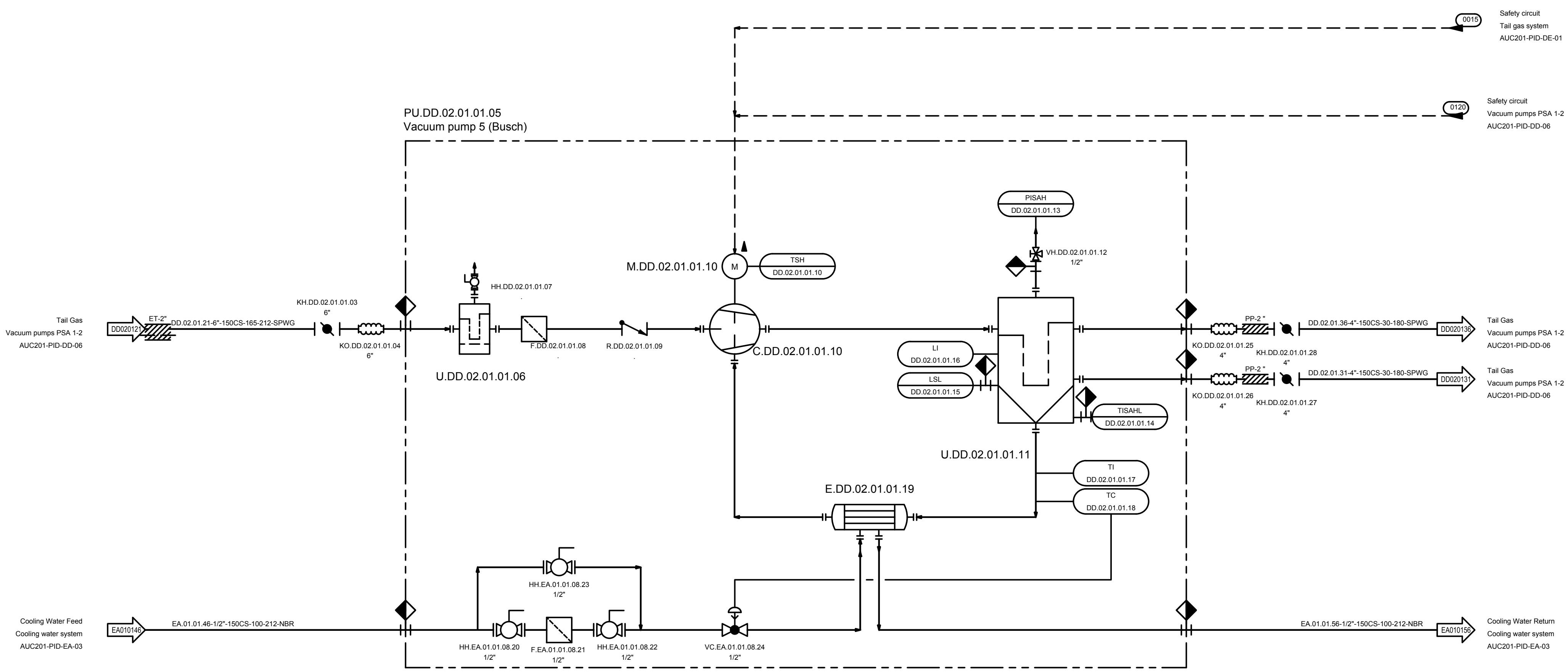
Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

NO.	REVISION	DATE
	first Draft	11/22/17
	change from 4 to 6 vessels	03/14/18
	generally revised	04/23/18
	Revision 3	12/01/18
	Issue for construction / IFC	01/31/19
	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE	P&ID Vacuum pumps PSA 1-2 manifolds
PROJ. NO.	AUC201
DSN. BY:	
DWN. BY:	SctP 2019-01-31
CHK. BY:	ZimT 2019-01-31
APP. BY:	----
PROJECT TITLE	Dane County WI BUP2500I Dane County
DRAWING NO.	AUC201-PID-DD-06
DATE	2019-01-31
SCALE:	
PAGE NO.	24 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

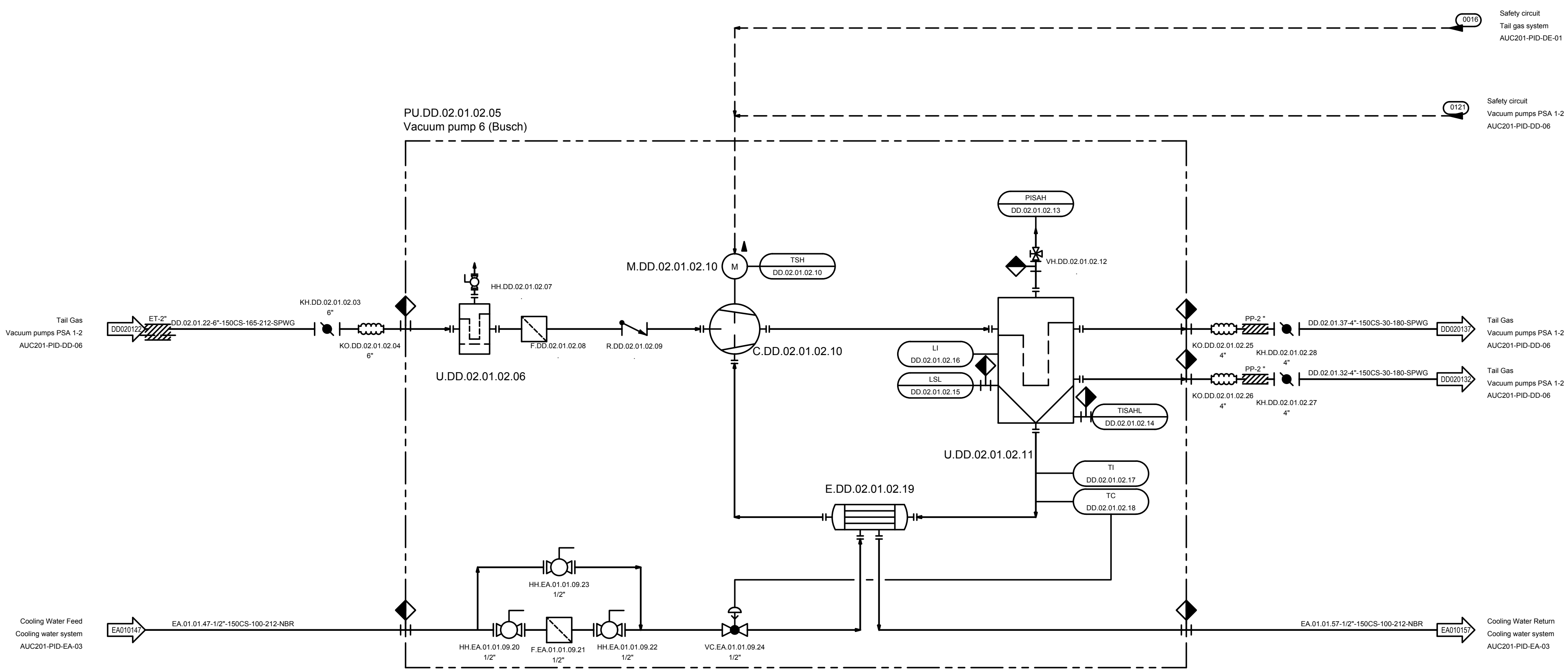
N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFERM™ ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID Vacuum Pump 5	PROJ. NO. AUC201				DATE: 2019-01-31
	DSN. BY:	DWN. BY: SctP 2019-01-31	CHK. BY: ZimT 2019-01-31	APP. BY: ----	SCALE:
PROJECT TITLE: Dane County WI BUP2500I Dane County	DRAWING NO: AUC201-PID-DD-07				PAGE NO. 25 / 72



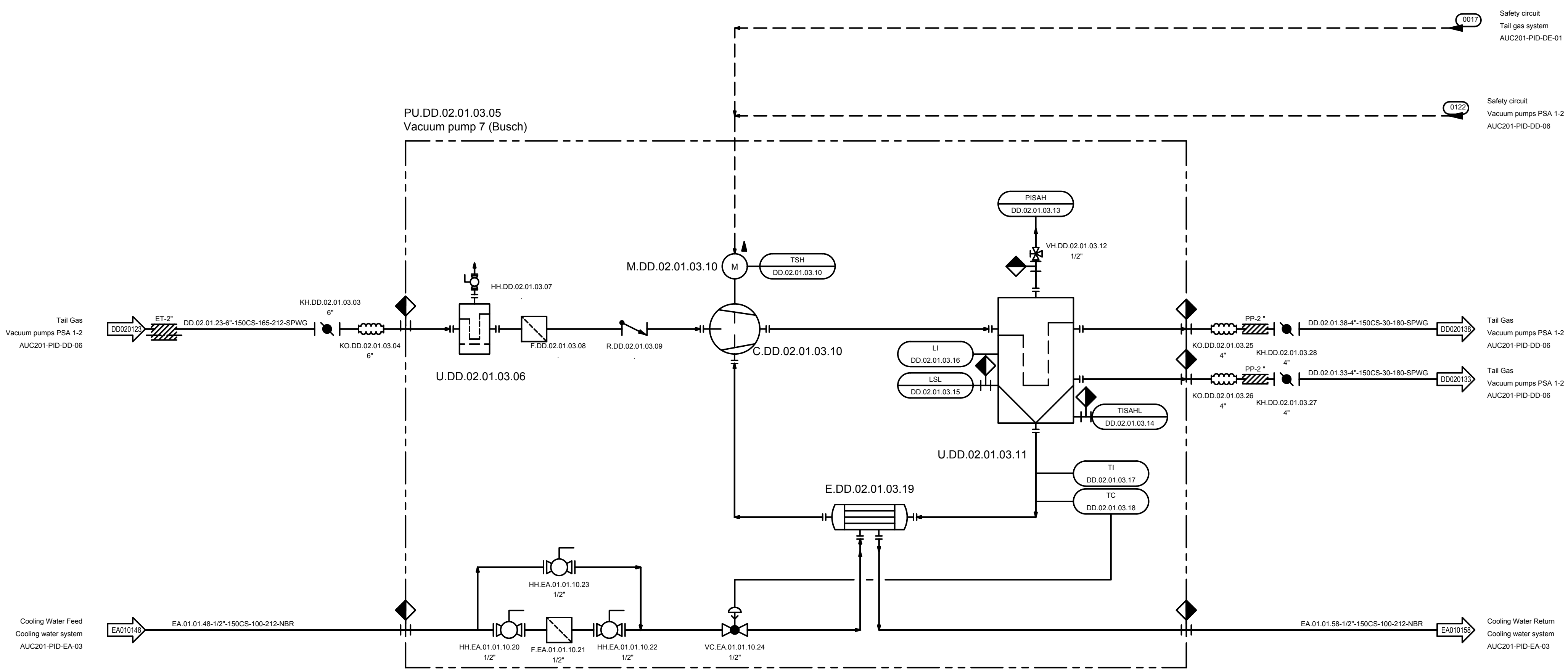
Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID Vacuum Pump 6	PROJ. NO. AUC201				DATE 2019-01-31
	DSN. BY:	DWN. BY: SctP 2019-01-31	CHK. BY: ZimT 2019-01-31	APP. BY: ----	SCALE:
PROJECT TITLE Dane County WI BUP2500I Dane County	DRAWING NO: AUC201-PID-DD-08				PAGE NO. 26 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFERM™ ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

COUNTY of DANE · WISCONSIN

SHEET TITLE P&ID
Vacuum Pump 7

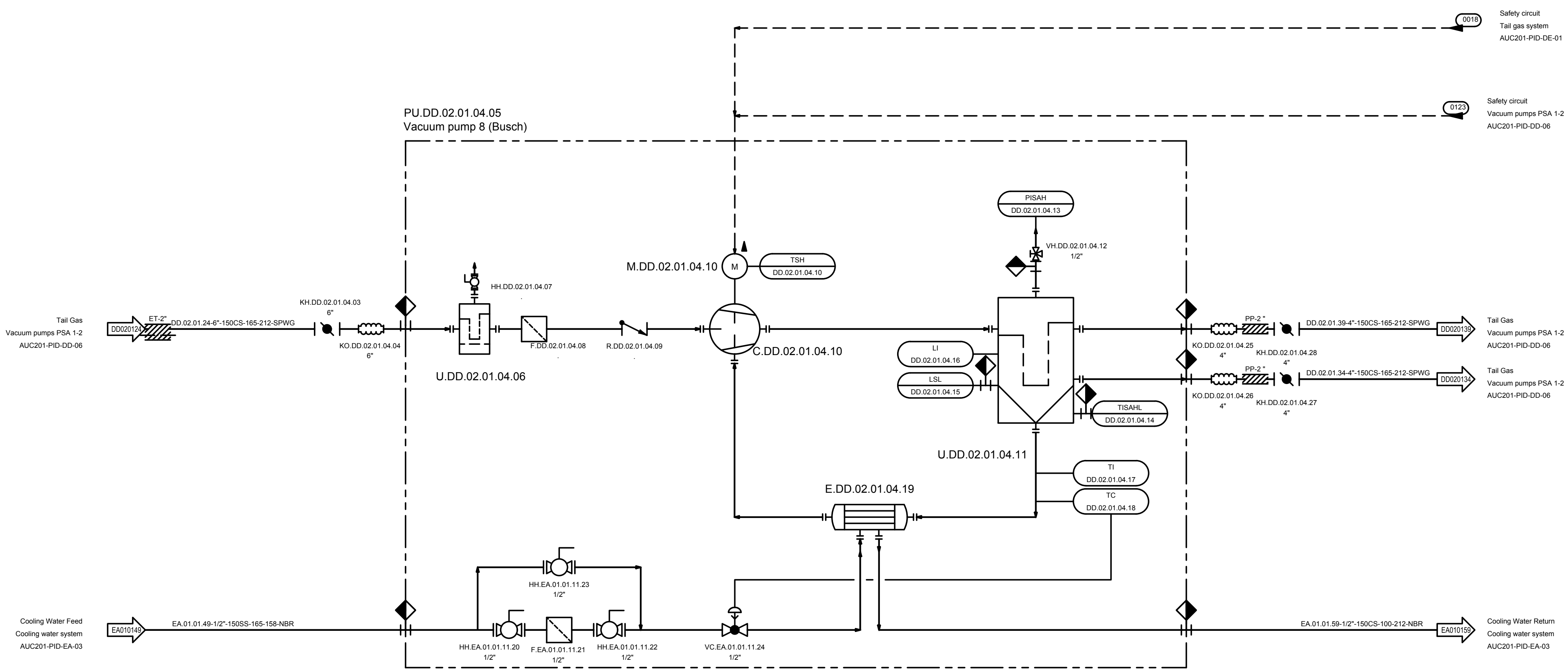
PROJ. NO. AUC201

DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

PROJECT TITLE
Dane County WI BUP2500I
Dane County

DRAWING NO: AUC201-PID-DD-09

DATE: 2019-01-31
SCALE:
PAGE NO.



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

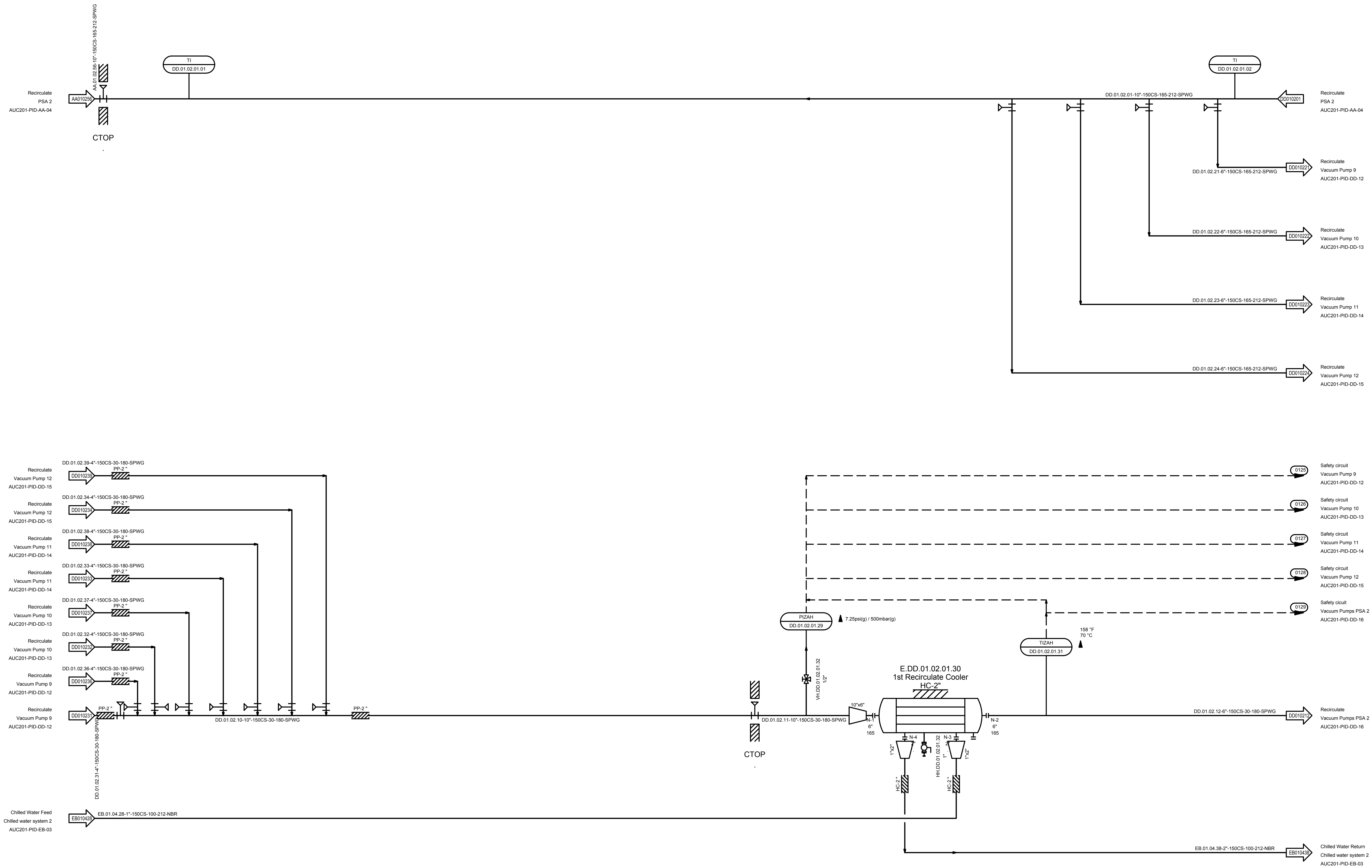
Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID
Vacuum Pump 8

PROJECT TITLE
Dane County WI BUP2500I
Dane County

PROJ. NO.	AUC201		
DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----
	2019-01-31	2019-01-31	
DRAWING NO:	AUC201-PID-DD-10		

DATE: 2019-01-31
SCALE:
PAGE NO.



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFERM™ ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

COUNTY of DANE WISCONSIN 1839

SHEET TITLE: P&ID
Vacuum pumps PSA 2
manifolds

PROJECT TITLE: Dane County WI BUP2500I
Dane County

PROJ. NO.: AUC201

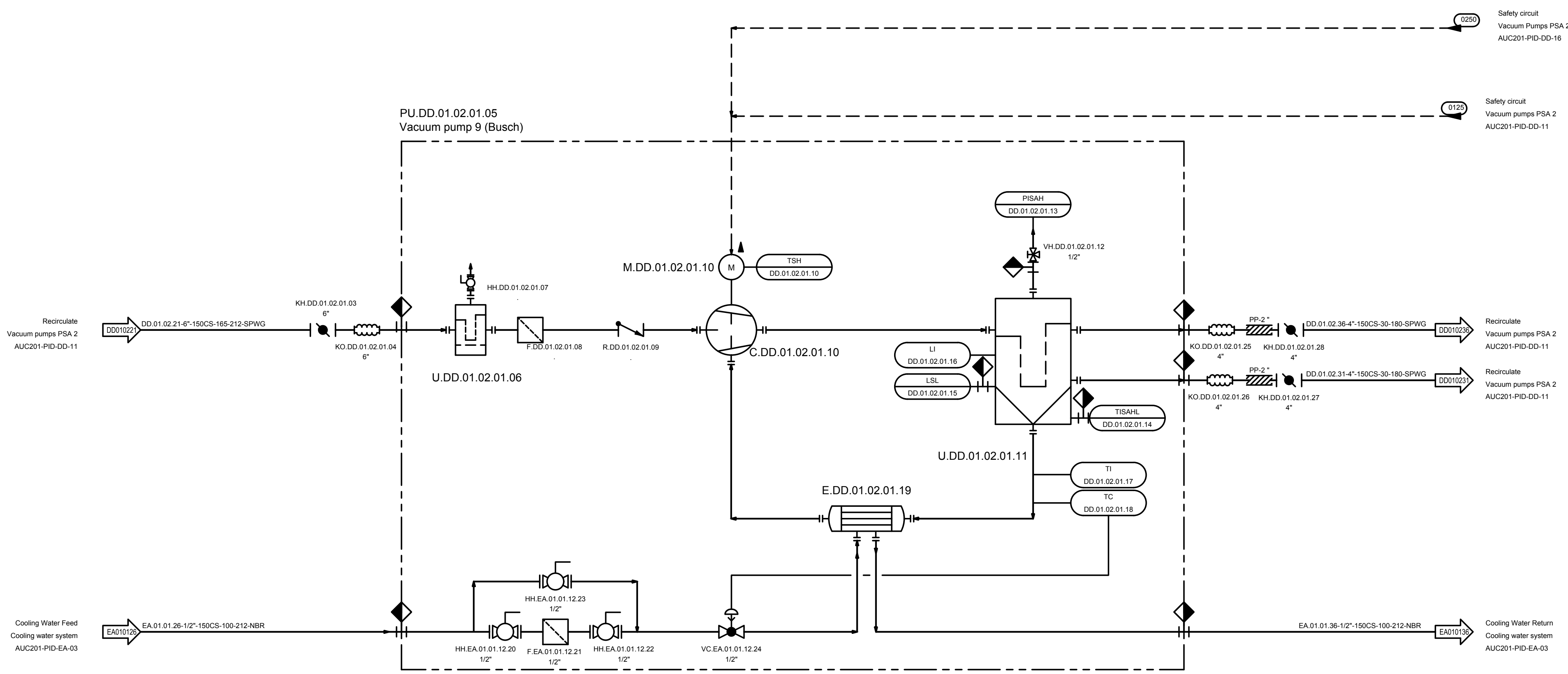
DSN. BY:	DWN. BY:	CHK. BY:	APP. BY:
	SctP	ZimT	----
	2019-01-31	2019-01-31	

DRAWING NO.: AUC201-PID-DD-11

DATE: 2019-01-31

SCALE:

PAGE NO.: 29 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFERM™ ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID Vacuum Pump 9

PROJ. NO.: AUC201

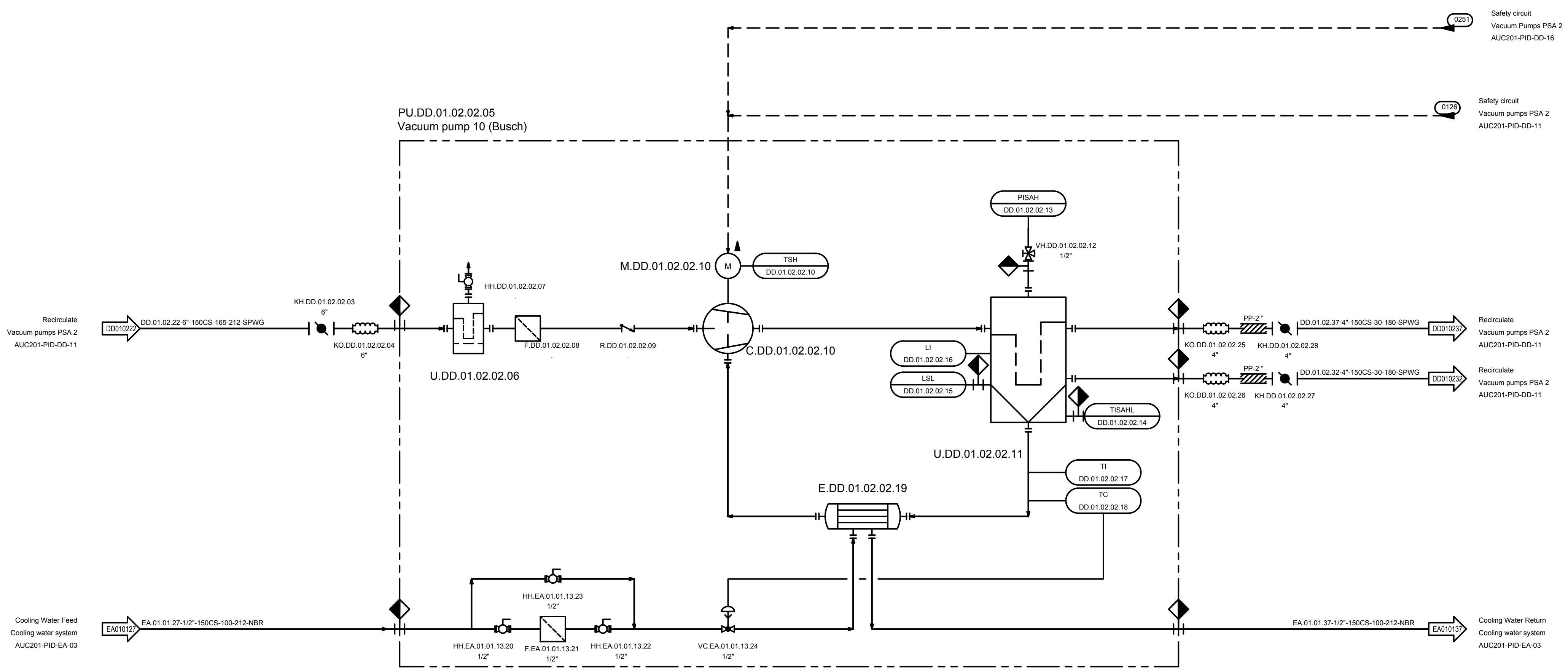
DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

PROJECT TITLE: Dane County WI BUP2500I Dane County

DRAWING NO: AUC201-PID-DD-12

DATE: 2019-01-31

SCALE:



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

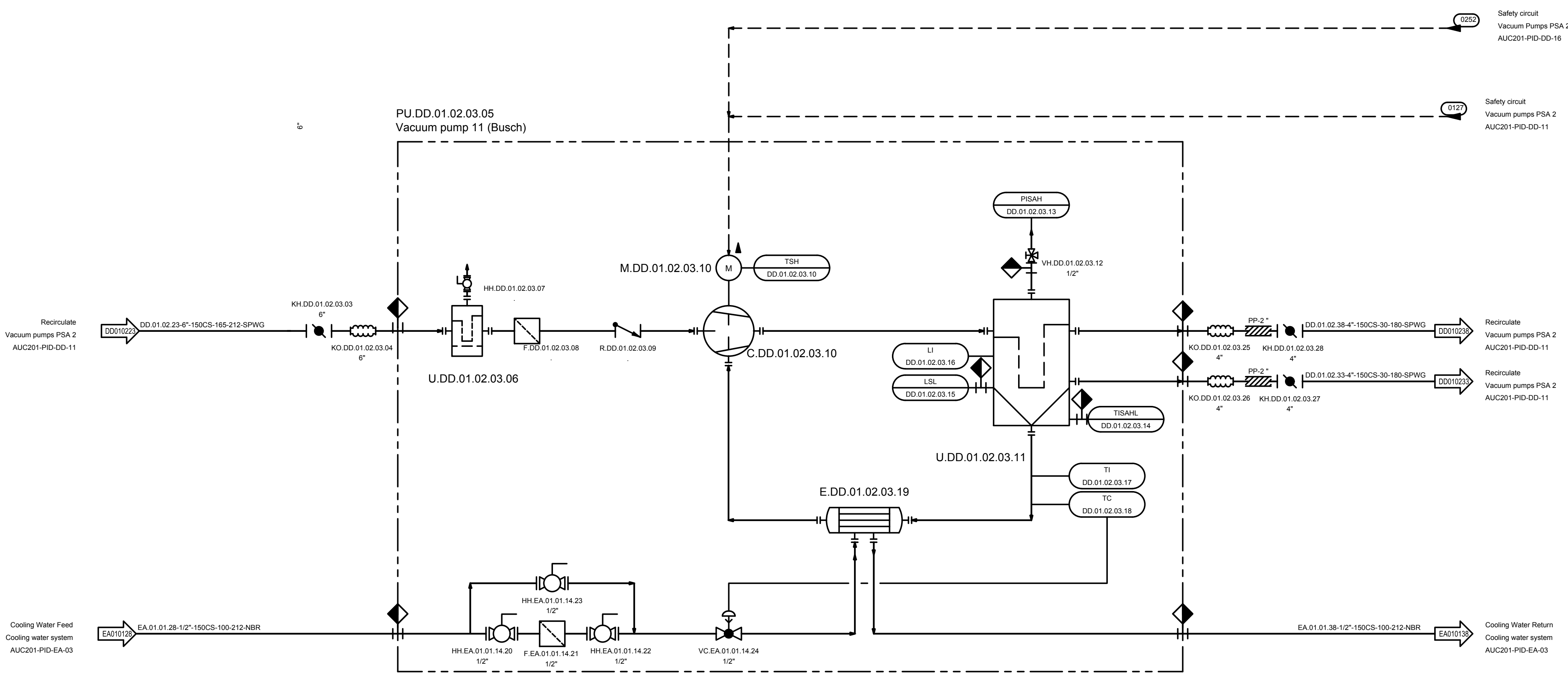
N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFERM ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID Vacuum Pump 10	PROJ. NO. AUC201				DATE: 2019-01-31
	DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----	SCALE:
PROJECT TITLE Dane County WI BUP2500I Dane County		2019-01-31	2019-01-31		PAGE NO.
	DRAWING NO: AUC201-PID-DD-13				31 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID Vacuum Pump 11

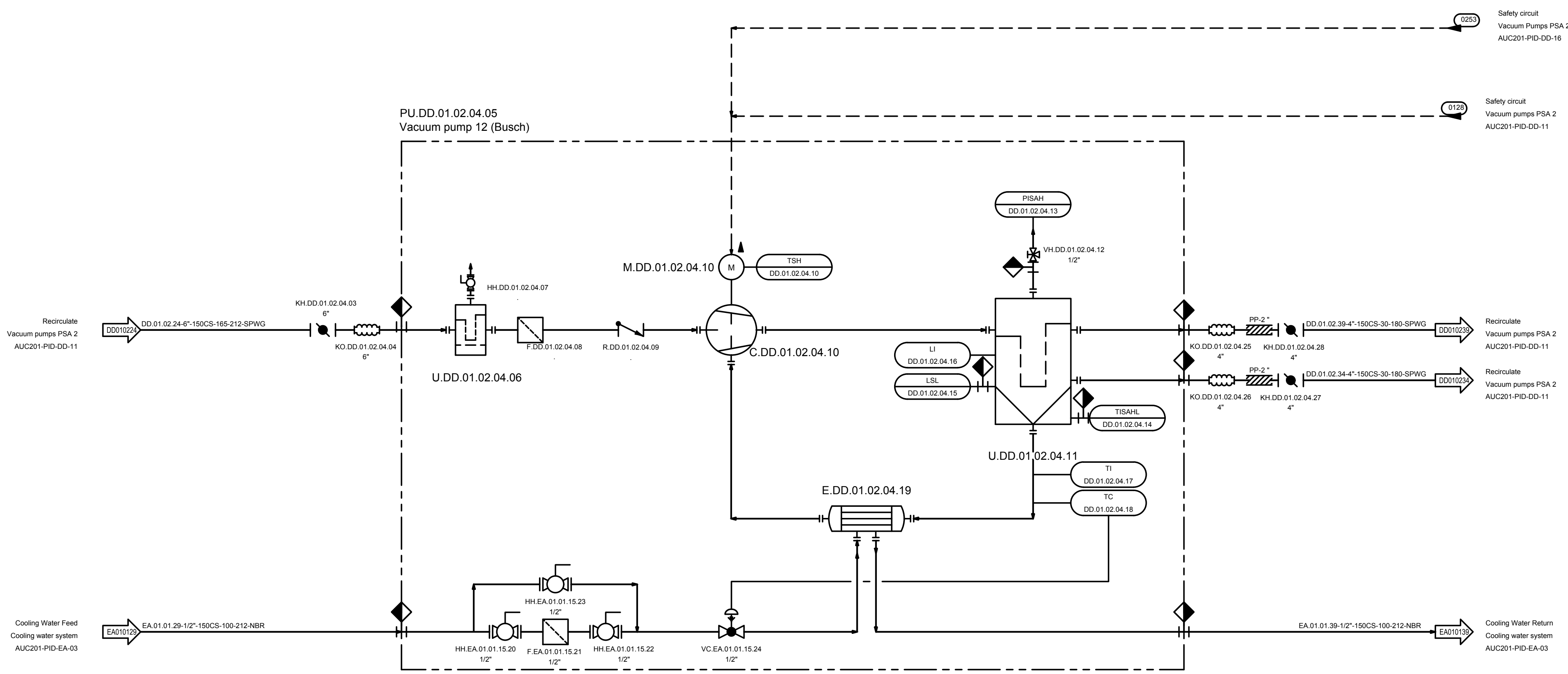
PROJECT TITLE: Dane County WI BUP2500I Dane County

