LG Chem

LG QuantumFlux™ MBR/Submerged UF Membrane

Technical Service Bulletin 808

MBR & Submerged UF System Design

This technical manual provides comprehensive guidance for engineers and system designers working on Membrane Bioreactor (MBR) & submerged ultrafiltration (UF) Systems. The information contained within addresses fundamental design considerations, operational parameters, and best practices for implementing successful UF & MBR installations in water and wastewater treatment applications.

Key Operating Parameter Definitions

Filtrate flow rate

Filtrate flow rate is the rate of the water that passes through the membrane from the feed side to the filtrate side. It is a function of the pressure, and the quality of the feed water. The filtrate flow rate should be set in according to LG Chem's recommended membrane flux.

Filtrate flux

Filtrate flux is the volume of filtered water passing through a unit of membrane surface area in a specified period of time. It is commonly expressed as lmh (Liters of filtered water/m^2 of surface area/hour of filtration time), gfd (gallons of filtered water/ft^2 of surface area/day of filtration time), or m/d (m^3 of filtered water/m^2 of surface area/day of filtration time). Appropriate flux selection is one of the most important design and operating considerations. The filtrate flux should be set according to LG Chem's recommendation for your specific application. The flux may be increased or decreased during operation to account for changes in feed water quality, temperature or product water demand.

Transmembrane Pressure

Transmembrane Pressure (TMP) is the pressure difference between the feed and filtrate sides of the membrane. It is commonly measured in units of bar, psi, or kPa. TMP is the driving force for filtration. Most ultrafiltration systems operate at a constant flow rate during filtration. As filtration occurs, solids deposited on the membrane surface will create resistance to filtration causing the TMP to increase. Proper design filtrate flux is necessary to control the rate of TMP increase. Physical and chemical cleaning are required to remove accumulated fouling and reduce TMP. The maximum allowable TMP is 0.05 MPa (7.2 psi).

Normalized permeability

Normalized permeability, or specific flux, is defined as filtrate flux per applied transmembrane pressure (differential pressure) corrected to a specified temperature, typically 20 or 25 degrees Celsius. It is commonly measured in units of lmh/bar or gfd/psi @20°C. Normalized permeability is one of the most important parameters used to measure the performance of the membrane system. In a properly designed and operated UF system, the normalized permeability will decrease slowly between cleanings and will return to previous levels after cleaning such that it remains essentially constant over long-term operation.

Filtration cycle duration

The filtration cycle duration is dependent on the quality of the feed water. An appropriate design value should be selected per LG Chem's recommendation. The actual time should be set by testing at site and adjusted according to the changes of the feed water quality during the operation. Typical filtration cycle duration is 20-60 minutes for submerged UF and 7-12 minutes for MBR applications.

Membrane Tank Sludge Limiting Conditions

Table 1: Allowable Membrane Tank Sludge Quality

Parameter	Allowed Range	Comments
pH in membrane tank	1 – 10 (TIPS)	1—14 allowed during cleaning (TIPS)
Particle Size[1]	≤ 2.0 mm	≤ 2 mm by automatic screening Perforated plate or punched hole
Mixed Liquor temperature ºC (ºF)	5 – 45 (41 – 113)	
MLSS in membrane tank, mg/L MBR only	5,000 – 12,000	Normal range 6,000 – 8,000 Check with LG if higher MLSS higher
Oil	<2 mg/L (TIPS)	To prevent membrane fouling
Dissolved Oxygen, mg/L	> 2	For MBR only
Total hardness (mg/L as $CaCO_3$)	Non-scaling	Dependent on pH and scaling Scaling to be removed by acid cleaning
Soluble BOD_5 Concentration (mg/L)	< 3	
NH_3-N concentration in mixed liquor entering membrane tanks (mg/L)	≤ 1.0	
Colloidal TOC (cTOC) concentration in mixed liquor entering membrane tanks (mg/L)	≤ 10	
Soluble alkalinity of mixed liquor entering membrane tanks (mg/L as $CaCO_3$)	50 – 150	

[1] Primarily concerned with the entry of sharp objects into the treatment system such as branches, plastic pieces, sand etc., and fibrous material, such as hair.

* This is not an extensive list and does not constitute the only conditions for a valid warranty claim. Refer to your project specific warranty document for all conditions that apply to your warranty.

Design Fundamentals

Membrane Selection

The selection of appropriate membrane materials and configurations forms the foundation of successful UF system design. Polymeric membranes, typically fabricated from PVDF (polyvinylidene fluoride), offer excellent chemical resistance and mechanical strength. The nominal pore size typically ranges from 0.01 to 0.04 micrometers, enabling effective removal of suspended solids, bacteria, and other particulates while allowing dissolved constituents to pass through.

Hydraulic Design Parameters

The hydraulic design of submerged UF/MBR systems must account for several critical parameters. The specific flux, typically expressed in liters per square meter per hour (LMH), determines the membrane area required. Design flux rates for submerged UF generally range from 40-70 LMH for drinking water applications and 30-50 LMH for wastewater applications, depending on feed water quality and operational conditions. For MBR, the typical flux rate is 10-25 LMH depending on the application.

Transmembrane pressure (TMP) must be carefully controlled, typically 0.5 bar, to maintain stable operation while preventing membrane damage. The relationship between flux and TMP should be evaluated during the design phase to ensure optimal performance throughout the system's lifecycle.

Module Configuration

Membrane modules must be arranged to facilitate effective air scouring and maintain uniform flow distribution. Typical configurations include vertical arrays with modules resting on the tank bottom. Adequate spacing between modules (typically 55-85mm) ensures proper air distribution and prevents localized fouling.

Air Scouring System Design

The air scouring system represents a crucial component in submerged UF/MBR design. Coarse bubble aeration provides mechanical cleaning action to control fouling and maintain membrane permeability. Air flow rates are provided in the LG Chem projection software output.

The air distribution system should incorporate the following design modules:

Header pipes must be sized to maintain uniform air distribution across all modules. Manifold design should account for pressure losses and ensure balanced flow.

Chemical Cleaning Systems

Effective chemical cleaning capabilities must be integrated into the system design. Both maintenance cleaning (MC) and recovery cleaning (RC) should be incorporated. The chemical cleaning system should include:

- Storage tanks sized for cleaning solution volumes based on module requirements
- Chemical metering pumps with appropriate materials of construction
- Distribution piping with proper chemical resistance
- Neutralization capabilities for spent cleaning solutions

Typical cleaning chemicals include sodium hypochlorite for organic fouling and citric acid for inorganic fouling. The appropriate cleaning chemicals, dosage rates and MC/RC frequencies are provided in the LG Chem design projection and are typically fine-tuned during startup and operation.

