Bushveld Vanchem

DESIGN PREMISE DOCUMENT

CEMS CONSULT DOCUMENT

DOCUMENT NUMBER:

P201120-DES-2010-001

Revision Schedule

Revision	Date	Description	Originator	Checked
A	22 January 2021	Design Premise Document for Client Review	C Theron	

Approval

Name	Designation	Company	Signature	Date
C Theron	Lead Engineer	CEMS Consult		
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CONTENT

1. Introduction

1.1. Project Description

The scope of the project involves the Detail Design and Costing of the Chemical Plant Expansion Project, Bushveld VANCHEM, Witbank, South Africa. The existing infrastructure have been assessed to identify the location for the Chemical Plant, the Scope of Work required to conduct a Detail Engineering Design and Costing for the Procurement, Manufacturing and Installation of the Equipment and the Infrastructure required to comply with the Chemical Plant Expansion.

1.2. Purpose of Document

The purpose of this document is to define the Project Design Basis for the installation of the Chemical Plant Equipment and associated Infrastructure.

1.3. Corresponding Parties

1.3.1. Client Responsible Person (Bushveld VANCHEM)

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2. Site Location

The proposed project will be in the area demarcated as identified and Bushveld VANCHEM in consultation with CEMS Consult. The proposed project is to be located at the Bushveld VANCHEM Chemical Plant, opposite the existing SST Reactors. Figure 1, 2 and 3 provides an indication of the proposed project site in relation to the rest of the process operations.

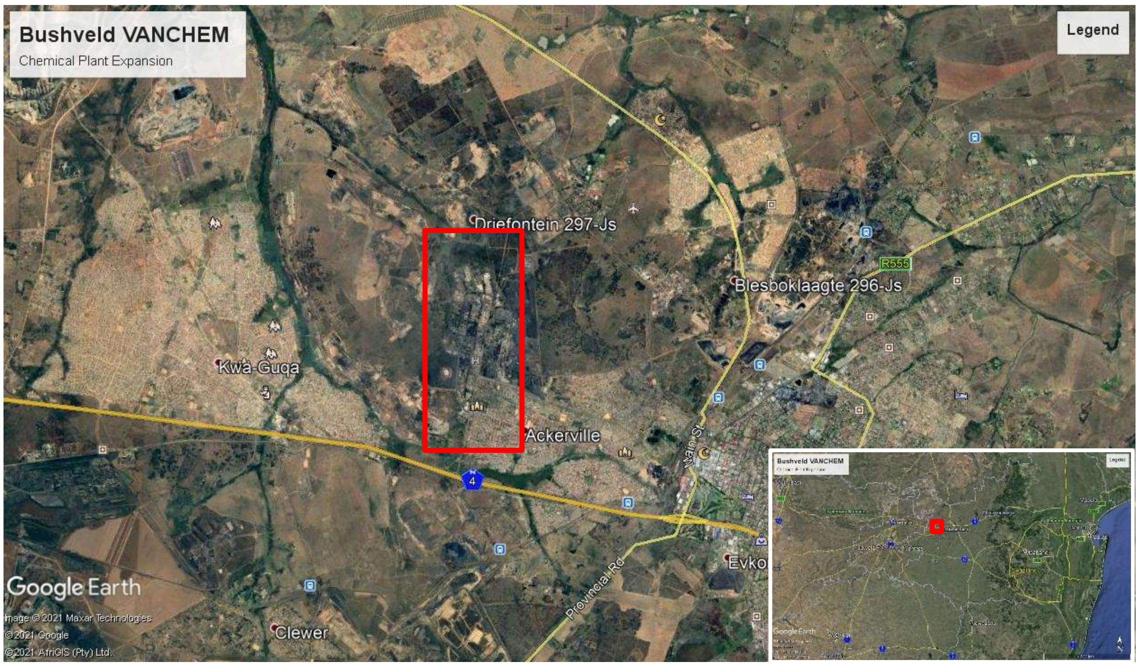


FIGURE 1 – LOCATION OF BUSHVELD VANCHEM, FERROBANK

Figure 2 – Overview of Bushveld VANCHEM Complex

Figure 3 – Location of new Chemical Plant and Pipe Routing

2.1. Environmental Data

The site is located at Bushveld VANCHEM, Ferrobank, Emalahleni in South Africa. Site conditions to be considered:

Location:	Emalahleni, Mpumalanga, South Africa
Elevation:	1534 m
Ambient Temperature:	25°C
Atmospheric Pressure:	86 kPa.