PROJ. NO.	AUC201		
DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----
	2019-01-31	2019-01-31	

DRAWING NO: AUC201-PID-DD-14

DATE: 2019-01-31

SCALE:



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID
Vacuum Pump 12

PROJECT TITLE
Dane County WI BUP2500I
Dane County

PROJ. NO. AUC201

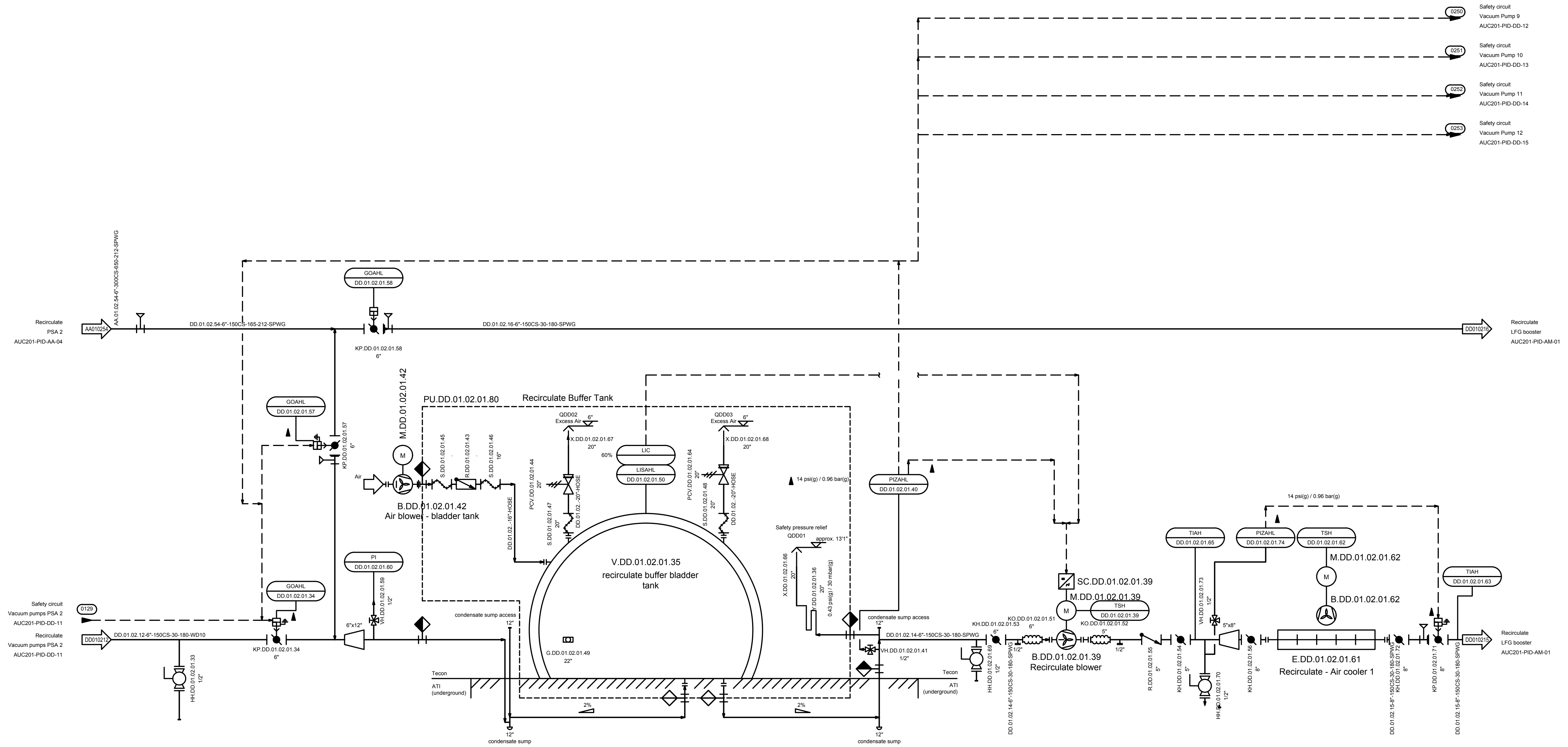
DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----
	2019-01-31	2019-01-31	

DRAWING NO: AUC201-PID-DD-15

DATE: 2019-01-31

SCALE:

PAGE NO. 33 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID
Vacuum Pumps PSA 2
Recirculate Buffer Bladder Tank

PROJECT TITLE
Dane County WI BUP2500I
Dane County

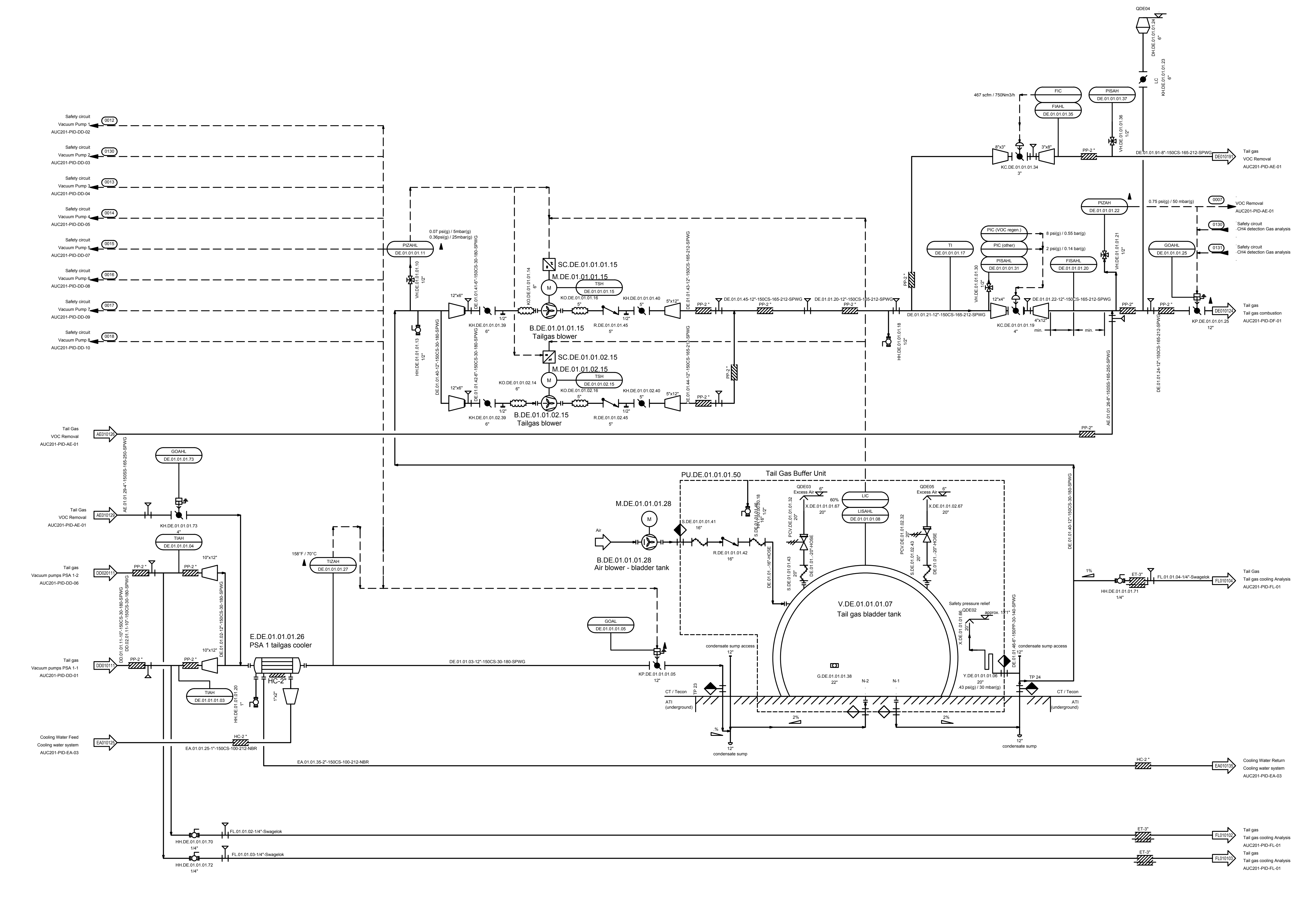
PROJ. NO. AUC201

DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----
	2019-01-31	2019-01-31	

DRAWING NO: AUC201-PID-DD-16

DATE: 2019-01-31

SCALE:



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

NO.	REVISION	DATE
	first Draft	11/22/17
	change from 4 to 6 vessels	03/14/18
	generally revised	04/23/18
	Revision 3	12/01/18
	Issue for construction / IFC	01/31/19
	— AS BUILT —	07/25/19

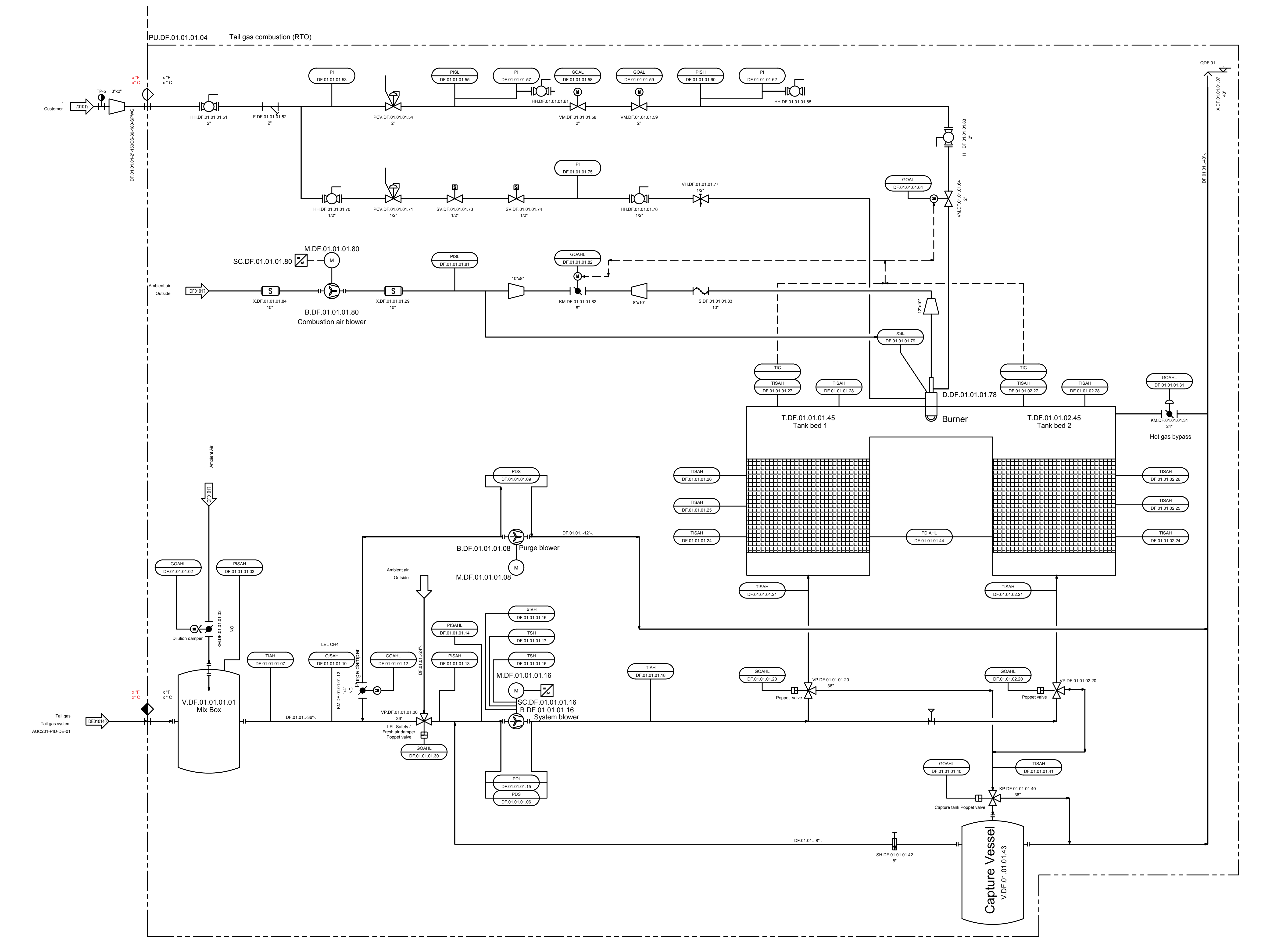
BIOFERM ENERGY SYSTEMS
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID
Tail gas system

PROJECT TITLE: Dane County WI BUP2500I
Dane County

PROJ. NO.: AUC201
DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----
DRAWING NO.: AUC201-PID-DE-01
DATE: 2019-01-31
SCALE:



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID
Tail gas combustion

PROJECT TITLE
Dane County WI BUP2500I
Dane County

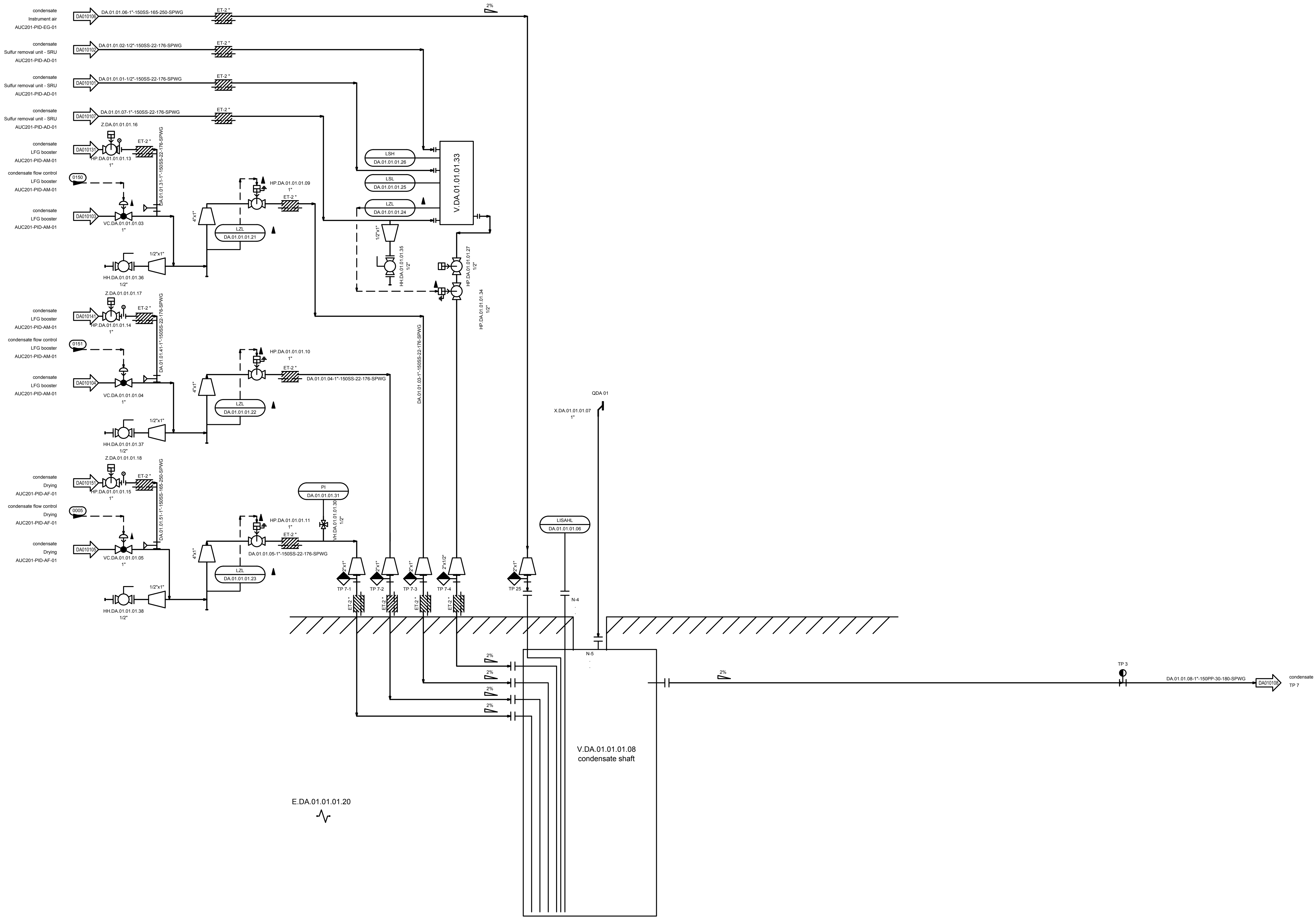
PROJ. NO. AUC201

DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

DRAWING NO. AUC201-PID-DF-01

DATE 2019-01-31

SCALE:



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID
Condensate System
####################

PROJECT TITLE: Dane County WI BUP2500I
Dane County

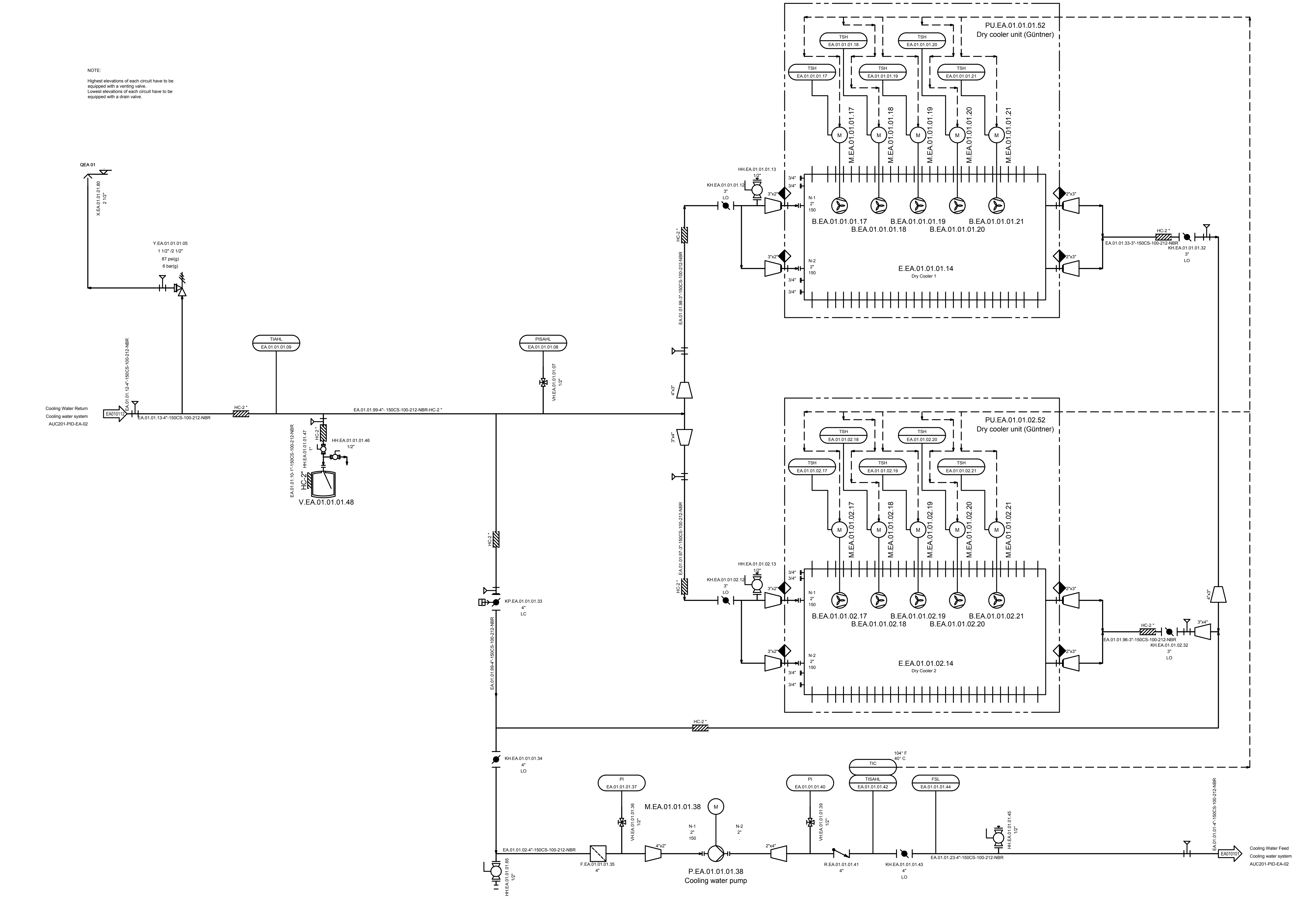
PROJ. NO. AUC201

DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----
	2019-01-31	2019-01-31	

DRAWING NO: AUC201-PID-DA-01

DATE: 2019-01-31
SCALE:
PAGE NO. 37 / 72

K:\Projekte_P3D\Dane_County_AUC201_WI_BUP2500I\2Dc_P_and_I_Drawings\37_AUC201-PID-DA-01_Condensate-system.dwg



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

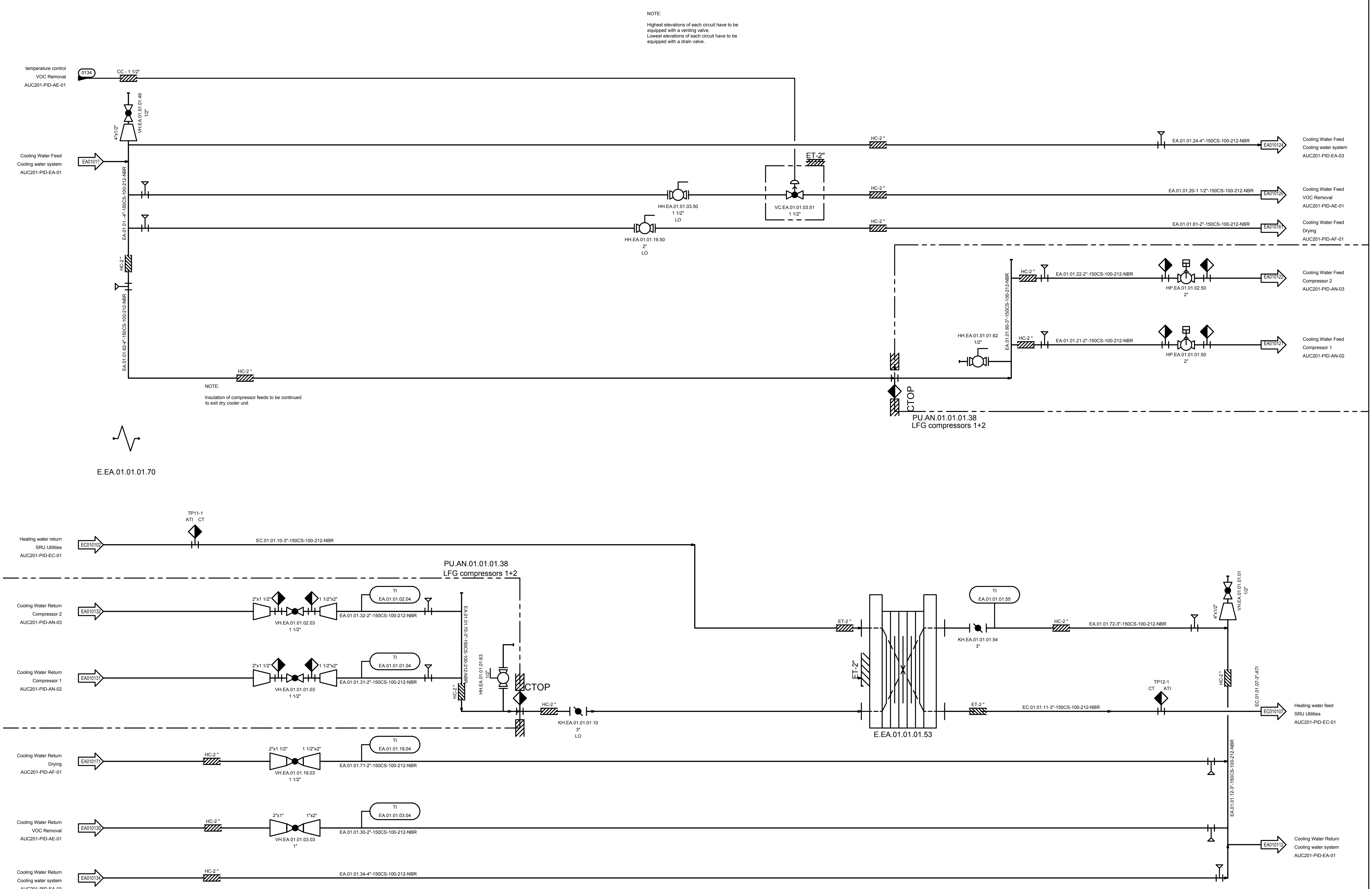
Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID
Cooling water system
Dry cooler

PROJECT TITLE
Dane County WI BUP2500I
Dane County

PROJ. NO. AUC201
DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----
DRAWING NO: AUC201-PID-EA-01

DATE: 2019-01-31
SCALE:
PAGE NO.



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID
Cooling water system
Distribution Compressors

PROJECT TITLE: Dane County WI BUP2500I
Dane County

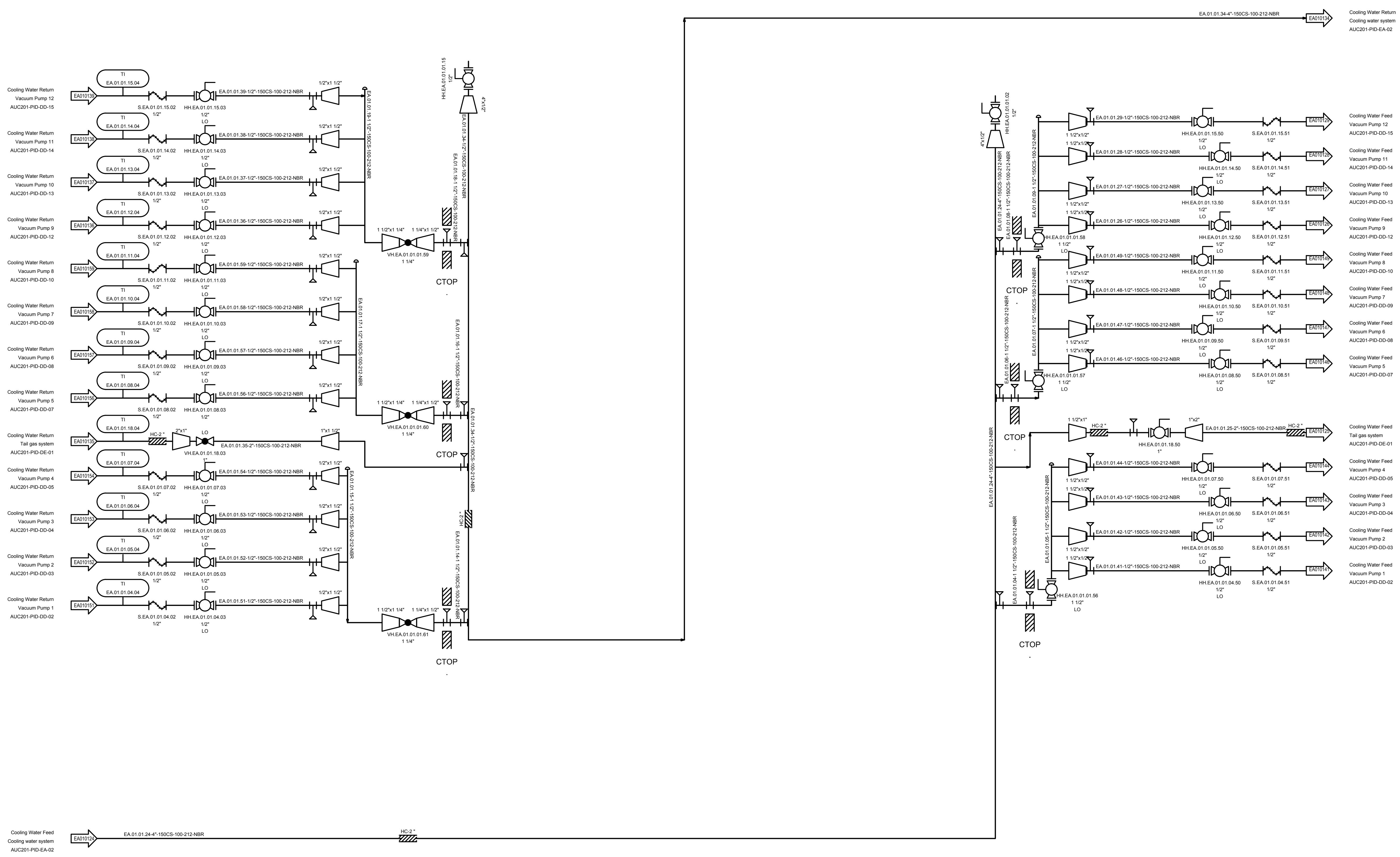
PROJ. NO. AUC201

DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----
	2019-01-31	2019-01-31	

DRAWING NO: AUC201-PID-EA-02

DATE: 2019-01-31

SCALE:



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

NO.	REVISION	DATE
	first Draft	11/22/17
	change from 4 to 6 vessels	03/14/18
	generally revised	04/23/18
	Revision 3	12/01/18
	Issue for construction / IFC	01/31/19
	— AS BUILT —	07/25/19

BIOFERM ENERGY SYSTEMS
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

COUNTY of DANE WISCONSIN

SHEET TITLE: P&ID
Cooling water system
Distribution Vacuum Pumps

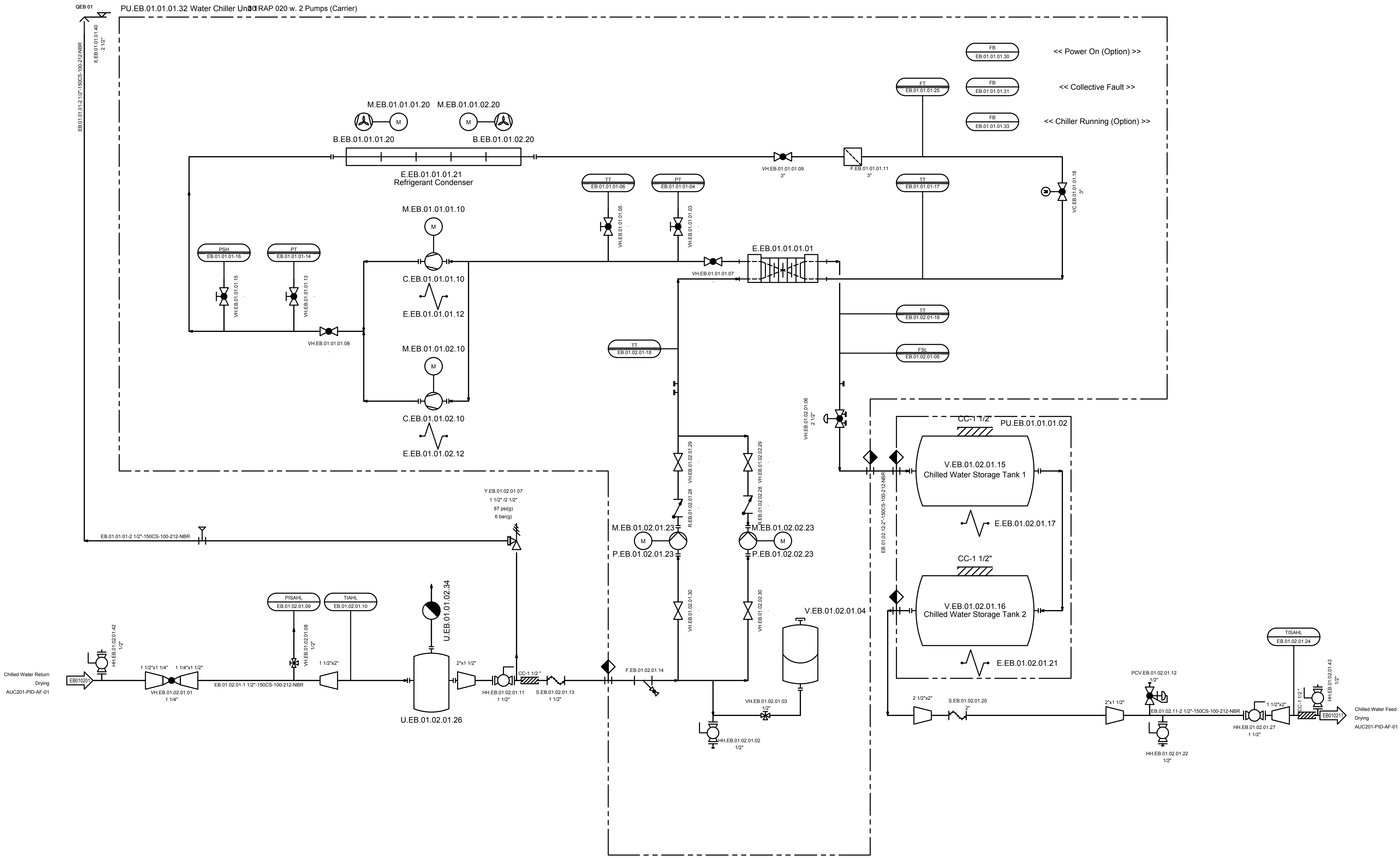
PROJ. NO.: AUC201

DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

PROJECT TITLE: Dane County WI BUP2500I
Dane County

DRAWING NO.: AUC201-PID-EA-03

DATE: 2019-01-31
SCALE:
PAGE NO.: 40 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