Instrumentation and Control

Robust instrumentation and control systems are essential for monitoring and optimizing UF system performance. Key parameters requiring continuous monitoring include:

- Flow rates (feed, permeate, and air scour)
- Transmembrane pressure
- Turbidity (feed and permeate)
- Temperature
- pH
- Pressure at various points in the system
- DO & MLSS for MBR applications only

The control system should automate critical processes including filtration cycles, backwashing sequences, and chemical cleaning operations. Integration with SCADA systems enables remote monitoring and data collection for performance optimization.

Pretreatment Requirements

Proper pretreatment design extends membrane life and optimizes system performance. Essential pretreatment steps may include:

- Screening to remove large particles and debris (typically 100-500 microns)
- Grit removal for applications with high suspended solids
- Chlorination for biological fouling control
- Coagulation/flocculation for enhanced particle removal

The pretreatment system should be designed based on detailed feed water analysis and anticipated variations in water quality.

Operational Considerations

Filtration Cycle Design

Filtration cycles must be optimized to balance productivity with membrane fouling control. Typical cycle times will be provided in the LG Chem design output and may be optimized based on operational experience and data. The specific duration cycle times may also be determined based on pilot testing.

Energy Efficiency

Energy consumption represents a significant operational cost for Submerged UF/MBR systems. Design considerations for energy efficiency include:

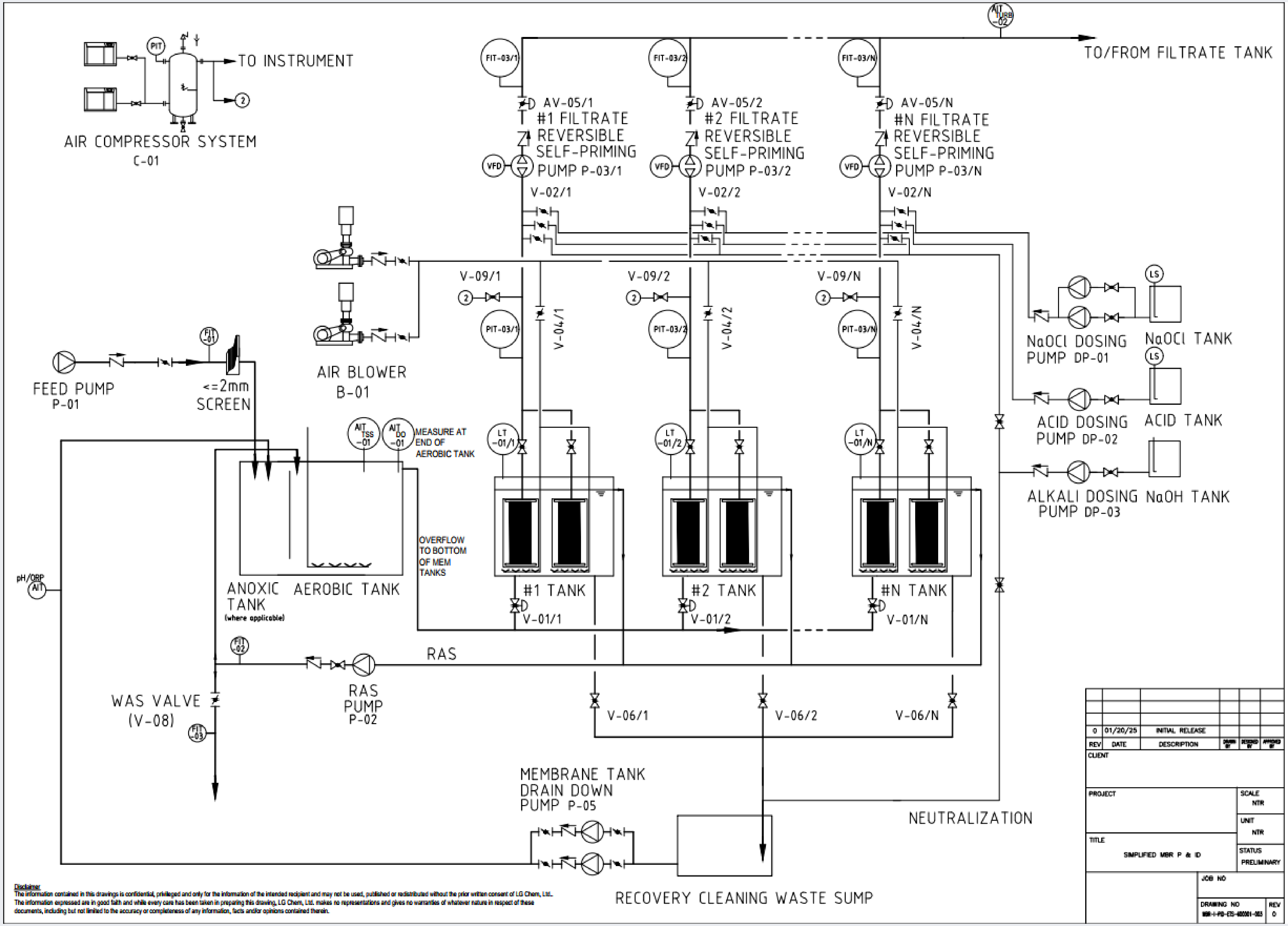
- Selection of energy-efficient pumps and blowers
- Optimization of air scour rates
- Implementation of energy recovery devices where applicable
- Use of variable frequency drives for equipment

Safety Considerations

System design must incorporate appropriate safety measures including:

- Chemical containment and handling systems
- Emergency shower and eyewash stations
- Proper ventilation for chemical storage areas
- Access platforms and railings for maintenance
- Lock-out/tag-out capabilities for all equipment

The following Simplified PFD refers to QuantumFlux S series modules For MBR Application