The equipment will be in an exposed outdoor location, subject to an arid inland atmosphere. It is not foreseen that any installations will exceed 10 meter elevation, and should wind conditions regarding structural loads / momentum not apply. The design environmental conditions are:

a) Ambient Temperature:
   - Maximum 30 deg C
   - Minimum -0.4 deg C

b) Relative Humidity:
   - Maximum 90 %
   - Minimum 10 %

c) Rainfall maximum 150 mm per month

d) Barometric Pressure 102 kPa

e) Solar Radiation 242 W/m2 (RCP4.5)

f) Wind Speed
   - Average 17 km/h (October)

   The regional basic wind velocity is 40 m/s (for a 3 second gust), for structural design purposes.

g) The facilities are located in a seismically active area. From the Probabilistic Seismic-Hazard Maps the site lies in a region with a peak ground acceleration (g) of about 0.13 with a 10% probability of being exceeded a 50 year period. The seismic activity occurring in the greater area of interest for the Bushveld Vanchem Project would mostly be associated with local mining activity (e.g. stope closure underground). There is no severe probability of such activity on the site. However, at design stage, the appropriate "earthquake" base factors are used in structural design calculations. The seismic design and return period requirements for the facility shall be as follows:
   - The plant to remain operable during seismic events for a 100 year return period; &
   - The plant shall remain intact, without serious damage, during seismic events for a 425 year return period.

h) Atmospheric conditions is wet and corrosive, with high air pollution concentrations. Material Selection and Corrosion Protection shall be selected accordingly.

3. Scope of Design

The design is broken into three discrete portions:

3.1. Chemical Plant Expansion

This section would require the detail design for two additional SST Reactors, complete with all required pumping and piping systems. An additional Desilication Press will be installed at the existing filter presses.

The new SST Reactors will be stand alone, complete with a hoist and crawl assembly for material handling and maintenance purposes. The section above the SST Reactors will be sectionally covered using cladding.

The piping system between the Clear Tanks and the new SST will be Stainless Steel Lines. A return line will also be provided from the new SST Reactors to the existing SST Reactors to provide flexibility should additional AMV production be required to the Chemical Plant.

All required Safety Systems, Electrical and Control, as well as services required for operation to be incorporated into the design.

The scope of design includes, but is not limited to the activities and tasks required to prepare the following:

- Process and Instrumentation Diagrams (P&IDs)
- Pump Specification
- Pipe Sizing
- Tank Sizing
- Valve sizing and specification
- Structural Drawings
- Plant General Arrangement Drawings
- Piping Routing Drawings

All design documents and drawings shall be prepared using metric (SI) units.

3.2. Overland Pipeline and LAROX integration

An overland HDPE-line will be installed to pump the ammonium metavanadate (AMV) solution to the LAROX Filter Press.

The HDPE-line will be run adjacent to the eastern perimeter, from where it will rejoin existing pipe racks at the Barren tanks and be routed to the LAROX Filter Press Feed Tanks.

Where possible, existing infrastructure would be used. These include existing pipe supports, pipe sections, existing tank and pump systems.

The scope of design includes, but is not limited to the activities and tasks required to prepare the following:

- Process and Instrumentation Diagrams (P&IDs)
- Pump Specification
- Pipe Sizing
- Tank Sizing / Verification

- Valve sizing and specification / Verification
- Structural Drawings (Where additional pipe supports are required)
- Plant General Arrangement Drawings
- Piping Routing Drawings

All design documents and drawings shall be prepared using metric (SI) units.

3.3. Barren Tank Conversion

The conversion of the existing Barren Tanks to be used as Settling Tanks would require the tank bottoms to be converted to prevent settling and solidification. Tank Floors would be sloped towards the outlets and designed to create the required velocities to be self-cleaning.

Modifications would be made to allow for a decanting outlet at 70% of normal volume. This decanting volume would be pumped using existing pumps and pipe network to Barren Tank 2.

The slurry, once settled would be pumped to the Pregnant Solution Tanks at the Chemical Plant, using the existing pipe network. A tie in, complete with valve bank would be required to facilitate automatic change over in directing Pregnant Solution from the Kiln, or Pregnant Solution from the Barren Tanks. The existing pumps at the Barren Tank would be amended to support the required volume flow rates.

4. Process Description

4.1. Chemical Plant Expansion

To find more cost-effective ways to increase AMV production throughput, Bushveld VANCHEM has identified to install additional reactors and associated equipment at the Chemical Plant. (Refer to proposal provided by Bushveld VANCHEM, 16 November 2021)

The installation of a new Desilication Press, as well as two new 60m^3 SST Reactors (6 & 7) would allow approximately 200m^3 slurry to be fed to the LAROX Filter Press. This would increase V_2O_5 production with approximately 10.7 t/d. A line would also be installed to return the AMV Slurry to the existing SST Reactors (1-5) instead of the LAROX Filters Press. This would allow maximum flexibility in processing the AMV Slurry from SST 6 & 7.