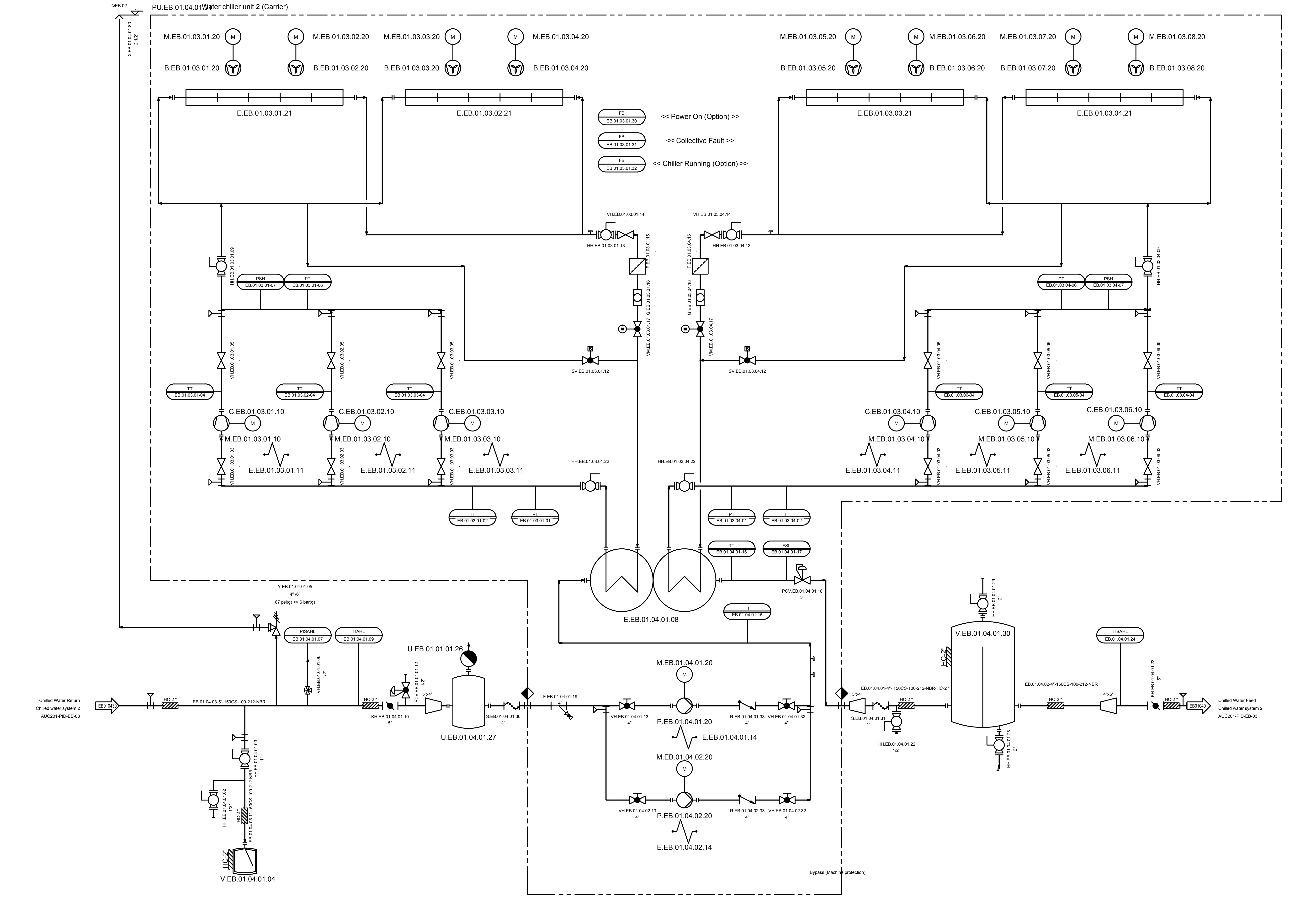
BIOFERM ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

COUNTY of DANE 1839 WISCONSIN

SHEET TITLE: P&ID Chilled water system 1 Chiller Unit 1	PROJ. NO.: AUC201				DATE: 2019-01-31
	DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----	SCALE:
PROJECT TITLE: Dane County WI BUP2500I Dane County		2019-01-31	2019-01-31		PAGE NO.
	DRAWING NO.: AUC201-PID-EB-01				41 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

NO.	REVISION	DATE
	first Draft	11/22/17
	change from 4 to 6 vessels	03/14/18
	generally revised	04/23/18
	Revision 3	12/01/18
	Issue for construction / IFC	01/31/19
	— AS BUILT —	07/25/19

BIOFERM ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

COUNTY of DANE WISCONSIN

SHEET TITLE P&ID
Chilled water system 2
Chiller Unit 2

PROJ. NO. AUC201

DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

PROJECT TITLE
Dane County WI BUP2500I
Dane County

DRAWING NO. AUC201-PID-EB-02

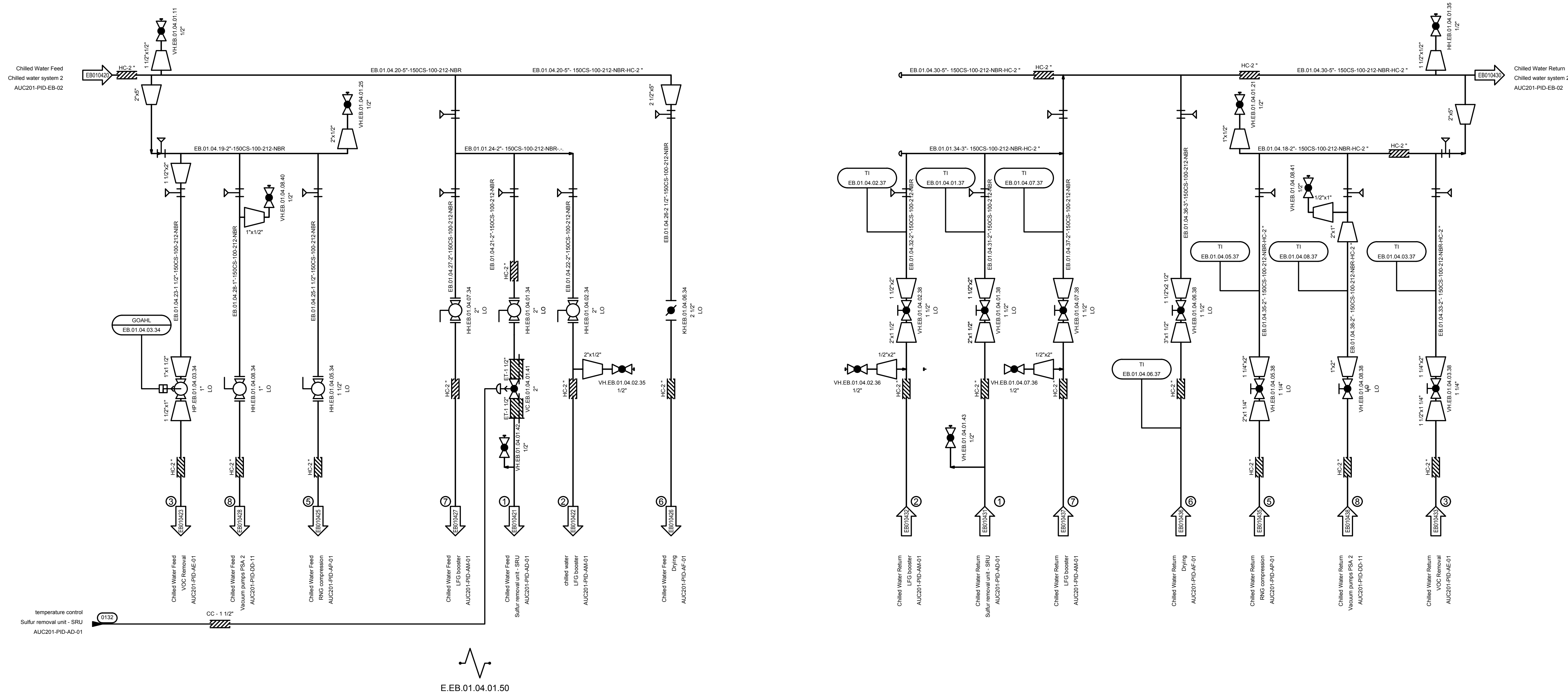
DATE 2019-01-31

SCALE:

PAGE NO.

NOTE:

Highest elevations of each circuit have to be equipped with a venting valve.
Lowest elevations of each circuit have to be equipped with a drain valve.



1 : E.AD.01.01.01.07

2 : E.AM.01.01.01.30

3 : E.AE.01.01.01.42

5 : E.AP.01.01.01.56

6 : E.AF.01.01.01.04

7 : E.AM.01.01.02.30

8 : E.DD.01.02.01.30

Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

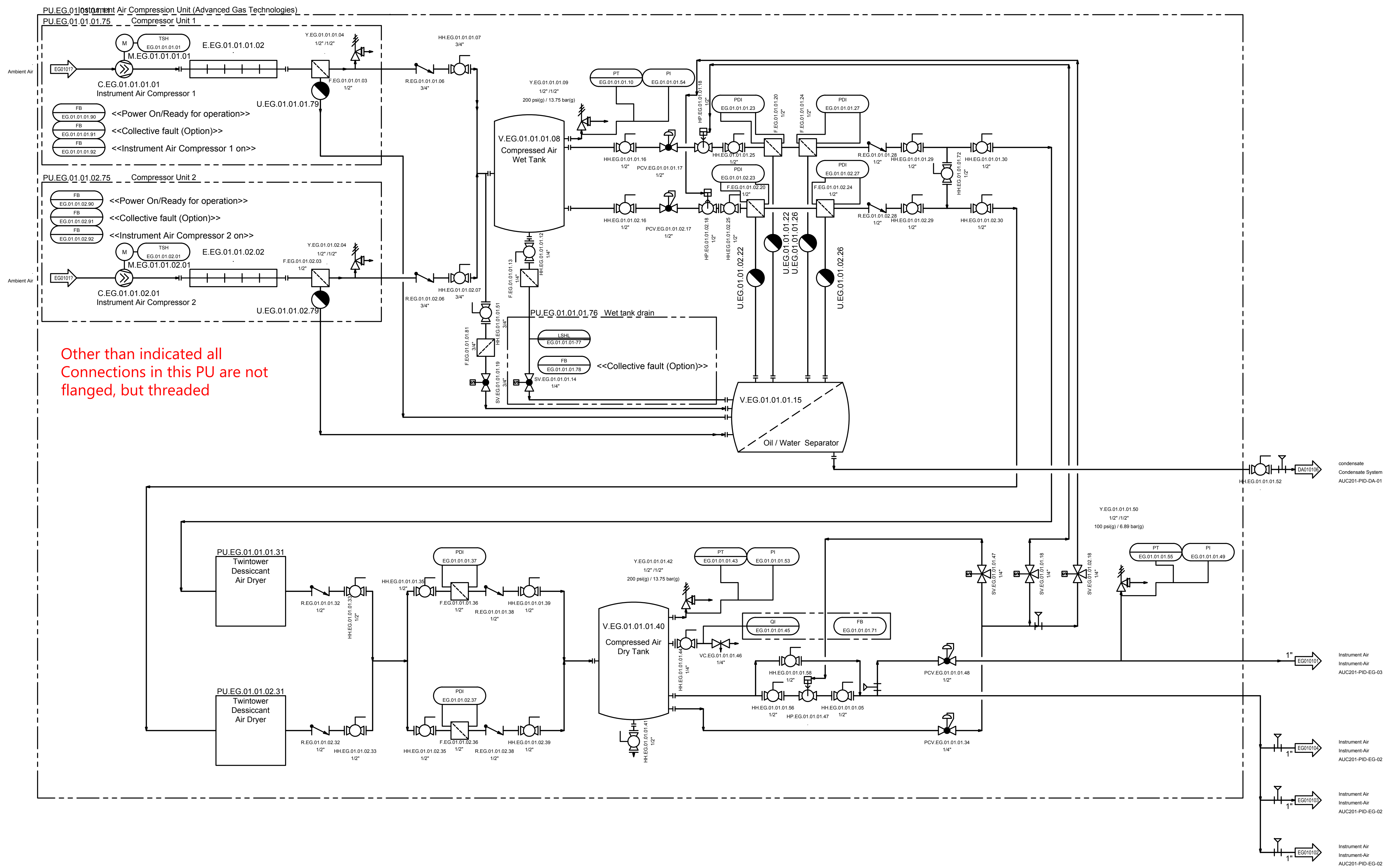
N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFERM™ ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID Chilled water system 2 Distribution	PROJ. NO. AUC201			DATE: 2019-01-31
	DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----
		2019-01-31	2019-01-31	SCALE:
PROJECT TITLE Dane County WI BUP2500I Dane County	DRAWING NO: AUC201-PID-EB-03			PAGE NO. 43 / 72



Other than indicated all Connections in this PU are not flanged, but threaded

Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID Instrument air compression

PROJECT TITLE Dane County WI BUP2500I Dane County

PROJ. NO. AUC201

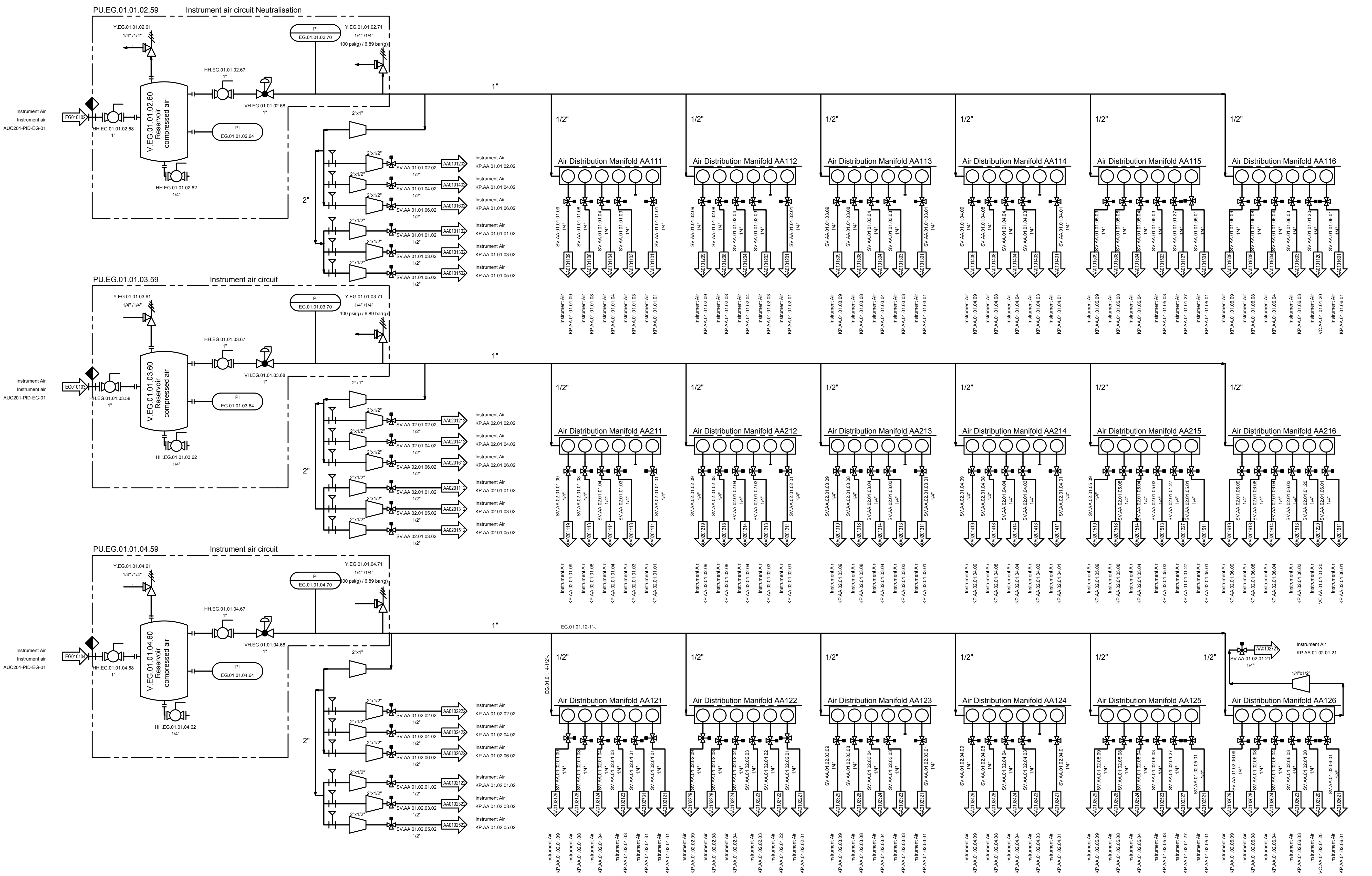
DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

DRAWING NO: AUC201-PID-EG-01

DATE: 2019-01-31

SCALE:

PAGE NO. 44 / 72



- The order of solenoid valve connections within each manifold is not fixed.
- The connections downstream of the manifolds are hoses. This is not indicated.

Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

NO.	REVISION	DATE
	first Draft	11/22/17
	change from 4 to 6 vessels	03/14/18
	generally revised	04/23/18
	Revision 3	12/01/18
	Issue for construction / IFC	01/31/19
	— AS BUILT —	07/25/19

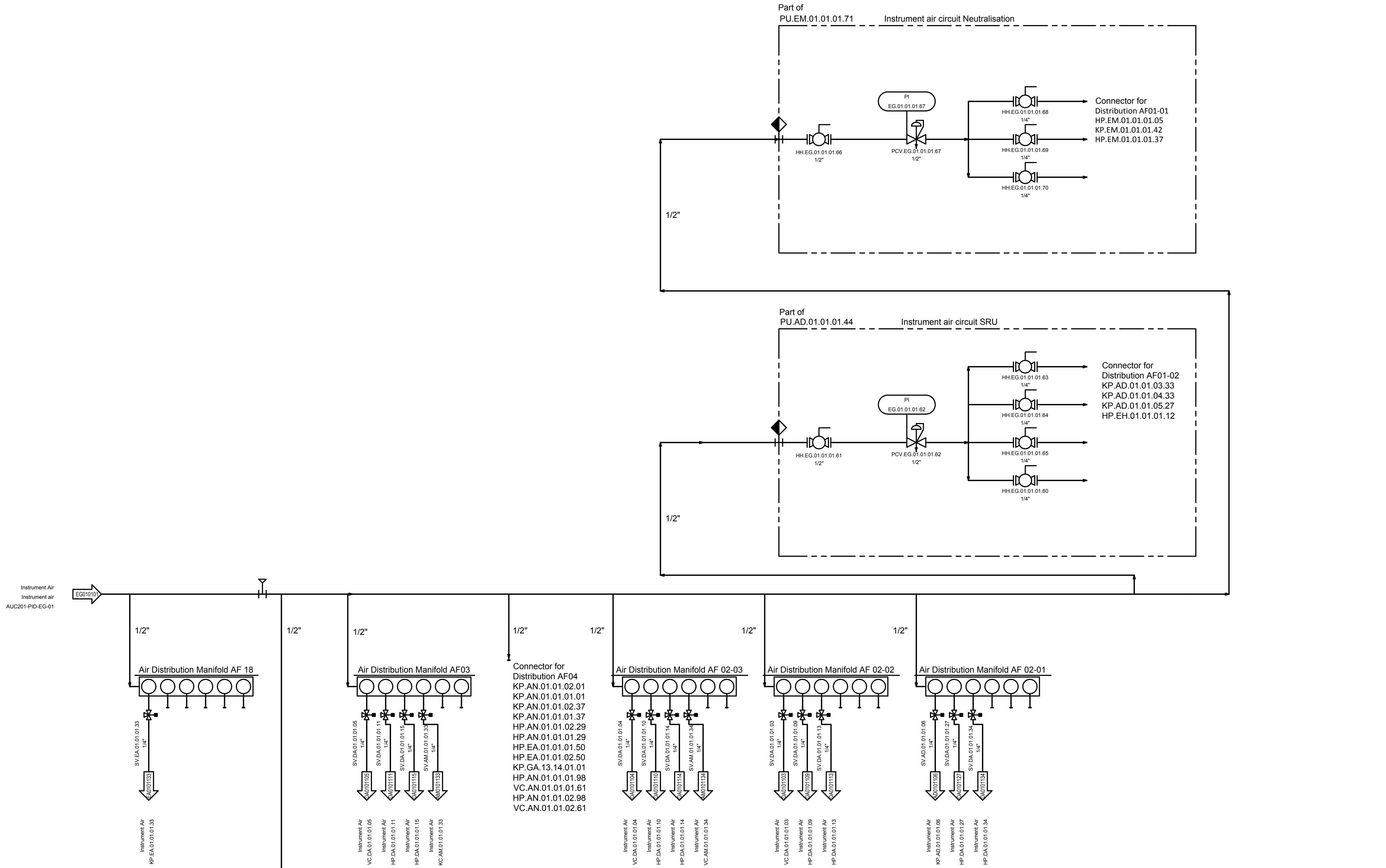
BIOFERM ENERGY SYSTEMS
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

COUNTY of DANE WISCONSIN

SHEET TITLE: P&ID Instrument-Air Distribution PSA
PROJ. NO.: AUC201
DATE: 2019-01-31
SCALE:
DSN. BY: | DWN. BY: SctP | CHK. BY: ZimT | APP. BY: ----
2019-01-31 | 2019-01-31
PROJECT TITLE: Dane County WI BUP2500I Dane County
DRAWING NO.: AUC201-PID-EG-02
PAGE NO.: 45 / 72

K:\Projekte_P3D\Dane_County_AUC201_WI_BUP2500I\2Dc_P_and_I_Drawings\45_AUC201-PID-EG-02_Instrument-air-distribution-PSA.dwg



- The order of solenoid valve connections within each manifold is not fixed.
- The connections downstream of the manifolds are hoses. This is not indicated.

Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID Instrument-Air Distribution-West

PROJ. NO. AUC201

DATE 2019-01-31

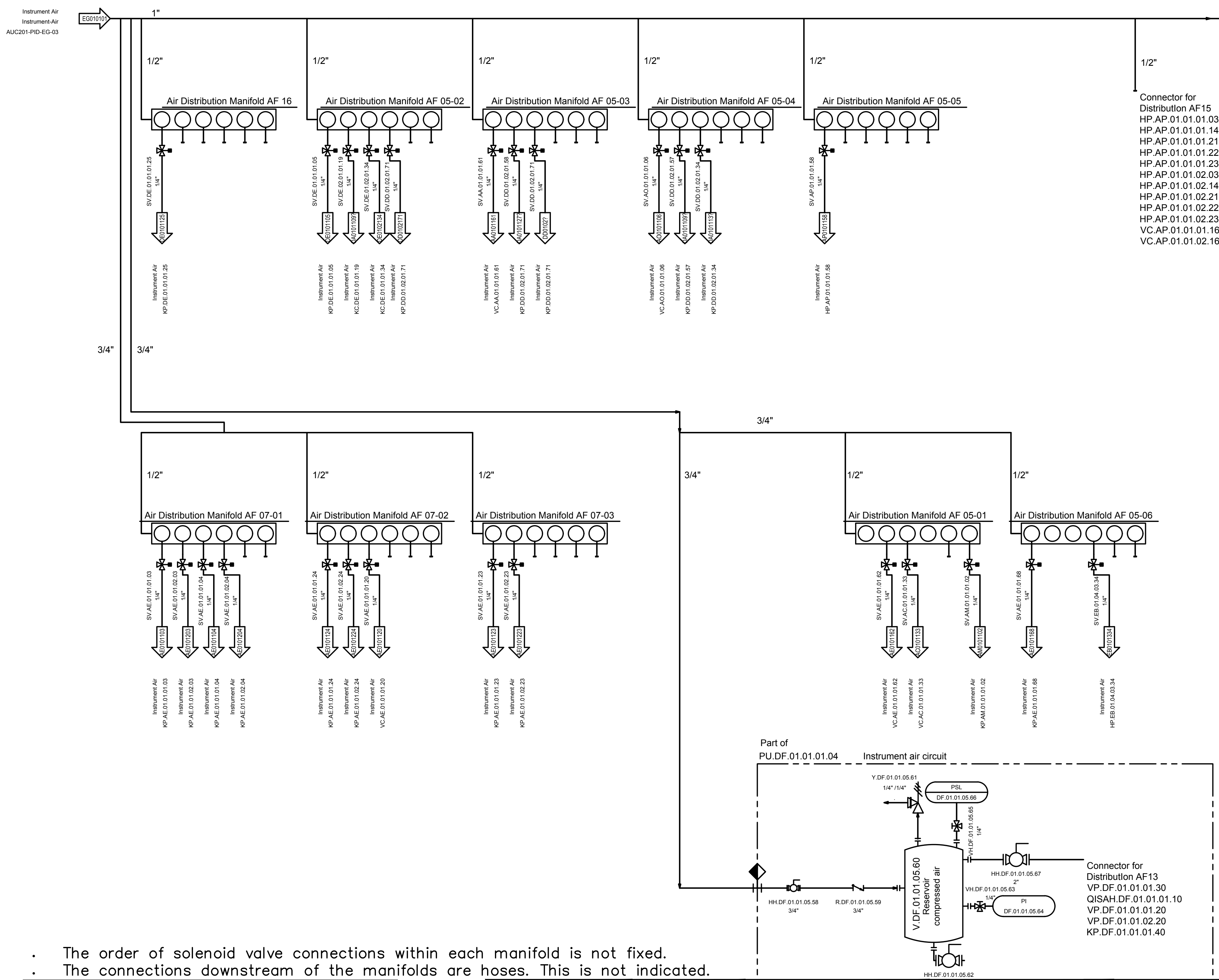
SCALE:

DSN. BY: DWN. BY: SctP 2019-01-31 CHK. BY: ZimT 2019-01-31 APP. BY: ----

PROJECT TITLE Dane County WI BUP2500I Dane County

DRAWING NO. AUC201-PID-EG-03

K:\Projekte_P3D\Dane_County_AUC201_WI_BUP2500I\2Dc_P_and_I_Drawings\46_AUC201-PID-EG-03_Instrument-air-distribution-west.dwg



- The order of solenoid valve connections within each manifold is not fixed.
- The connections downstream of the manifolds are hoses. This is not indicated.

Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

NO.	REVISION	DATE
	first Draft	11/22/17
	change from 4 to 6 vessels	03/14/18
	generally revised	04/23/18
	Revision 3	12/01/18
	Issue for construction / IFC	01/31/19
	— AS BUILT —	07/25/19

BIOFERM ENERGY SYSTEMS
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID Instrument-Air Distribution-East
PROJ. NO.: AUC201
DATE: 2019-01-31
DSN. BY: | DWN. BY: SctP | CHK. BY: ZimT | APP. BY: ----
2019-01-31 | 2019-01-31
SCALE:
PROJECT TITLE: Dane County WI BUP2500I Dane County
DRAWING NO.: AUC201-PID-EG-04
PAGE NO.: 47 / 72

K:\Projekte_P3D\Dane_County_AUC201_WI_BUP2500I\2Dc_P_and_I_Drawings\47_AUC201-PID-EG04_Instrument-air-distribution-east.dwg

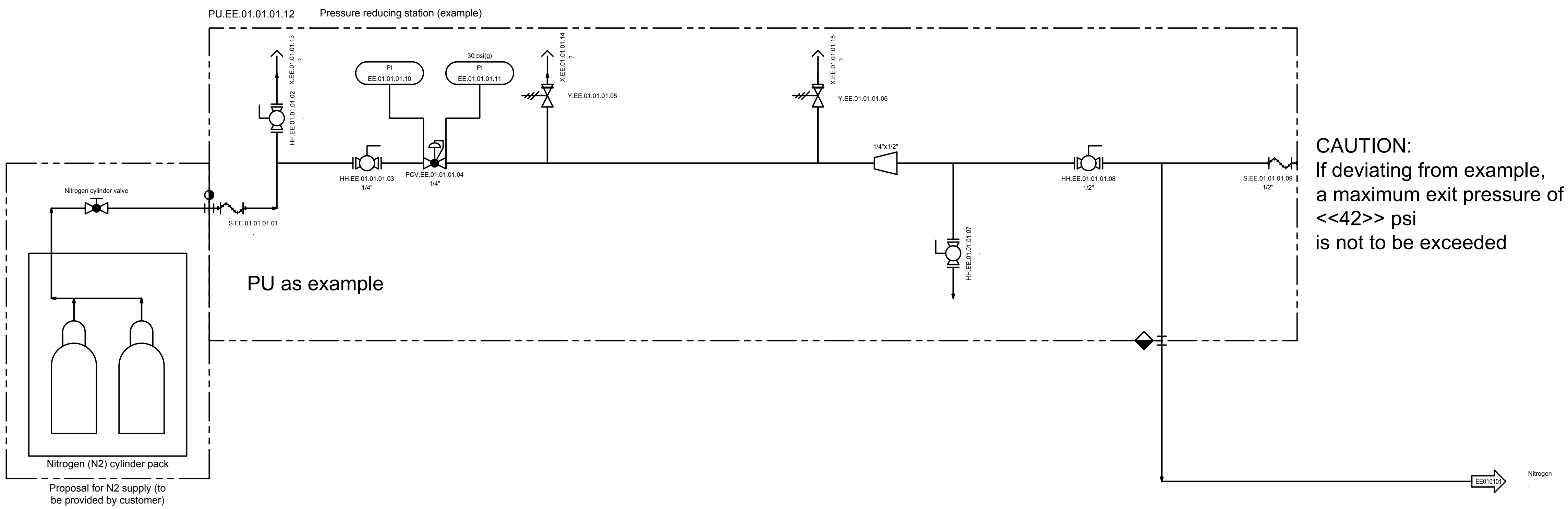


Table of inert gas inputs
HH.AM.01.01.01.03
HH.AN.01.01.01.02
HH.AN.01.01.02.02
HH.AE.01.01.01.05
HH.AC.01.01.01.04
HH.AC.01.01.02.04
HH.AC.01.01.01.34
HH.AA.01.01.01.51
HH.AO.01.01.01.11
HH.DD.01.02.01.32

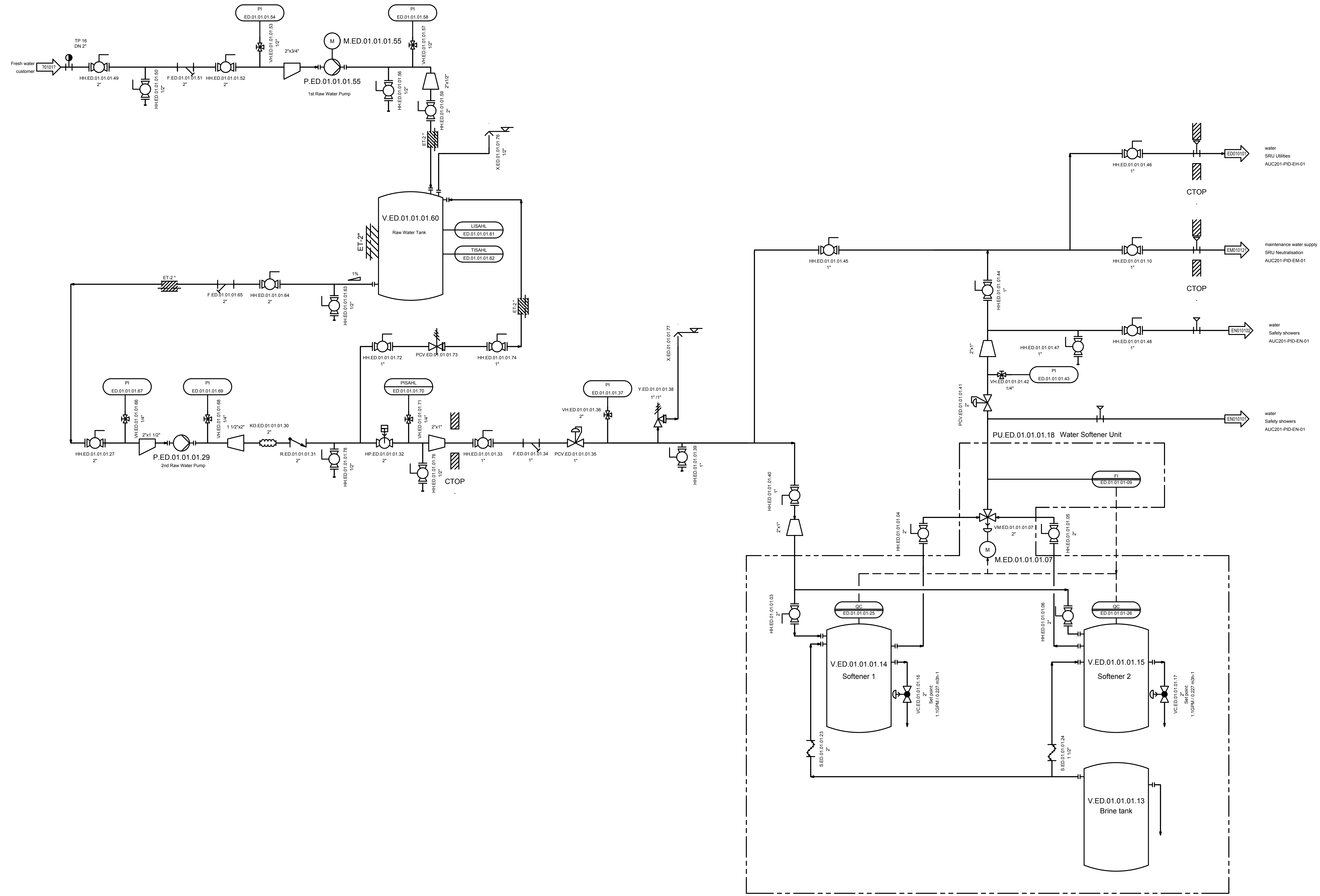
Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID Nitrogen system	PROJ. NO. AUC201				DATE: 2019-01-31
	DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----	SCALE:
PROJECT TITLE: Dane County WI BUP2500I Dane County		2019-01-31	2019-01-31		PAGE NO.
	DRAWING NO: AUC201-PID-EE-01				48 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