TO INSTRUMENT
AIR COMPRESSOR SYSTEM
C-01
TO/FROM FILTRATE TANK
AV-05/1
#1 FILTRATE REVERSIBLE SELF-PRIMING PUMP P-03/1
AV-05/2
#2 FILTRATE REVERSIBLE SELF-PRIMING PUMP P-03/2
AV-05/N
#N FILTRATE REVERSIBLE SELF-PRIMING PUMP P-03/N
V-02/1
V-02/2
V-02/N
V-09/1
V-09/2
V-09/N
V-04/1
V-04/2
V-04/N
AIR BLOWER
B-01
FEED PUMP
P-01
<=2mm SCREEN
MEASURE AT END OF AEROBIC TANK
NaOCl DOSING PUMP DP-01
NaOCl TANK
ACID DOSING PUMP DP-02
ACID TANK
ALKALI DOSING PUMP DP-03
NaOH TANK
OVERFLOW TO BOTTOM OF MEM TANKS
ANOXIC TANK
(where applicable)
AEROBIC TANK
#1 TANK
#2 TANK
#N TANK
V-01/1
V-01/2
V-01/N
RAS
RAS PUMP
P-02
WAS VALVE
(V-08)
V-06/1
V-06/2
V-06/N
MEMBRANE TANK DRAIN DOWN PUMP P-05
NEUTRALIZATION
RECOVERY CLEANING WASTE SUMP
0 01/20/25 INITIAL RELEASE
REV DATE DESCRIPTION
CLIENT
PROJECT
SCALE NTR
UNIT NTR
TITLE SIMPLIFIED MBR P & ID
STATUS PRELIMINARY
JOB NO
DRAWING NO
REV 0
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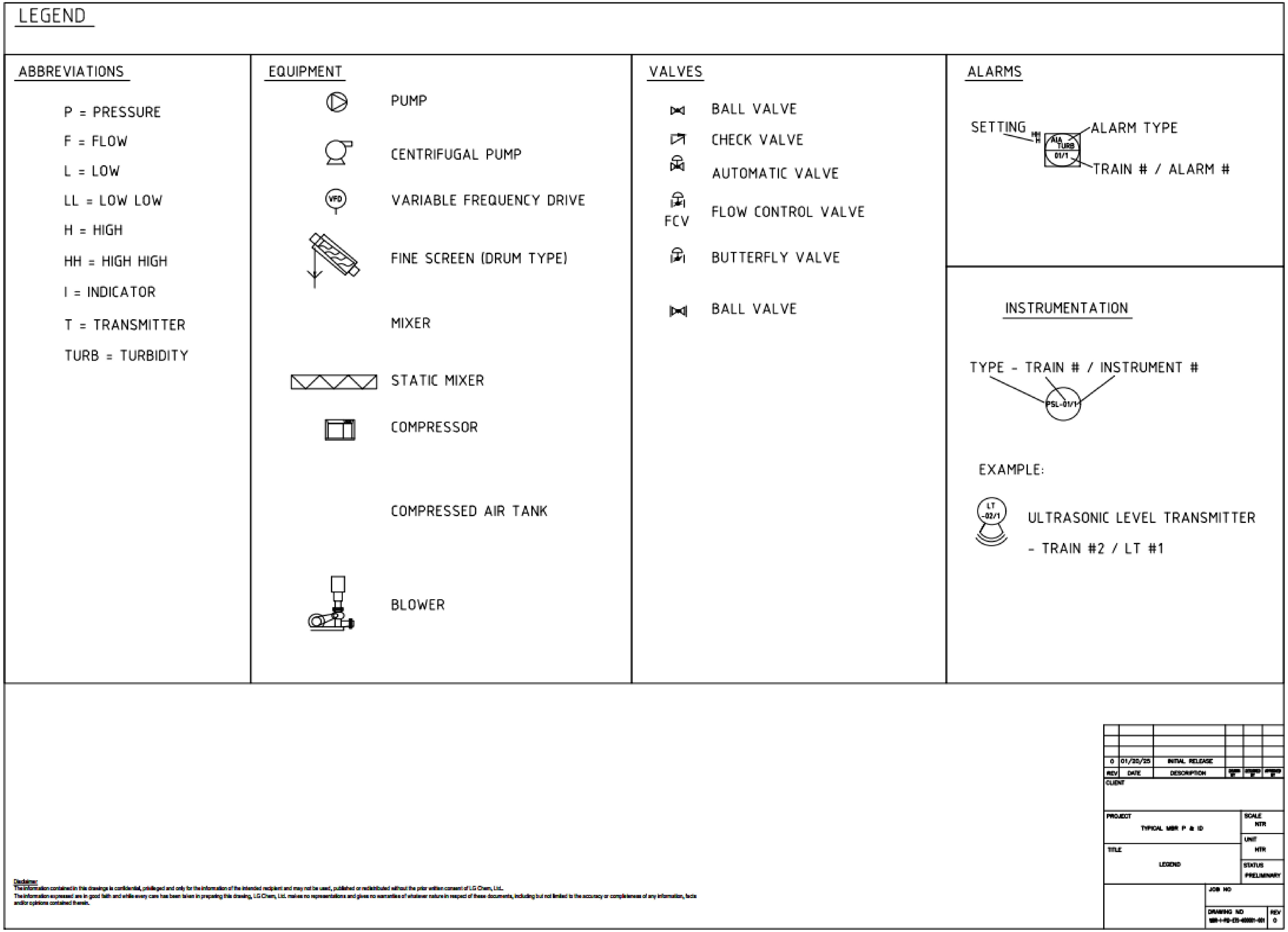
**The following P&I Diagrams refer to QuantumFlux S Series modules
For MBR Applications**