The new SST Reactors (6 & 7) can receive feed from both the existing Clear Water Tanks, or directly from the Desilication Press.

Decanted material would account to approximately 30m^3 between the two new SST Reactors and would be returned to the AMV Settling Tanks to recover the ultra-fine AMV and the AMV that post precipitates.

5. Description of Facilities

5.1. Chemical Plant Expansion – SST and Filter Press

The Chemical Plant Expansion will entail the installation of additional reactor and filter capacity.

This will require addition of:

- 2 x 60m^3 Stainless Steel Tank (SST Reactors) complete with Agitators, Bulk Bag Break and Sampling Hatches
- Decanting Pump Set to be shared between the two Tanks to pump decanted material back to settling tanks
- AMV Slurry Pump Set for each SST to pump slurry to LAROX Filter Press or back to existing SST's
- All relevant interstage piping and supports
- All relevant Valves
- All relevant instrumentation and controls
- Electrical Feed Supply from Chemical Sub-Station (Feeder)
- Local MCC and JB for Instrumentation Network
- All relevant Civil and Structural works to support new Tanks and Pump System
- Overhead crawl for purposes of AmSul Dosing and maintenance
- Structural support for covered area
- Sump Pump and Return Line for new Bund Area
- New Desilication Press complete with Hydraulic Pack
- Conveyor system for removal of Filter Cake
- Refurbishment of existing facilities (Filter Press Bund Area, Acid Bricking, Supports)
- Assess existing pump capacities for Clearwater Pumps and Filter Feed Pumps to ensure sufficient capacity to new SST's

5.2. Overland Line and LAROX Integration

AMV Slurry from the new SST Reactors will be pumped to the existing LAROX Filter Press Feed Tanks. This system will require:

- Installation of associated HDPE Pipeline
- All relevant valves
- All relevant Pipe Supports (both Civil blocks, as well as pipe rack extensions)
- Refurbishment of existing Tank and LAROX Feed Pumps.
- Refurbishment of LAROX Filter Wastewater Pumps (Sump Pumps)

5.3. Conversion of Barren Tanks

The use of the existing Barren Tanks for settling of AMV to recover the ultra-fine AMV and the AMV that post precipitates would require upgrade of tank system to prevent settling and solidification of the slurry at the tank floor. These changes would require:

- Modification of Tank Bottom to have sloped / conical floor. This will aid in the self-cleaning mechanism and prevent solidification of slurry settlement.
- Refurbishment of Pumps and associated pipe works. This include addition of new take off points.
- All relevant interstage piping and supports
- All relevant Valves to be refurbished
- All relevant instrumentation and controls

6. Design Principles

6.1. General

- Where possible, equipment and components shall be selected from the vendors standard range suitable for the specified design and operating criteria, with readily available spares and replacement parts.
- Equipment and materials of construction shall be new and of industry standard. Prohibited materials, including asbestos and PCB's shall not be used in any components.
- Equipment and components e.g. gears, shafts, bearings etc. including all fasteners shall be metric. Soft conversions shall not be permitted.
- Manufacturing and construction methods, including welding, castings, machining, surface finish, limits and fits etc. shall be in accordance with the relevant standards and codes.
- Where practical possible, existing equipment and infrastructure will be used to reduce installation time. Redundant equipment will be removed where plot space is required.

6.2. Operating Duty

- Unless noted otherwise, equipment and associated items shall be designed to operate continuously, safely and reliably, 24 hours per day, 365 days per year under the nominated design conditions.
- Equipment shall be designed to operate in the environment at the location described in section 1, and may be exposed to dust, heat, vibration, process water, direct sunlight, rain and other arid weather elements.

6.3. Design Life

- Equipment shall be designed for the project-specific service life of 15 years
- Mild steel platework shall have an external corrosion allowance of 2mm, whilst allowance for stainless steel shall be 1.5mm.