NO.	REVISION	DATE
	first Draft	11/22/17
	change from 4 to 6 vessels	03/14/18
	generally revised	04/23/18
	Revision 3	12/01/18
	Issue for construction / IFC	01/31/19
	— AS BUILT —	07/25/19

BIOFERM ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID Water Treatment ##################

PROJ. NO.: AUC201

DATE: 2019-01-31

SCALE:

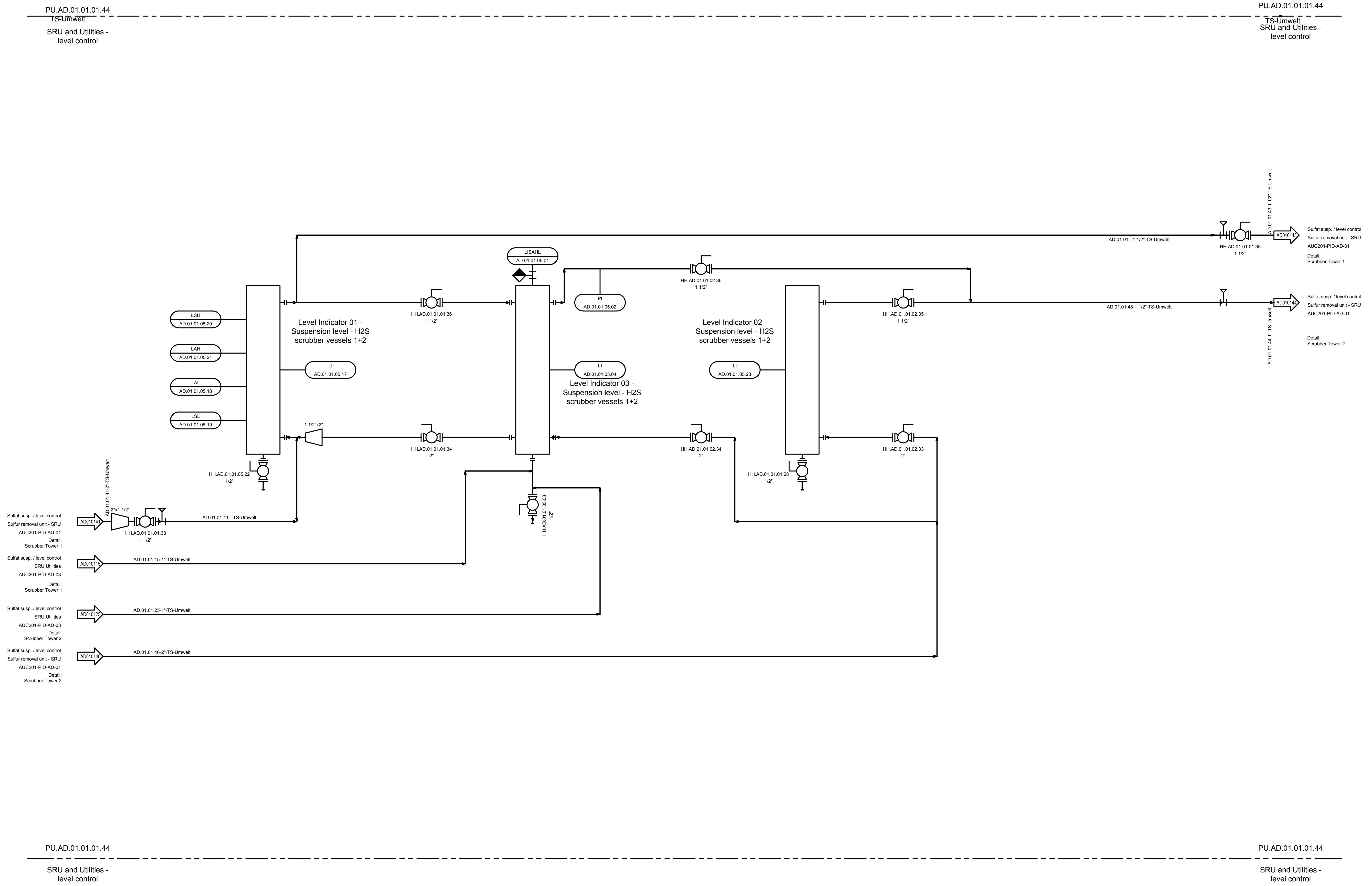
DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

PROJECT TITLE: Dane County WI BUP2500I Dane County

DRAWING NO.: AUC201-PID-ED-01

PAGE NO. 49 / 72

K:\Projekte_P3D\Dane_County_AUC201_WI_BUP2500I\2Dc_P_and_I_Drawings\49_AUC201-PID-ED-01_Water-Treatment.dwg



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

NO.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

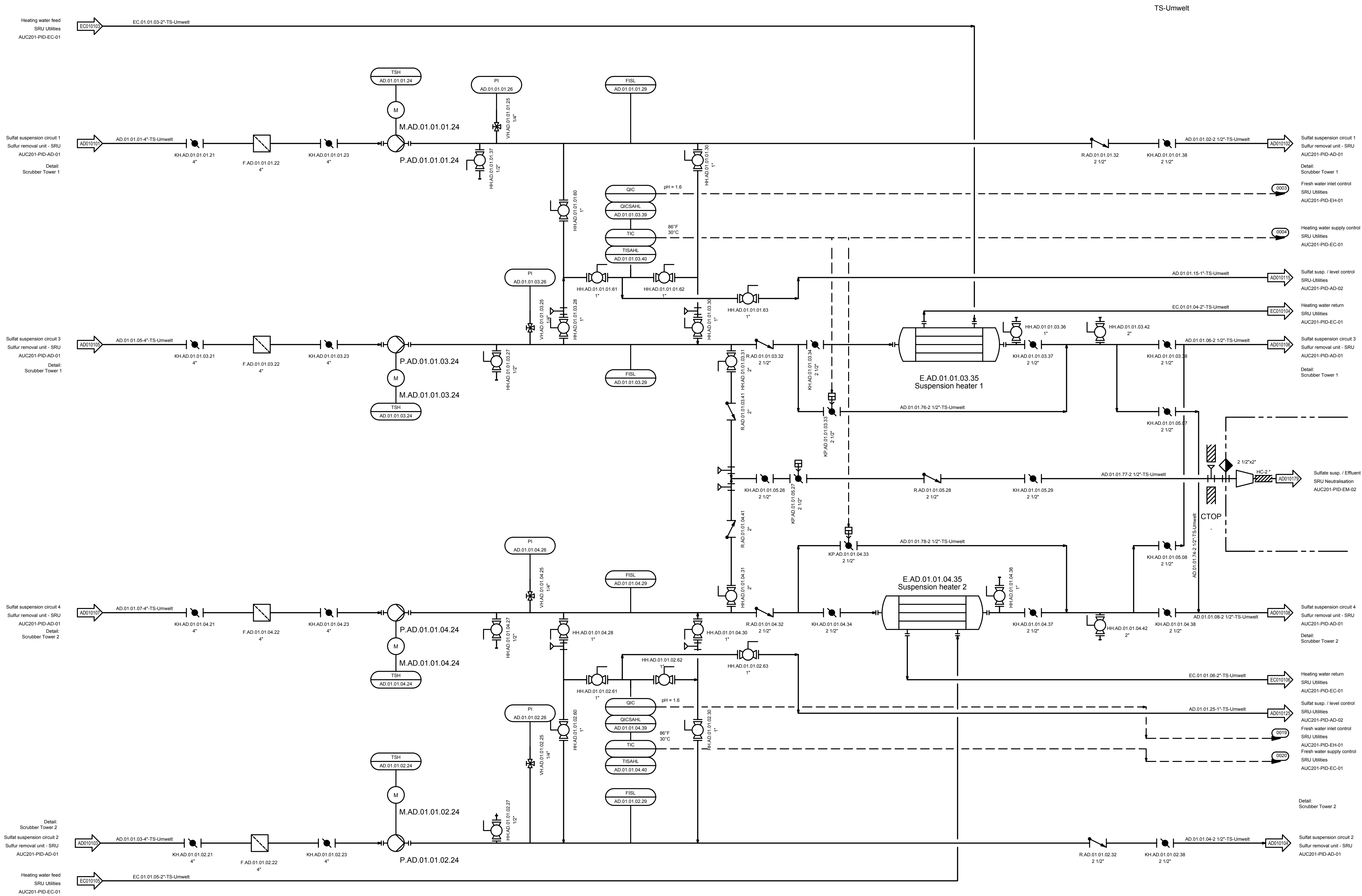
BIOFERM ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

COUNTY of DANE 1839 WISCONSIN

SHEET TITLE	P&ID SRU-Utilities level control
PROJECT TITLE	Dane County WI BUP2500I Dane County
PROJ. NO.	AUC201
DSN. BY:	
DWN. BY:	SctP 2019-01-31
CHK. BY:	ZimT 2019-01-31
APP. BY:	----
DRAWING NO:	AUC201-PID-AD-02
DATE:	2019-01-31
SCALE:	
PAGE NO.	50 / 72



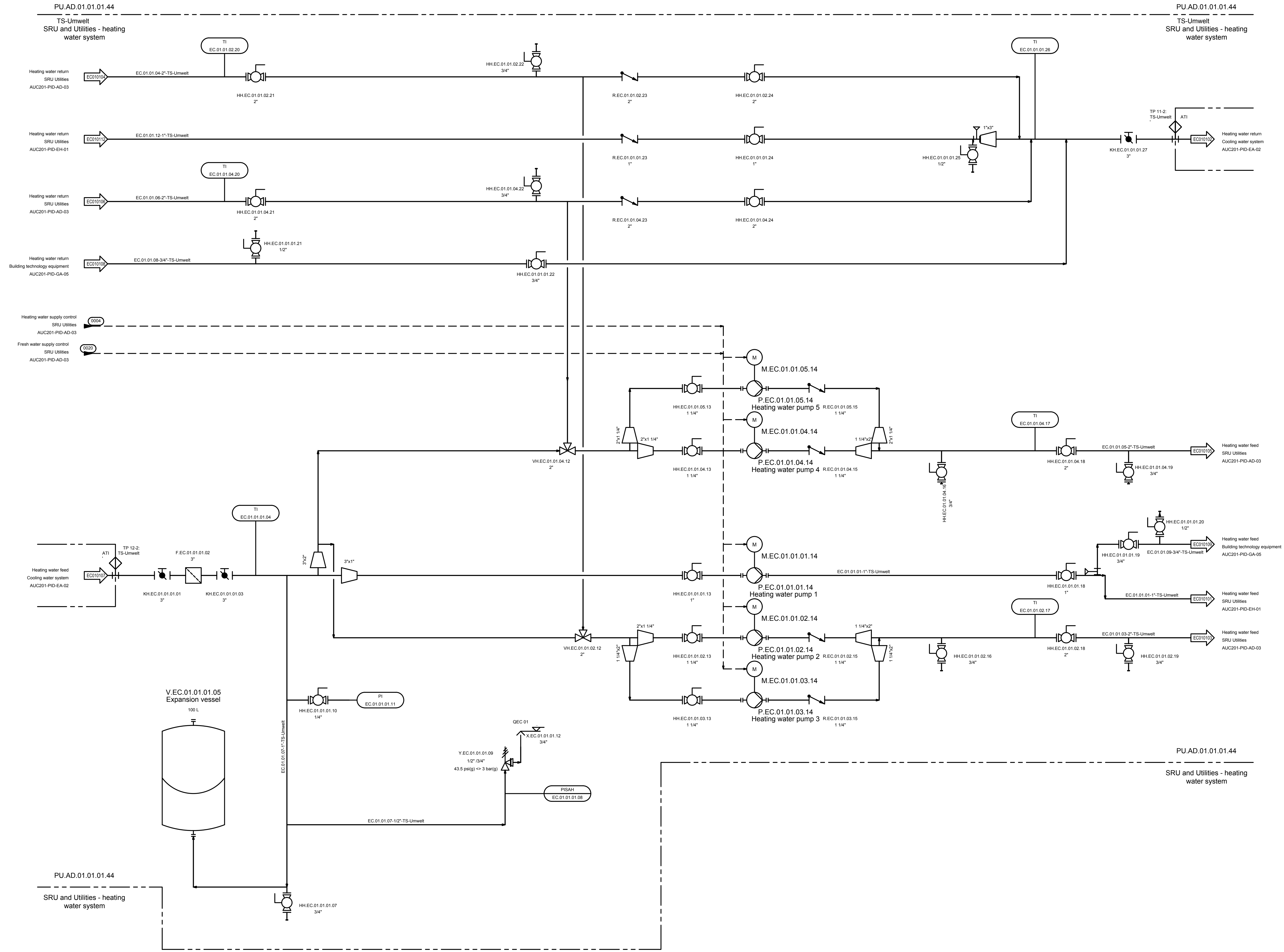
Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID SRU Utilities suspension circuits 1-4	PROJ. NO.: AUC201				DATE: 2019-01-31
	DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----	SCALE:
		2019-01-31	2019-01-31		
PROJECT TITLE: Dane County WI BUP2500I Dane County	DRAWING NO: AUC201-PID-AD-03				PAGE NO. 51 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

NO.	REVISION	DATE
	first Draft	11/22/17
	change from 4 to 6 vessels	03/14/18
	generally revised	04/23/18
	Revision 3	12/01/18
	Issue for construction / IFC	01/31/19
	--- AS BUILT ---	07/25/19

BIOFERM ENERGY SYSTEMS
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

COUNTY of DANE WISCONSIN

SHEET TITLE P&ID
SRU Utilities
Heating water system

PROJ. NO. AUC201

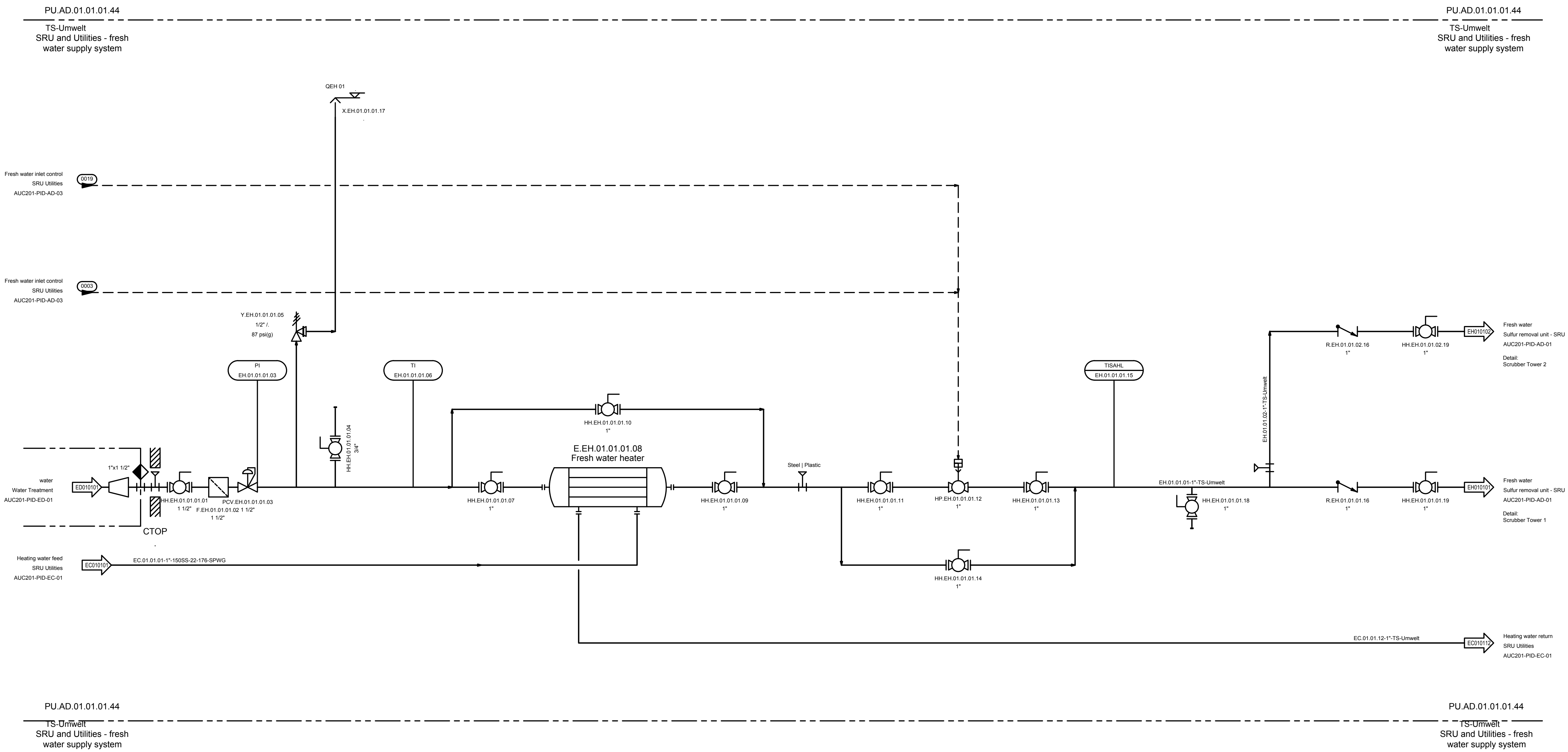
DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

PROJECT TITLE
Dane County WI BUP2500I
Dane County

DRAWING NO. AUC201-PID-EC-01

DATE 2019-01-31

SCALE:



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID
SRU Utilities
Fresh water supply system

PROJ. NO. AUC201

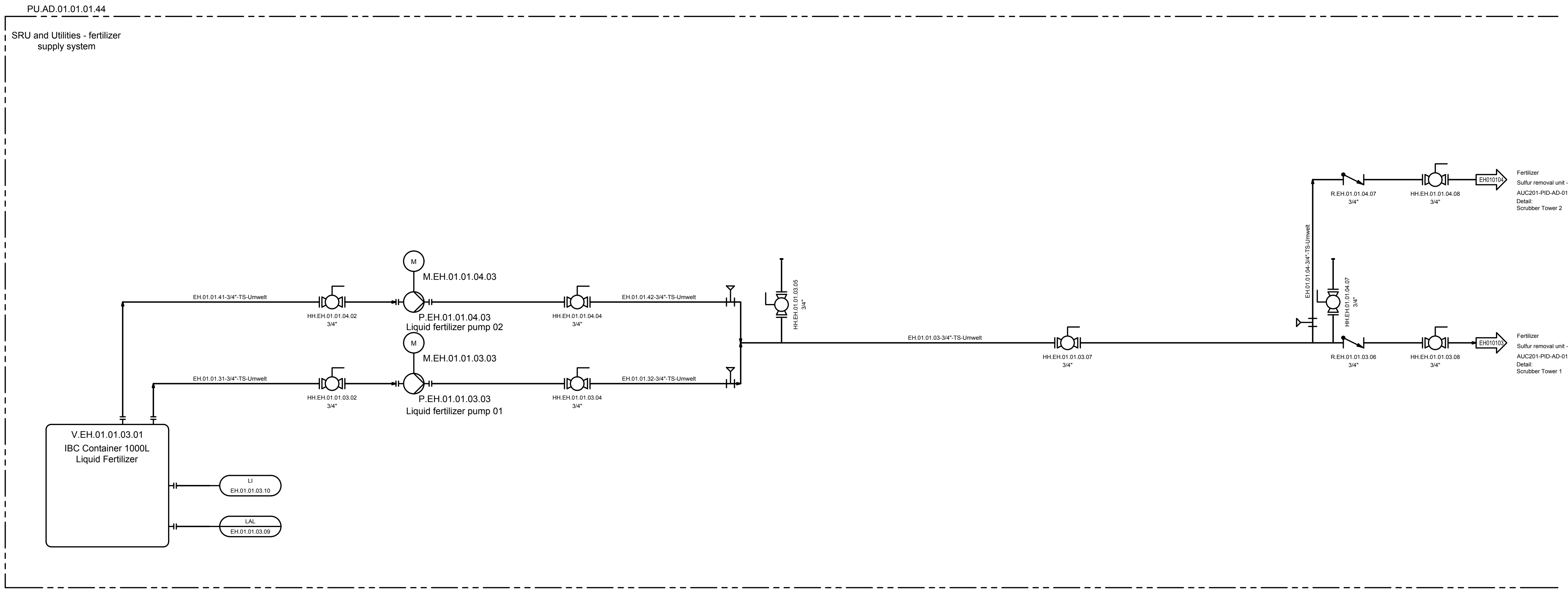
DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

PROJECT TITLE
Dane County WI BUP2500I
Dane County

DRAWING NO: AUC201-PID-EH-01

DATE: 2019-01-31

SCALE:



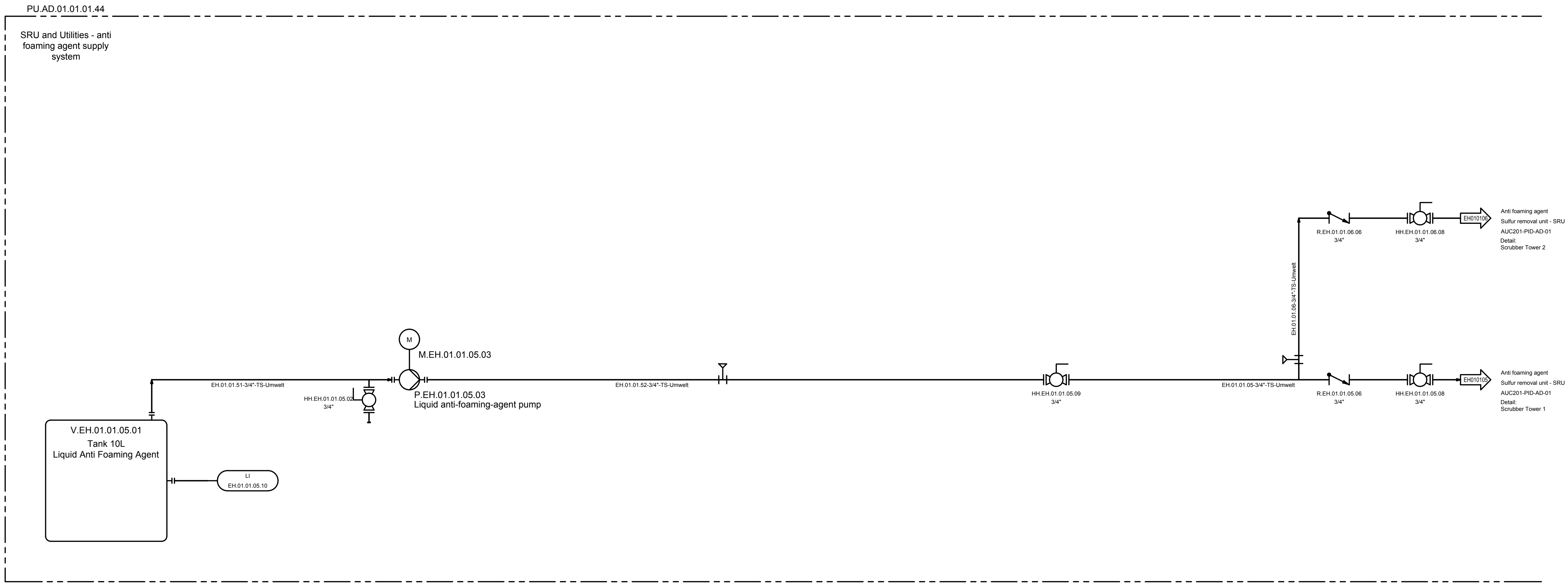
Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID SRU Utilities Fertilizer supply system	PROJ. NO. AUC201				DATE: 2019-01-31
	DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----	SCALE:
		2019-01-31	2019-01-31		
PROJECT TITLE: Dane County WI BUP2500I Dane County	DRAWING NO: AUC201-PID-EH-02				PAGE NO. 54 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

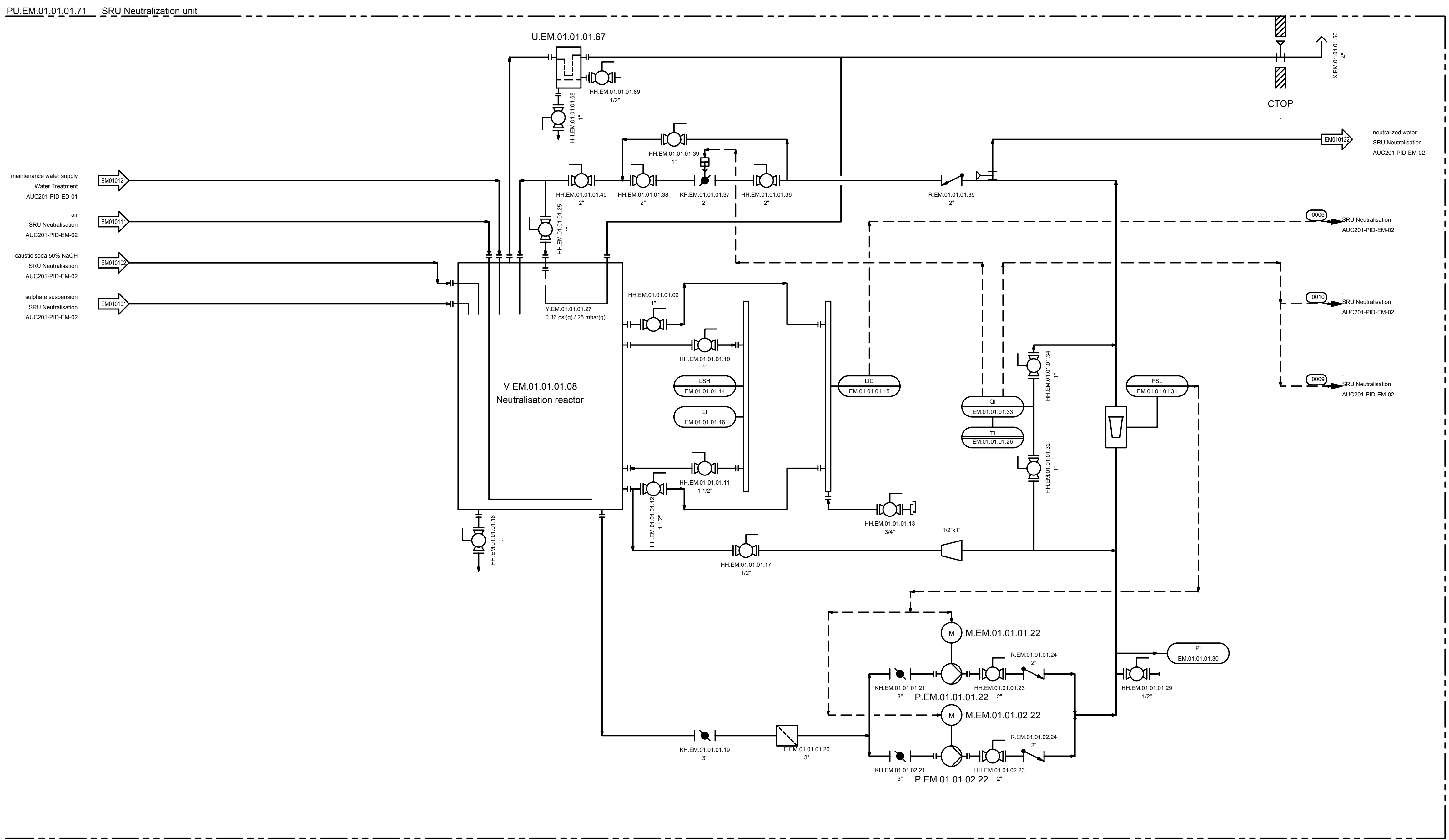
SHEET TITLE: P&ID
SRU Utilities
Anti foaming agent supply system

PROJECT TITLE: Dane County WI BUP2500I
Dane County

PROJ. NO.	AUC201		
DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----
	2019-01-31	2019-01-31	

DRAWING NO: AUC201-PID-EH-03

DATE: 2019-01-31
SCALE:



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID
SRU Neutralisation
page 01

PROJECT TITLE
Dane County WI BUP2500I
Dane County

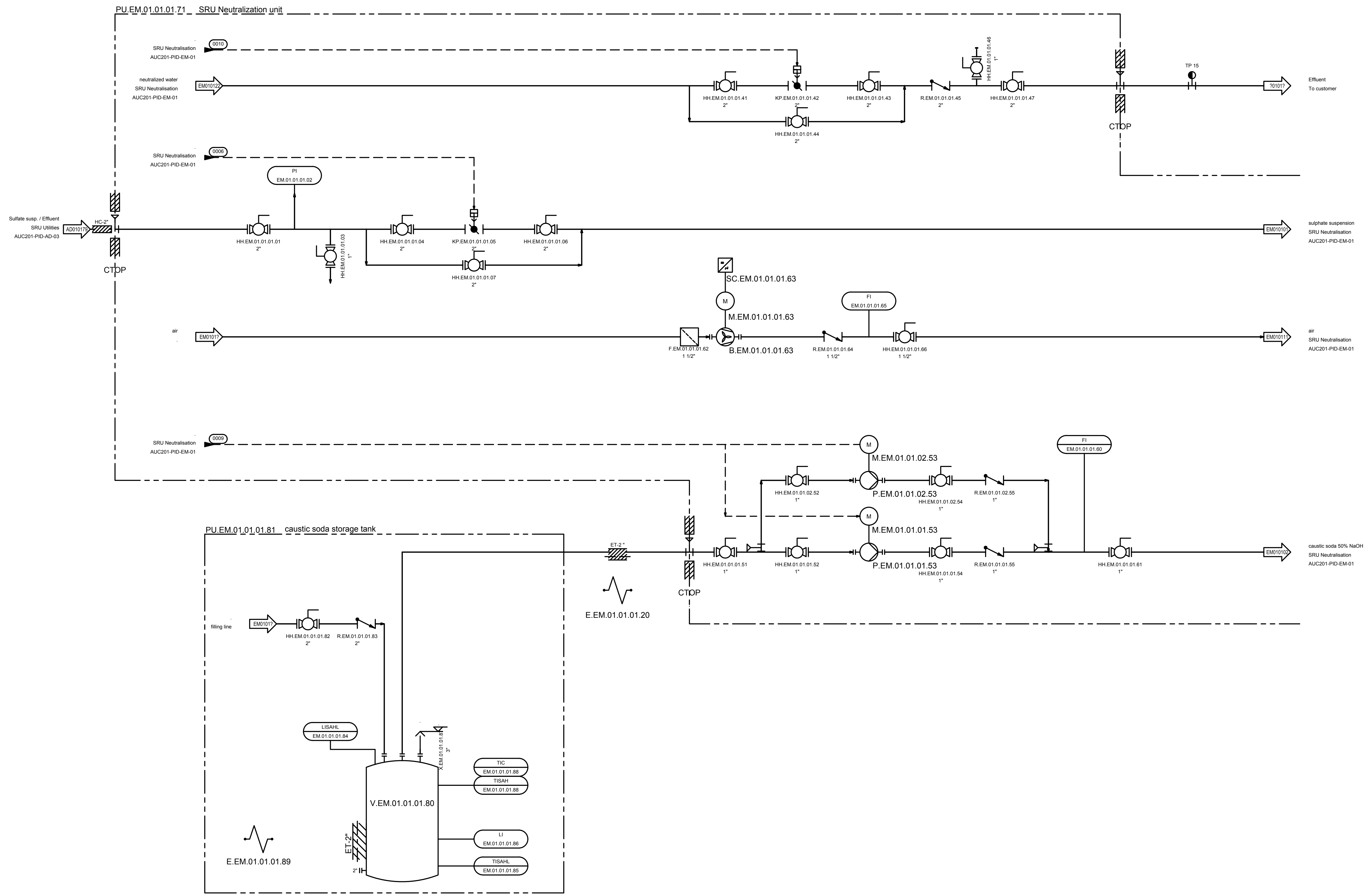
PROJ. NO. AUC201

DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----
	2019-01-31	2019-01-31	

DRAWING NO: AUC201-PID-EM-01

DATE: 2019-01-31
SCALE:
PAGE NO. 56 / 72

K:\Projekte_P3D\Dane_County_AUC201_WI_BUP2500I\2Dc_P_and_I_Drawings\66_AUC201-PID-EM-01_SRU_Neutralisation-01.dwg



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID
SRU Neutralisation
page 02