LEGEND
ABBREVIATIONS
P = PRESSURE
F = FLOW
L = LOW
LL = LOW LOW
H = HIGH
HH = HIGH HIGH
I = INDICATOR
T = TRANSMITTER
TURB = TURBIDITY
EQUIPMENT
PUMP
CENTRIFUGAL PUMP
VFD
VARIABLE FREQUENCY DRIVE
FINE SCREEN (DRUM TYPE)
MIXER
STATIC MIXER
COMPRESSOR
COMPRESSED AIR TANK
BLOWER
VALVES
BALL VALVE
CHECK VALVE
AUTOMATIC VALVE
FCV
FLOW CONTROL VALVE
BUTTERFLY VALVE
BALL VALVE
ALARMS
SETTING
ALARM TYPE
TRAIN # / ALARM #
HH
AIA
TURB
01/1
INSTRUMENTATION
TYPE - TRAIN # / INSTRUMENT #
PSL-01/1
EXAMPLE:
LT
-02/1
ULTRASONIC LEVEL TRANSMITTER
- TRAIN #2 / LT #1
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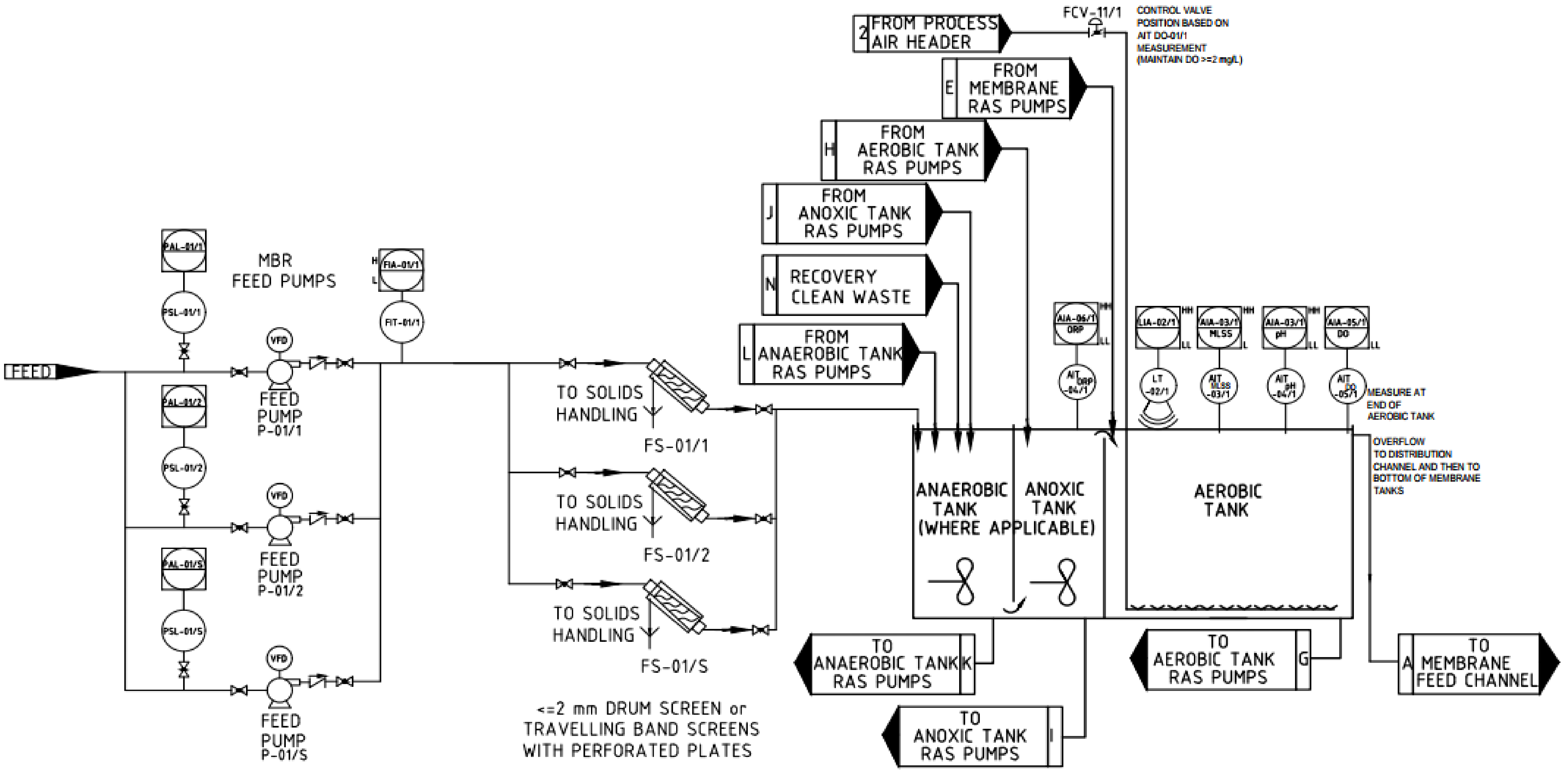