6.4. Design Loads

6.4.1. General

Design loads shall be the most adverse combination of loading and shall include, but not necessarily be limited to the following:

- Dead loads
- Live loads
- Thermal loads
- Wind loads (including cyclonic winds whilst either empty or full)
- Earthquake loads
- Pressure induced loads
- Machine action loads (including applied torque)
- Acceleration or deceleration/inertia loads (including braking forces)
- Impact loads
- Material expansion and contraction loads

- Upset conditions
- Plant maintenance activities and access
- Transportation and installation loads

6.4.2. Fatigue Life

- Equipment shall be designed for a fatigue life at least equal to the project-specific service life when applying maximum operating loads.
- Design loads for fatigue failure analysis shall be determined from those loads applied to, or produced by the equipment whilst performing at its maximum rated capacity.
- Where practical, the load variations contributing to fatigue shall be designed to eliminate or reduce stress reversals.

6.4.3. Maximum Loads

- Equipment shall be designed to accommodate the maximum loadings to which it may be reasonably subjected to during its design life, without the risk of equipment damage or risk of injury to personnel.
- Where equipment is driven by a prime-mover e.g. motor, engine, turbine etc, the equipment and it's mounting systems shall be designed to withstand the maximum load that can be produced or securely limited, whilst maintaining deflections and stress limits within required tolerances

6.4.4. Unitized Equipment

- Unitized equipment shall be mounted on designed-for-purpose, integral skid bases. The skid base shall facilitate easy access to equipment for maintenance purposes, whilst remaining compact and transportable.
- Self-contained assemblies shall be supplied:
    - Complete with on-board electrical wiring, components, instruments and devices complete and installed. Wiring and conduit shall be marshalled, identified and terminated at on-board junction boxes.
    - Complete with on-board pipework, valves, hoses and fittings complete and installed.

6.5. Safety in Design

6.5.1. Design for Safety Reviews

- A formal design for safety review shall be conducted during basic design phase.
- A final hazard review will be performed prior to verifications and final design completion.

6.5.2. Risk Management

- Risk management processes shall be applied in accordance with the project-specific requirements.
- Risk reviews, risk analysis, hazard identification and controls shall comply with relevant OH&S regulations.

6.5.3. Isolation

- Isolation plans shall be developed by suitably qualified personnel and applied in accordance with the project-specific requirements.

- Where isolation may need to be frequently established and re-established e.g. for maintenance testing, the isolation point shall be readily accessible and adjacent to the equipment.
- As a minimum, positive isolation shall be provided for the following situations:
    - Confined space entry e.g. lethal atmosphere, low or high temperatures and pressures, low oxygen, high toxicity, flood or inundation
    - High-risk non-confined space entry e.g. prevention of catastrophic events etc.
    - Critical process isolations e.g. as required by relevant codes
    - Potential energy exists e.g. high-pressure fluids, stored mechanical energy, gravitational energy, electrical energy etc.
- Examples of positive isolation include:
    - Double block valve or damper with bleed of intervening space – bleed shall be adequately sized to match expected leakage rates
    - Double block valve or damper with positive pressurization of intervening space with a safe medium
    - Single block, removable spool piece and blind on open end
    - Blind with upstream isolation valve and vent or drain – blind shall be gas tight, upstream isolation valve only required for blind placement.
    - Blind with pressurized seals – non-preferred method
    - System isolation and purge with test of safe atmosphere

6.5.4. Confined Spaces

- A minimum of 2 access ways shall be provided to any area designated as a confined space.
- Access ways shall be defined as part of the project-specific risk review process.
- Suitable anchor points shall be provided to allow safe working and to allow rescue of injured or disabled personnel should this be required.
- Suitable hinged access covers shall be provided which can be opened and closed by one person.
- Access covers shall be insulated and clad in the same manner as the vessel to which they are attached.

6.5.5. Hot Surfaces

- There are no identified hot surfaces applicable to this project.

6.5.6. Guarding

- Guarding shall be in accordance with relevant standards and project specific requirements.

6.5.7. Working at Heights

- Where practical, all equipment shall be designed to enable assembly at ground level before being lifted into position so as to reduce working at heights during installation.
- Stairs, ladders, access platforms and hand railing shall be in accordance with relevant standards and project specific requirements.

7. Design Criteria

7.1. Key Performance Measurements

The equipment shall be designed for a 15-year service life in the environment indicated in the applicable site climatic conditions.