PROJECT TITLE: Dane County WI BUP2500I
Dane County

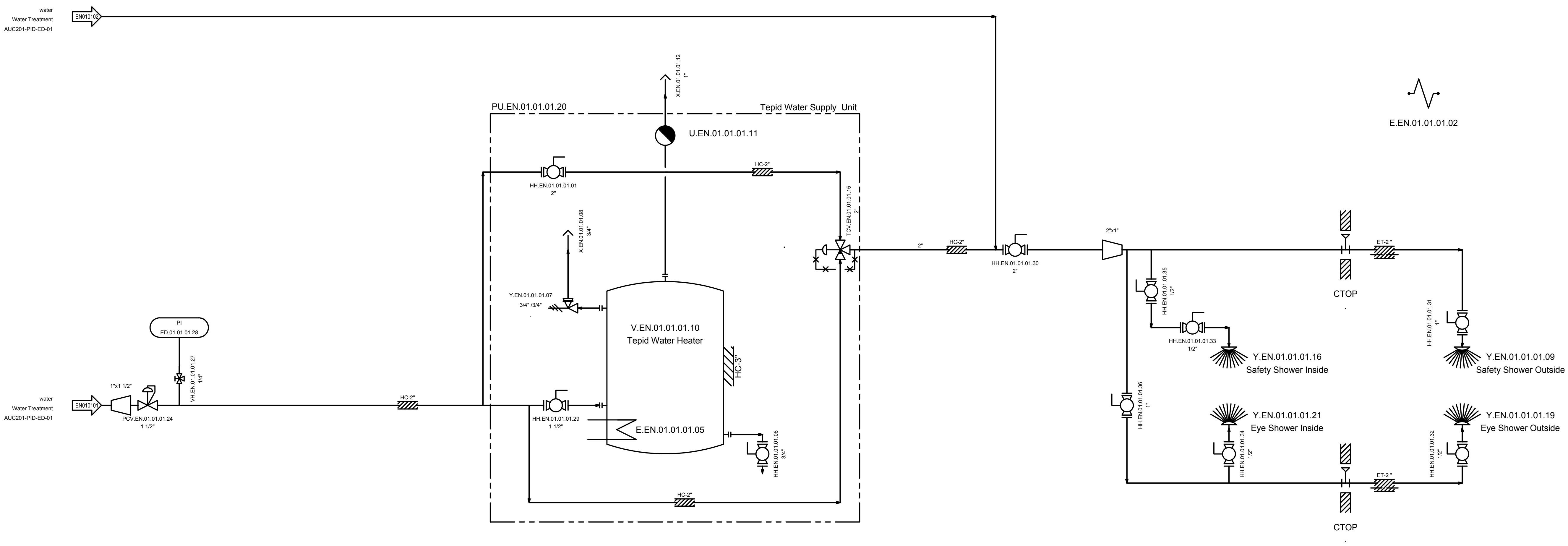
PROJ. NO.: AUC201

DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

DRAWING NO: AUC201-PID-EM-02

DATE: 2019-01-31

SCALE:



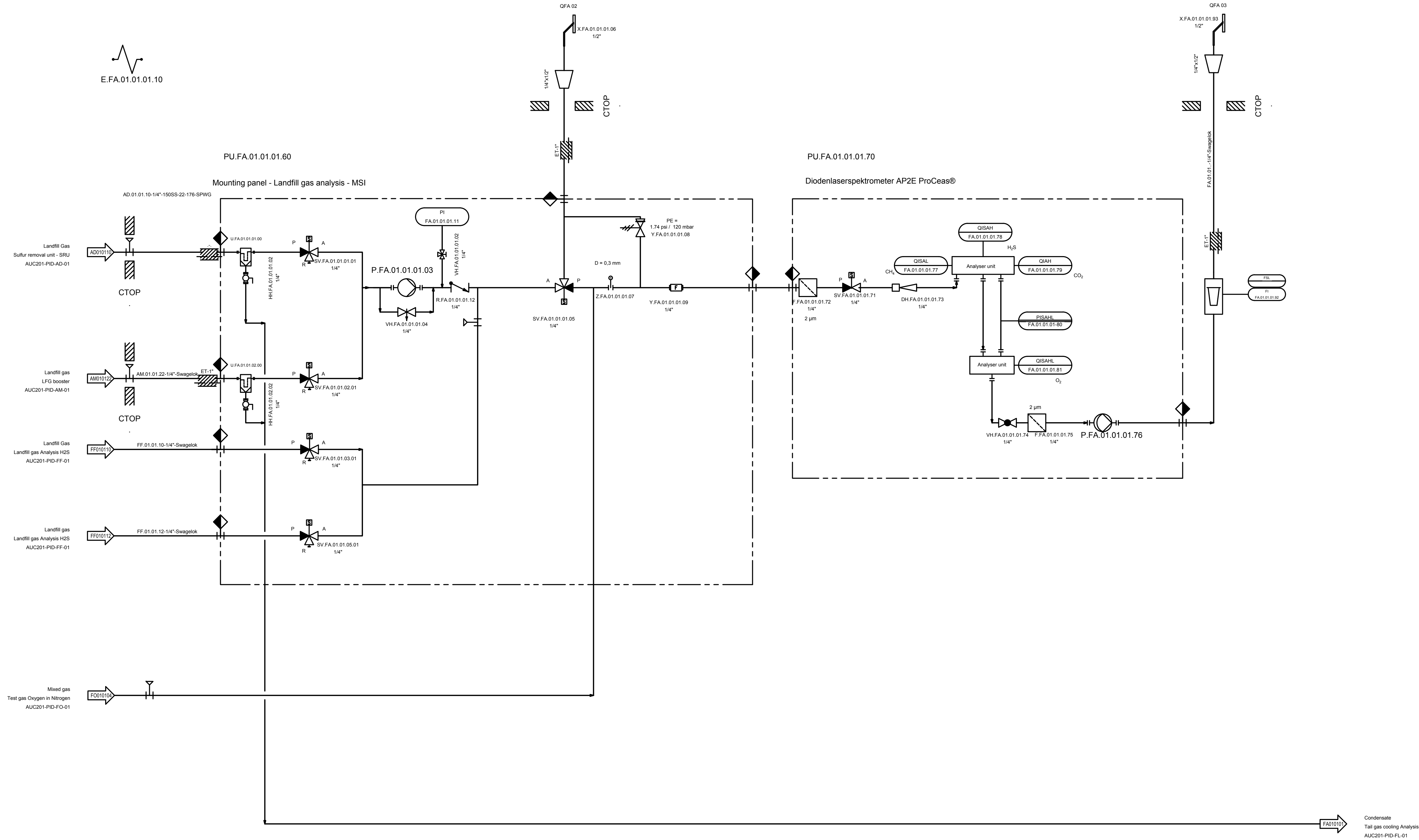
Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE	P&ID Safety showers ###################
PROJECT TITLE	Dane County WI BUP2500I Dane County
PROJ. NO.	AUC201
DSN. BY:	
DWN. BY:	SctP, 2019-01-31
CHK. BY:	ZimT, 2019-01-31
APP. BY:	----
DRAWING NO:	AUC201-PID-EN-01
DATE:	2019-01-31
SCALE:	
PAGE NO.	58 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID
Landfill gas Analysis

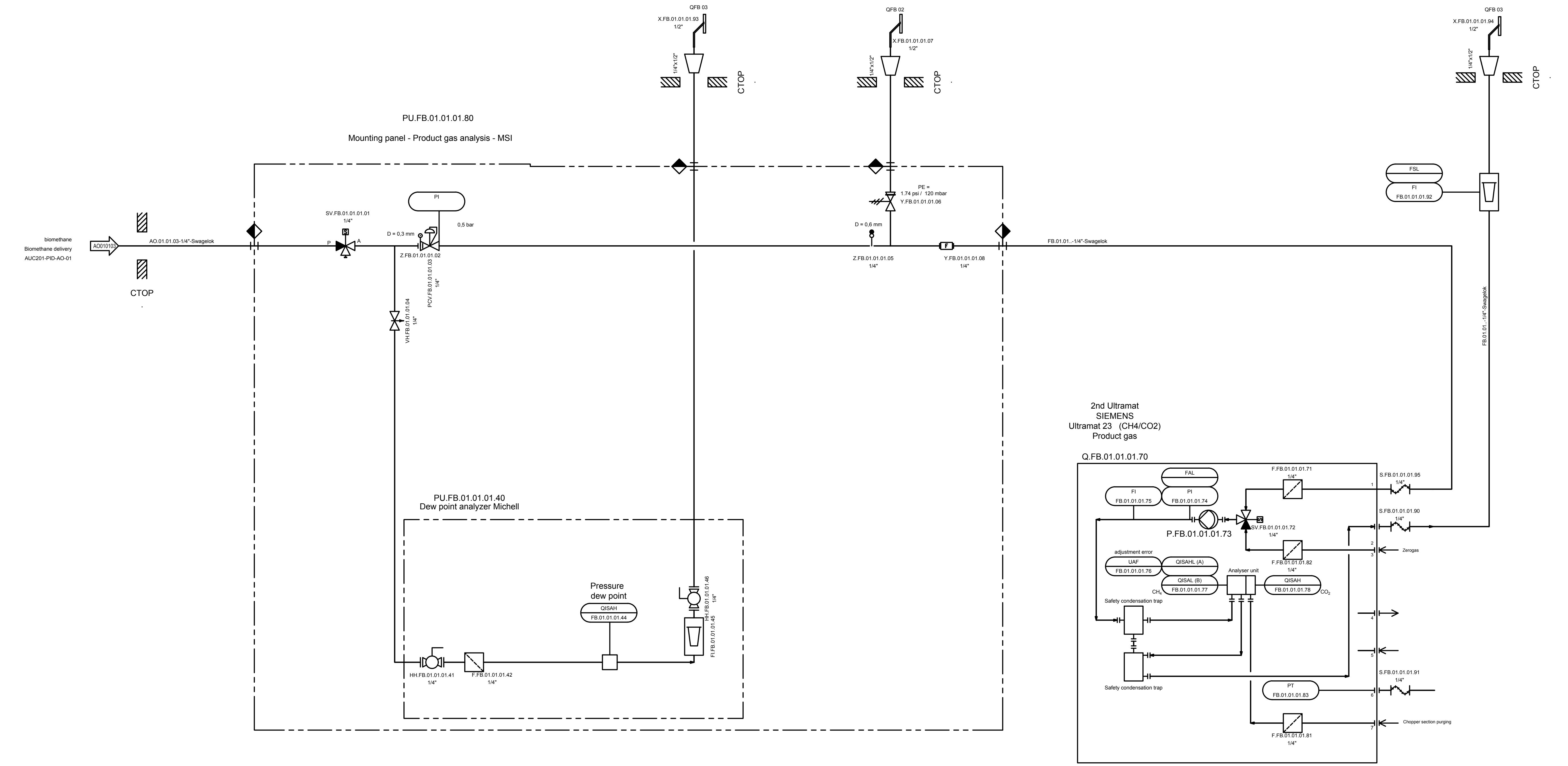
PROJECT TITLE
Dane County WI BUP2500I
Dane County

PROJ. NO. AUC201

DSN. BY:	DWN. BY: Mbgl	CHK. BY: ZimT	APP. BY: ----
	2019-01-31	2019-01-31	

DRAWING NO: AUC201-PID-FA-01

DATE: 2019-01-31
SCALE:
PAGE NO.



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

NO.	REVISION	DATE
	first Draft	11/22/17
	change from 4 to 6 vessels	03/14/18
	generally revised	04/23/18
	Revision 3	12/01/18
	Issue for construction / IFC	01/31/19
	--- AS BUILT ---	07/25/19

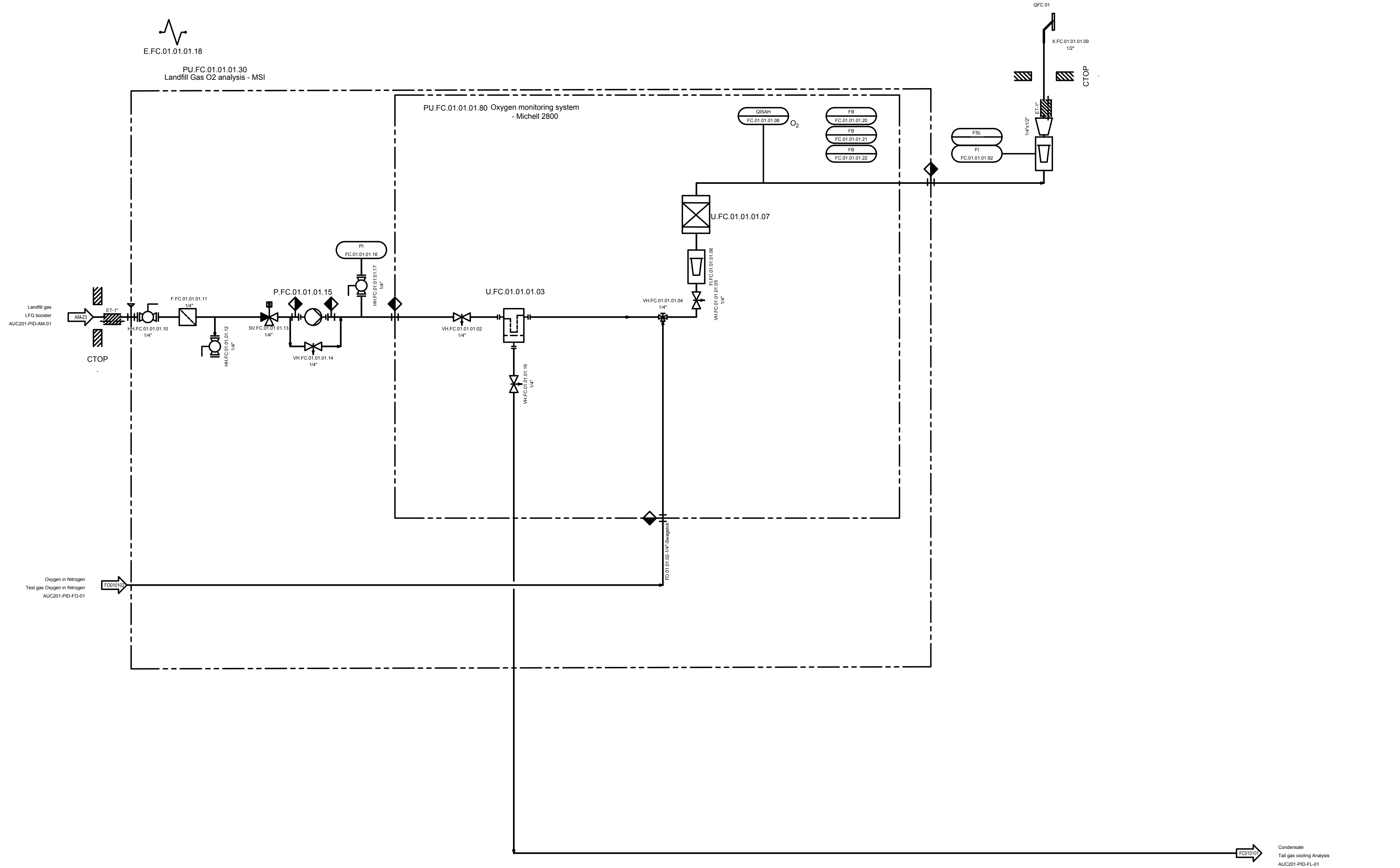
BIOFERM ENERGY SYSTEMS
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

COUNTY of DANE WISCONSIN

SHEET TITLE: P&ID Product Gas Analysis
####################
PROJ. NO.: AUC201
DATE: 2019-01-31
SCALE:
DSN. BY: | DWN. BY: Mbgl 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----
PROJECT TITLE: Dane County WI BUP2500I Dane County
DRAWING NO.: AUC201-PID-FB-01
PAGE NO.: 60 / 72

K:\Projekte_P3D\Dane_County_AUC201_WI_BUP2500I\2Dc_P_and_I_Drawings\71_AUC201-PID-FB-01_Product-Gas-Analysis.dwg



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID Landfill gas Analysis O2 monitoring

PROJ. NO.: AUC201

DATE: 2019-01-31

SCALE:

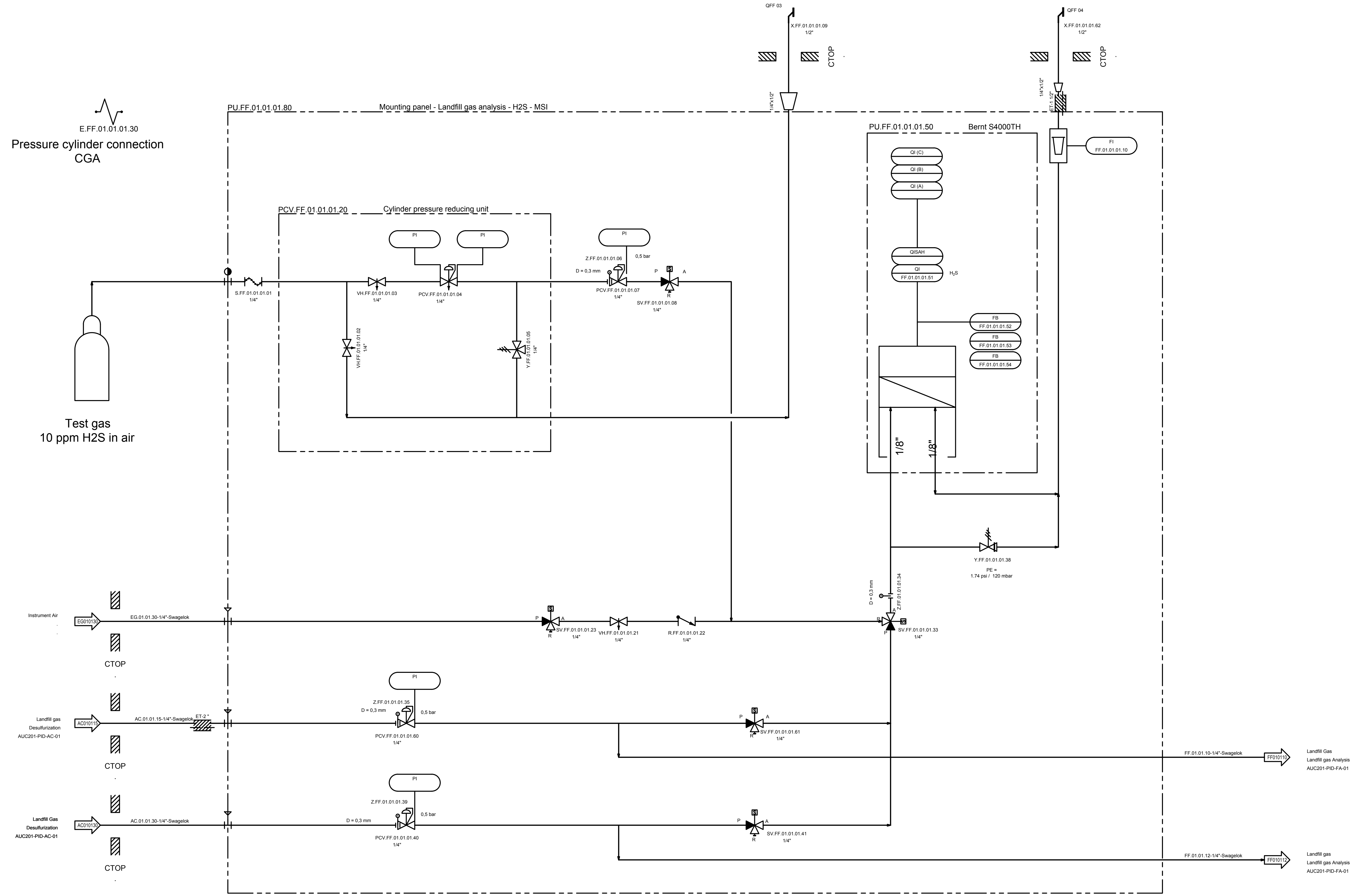
DSN. BY: | DWN. BY: Mbgl 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

PROJECT TITLE: Dane County WI BUP2500I Dane County

DRAWING NO: AUC201-PID-FC-01

PAGE NO. 61 / 72

K:\Projekte_P3D\Dane_County_AUC201_WI_BUP2500I\2Dc_P_and_I_Drawings\2_AUC201-PID-FC-01_Landfill-gas-Analysis-oxygen-monitoring.dwg



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID
Landfill gas Analysis H2S
Bernt

PROJECT TITLE
Dane County WI BUP2500I
Dane County

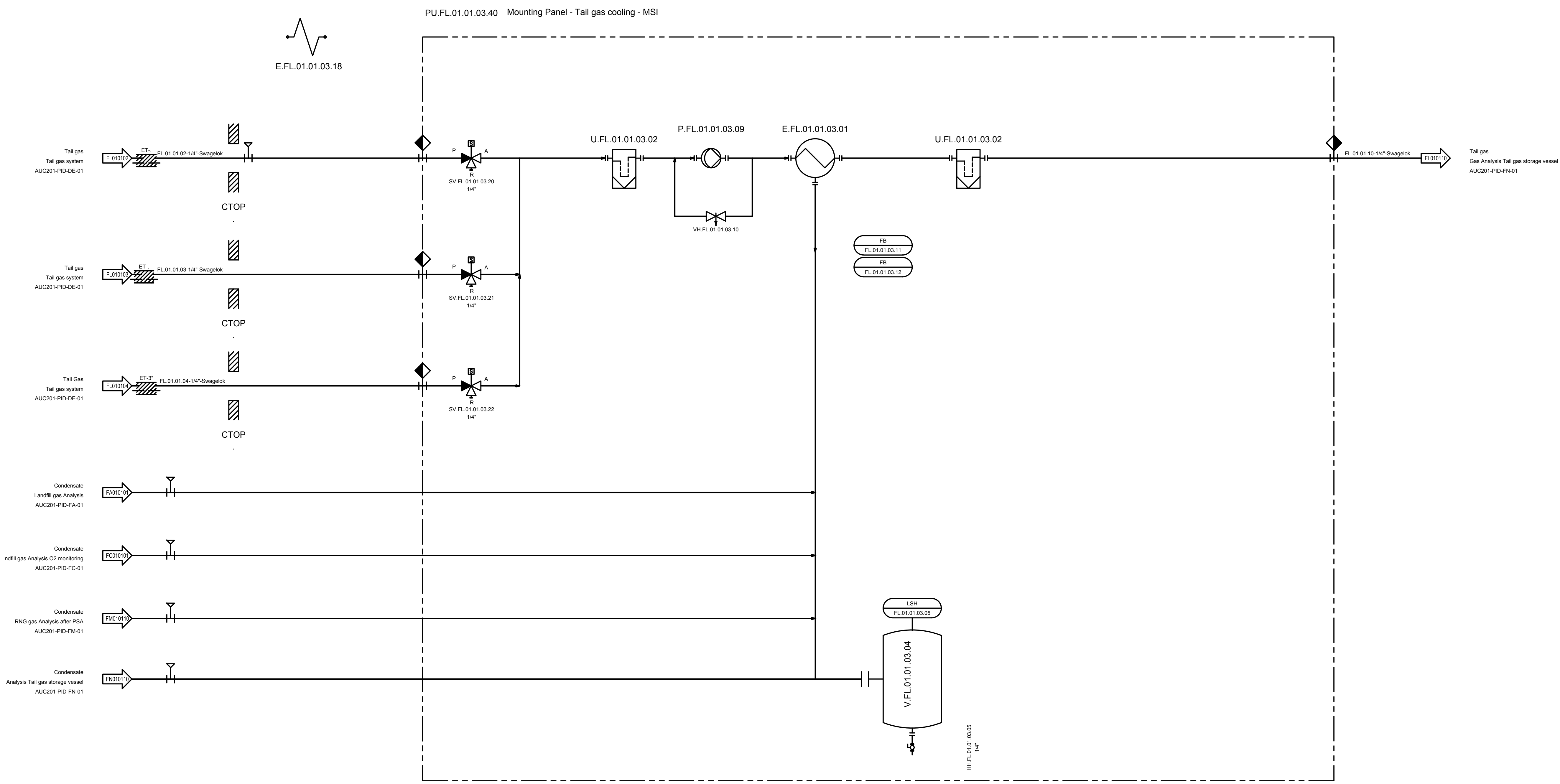
PROJ. NO. AUC201

DSN. BY: | DWN. BY: Mbgl 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

DRAWING NO: AUC201-PID-FF-01

DATE: 2019-01-31

SCALE:



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFERM™ ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID
Tail gas cooling Analysis
Cooling

PROJECT TITLE: Dane County WI BUP2500I
Dane County

PROJ. NO.: AUC201

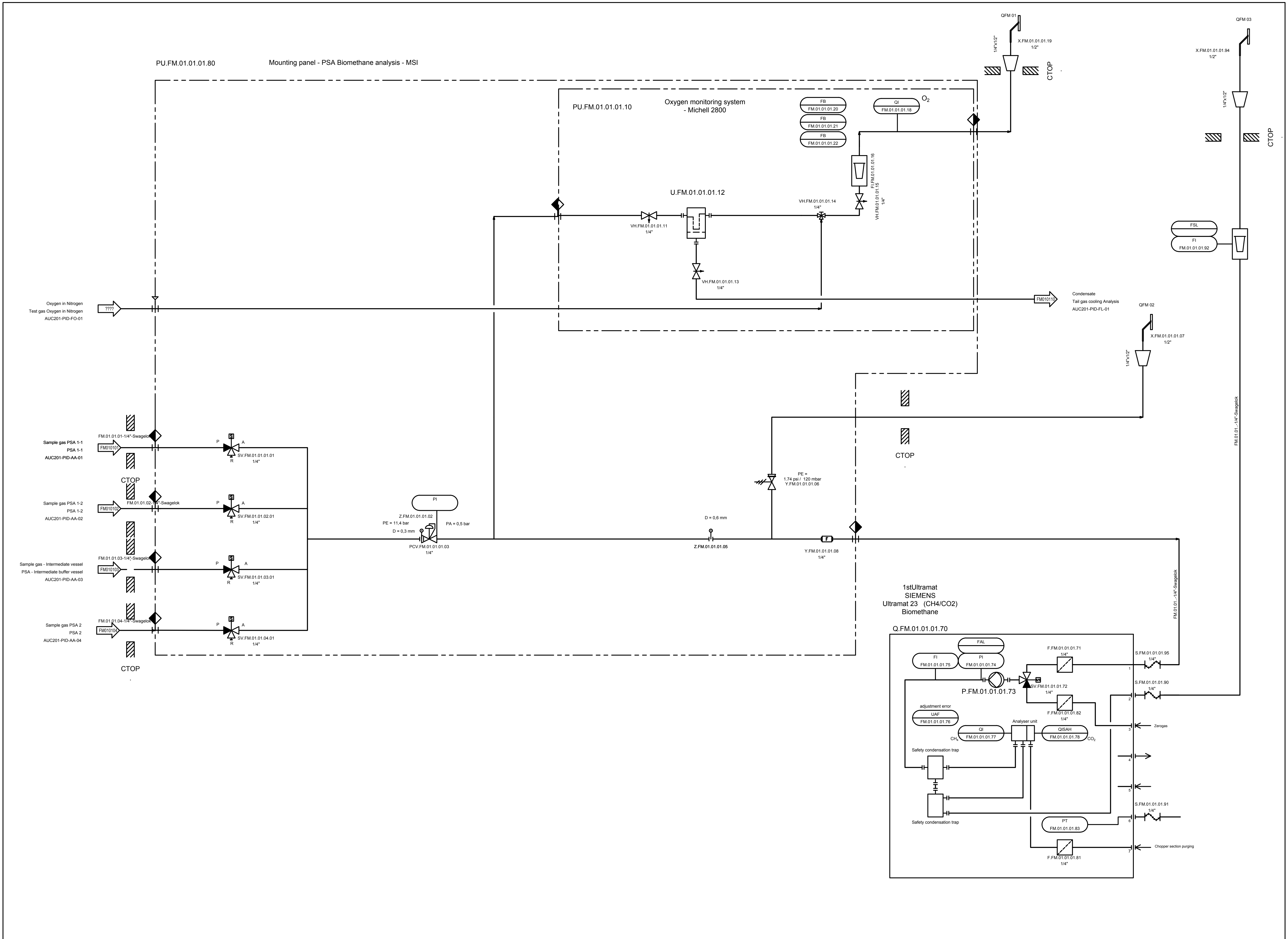
DSN. BY: | DWN. BY: Mbeuga 19.04.18 | CHK. BY: Strunk 19.04.18 | APP. BY: ----

DRAWING NO.: AUC201-PID-FL-01

DATE: 2019-01-31

SCALE:

PAGE NO.:



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

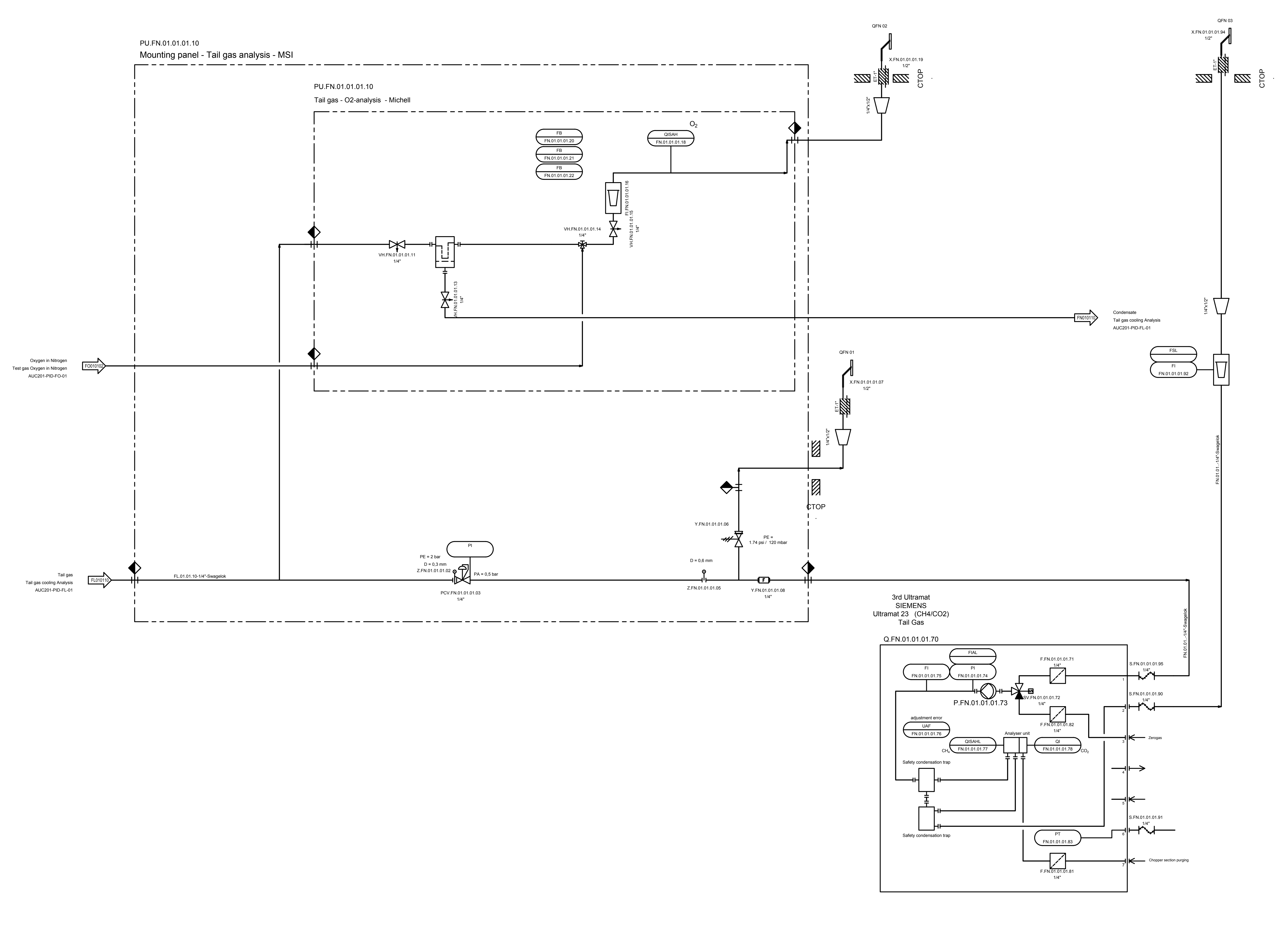
N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID RNG gas Analysis after PSA ####################	PROJ. NO. AUC201			DATE: 2019-01-31
	DSN. BY:	DWN. BY: Mbgl	CHK. BY: ZimT	APP. BY: ----
		2019-01-31	2019-01-31	SCALE:
PROJECT TITLE: Dane County WI BUP2500I Dane County	DRAWING NO: AUC201-PID-FM-01			PAGE NO. 64 / 72

K:\Projekte_P3D\Dane_County_AUC201_WI_BUP2500I\2D\c_P_and_I_Drawings\75_AUC201-PID-FM-01_RNG-Analysis-after-PSA.dwg