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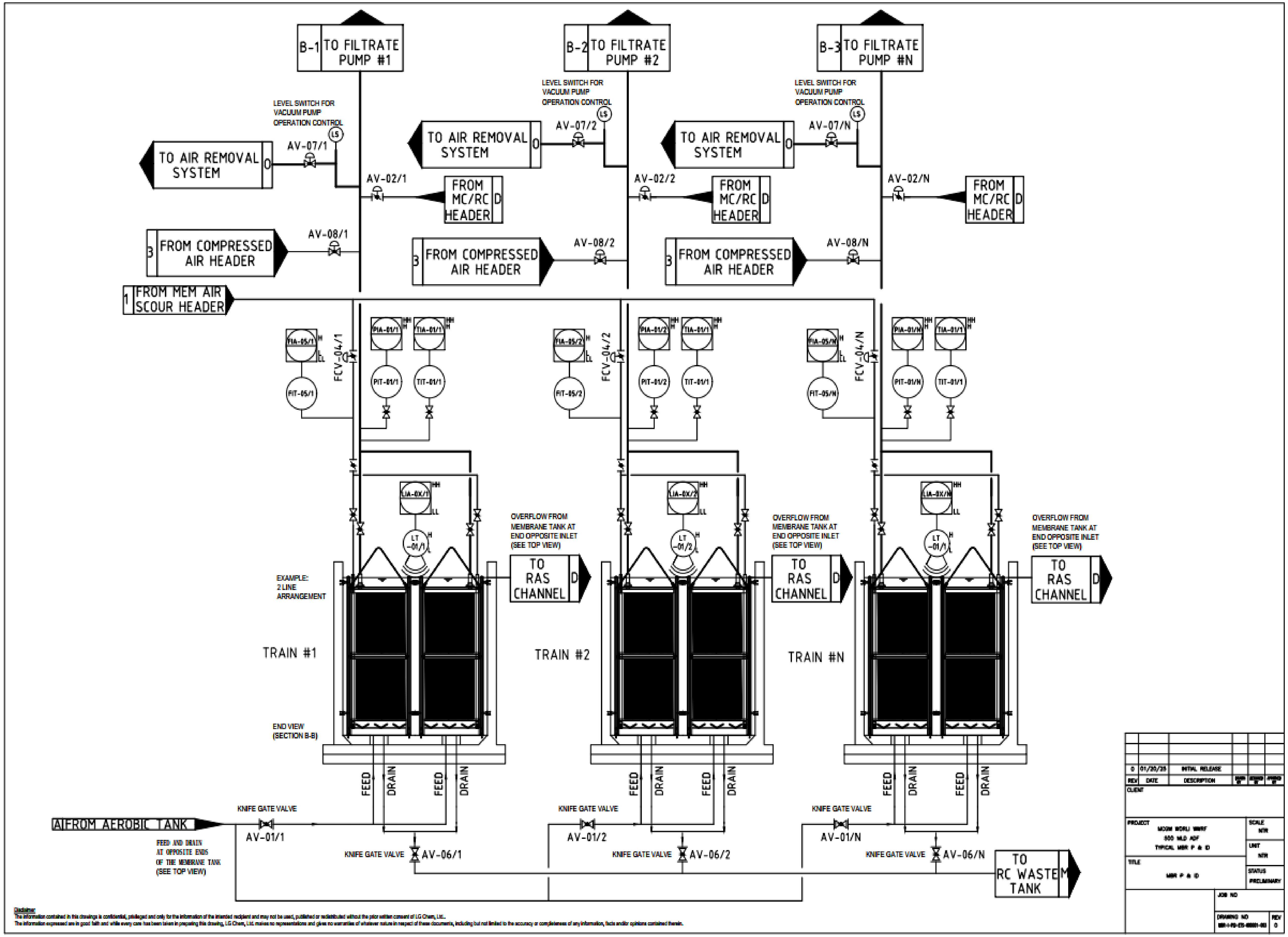
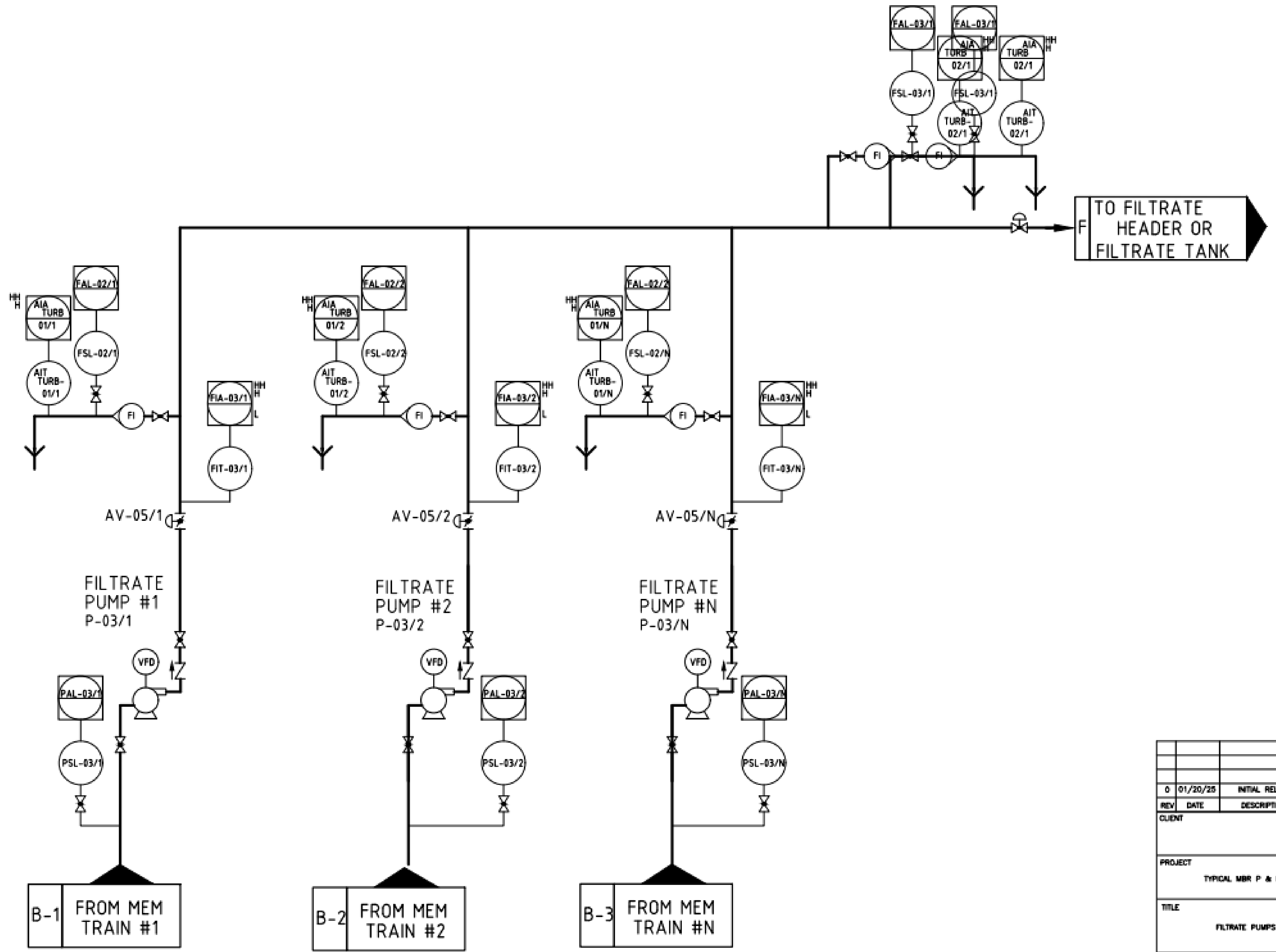

B-1 TO FILTRATE PUMP #1
B-2 TO FILTRATE PUMP #2
B-3 TO FILTRATE PUMP #N
LEVEL SWITCH FOR VACUUM PUMP OPERATION CONTROL
TO AIR REMOVAL SYSTEM
AV-07/1
AV-07/2
AV-07/N
AV-02/1
AV-02/2
AV-02/N
FROM MC/RC HEADER
FROM COMPRESSED AIR HEADER
AV-08/1
AV-08/2
AV-08/N
FROM MEM AIR SCOUR HEADER
FCV-04/1
FCV-04/2
FCV-04/N
OVERFLOW FROM MEMBRANE TANK AT END OPPOSITE INLET (SEE TOP VIEW)
TO RAS CHANNEL
EXAMPLE: 2 LINE ARRANGEMENT
TRAIN #1
TRAIN #2
TRAIN #N
END VIEW (SECTION B-B)
FEED
DRAIN
KNIFE GATE VALVE
FROM AEROBIC TANK
AV-01/1
AV-01/2
AV-01/N
AV-06/1
AV-06/2
AV-06/N
FEED AND DRAIN AT OPPOSITE ENDS OF THE MEMBRANE TANK (SEE TOP VIEW)
TO RC WASTE TANK
INITIAL RELEASE
MBR P & ID
PRELIMINARY