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

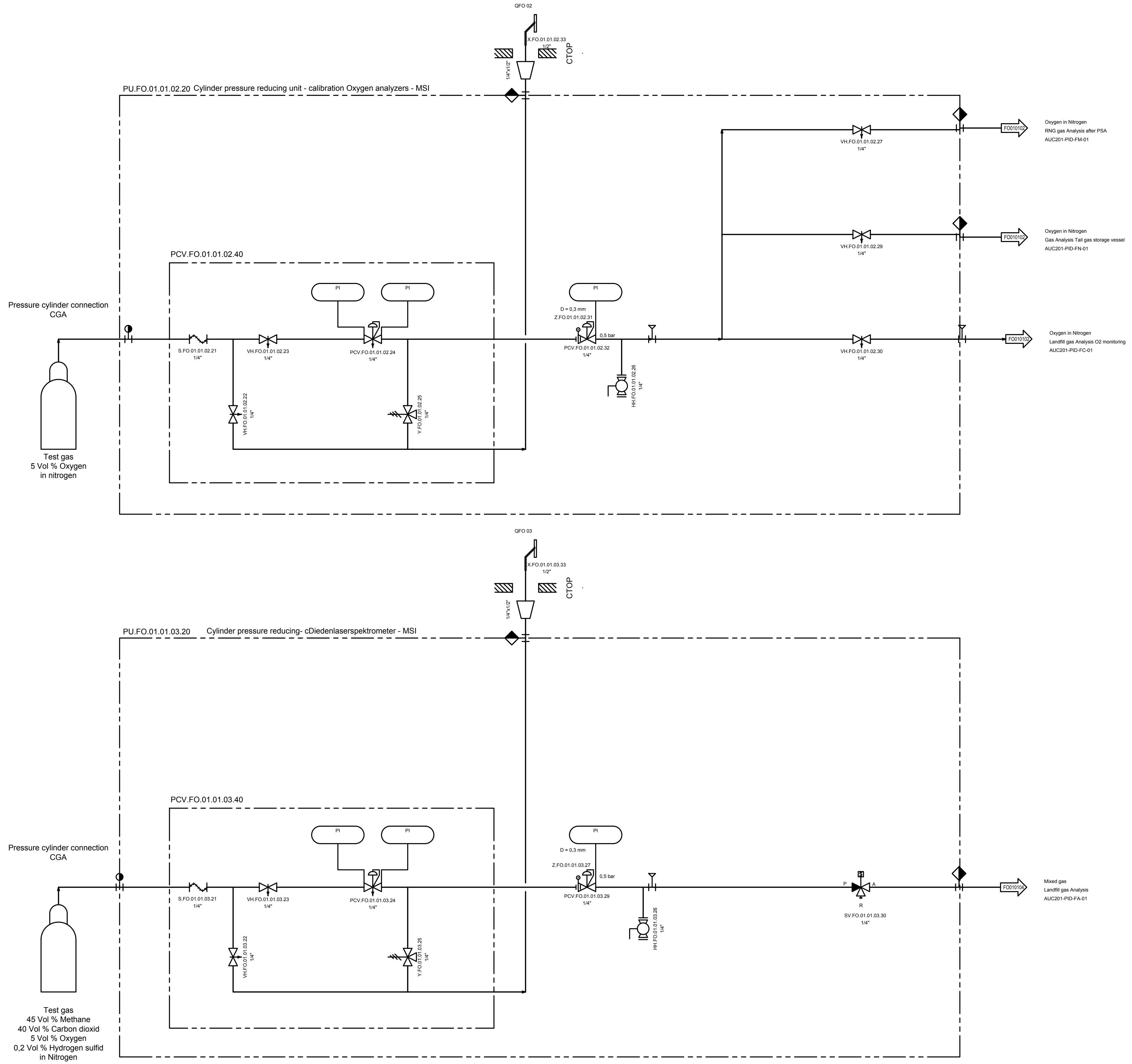
SHEET TITLE P&ID
Gas Analysis Tail gas storage vessel
###################

PROJ. NO. AUC201
DSN. BY: DWN. BY: Mbgl 2019-01-31 CHK. BY: ZimT 2019-01-31 APP. BY: ----

PROJECT TITLE
Dane County WI BUP2500I
Dane County

DRAWING NO: AUC201-PID-FN-01

DATE: 2019-01-31
SCALE:
PAGE NO. 65 / 72



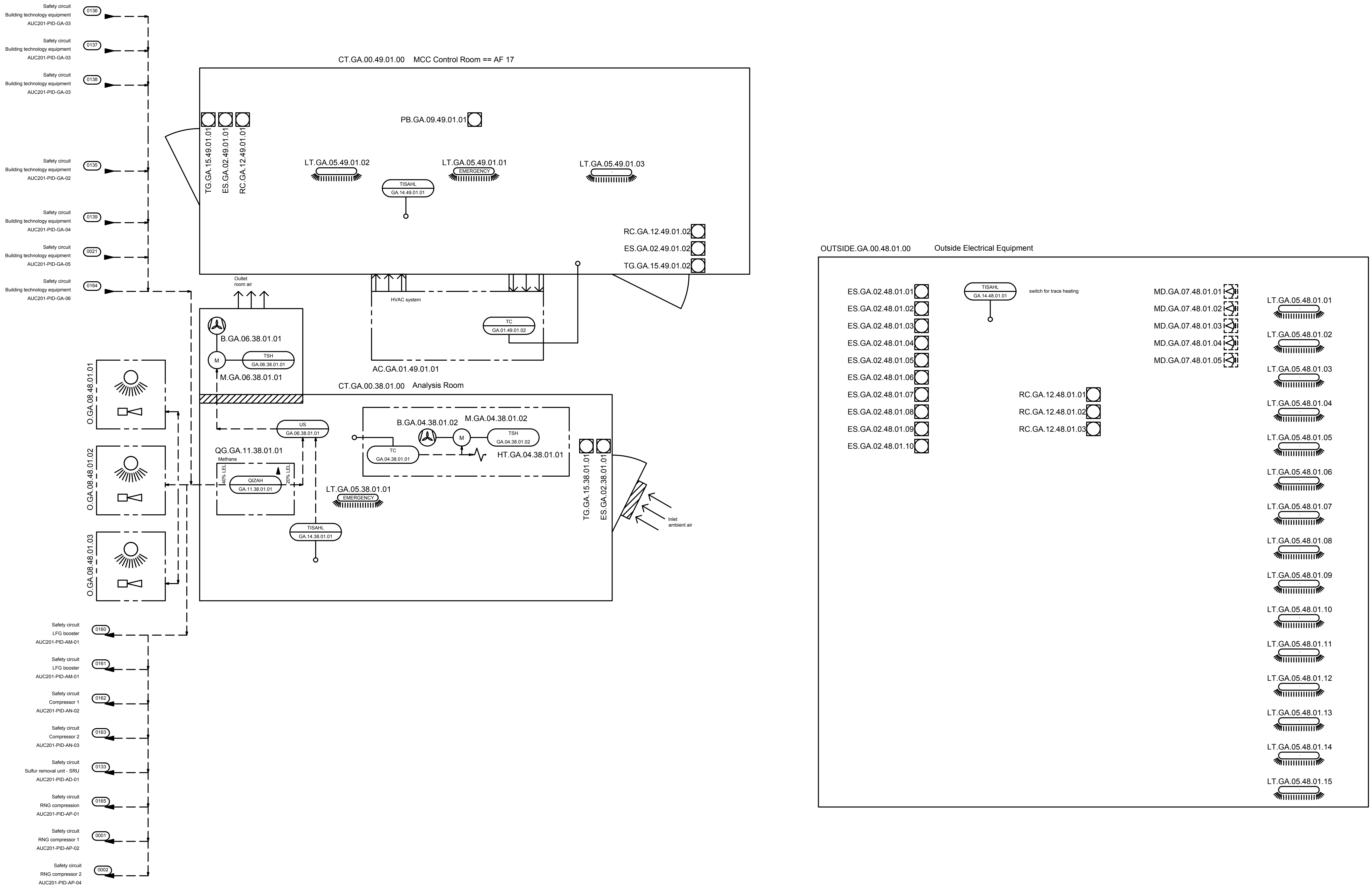
Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFERM™ ENERGY SYSTEMS
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID Test gas Oxygen in Nitrogen	PROJ. NO.: AUC201			DATE: 2019-01-31
	DSN. BY:	DWN. BY: Mbgl 2019-01-31	CHK. BY: ZimT 2019-01-31	APP. BY: ----
PROJECT TITLE: Dane County WI BUP2500I Dane County	DRAWING NO: AUC201-PID-FO-01			SCALE:
				PAGE NO. 66 / 72



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

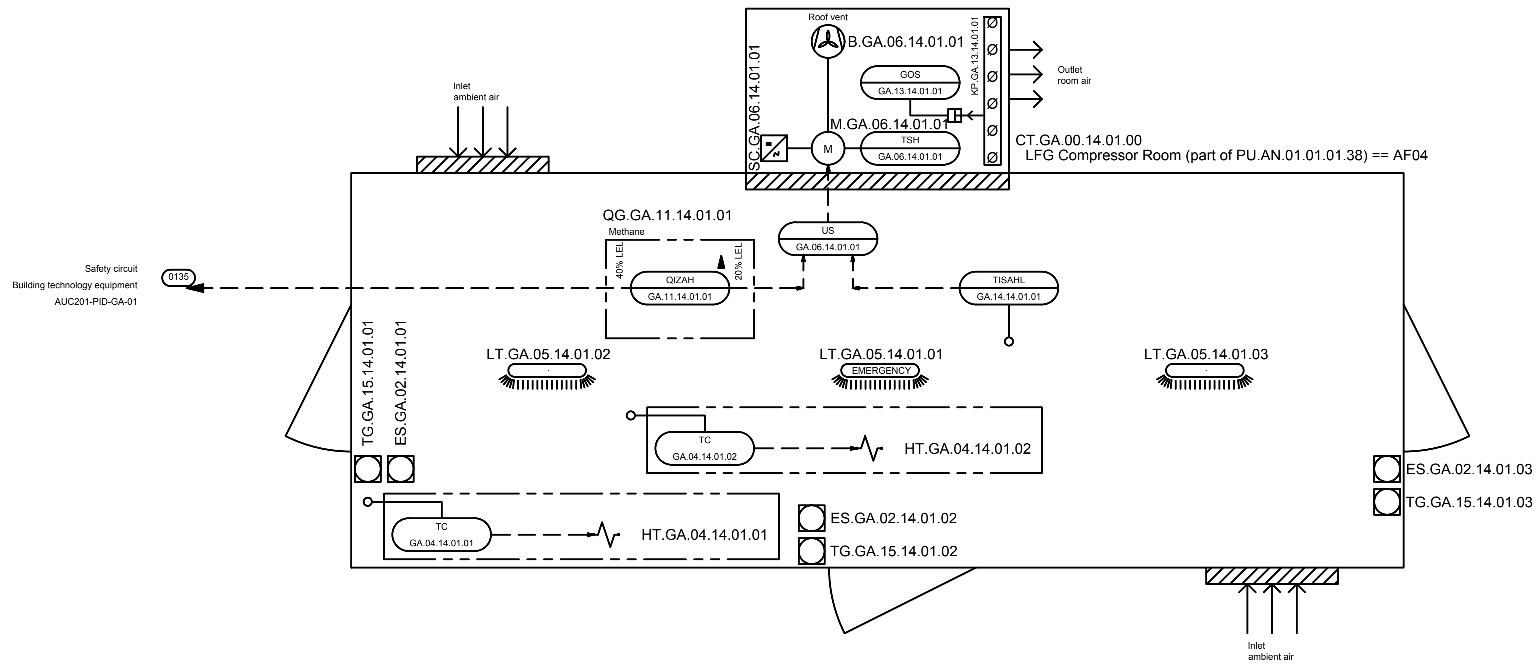
N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

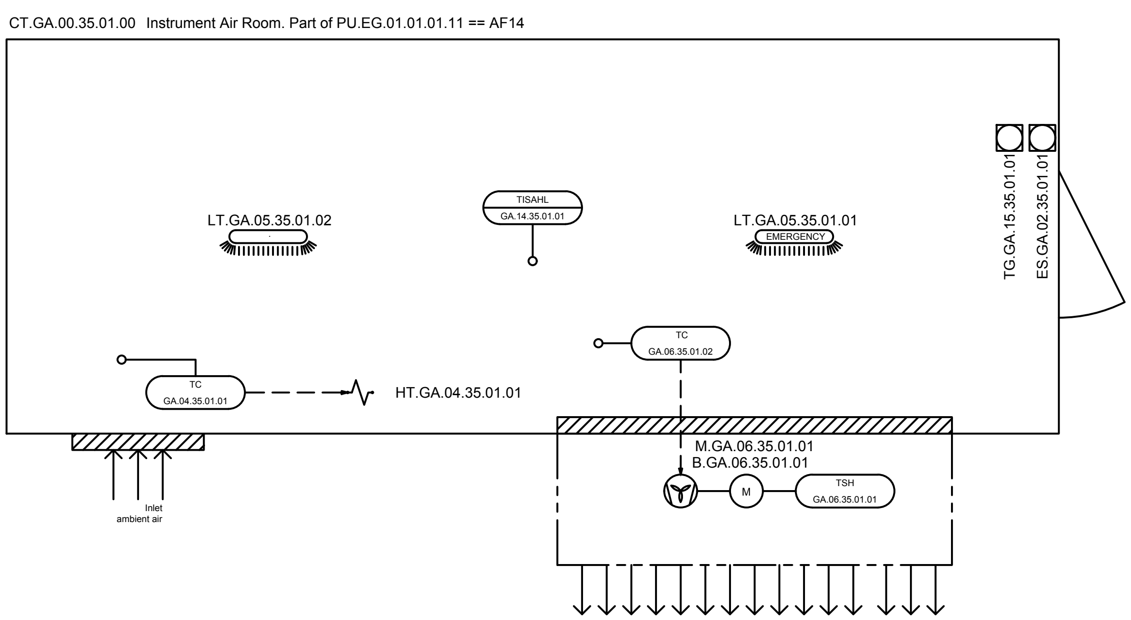
BIOFERM ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE	P&ID Building technology equipment MCC & Analysis rooms	PROJ. NO. AUC201			DATE: 2019-01-31
		DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----
			2019-01-31	2019-01-31	SCALE:
PROJECT TITLE	Dane County WI BUP2500I Dane County	DRAWING NO: AUC201-PID-GA-01			PAGE NO. 67 / 72





Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFERM™ ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID
Building technology equipment
LFG and Instrument air

PROJECT TITLE
Dane County WI BUP2500I
Dane County

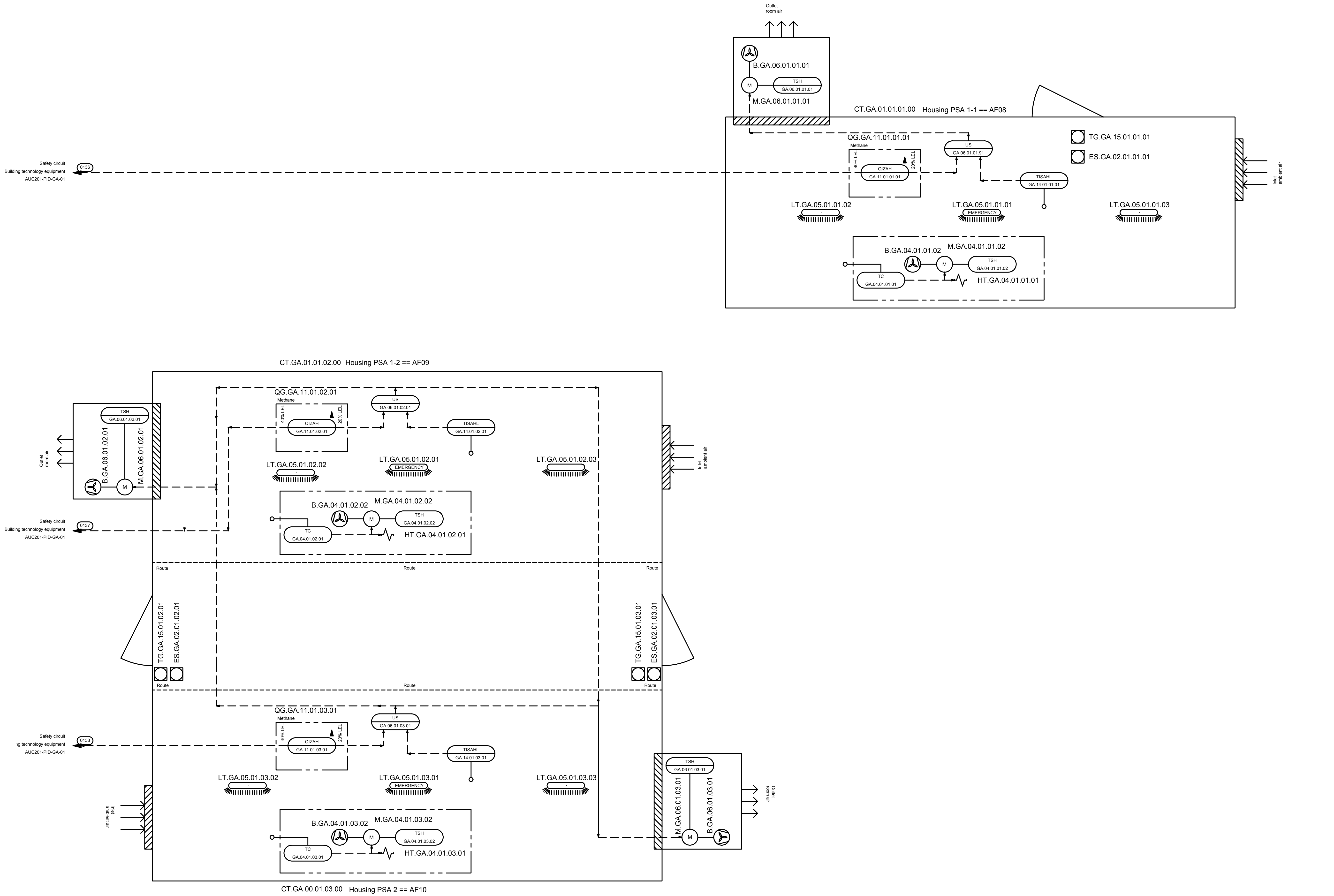
PROJ. NO. AUC201

DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

DRAWING NO: AUC201-PID-GA-02

DATE: 2019-01-31

SCALE:



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE: P&ID
Building technology equipment
PSA

PROJECT TITLE: Dane County WI BUP2500I
Dane County

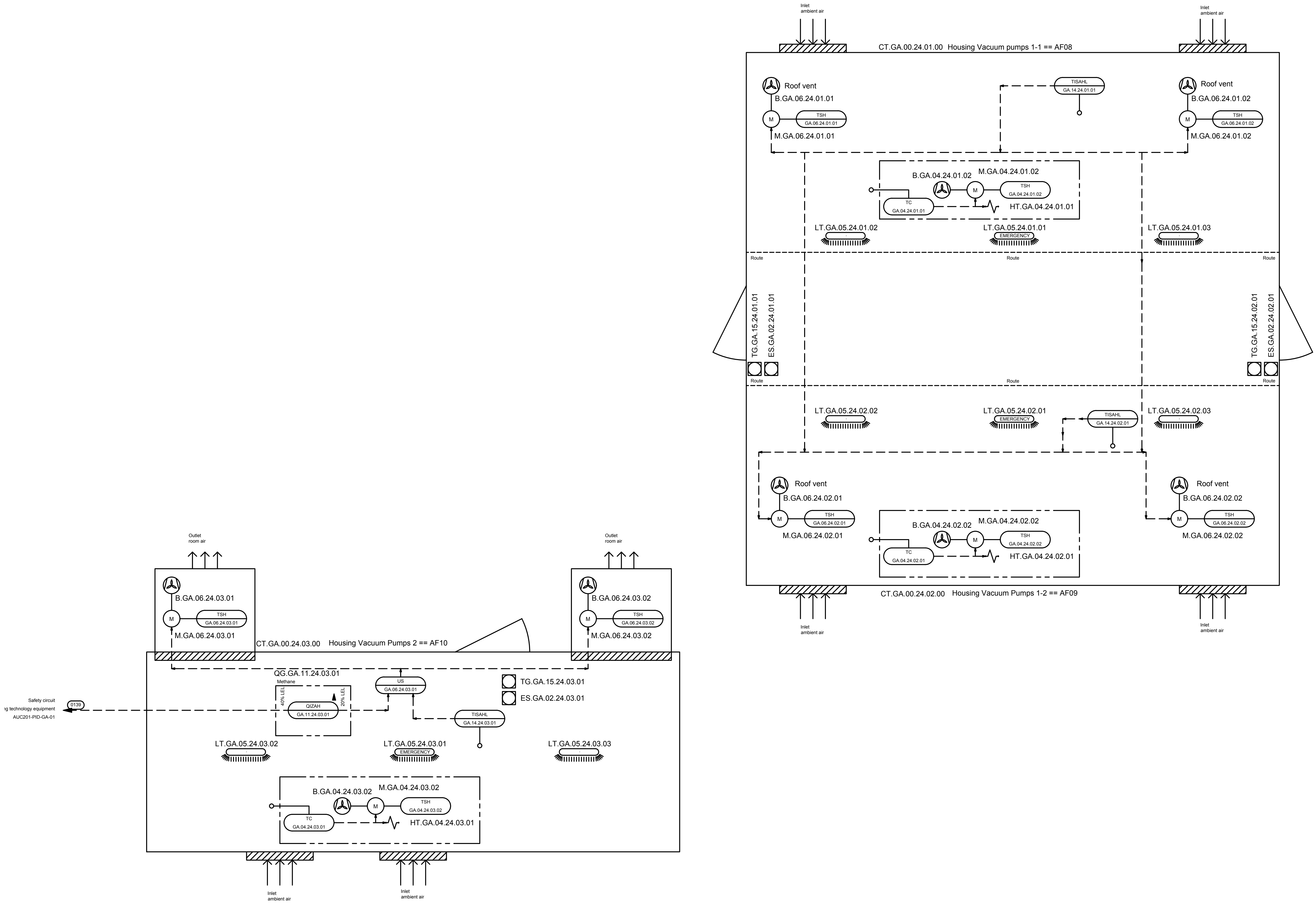
PROJ. NO.: AUC201

DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----
	2019-01-31	2019-01-31	

DRAWING NO.: AUC201-PID-GA-03

DATE: 2019-01-31

SCALE:



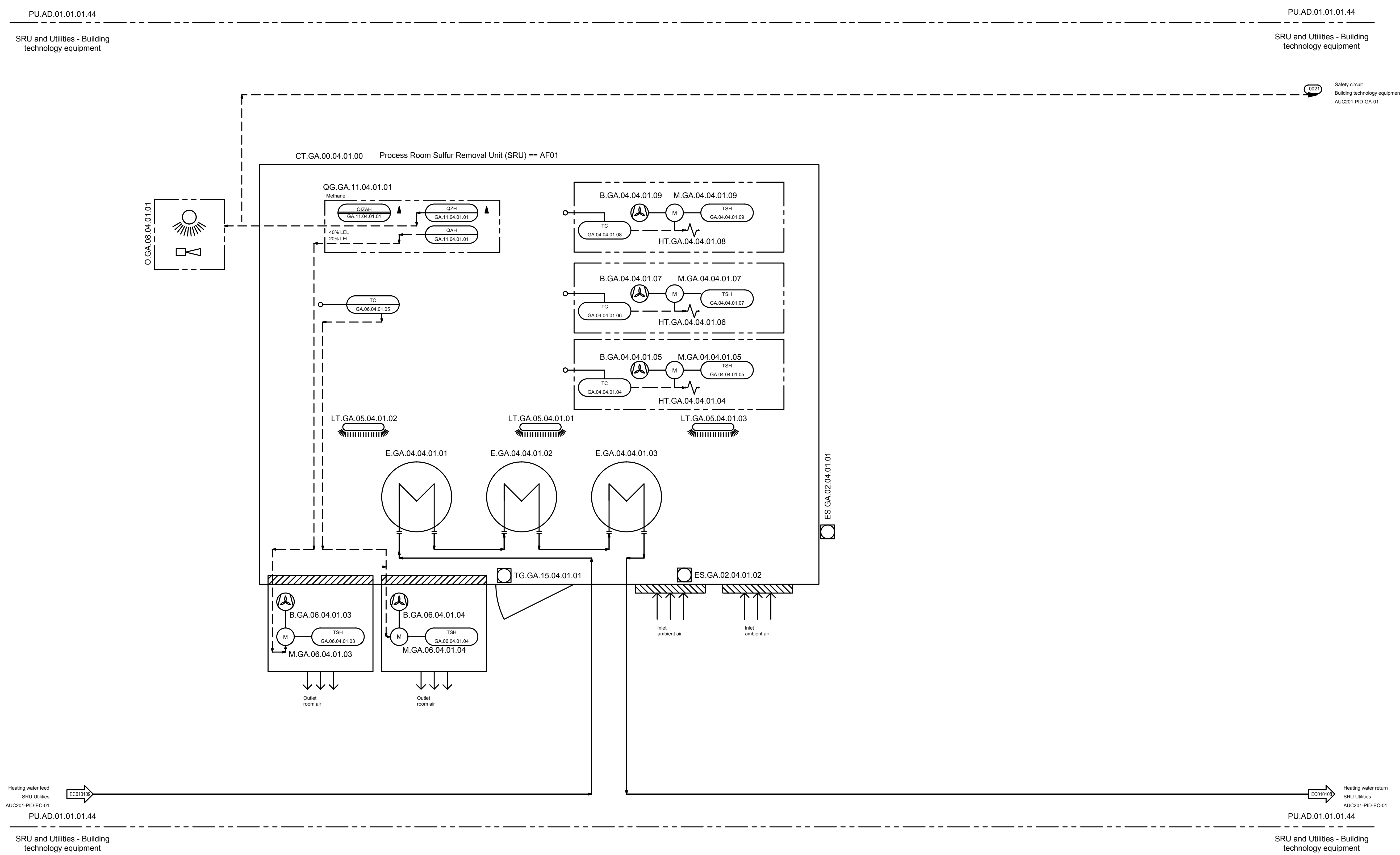
Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE	P&ID Building technology equipment Vacuum pumps
PROJECT TITLE	Dane County WI BUP2500I Dane County
PROJ. NO.	AUC201
DSN. BY:	
DWN. BY:	SctP 2019-01-31
CHK. BY:	ZimT 2019-01-31
APP. BY:	----
DRAWING NO:	AUC201-PID-GA-04
DATE:	2019-01-31
SCALE:	



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFERM™ ENERGY SYSTEMS

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID
Building technology equipment
SRU control room

PROJECT TITLE
Dane County WI BUP2500I
Dane County

PROJ. NO. AUC201

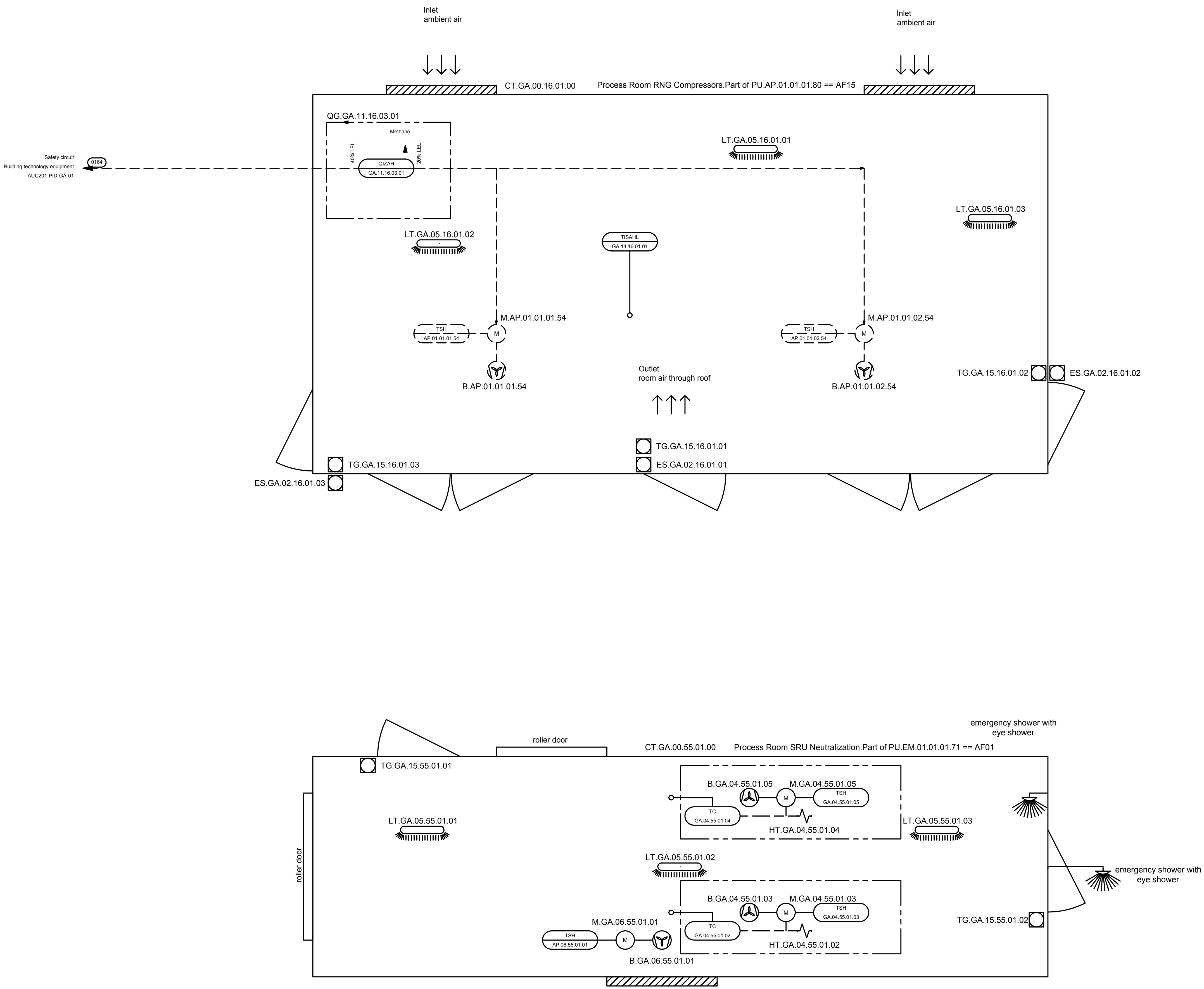
DSN. BY: | DWN. BY: SctP 2019-01-31 | CHK. BY: ZimT 2019-01-31 | APP. BY: ----

DRAWING NO: AUC201-PID-GA-05

DATE: 2019-01-31

SCALE:

PAGE NO.



Primary Gas Treatment	AD01 -> AM -> AN -> AF -> AE -> AC -> AA -> AO -> AP
Secondary Gas Treatment	DD -> DE -> DF -> DA
Utilities	EA -> EB -> EG -> EE -> ED -> AD02+03 -> EC -> EH -> EM -> EN
Analysis	FA -> FB -> FC -> FF -> FL -> FM -> FN -> FO
Building Technology	GA

N0.	REVISION	DATE
1	first Draft	11/22/17
2	change from 4 to 6 vessels	03/14/18
3	generally revised	04/23/18
4	Revision 3	12/01/18
5	Issue for construction / IFC	01/31/19
6	--- AS BUILT ---	07/25/19

BIOFERM™ ENERGY SYSTEMS
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
Gas Systems GmbH
Kronprinzenstrasse 30, D-45128 Essen, Germany

SHEET TITLE P&ID Building technology equipment RNG-compressors	PROJ. NO. AUC201				DATE: 2019-01-31
	DSN. BY:	DWN. BY: SctP	CHK. BY: ZimT	APP. BY: ----	SCALE:
PROJECT TITLE Dane County WI BUP2500I Dane County		2019-01-31	2019-01-31		
	DRAWING NO: AUC201-PID-GA-06				PAGE NO. 72 / 72

AUC201 Dane County

Hazardous Area Classification
according to API recommended practice 500,
third edition, December 2012

Input value
Calculated value or value from API 500
Updated data
Data needed

For relief valves (see chapter 8.2.3.4.1)
The minimum required classified area is a sphere with a radius of 3 m (10 ft) aournd the opening of the venting pipe, which is classified as Class I, Division 2.

Hazardous areas with a spherical shape have their center in the middle of the vent opening.

Openings of enclosures that are classified Class I, Division 2, i.e. air inlet grilles, air outlets or openings for pipe penetrations, have a shell of 1.5 m (5 ft.) thickness around it, which is also classified as Class 1, Division 2. Openings of enclosures that are classified Class I, Division 1 have a shell of 1.5 m (5 ft.) thickness around it, which is also classified as Class 1, Division 1, and another shell around it with a thickness of 1.5 m (5 ft.), which is classified Class I, Division 2.

The shell around sources located within non-vaportight walls do not end at the wall, but expand beyond the wall. In addition the whole volume enclosed by the non-vaportight walls is considered to be the same classified hazardous area.