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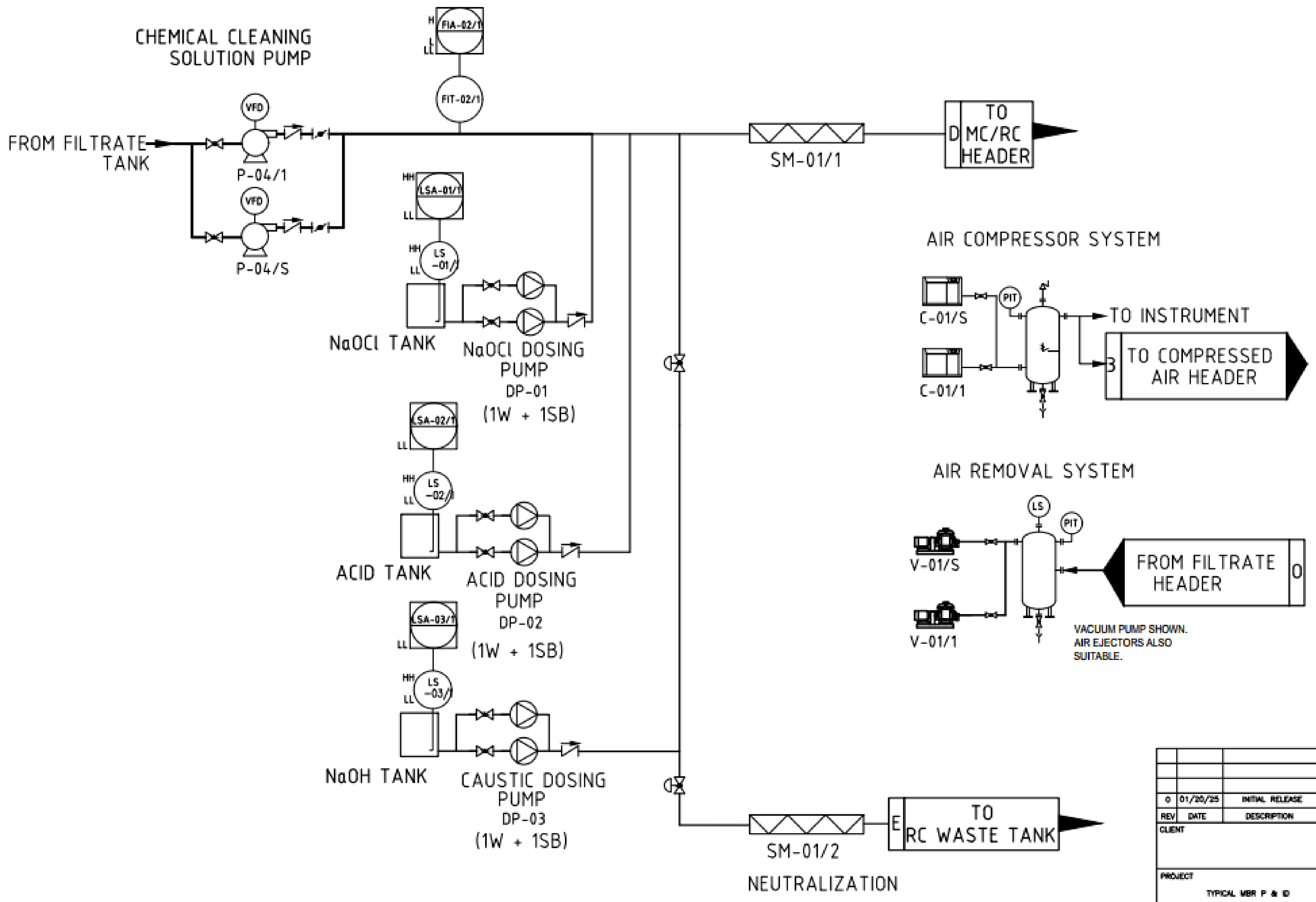

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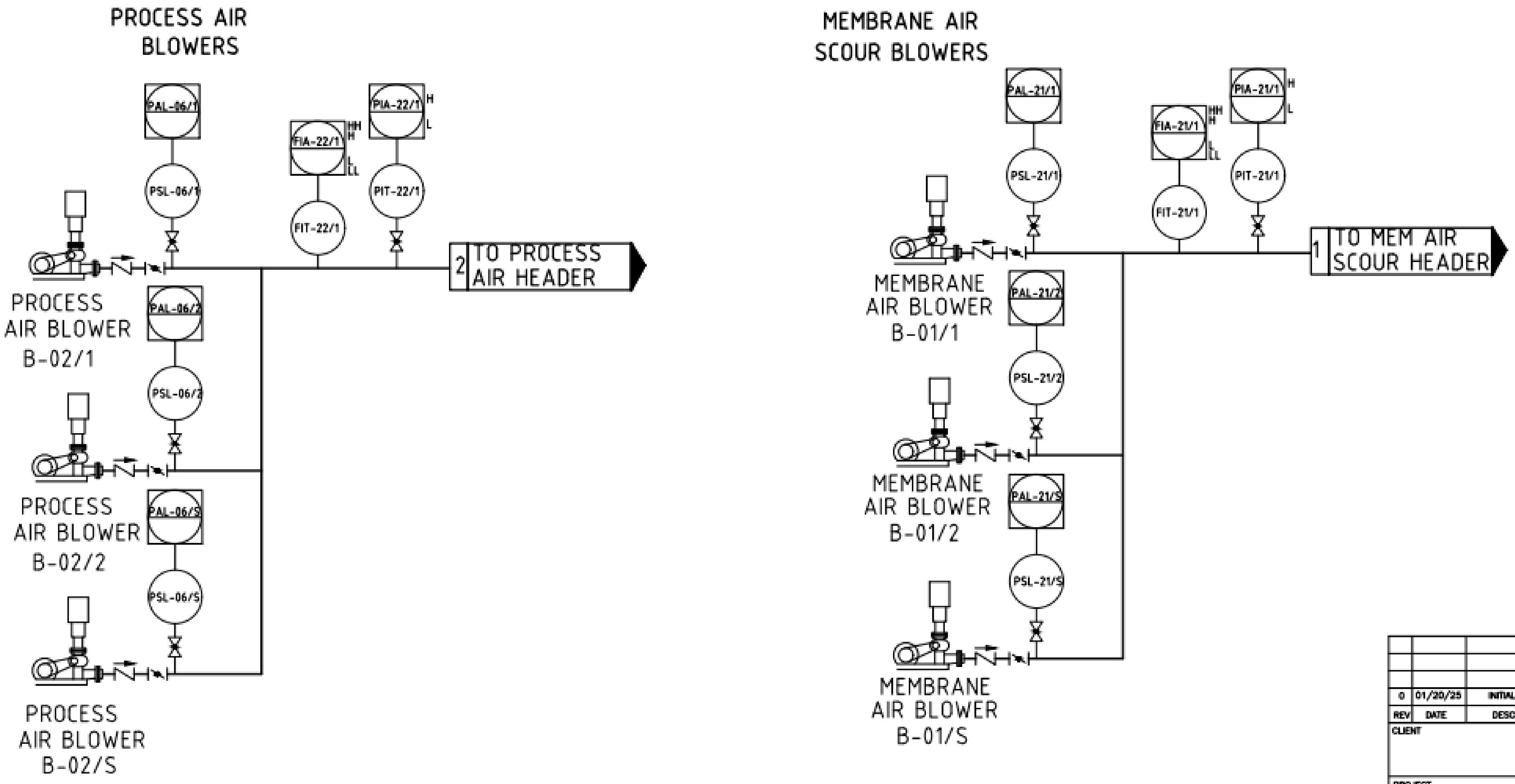