Compressors or pumps handling flammable gases or vapors lighter than air, that are situated in a nonenclosed or enclosed area are surrounded by a shell of 3 m (10 ft.) classified as Class 1, Division 2 if pressure inside the compressor is below 19 bar and ventilation is adequately. If operatiing pressure of the compressor is above 19 bar (a), the shell is extended to 7.5m (25 ft.) for all non-vaportight walls and air outlets. (see chapter 14.3.8)

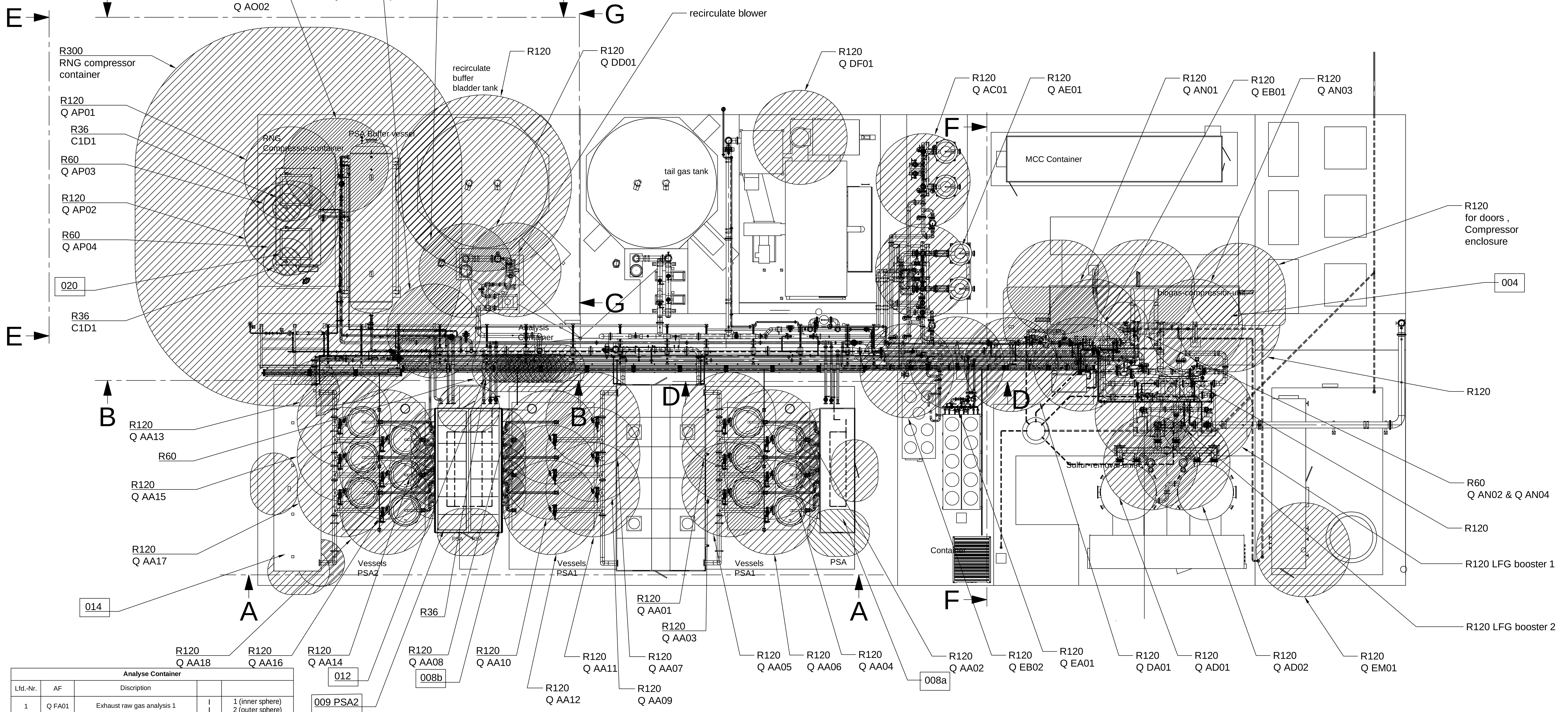
Enclosed areas are adequately ventilated if minimum six air changes per hour are provided.

Important notice: Special rules apply for Analyzer Buildings/ Enclosures. Even though the enclosure can be unclassified by means of installation of combustible gas detection equipment in addition to adequate ventilation, all electrical equipment shall be suitable for an area classified as Class I, Division 2. Otherwise malfunction of the ventilation has to trigger immediate power-off of all electrical equipment within the enclosure automatically.

Source number	Description	Hazardous Area Classification		Tag number of source	Type of vent	nominal diameter of vent	diameter of vent (d)	shape of hazardous area	height of vent opening above ground (L+h)		radius (R)		vertical extention [H]		distance of lower limitation (h)		height of lower limitation (L) above ground level	
		Class	Division				[mm]		[m]	[ft, inch]	[m]	[ft, inch]	[m]	[ft, inch]	[m]	[ft, inch]	[m]	[ft, inch]
Q AD01	Overpressure protection biological desulfurization scrubber 1	I	2	X.AD.01.01.01.16	vertical pipe upwards	6 "	152,4	sphere	18,3	60	3,0	10	6,1	20	3,0	10	15,3	50 1/8
Q AD02	Overpressure protection biological desulfurization scrubber 2	I	2	X.AD.01.01.02.16	vertical pipe upwards	6 "	152,4	sphere	18,3	60	3,0	10	6,1	20	3,0	10	15,3	50 1/8
Q AN01	Overpressure proctection LFG compressor 1	I	2	X.AN.01.01.01.42	vertical pipe upwards	3 "	76,2	sphere	4,0	13 1/8	3,0	10	6,1	20	3,0	10	1,0	3 1/8
Q AN02	Vent line LFG compressor 1 , maintenance	I	2	X.AN.01.01.01.36	lambda exhaust	1/2 "	12,7	sphere	4,0	13 1/8	1,5	5	2,0	6 4/8	1,5	5	2,5	8 1/8
Q AN03	Overpressure proctection LFG compressor 2	I	2	X.AN.01.01.02.42	vertical pipe upwards	3 "	76,2	sphere	4,0	13 1/8	3,0	10	6,1	20	3,0	10	1,0	3 1/8
Q AN04	Vent line LFG compressor 2, maintenance	I	2	X.AN.01.01.02.36	lambda exhaust	1/2 "	12,7	sphere	4,0	13 1/8	1,5	5	2,0	6 4/8	1,5	5	2,5	8 1/8
Q AE01	Overpressure protection VOC removal	I	2	X.AE.01.01.01.28	vertical pipe upwards	1 1/2 "	38,1	sphere	7,5	24 5/8	3,0	10	6,1	20	3,0	10	4,5	14 5/8
Q AC01	Overpressure protection AC desulphurization	I	2	X.AC.01.01.01.38	vertical pipe upwards	1 1/2 "	38,1	sphere	6,2	20 1/8	3,0	10	6,1	20	3,0	10	3,1	10 2/8
Q AA01	Overpressure protection PSA1, Vessel 1	I	2	X.AA.01.01.01.11	vertical pipe upwards	1 1/2 "	38,1	sphere	5,6	18 3/8	3,0	10	6,1	20	3,0	10	2,6	8 3/8
Q AA02	Overpressure protection PSA1, Vessel 2	I	2	X.AA.01.01.02.11	vertical pipe upwards	1 1/2 "	38,1	sphere	3,3	10 7/8	3,0	10	6,1	20	3,0	10	0,3	7/8
Q AA03	Overpressure protection PSA1, Vessel 3	I	2	X.AA.01.01.03.11	vertical pipe upwards	1 1/2 "	38,1	sphere	5,6	18 3/8	3,0	10	6,1	20	3,0	10	2,6	8 3/8
Q AA04	Overpressure protection PSA1, Vessel 4	I	2	X.AA.01.01.04.11	vertical pipe upwards	1 1/2 "	38,1	sphere	3,3	10 7/8	3,0	10	6,1	20	3,0	10	0,3	7/8
Q AA05	Overpressure protection PSA1, Vessel 5	I	2	X.AA.01.01.05.11	vertical pipe upwards	1 1/2 "	38,1	sphere	5,6	18 3/8	3,0	10	6,1	20	3,0	10	2,6	8 3/8
Q AA06	Overpressure protection PSA1, Vessel 6	I	2	X.AA.01.01.06.11	vertical pipe upwards	1 1/2 "	38,1	sphere	3,3	10 7/8	3,0	10	6,1	20	3,0	10	0,3	7/8
Q AA07	Overpressure protection PSA1, Vessel 7	I	2	X.AA.02.01.01.11	vertical pipe upwards	1 1/2 "	38,1	sphere	5,6	18 3/8	3,0	10	6,1	20	3,0	10	2,6	8 3/8
Q AA08	Overpressure protection PSA1, Vessel 8	I	2	X.AA.02.01.02.11	vertical pipe upwards	1 1/2 "	38,1	sphere	3,3	10 7/8	3,0	10	6,1	20	3,0	10	0,3	7/8
Q AA09	Overpressure protection PSA1, Vessel 9	I	2	X.AA.02.01.03.11	vertical pipe upwards	1 1/2 "	38,1	sphere	5,6	18 3/8	3,0	10	6,1	20	3,0	10	2,6	8 3/8
Q AA10	Overpressure protection PSA1, Vessel 10	I	2	X.AA.02.01.04.11	vertical pipe upwards	1 1/2 "	38,1	sphere	3,3	10 7/8	3,0	10	6,1	20	3,0	10	0,3	7/8
Q AA11	Overpressure protection PSA1, Vessel 11	I	2	X.AA.02.01.05.11	vertical pipe upwards	1 1/2 "	38,1	sphere	5,6	18 3/8	3,0	10	6,1	20	3,0	10	2,6	8 3/8
Q AA12	Overpressure protection PSA1, Vessel 12	I	2	X.AA.02.01.06.11	vertical pipe upwards	1 1/2 "	38,1	sphere	3,3	10 7/8	3,0	10	6,1	20	3,0	10	0,3	7/8
Q AA13	Overpressure protection PSA2, Vessel 1	I	2	X.AA.01.02.01.11	vertical pipe upwards	1 1/2 "	38,1	sphere	3,3	10 7/8	3,0	10	6,1	20	3,0	10	0,3	7/8
Q AA14	Overpressure protection PSA2, Vessel 2	I	2	X.AA.01.02.02.11	vertical pipe upwards	1 1/2 "	38,1	sphere	3,3	10 7/8	3,0	10	6,1	20	3,0	10	0,3	7/8
Q AA15	Overpressure protection PSA2, Vessel 3	I	2	X.AA.01.02.03.11	vertical pipe upwards	1 1/2 "	38,1	sphere	3,3	10 7/8	3,0	10	6,1	20	3,0	10	0,3	7/8
Q AA16	Overpressure protection PSA2, Vessel 4	I	2	X.AA.01.02.04.11	vertical pipe upwards	1 1/2 "	38,1	sphere	3,3	10 7/8	3,0	10	6,1	20	3,0	10	0,3	7/8
Q AA17	Overpressure protection PSA2, Vessel 5	I	2	X.AA.01.02.05.11	vertical pipe upwards	1 1/2 "	38,1	sphere	3,3	10 7/8	3,0	10	6,1	20	3,0	10	0,3	7/8
Q AA18	Overpressure protection PSA2, Vessel 6	I	2	X.AA.01.02.06.11	vertical pipe upwards	1 1/2 "	38,1	sphere	3,3	10 7/8	3,0	10	6,1	20	3,0	10	0,3	7/8
Q AA19	Overpressure protection PSA intermediate vessel	I	2	X.AA.01.01.01.69	vertical pipe upwards	1 1/2 "	38,1	sphere	7,2	23 4/8	3,0	10	6,1	20	3,0	10	4,1	13 4/8
Q AA20	Vent line PSA intermediate vessel	I	2	X.AA.01.01.01.XX	vertical pipe upwards	1 1/2 "	38,1	sphere	6,0	19 5/8	3,0	10	6,1	20	3,0	10	3,0	9 6/8
Q AO01	Overpressure protection Biomethane vessel	I	2	X.AO.01.01.01.28	vertical pipe upwards	1 "	25,4	sphere	7,2	23 4/8	3,0	10	6,1	20	3,0	10	4,1	13 4/8
Q AO02	Vent line Biomethane vessel, maintenance	I	2	X.AO.01.01.01.29	vertical pipe upwards	1 1/2 "	38,1	sphere	7,2	23 4/8	3,0	10	6,1	20	3,0	10	4,1	13 4/8
Q AP01	Overpressure protection RNG compressor 1	I	2	X.AP.01.01.01.80	vertical pipe upwards	2 "	50,8	sphere	3,8	12 4/8	3,0	10	6,1	20	3,0	10	0,8	2 4/8
Q AP02	Overpressure protection RNG compressor 2	I	2	X.AP.01.01.02.80	vertical pipe upwards	2 "	50,8	sphere	3,8	12 4/8	3,0	10	6,1	20	3,0	10	0,8	2 4/8
Q AP03	Vent line crankcase breather RNG compressor 1	I I	1 (inner sphere) 2 (outer sphere)		vertical pipe upwards	1/2 "	12,7	sphere	3,8	12 4/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	2,8	9 1/8
Q AP04	Vent line crankcase breather RNG compressor 2	I I	1 (inner sphere) 2 (outer sphere)		vertical pipe upwards	1/2 "	12,7	sphere	3,8	12 4/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	2,8	9 1/8
Q DA01	Vent line condensate vessel	I	2	X.DA.01.01.01.07	lambda exhaust	1 "	25,4	sphere	6,0	19 5/8	3,0	10	3,0	10	1,5	4 7/8	4,5	14 6/8
Q DD02	Overpressure protection recirculate bladder tank	I	2	X.DD.01.02.01.66	vertical pipe upwards	6 "	152,4	sphere	0,3	1 4/8	1,5	4 7/8	3,0	9 7/8	1,5	4 7/8	0,0	0
Q DD01	Vent line excess air recirculate bladder tank 1	I	2	X.DD.01.02.01.67	vertical pipe upwards	13 "	330,2	sphere	3,3	10 7/8	3,0	10	6,1	20	3,0	10	0,0	0
Q DD03	Vent line excess air recirculate bladder tank 2	I	2	X.DD.01.02.01.68	vertical pipe upwards	6 "	152,4	sphere	0,3	1 4/8	1,5	4 7/8	3,0	9 7/8	1,5	4 7/8	0,0	0
Q DE02	Overpressure protection tail gas bladder tank,safety relief va	not classified		X.DE.01.01.01.66	vertical pipe upwards	---	---	---	---	---	---	---	---	---	---	---	---	---
Q DE03	Vent line excess air tail gas bladder tank 1	not classified		X.DE.01.01.01.67	vertical pipe upwards	---	---	---	---	---	---	---	---	---	---	---	---	---
Q DE04	Overpressure protection tail gas combustion	not classified		DH.DE.01.01.01.24	vertical pipe upwards	---	---	---	---	---	---	---	---	---	---	---	---	---
Q DE05	Vent line excess air tail gas bladder tank 2	not classified		X.DE.01.01.02.67	vertical pipe upwards	---	---	---	---	---	---	---	---	---	---	---	---	---
Q DF01	Chimney RTO	I	2	X.DF.01.01.01.07	chimney	40 "	1016,0	sphere	9,2	30	3,0	10	6,1	20	3,0	10	6,1	20
Q EA01	Overpressure protection cooling water	I	2	X.EA.01.01.01.68	vertical pipe upwards	2 "	50,8	sphere	6,0	19 5/8	3,0	10	6,1	20	3,0	10	3,0	9 6/8
Q EB01	Overpressure protection chilled water 1	I	2	X.EB.01.01.01.40	vertical pipe upwards	2 1/2 "	63,5	sphere	6,0	19 5/8	3,0	10	6,1	20	3,0	10	3,0	9 6/8
Q EB02	Overpressure protection chilled water 2	I	2	X.EB.01.04.01.08	vertical pipe upwards	6 "	152,4	sphere	6,0	19 5/8	3,0	10	6,1	20	3,0	10	3,0	9 6/8
Q EM01	Vent line Mixing station mixing tank	I	2	X.EM.01.04.01.08	vertical pipe upwards	4 "	101,6	sphere	5,0	16 3/8	3,0	10	6,1	20	3,0	10	2,0	6 3/8
Q FA01	Exhaust raw gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)	X.FA.01.01.01.29	lambda exhaust	1/2 "	12,7	sphere	5,0	16 3/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	4,0	13 1/8
Q FA02	Exhaust raw gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)	X.FA.01.01.01.07	lambda exhaust	1/2 "	12,7	sphere	5,0	16 3/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	4,0	13 1/8
Q FA03	Exhaust raw gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)	X.FA.01.01.01.93	lambda exhaust	1/2 "	12,7	sphere	5,0	16 3/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	4,0	13 1/8
Q FB01	Exhaust product gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)	X.FB.01.01.01.29	lambda exhaust	1/2 "	12,7	sphere	5,0	16 3/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	4,0	13 1/8
Q FB02	Exhaust product gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)	X.FB.01.01.01.07	lambda exhaust	1/2 "	12,7	sphere	5,0	16 3/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	4,0	13 1/8
Q FB03	Exhaust product gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)	X.FB.01.01.01.93	lambda exhaust	1/2 "	12,7	sphere	5,0	16 3/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	4,0	13 1/8
Q FC01	Exhaust raw gas oxygen analysis 1	I I	1 (inner sphere) 2 (outer sphere)	X.FC.01.01.01.08	lambda exhaust	1/2 "	12,7	sphere	5,0	16 3/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	4,0	13 1/8
Q FC02	Exhaust raw gas oxygen analysis 2	I I	1 (inner sphere) 2 (outer sphere)	X.FC.01.01.01.26	lambda exhaust	1/2 "	12,7	sphere	5,0	16 3/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	4,0	13 1/8
Q FF01	Exhaust raw gas H2S analysis 1	I I	1 (inner sphere) 2 (outer sphere)	X.FF.01.01.01.09	lambda exhaust	1/2 "	12,7	sphere	5,0	16 3/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	4,0	13 1/8
Q FF02	Exhaust raw gas H2S analysis 2	I I	1 (inner sphere) 2 (outer sphere)	X.FF.01.01.01.61	lambda exhaust	1/2 "	12,7	sphere	5,0	16 3/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	4,0	13 1/8
Q FF03	Exhaust raw gas H2S analysis 3	I I	1 (inner sphere) 2 (outer sphere)	X.FF.01.01.02.09	lambda exhaust	1/2 "	12,7	sphere	5,0	16 3/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	4,0	13 1/8
Q FF04	Exhaust raw gas H2S analysis 4	I I	1 (inner sphere) 2 (outer sphere)	X.FF.01.01.02.61	lambda exhaust	1/2 "	12,7	sphere	5,0	16 3/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	4,0	13 1/8
Q FM01	Exhaust process gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)	X.FM.01.01.01.29	lambda exhaust	1/2 "	12,7	sphere	5,0	16 3/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	4,0	13 1/8
Q FM02	Exhaust process gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)	X.FM.01.01.01.07	lambda exhaust	1/2 "	12,7	sphere	5,0	16 3/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	4,0	13 1/8
Q FM03	Exhaust process gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)	X.FM.01.01.01.93	lambda exhaust	1/2 "	12,7	sphere	5,0	16 3/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	4,0	13 1/8
Q FN01	Exhaust off gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)	X.FN.01.01.01.29	lambda exhaust	1/2 "	12,7	sphere	5,0	16 3/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	4,0	13 1/8
Q FN02	Exhaust off gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)	X.FN.01.01.04.07	lambda exhaust	1/2 "	12,7	sphere	5,0	16 3/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	4,0	13 1/8
Q FN03	Exhaust off gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)	X.FN.01.01.01.93	lambda exhaust	1/2 "	12,7	sphere	5,0	16 3/8	0,5 (inner sphere) 1 (outer sphere)	18" (inner sphere) 3' (outer sphere)	2,0	6 4/8	1,0	3 2/8	4,0	13 1/8
	LFG Booster 1	I	2	B.AM.01.01.01.16	---	---	---	shell	---	---	3,0	10	---	---	---	---	---	---
	LFG Booster 2	I	2	B.AM.01.01.02.16	---	---	---	shell	---	---	3,0	10	---	---	---	---	---	---
	Recirculate Blower	I	2	B.DD.01.02.01.39	---	---	---	shell	---	---	3,0	10	---	---	---	---	---	---
	Recirculate buffer bladder tank	I	2	V.DD.01.02.01.35	---	---	---	shell	8,5	27 7/8	3,0	10	13,1	42 7/8	0	0	13,1	42 7/8

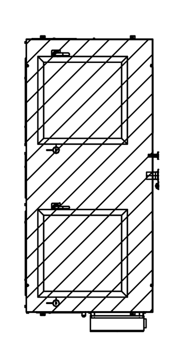
Enclosures	Hazardous Area Classification		Tag number of source	Type of vent	nominal diameter of vent	inner diameter of vent (d)	shape of hazardous area	height of vent opening above ground (L+h)		radius (R)		vertical extention [H]		distance of lower limitation (h)		height of lower limitation (L)	
	Class	Division				[mm]		[m]	[ft, inch]	[m]	[ft, inch]	[m]	[ft, inch]	[m]	[ft, inch]	[m]	[ft, inch]
MCC Control Room	not classified			---	---	---	---	---	---	---	---	---	---	---	---	---	---
Analysis Room	not classified (see notice)			---	---	---	---	---	---	---	---	---	---	---	---	---	---
Instrument Air Room	not classified			---	---	---	---	---	---	---	---	---	---	---	---	---	---
LFG Compressor Room	I	2		---	---	---	shell around doors, vents and non-vaportight walls of the enclosure	---	---	3,0	10'	3,0	10'	---	---	3,0	10'
Housing PSA 1-1 valve skid	I	2		---	---	---	shell around doors, vents and non-vaportight walls of the enclosure	---	---	3,0	10'	3,0	10'	---	---	3,0	10'
Housing PSA 1-2 + PSA2 valve skid	I	2		---	---	---	shell around doors, vents and non-vaportight walls of the enclosure	---	---	3,0	10'	3,0	10'	---	---	3,0	10'
Enclosure Vacuum pumps 1-8	not classified			---	---	---	---	---	---	---	---	---	---	---	---	---	---
Enclosure Vacuum pumps 9-12	I	2		---	---	---	shell around doors, vents and non-vaportight walls of the enclosure	---	---	3,0	10'	3,0	10'	---	---	3,0	10'
Process Room Sulfur Removal Unit	not classified			---	---	---	---	---	---	---	---	---	---	---	---	---	---
Process Room Mixing station	not classified			---	---	---	---	---	---	---	---	---	---	---	---	---	---
Housing Product Gas Compressors	I	2		---	---	---	shell around doors, vents and non-vaportight walls of the enclosure	---	---	7,5	25'	7,5	25'	---	---	7,5	25'

Top view

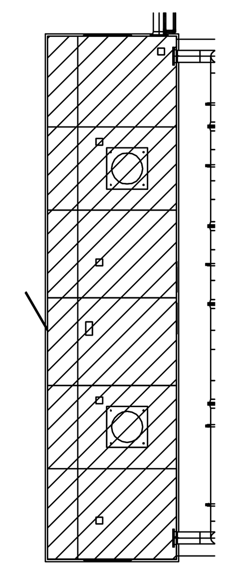


Analyse Container				
Lfd.-Nr.	AF	Discription		
1	Q FA01	Exhaust raw gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)
2	Q FA02	Exhaust raw gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)
3	Q FA03	Exhaust raw gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)
4	Q FB01	Exhaust product gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)
5	Q FB02	Exhaust product gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)
6	Q FB03	Exhaust product gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)
7	Q FC01	Exhaust raw gas oxygen analysis 1	I I	1 (inner sphere) 2 (outer sphere)
8	Q FC02	Exhaust raw gas oxygen analysis 2	I I	1 (inner sphere) 2 (outer sphere)
9	Q FF01	Exhaust raw gas H2S analysis 1	I I	1 (inner sphere) 2 (outer sphere)
10	Q FF02	Exhaust raw gas H2S analysis 2	I I	1 (inner sphere) 2 (outer sphere)
11	Q FF03	Exhaust raw gas H2S analysis 3	I I	1 (inner sphere) 2 (outer sphere)
12	Q FF04	Exhaust raw gas H2S analysis 4	I I	1 (inner sphere) 2 (outer sphere)
13	Q FM01	Exhaust process gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)
14	Q FM02	Exhaust process gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)
15	Q FM03	Exhaust process gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)
16	Q FN01	Exhaust off gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)
17	Q FN02	Exhaust off gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)
18	Q FN03	Exhaust off gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)

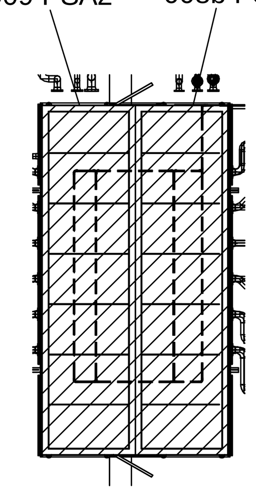
020 RNG Compressor-container



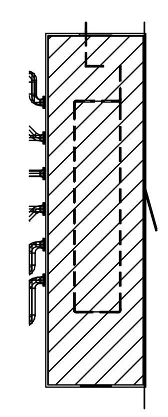
014 vacuum pumps PSA2



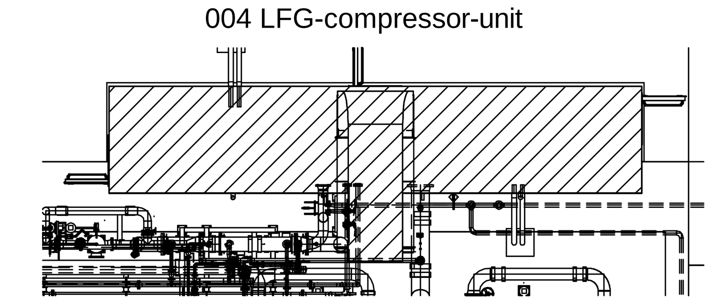
009 PSA2 008b PSA



008a PSA



004 LFG-compressor-unit



DRAWINGS		
sections	DWG	sheet
Top view	x	1
A-A	x	2
B-B	x	3
C-C	x	4
D-D	x	5
E-E	x	6
F-F	x	7
G-G	x	8

EQP / Modul Designation

Item	*description*	*AF....*	-
004	LFG compression	AF04	
008a	PSA -1st stage-valve modul	AF08	
008b	PSA -1st stage-valve modul	AF09	
009	PSA - 2nd stage-valve modul	AF10	
012	Analysis container	AF05	
014	vacuum pump modul; 2nd stage	AF10	
020	RNG compressor	AF15	

Hazardous Area classification derived from NFPA 497 and API RP500.

Class I, Division 1

Class I,Division 2

N0.	REVISION	DATE
1	as built	07/26/2019

BIOFERM ENERGY SYSTEMS

VIESSMANN Group

BIOFerm Energy Systems

440 Science Drive, Suite 300, Madison, WI 53711

Carbotech

VIESSMANN Group

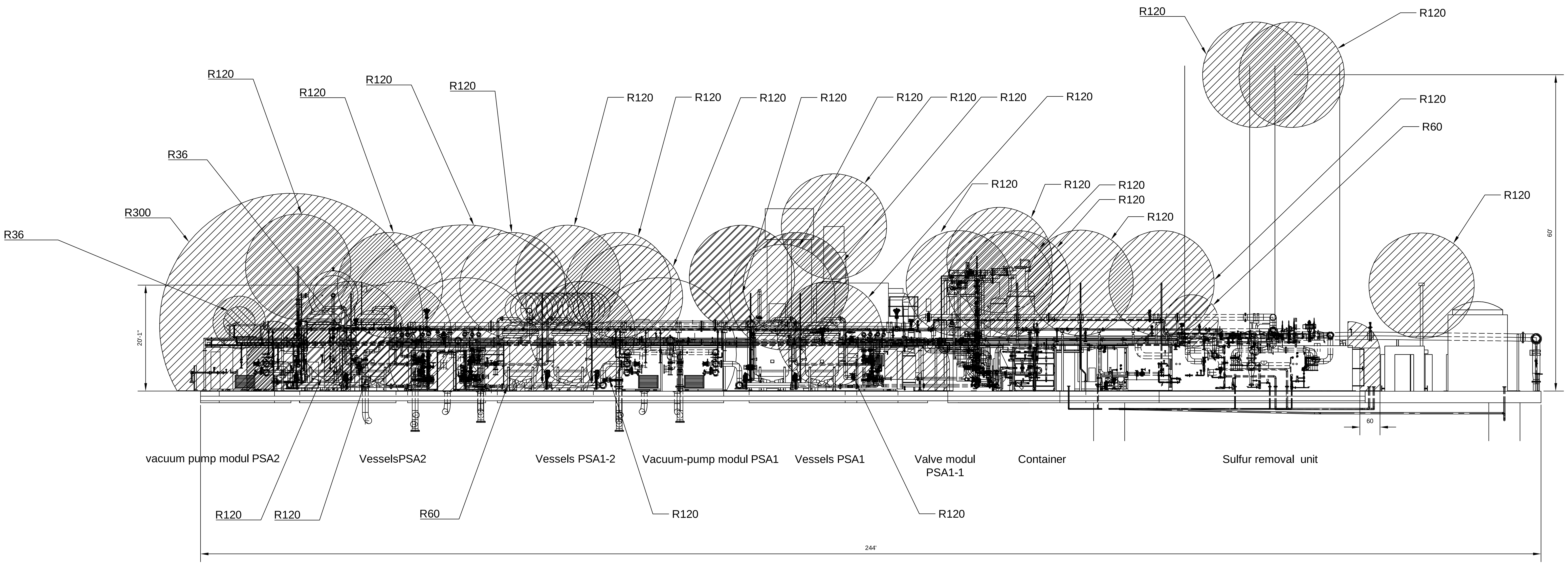
Carbotech Gas Systems GmbH

Kronprinzenstraße 30, 45128 Essen, Germany

SHEET TITLE	DWG EX-Zone-plant Hazardous-Zone-plan front view	PROJ. NO.	AUC201	DATE:	8/08/2018
		DSN. BY:	DWN. BY: DauHG 8/08/2018	CHK. BY: FieT 8/08/2018	APP. BY: ----
PROJECT TITLE	Dane County WI BUP 2500I Dane County	DRAWING NO:	AUC201-HZP-00-01	SCALE:	1 / 100
				PAGE NO.	1 / 9

K:\Projekte_P3D\Dane_County_AUC201_WI_BUP2500I\2D\n_Hazardous_Zone_Classification\AUC201-HZP-00-01-Hazard-Zone-plan-Top_and_Front-View.dwg

Front view



DRAWINGS		
sections	DWG	sheet
Top view	x	1
A-A	x	2
B-B	x	3
C-C	x	4
D-D	x	5
E-E	x	6
F-F	x	7
G-G	x	8
Front view	x	9

view isn't true scale !

Hazardous Area classification derived from NFPA 497 and API RP500.

Class I, Division 1

Class I,Division 2

N0.	REVISION	DATE
1	as built	07/26/2019

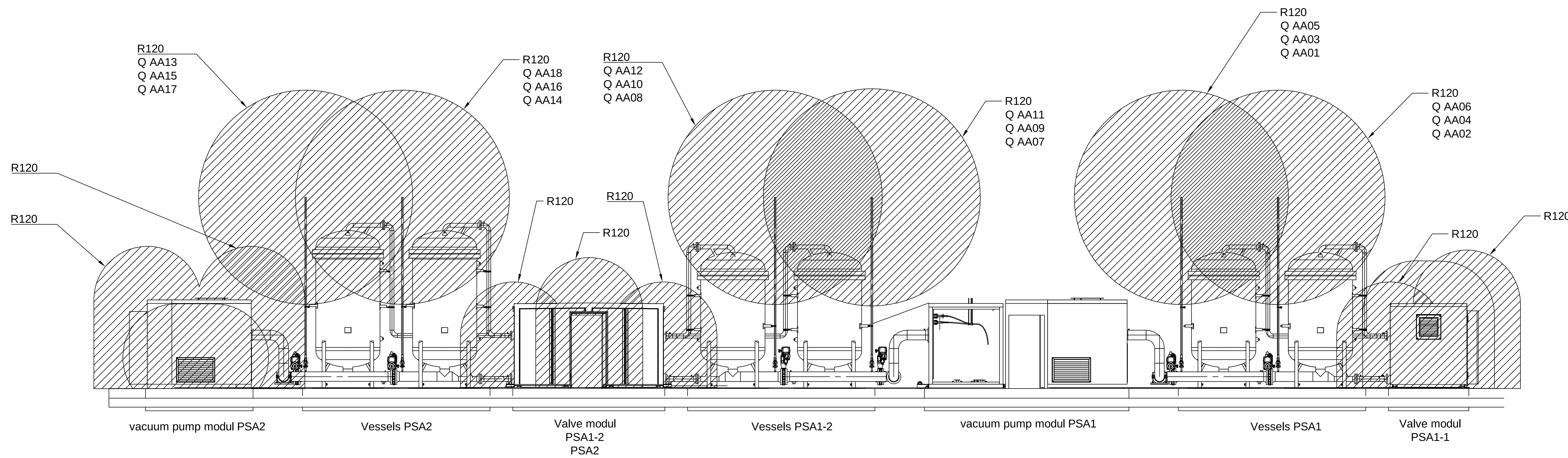
BIOFERM ENERGY SYSTEMS
VIESSMANN Group
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
VIESSMANN Group
Carbotech Gas Systems GmbH
Kronprinzenstraße 30, 45128 Essen, Germany

COUNTY of DANE WISCONSIN 1839

SHEET TITLE: DWG EX-Zone-plant Hazardous-Zone-plan front view	PROJ. NO.: AUC201			DATE: 8/08/2018
	DSN. BY:	DWN. BY: DauHG	CHK. BY: FieT	APP. BY: ----
		8/08/2018	8/08/2018	SCALE: 1 / 100
PROJECT TITLE: Dane County WI BUP 2500I Dane County	DRAWING NO: AUC201-HZP-00-01			PAGE NO. 9 / 9

Section A-A



Hazardous Area classification derived from NFPA 497 and API RP500.