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SCALE: NTR

UNIT: NTR

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STATUS: PRELIMINARY

JOB NO

DRAWING NO

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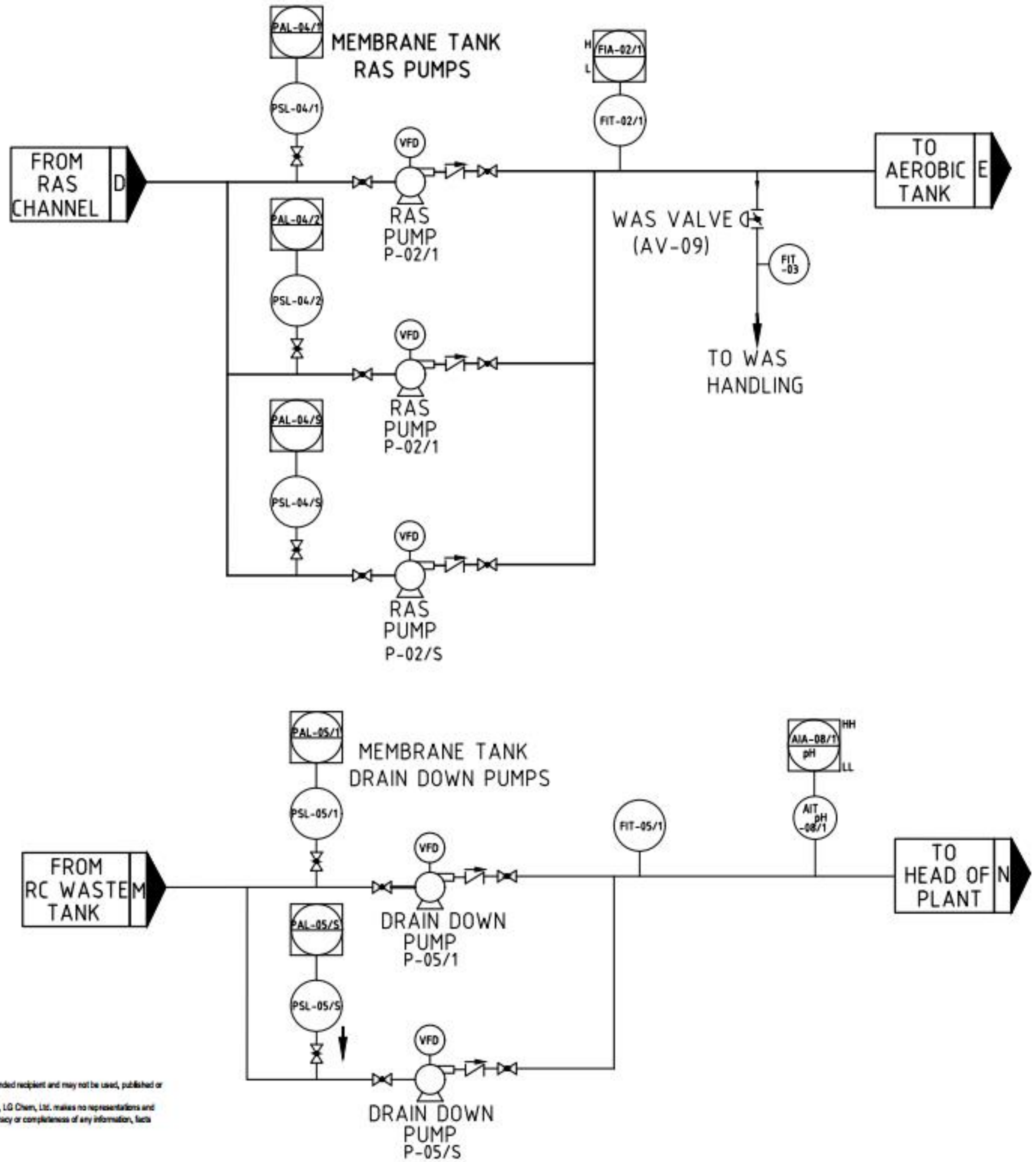

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PROJECT TYPICAL MBR P & ID	SCALE NTR
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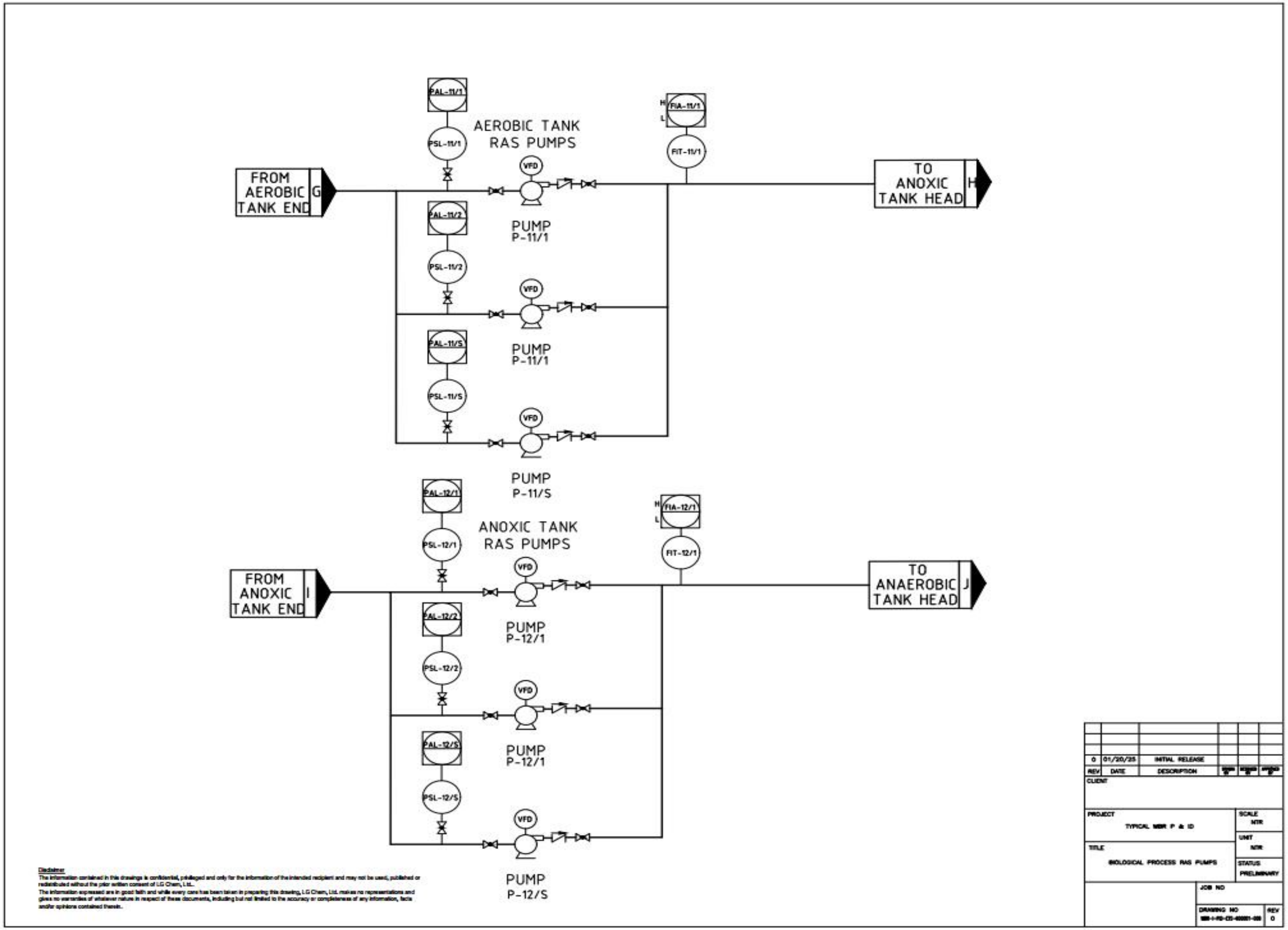
AEROBIC TANK
RAS PUMPS
FROM
AEROBIC
TANK END
G
PAL-11/1
PSL-11/1
VFD
H
L
FIA-11/1
FIT-11/1
TO
ANOXIC
TANK HEAD
H
PAL-11/2
PSL-11/2
PUMP
P-11/1
PAL-11/S
PSL-11/S
PUMP
P-11/1
PUMP
P-11/S
ANOXIC TANK
RAS PUMPS
FROM
ANOXIC
TANK END
I
PAL-12/1
PSL-12/1
FIA-12/1
FIT-12/1
TO
ANAEROBIC
TANK HEAD
J
PAL-12/2
PSL-12/2
PUMP
P-12/1
PAL-12/S
PSL-12/S
PUMP
P-12/1
PUMP
P-12/S
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BIOLOGICAL PROCESS RAS PUMPS
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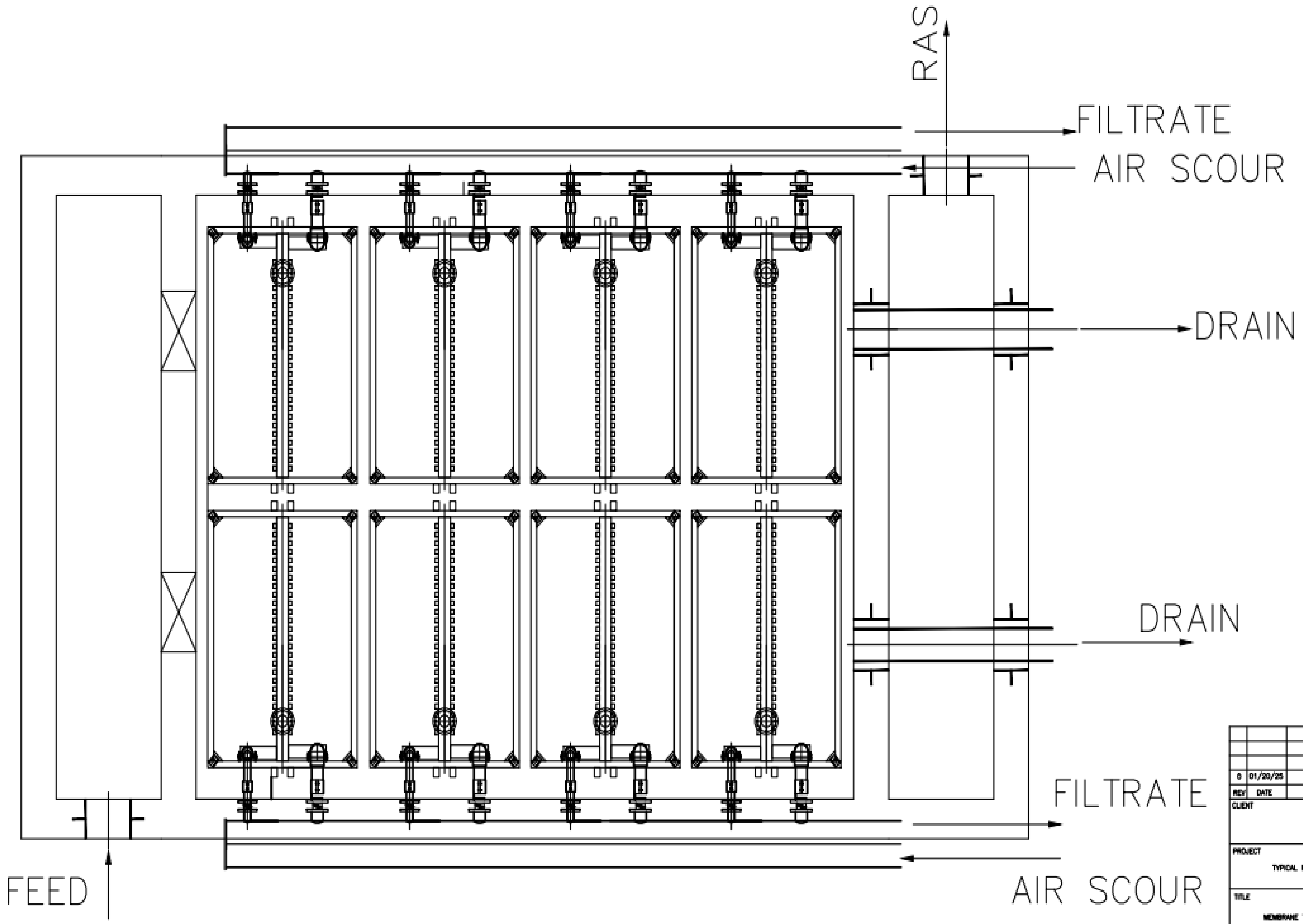
MEMBRANE TANK TOP VIEW
(2-LINE ARRANGEMENT)



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