Class I, Division 1

Class I,Division 2

DRAWINGS		
sections	DWG	sheet
Top view	x	1
A-A	x	2
B-B	x	3
C-C	x	4
D-D	x	5
E-E	x	6
F-F	x	7
G-G	x	8

N0.	REVISION	DATE
1	as built	07/26/2019

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstraße 30, 45128 Essen, Germany

SHEET TITLE: DWG
EX-Zone-plant
Hazardous-Zone-plan A-A

PROJECT TITLE: Dane County WI BUP 2500I
Dane County

PROJ. NO.: AUC201

DSN. BY:	DWN. BY:	CHK. BY:	APP. BY:
	DauHG	FieT	----
	8/08/2018	8/08/2018	

DRAWING NO: AUC201-HZP-00-02

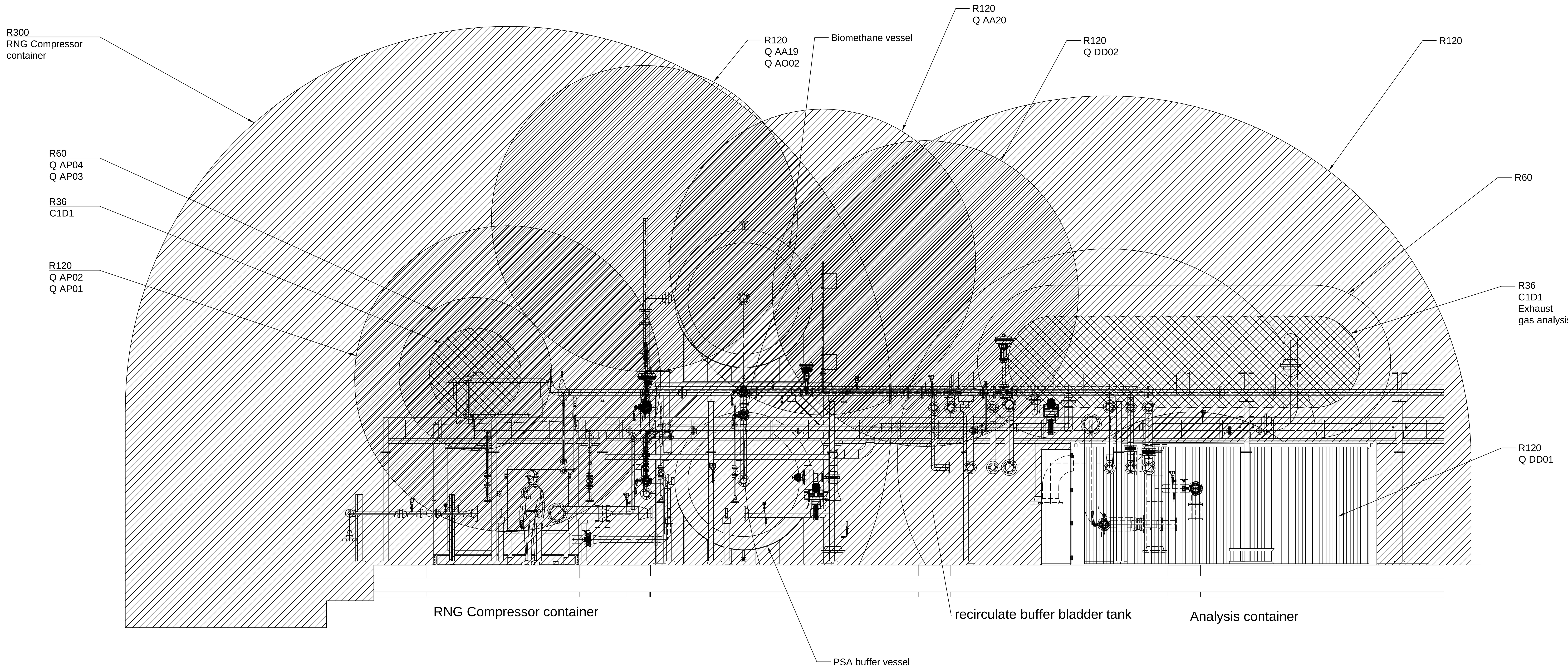
DATE: 8/08/2018

SCALE: 1 / 50

PAGE NO. 2 / 9

K:\Projekte_P3D\Dane_County_AUC201_WI_BUP2500I\2D\n_Hazardous_Zone_Classification\AUC201-HZP-00-01-Hazard-Zone-plan-A-A.dwg

section B-B



Analyse Container				
Lfd.-Nr.	AF	Discription		
1	Q FA01	Exhaust raw gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)
2	Q FA02	Exhaust raw gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)
3	Q FA03	Exhaust raw gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)
4	Q FB01	Exhaust product gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)
5	Q FB02	Exhaust product gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)
6	Q FB03	Exhaust product gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)
7	Q FC01	Exhaust raw gas oxygen analysis 1	I I	1 (inner sphere) 2 (outer sphere)
8	Q FC02	Exhaust raw gas oxygen analysis 2	I I	1 (inner sphere) 2 (outer sphere)
9	Q FF01	Exhaust raw gas H2S analysis 1	I I	1 (inner sphere) 2 (outer sphere)
10	Q FF02	Exhaust raw gas H2S analysis 2	I I	1 (inner sphere) 2 (outer sphere)
11	Q FF03	Exhaust raw gas H2S analysis 3	I I	1 (inner sphere) 2 (outer sphere)
12	Q FF04	Exhaust raw gas H2S analysis 4	I I	1 (inner sphere) 2 (outer sphere)
13	Q FM01	Exhaust process gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)
14	Q FM02	Exhaust process gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)
15	Q FM03	Exhaust process gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)
16	Q FN01	Exhaust off gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)
17	Q FN02	Exhaust off gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)
18	Q FN03	Exhaust off gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)

Hazardous Area classification derived from NFPA 497 and API RP500.

Class I, Division 1

Class I,Division 2

DRAWINGS		
sections	DWG	sheet
Top view	x	1
A-A	x	2
B-B	x	3
C-C	x	4
D-D	x	5
E-E	x	6
F-F	x	7
G-G	x	8

N0.	REVISION	DATE
1	as built	07/26/2019

BIOFERM ENERGY SYSTEMS
VIESSMANN Group
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

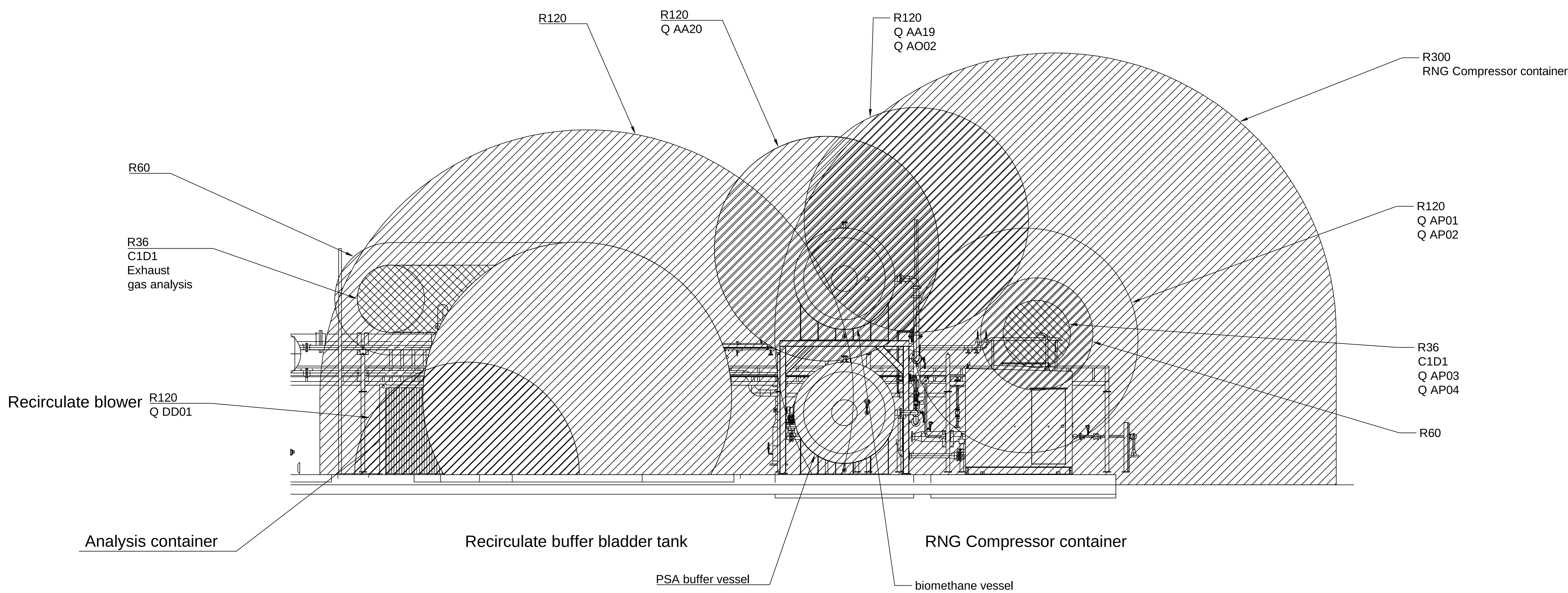
Carbotech
VIESSMANN Group
Carbotech Gas Systems GmbH
Kronprinzenstraße 30, 45128 Essen, Germany

COUNTY of DANE WISCONSIN 1839

SHEET TITLE: DWG EX-Zone-plant Hazardous-Zone-plan B-B	PROJ. NO. AUC201			DATE: 8/08/2018
	DSN. BY:	DWN. BY: DauHG	CHK. BY: FieT	APP. BY: ----
		8/08/2018	8/08/2018	SCALE: 1 / 30
PROJECT TITLE: Dane County WI BUP 2500I Dane County	DRAWING NO: AUC201-HZP-00-03			PAGE NO. 3 / 9

K:\Projekte_P3D\Dane_County_AUC201_WI_BUP2500I\2D\n_Hazardous_Zone_Classification\AUC201-HZP-00-01-Hazard-Zone-plan-B-B.dwg

view C-C



Analyse Container				
Lfd.-Nr.	AF	Discription		
1	Q FA01	Exhaust raw gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)
2	Q FA02	Exhaust raw gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)
3	Q FA03	Exhaust raw gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)
4	Q FB01	Exhaust product gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)
5	Q FB02	Exhaust product gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)
6	Q FB03	Exhaust product gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)
7	Q FC01	Exhaust raw gas oxygen analysis 1	I I	1 (inner sphere) 2 (outer sphere)
8	Q FC02	Exhaust raw gas oxygen analysis 2	I I	1 (inner sphere) 2 (outer sphere)
9	Q FF01	Exhaust raw gas H2S analysis 1	I I	1 (inner sphere) 2 (outer sphere)
10	Q FF02	Exhaust raw gas H2S analysis 2	I I	1 (inner sphere) 2 (outer sphere)
11	Q FF03	Exhaust raw gas H2S analysis 3	I I	1 (inner sphere) 2 (outer sphere)
12	Q FF04	Exhaust raw gas H2S analysis 4	I I	1 (inner sphere) 2 (outer sphere)
13	Q FM01	Exhaust process gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)
14	Q FM02	Exhaust process gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)
15	Q FM03	Exhaust process gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)
16	Q FN01	Exhaust off gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)
17	Q FN02	Exhaust off gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)
18	Q FN03	Exhaust off gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)

K:\Projekte_P3D\Dane_County_AUC201_WI_BUP2500I\2D\n_Hazardous_Zone_Classification\AUC201-HZP-00-01-Hazard-Zone-Plan-C-C.dwg

Hazardous Area classification derived from NFPA 497 and API RP500.

Class I, Division 1

Class I,Division 2

DRAWINGS		
sections	DWG	sheet
Top view	x	1
A-A	x	2
B-B	x	3
C-C	x	4
D-D	x	5
E-E	x	6
F-F	x	7
G-G	x	8

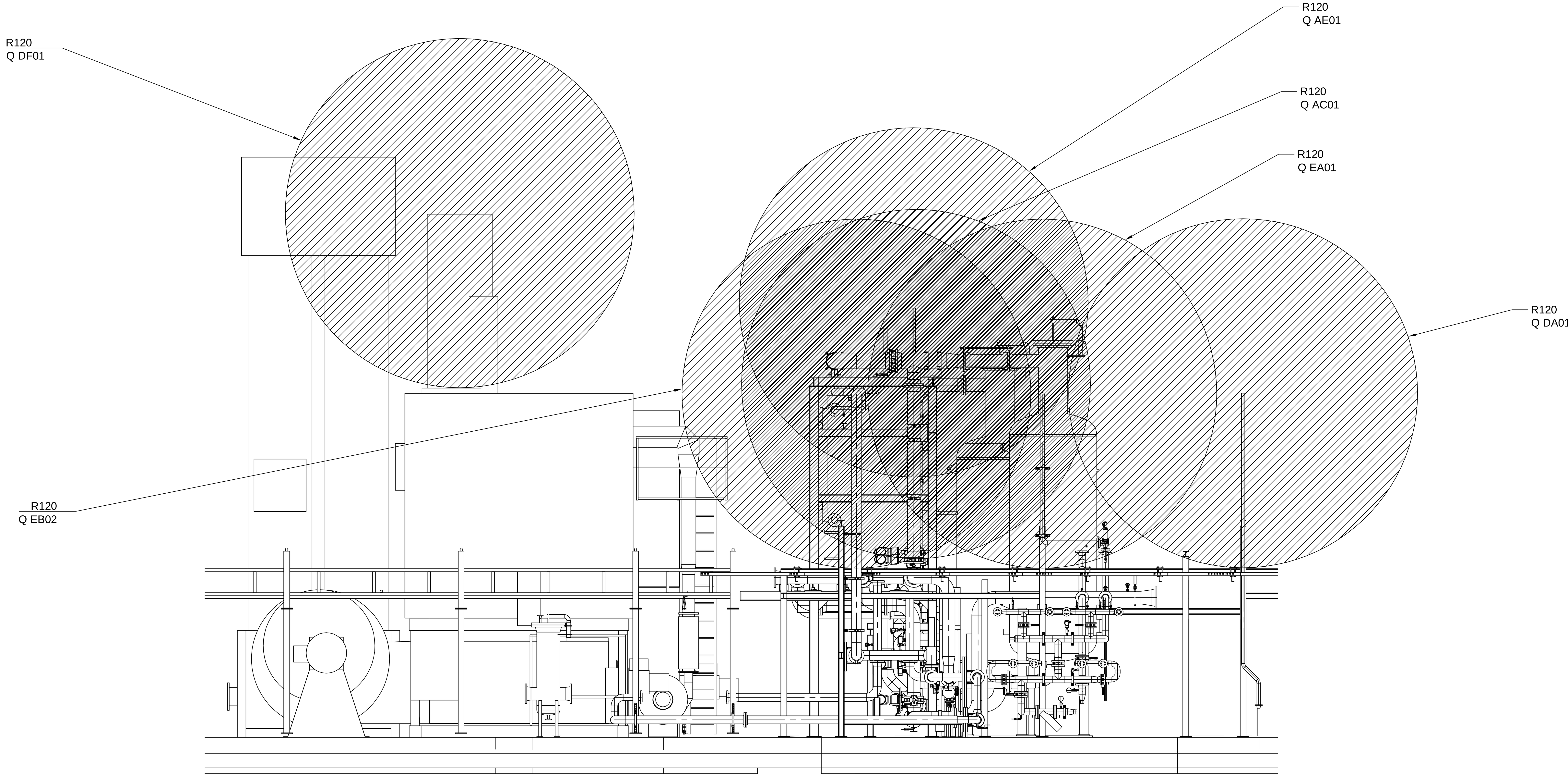
N0.	REVISION	DATE
1	as built	07/26/2019

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstraße 30, 45128 Essen, Germany

SHEET TITLE: DWG EX-Zone-plant Hazardous-Zone-plan C-C	PROJ. NO.: AUC201			DATE: 8/08/2018
	DSN. BY:	DWN. BY: DauHG	CHK. BY: FieT	APP. BY: ----
		8/08/2018	8/08/2018	SCALE: 1 / 50
PROJECT TITLE: Dane County WI BUP 2500I Dane County	DRAWING NO: AUC201-HZP-00-04			PAGE NO. 4 / 9

section D-D



tail gas combustion

desulfurization vessel

Hazardous Area classification derived from NFPA 497 and API RP500.

Class I, Division 1

Class I,Division 2

DRAWINGS		
sections	DWG	sheet
Top view	x	1
A-A	x	2
B-B	x	3
C-C	x	4
D-D	x	5
E-E	x	6
F-F	x	7
G-G	x	8

N0.	REVISION	DATE
1	as built	07/26/2019

BIOFERM ENERGY SYSTEMS
VIESSMANN Group
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
VIESSMANN Group
Carbotech Gas Systems GmbH
Kronprinzenstraße 30, 45128 Essen, Germany

SHEET TITLE: DWG
EX-Zone-plant
Hazardous-Zone-plan D-D

PROJECT TITLE: Dane County WI BUP 2500I
Dane County

PROJ. NO. AUC201

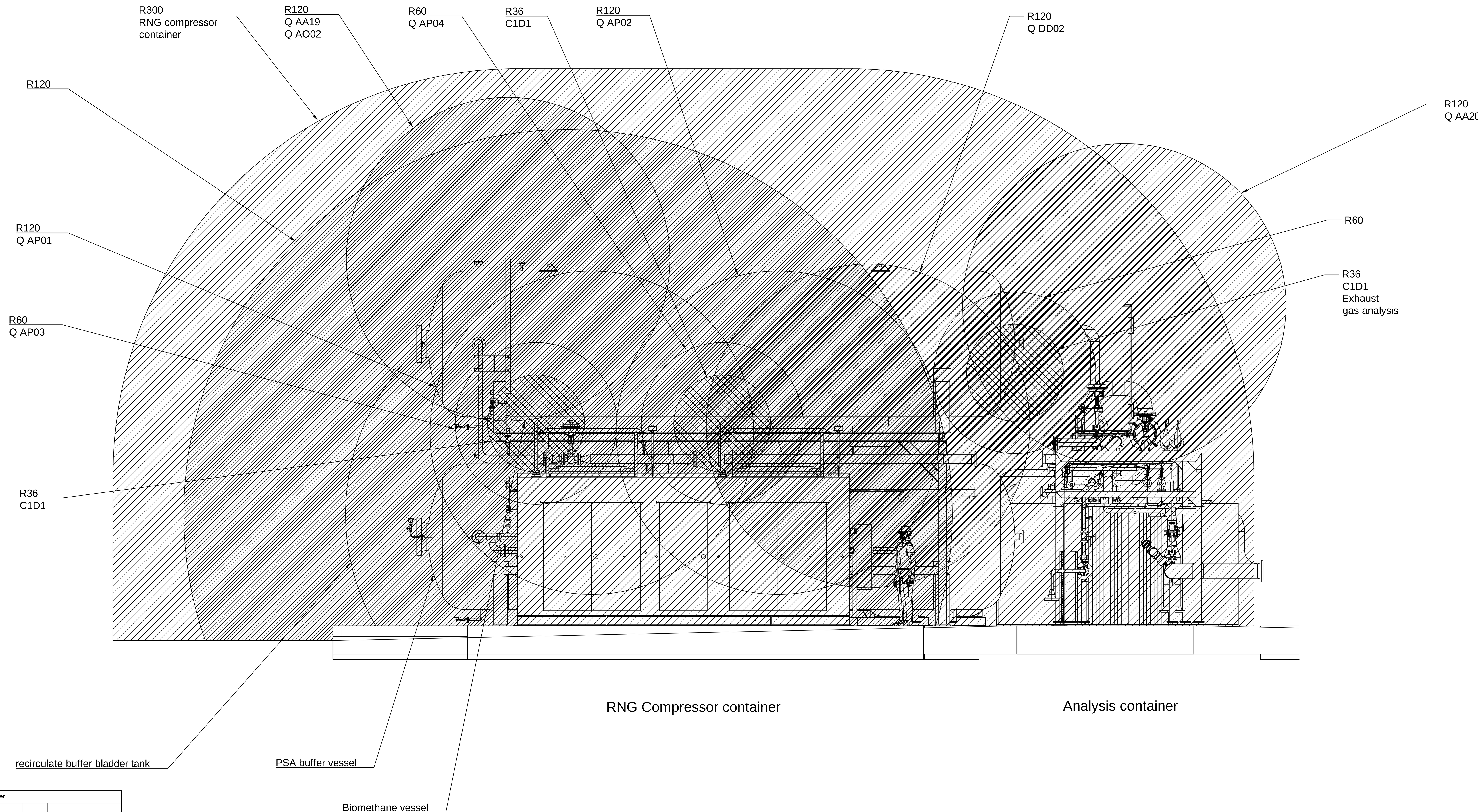
DSN. BY:	DWN. BY: DauHG	CHK. BY: FieT	APP. BY: ----
	8/08/2018	8/08/2018	

DRAWING NO: AUC201-HZP-00-05

DATE: 8/08/2018
SCALE: 1 / 30
PAGE NO. 5 / 9

K:\Projekte_P3D\Dane_County_AUC201_WI_BUP2500I\Zone_Classification\AUC201-HZP-00-01-Hazard-Zone-plan-D-D.dwg

view E-E



Analyse Container				
Lfd.-Nr.	AF	Discription		
1	Q FA01	Exhaust raw gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)
2	Q FA02	Exhaust raw gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)
3	Q FA03	Exhaust raw gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)
4	Q FB01	Exhaust product gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)
5	Q FB02	Exhaust product gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)
6	Q FB03	Exhaust product gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)
7	Q FC01	Exhaust raw gas oxygen analysis 1	I I	1 (inner sphere) 2 (outer sphere)
8	Q FC02	Exhaust raw gas oxygen analysis 2	I I	1 (inner sphere) 2 (outer sphere)
9	Q FF01	Exhaust raw gas H2S analysis 1	I I	1 (inner sphere) 2 (outer sphere)
10	Q FF02	Exhaust raw gas H2S analysis 2	I I	1 (inner sphere) 2 (outer sphere)
11	Q FF03	Exhaust raw gas H2S analysis 3	I I	1 (inner sphere) 2 (outer sphere)
12	Q FF04	Exhaust raw gas H2S analysis 4	I I	1 (inner sphere) 2 (outer sphere)
13	Q FM01	Exhaust process gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)
14	Q FM02	Exhaust process gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)
15	Q FM03	Exhaust process gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)
16	Q FN01	Exhaust off gas analysis 1	I I	1 (inner sphere) 2 (outer sphere)
17	Q FN02	Exhaust off gas analysis 2	I I	1 (inner sphere) 2 (outer sphere)
18	Q FN03	Exhaust off gas analysis 3	I I	1 (inner sphere) 2 (outer sphere)

K:\Projekte_P3D\Dane_County_AUC201_WI_BUP2500I\2D\n_Hazardous_Zone_Classification\AUC201-HZP-00-01-Hazard-Zone-plan-E-E.dwg

DRAWINGS		
sections	DWG	sheet
Top view	x	1
A-A	x	2
B-B	x	3
C-C	x	4
D-D	x	5
E-E	x	6
F-F	x	7
G-G	x	8

Hazardous Area classification derived from NFPA 497 and API RP500.

Class I, Division 1

Class I,Division 2

N0.	REVISION	DATE
1	as built	07/26/2019

BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech Gas Systems GmbH
Kronprinzenstraße 30, 45128 Essen, Germany

SHEET TITLE: DWG EX-Zone-plant Hazardous-Zone-plan E-E

PROJECT TITLE: Dane County WI BUP 2500I Dane County

PROJ. NO.: AUC201

DSN. BY: | DWN. BY: DauHG 8/08/2018 | CHK. BY: FieT 8/08/2018 | APP. BY: ----

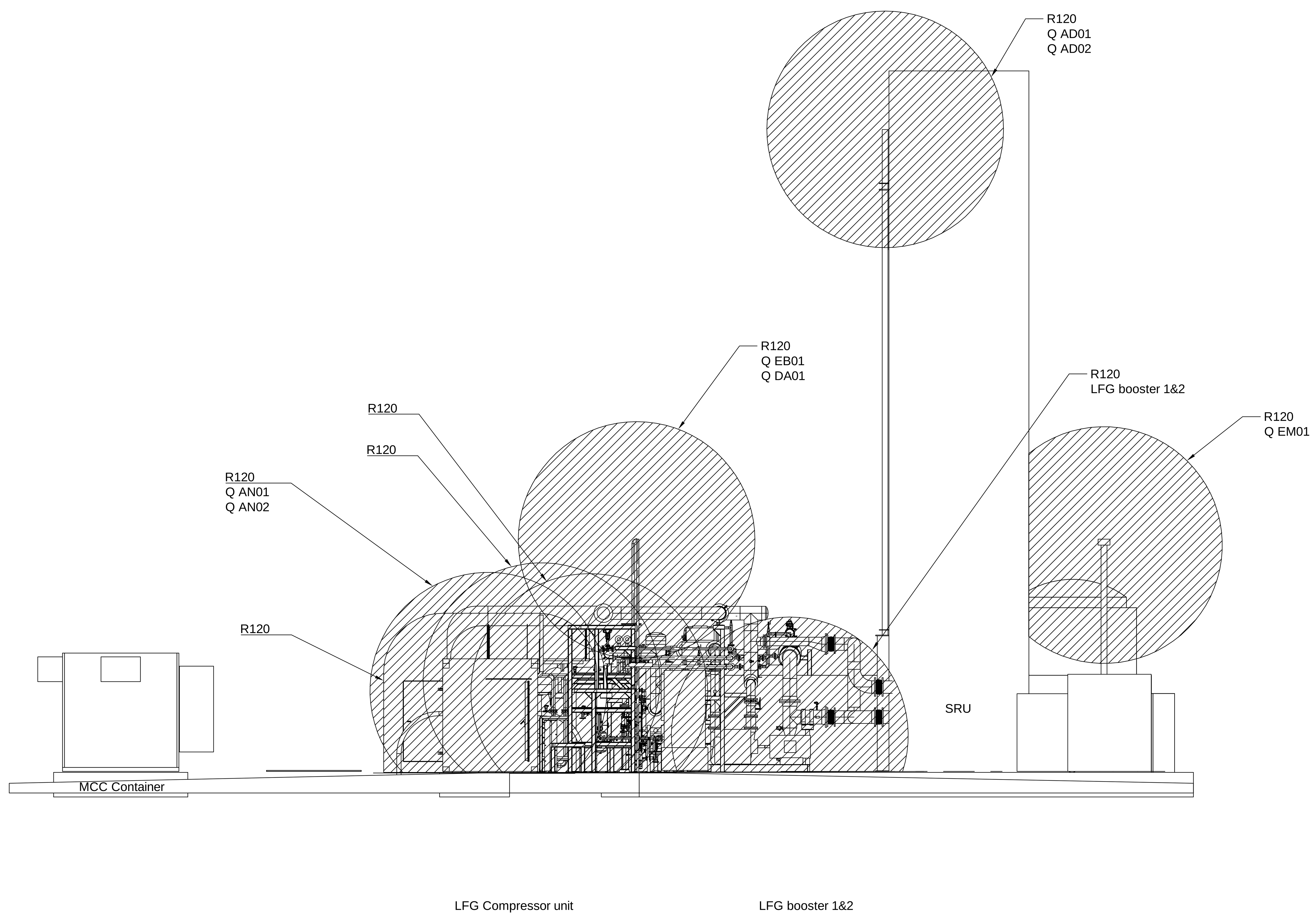
DRAWING NO: AUC201-HZP-00-06

DATE: 8/08/2018

SCALE: 1 / 30

PAGE NO. 6 / 9

section F-F



DRAWINGS		
sections	DWG	sheet
Top view	x	1
A-A	x	2
B-B	x	3
C-C	x	4
D-D	x	5
E-E	x	6
F-F	x	7
G-G	x	8

Hazardous Area classification derived from NFPA 497 and API RP500.

Class I, Division 1

Class I,Division 2

NO.	REVISION	DATE
1	as built	07/26/2019

BIOFERM ENERGY SYSTEMS

VIESSMANN Group

BIOFerm Energy Systems

440 Science Drive, Suite 300, Madison, WI 53711

Carbotech

VIESSMANN Group

Carbotech Gas Systems GmbH

Kronprinzenstraße 30, 45128 Essen, Germany

COUNTY of DANE 1839 WISCONSIN

SHEET TITLE: DWG
EX-Zone-plant
Hazardous-Zone-plan F-F

PROJECT TITLE: Dane County WI BUP 2500I
Dane County

PROJ. NO.: AUC201

DSN. BY:	DWN. BY: DauHG	CHK. BY: FieT	APP. BY: ----
	8/08/2018	8/08/2018	

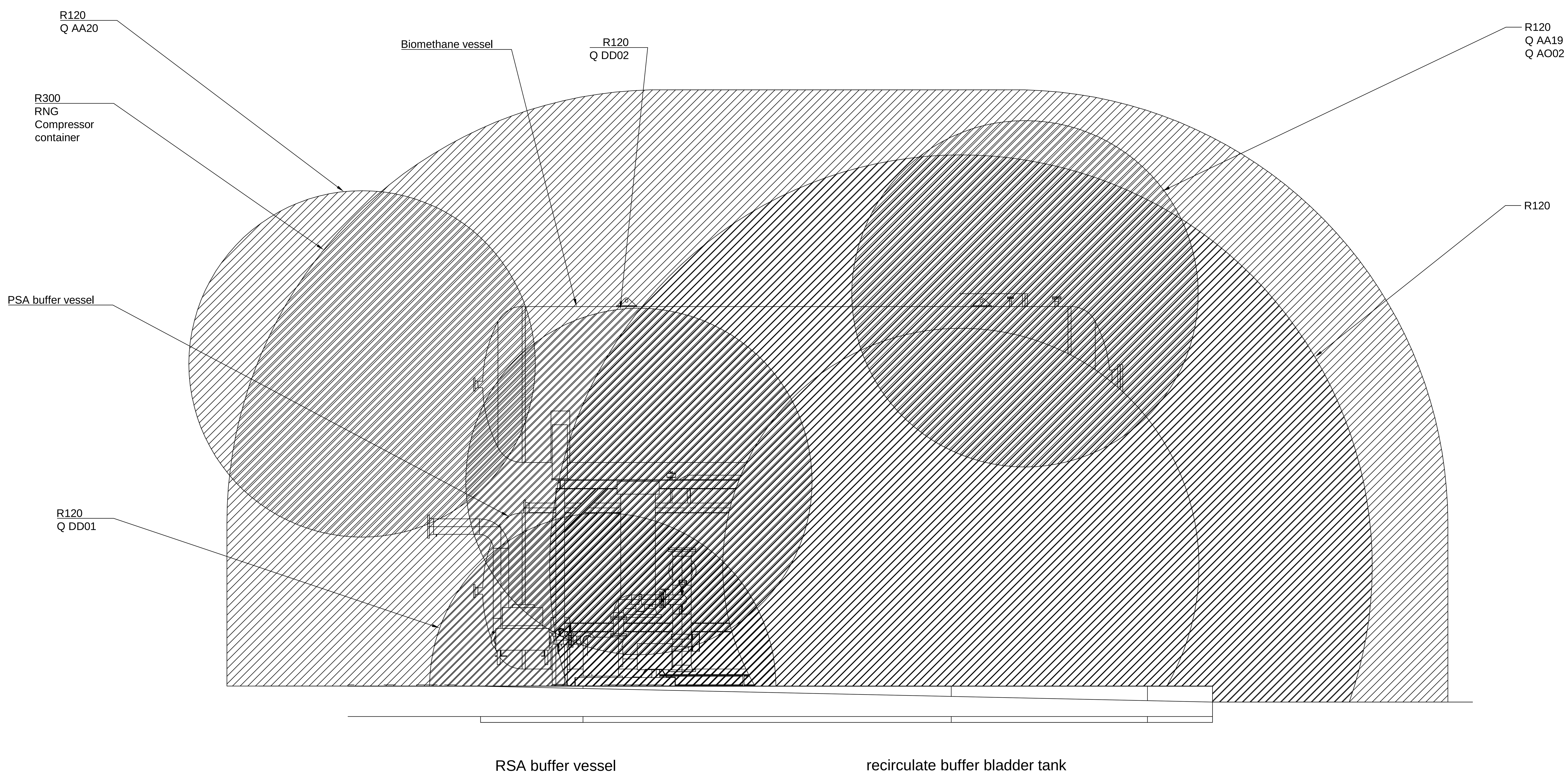
DRAWING NO: AUC201-HZP-00-07

DATE: 8/08/2018

SCALE: 1 / 50

PAGE NO. 7 / 9

section G-G



Hazardous Area classification derived from NFPA 497 and API RP500.

(cross-hatch)	Class I, Division 1
(single hatch)	Class I,Division 2

DRAWINGS		
sections	DWG	sheet
Top view	x	1
A-A	x	2
B-B	x	3
C-C	x	4
D-D	x	5
E-E	x	6
F-F	x	7
G-G	x	8

N0.	REVISION	DATE
1	as built	07/26/2019

BIOFERM ENERGY SYSTEMS
VIESSMANN Group
BIOFerm Energy Systems
440 Science Drive, Suite 300, Madison, WI 53711

Carbotech
VIESSMANN Group
Carbotech Gas Systems GmbH
Kronprinzenstraße 30, 45128 Essen, Germany

COUNTY of DANE WISCONSIN 1839

SHEET TITLE	DWG EX-Zone-plant Hazardous-Zone-plan G-G
PROJECT TITLE	Dane County WI BUP 2500I Dane County
PROJ. NO.	AUC201
DSN. BY:	
DWN. BY:	DauHG 8/08/2018
CHK. BY:	FieT 8/08/2018
APP. BY:	----
DRAWING NO:	AUC201-HZP-00-08
DATE:	8/08/2018
SCALE:	1 / 50
PAGE NO.	8 / 9

K:\Projekte_P3D\Dane_County_AUC201_WI_BUP2500I\20\n_Hazardous_Zone_Classification\AUC201-HZP-00-01-Hazard-Zone-plan-G-G.dwg