- The capacity of the circuit shall be:
  - The **desilication press** should be able to filter 4.5 tons of sludge for every 100m3 of solution filtered through it. The outlet of the press should go to the Clear tank and must also be able to go directly to the new SST's, SST 6 and 7 respectively. This press should have the capacity to filter at least 300m3 of Pregnant Solution in a 24hr period. The SG of the material is 1.14kg/m^3.
  - Both **SST Reactors** have a capacity of 60m^3 which will produce a total of 10.7 tons of V_2O_5 over a 24hr period. The slurry to be pumped has an approximate density of 97kg of AMV for every m^3 of barren. The total slurry to be pumped to the LAROX press over a 24hr span will be a minimum of 200m^3. The Slurry Pumps will be sized to pump 25m^3/hr. These 2 x **SST Reactors** can receive desilicated Preg from the Clear Tank as well as directly from the new Desilication Presses. The decanting barren lines will decant 30 percent of the original volume of 50m^3 (i.e. 15m^3). This decanted barren is pumped to the AMV settling tanks to recover the ultra-fine AMV and the AMV that post precipitates. There is also a line that can pump the AMV slurry back to the SST's in the Chemical plant instead of the LAROX filter at the Fusion. This is to allow for maximum flexibility in processing the AMV from SST 6 and 7.

7.2. Specific Requirements

7.2.1. Storage Tanks

- Vessels shall be designed and fabricated in accordance with accepted good engineering practice and the specific requirements of this Standard.
- All vessels shall be furnished with attachments for lifting transportation and mounting, and with earthing lugs and nameplates. Additional fittings may be specified or implied in the drawing/data sheet.
- All Steelwork to be SABS 1431. Refer to Corrosion Protection Specification
- All Plate Work to be 6mm thick U.O.N.
- Welding to be 6mm continuous fillet or full penetration butt welds.
- Fabrication and Erection to SABS 1200H
- Fabricator to split tank for shipment to site
- All vertical joints to be staggered
- To be completed based on design from Christo

7.2.2. Civil Works and Structures

- All Civil Works to comply with SANS 1200AH accuracy level II
- All Concrete work to be founded on ground with minimum bearing capacity as specified by the structural / geotechnical engineer

- Structural Concrete to be as specified on the Civil Construction Drawings
- Structural Concrete to be 30MPA at 38 Days (Water / Cement Ratios = 0.45 for all structural plinths)
- Mass Concrete to be 10MPA at 28 Days
- 20mm Chamfer to all exposed corners
- 50mm Min Cover to reinforcing on structural concrete and 40mm Min Cover to mesh in slabs
- Smooth Shutter finish to exposed surfaces
- Smooth Wood Float finish to all slabs, unless otherwise noted
- Bars to be bundled and tagged with Bar No, Dwg No and Member No before delivery to site
- Grouting – M-Bed Superflow or Engineer Approved Equivalent
- Backfill material to be compacted in layers not exceeding 200mm to 95% MOD AASHTO (min) or as specified on the construction drawings
- No-Fines Concrete Aggregate: Cement Ratio (By Volume) = 10.5 (19mm Stone Size)
- Reinforcing Steel to SANS 920 as amended Bending to be in accordance with SANS 282 or Equivalent
- Reinforcement shall be positioned as shown on the drawing and maintained in those positions with the tolerances given in SABS1200G Section 6.2
- All Reinforcement Bars must be secured at every intersection with wire as per SABS 1200G Section 5.1.2 with every second intersection secured with double wire
- All HD Bolts to be Black Bolts Gr300WA unless otherwise shown on Civil Construction Drawings
- All Foundations to be constructed on 50mm Blinding layer (10Mpa)
- All Surface Beds to be constructed on 250Micron Polyethylene Sheeting
- Where cast in bolts are not specified handrail mounting onto concrete to be fixed with M16 Chemical Anchor Bolts installed to Supplier Recommendations. Bund Widths local to support to be minimum 150mm wide
- All grouting to be at 45° starting at the edge of the base plat

7.2.3. Pumping Systems

- Pumping systems shall be designed for minimal wear and no blockages.
- Pumps shall have facility for removal by overhead hoist, monorail or mobile crane, with the lifting access to include the pump, motors, valves and other equipment as applicable.
- Pumps shall be selected to such that they incur minimal wear.
- Pump shaft sealing shall be high flow packed gland seals.
- Piping shall be standard lengths and standard diameters where possible.
- Steel piping shall be constructed from sections than can be dismantled.
- Polyethylene piping shall be adequately supported.
- Piping shall be supplied with either loose flanges or one fixed and one loose.
- Piping shall be positioned to allow reasonable access for maintenance.
- Valves shall be positioned to be accessible for operations and maintenance.
- Valves shall be lockable for isolation purposes where indicated on P&IDs

7.2.4. Piping Systems

- For all Piping material specifications refer to the Piping and Valve Specification

- Pump Suctions and Reducers to be manufactured as per individual drawings
- As per Item 1, for HDPE Lines refer to Piping and Valve Specifications
- Gravity Lines for Slurry lines to have 3D Bends
- All items manufactured off-site to be clearly marked on pipe approximately 300mm from the fixed flange, indicating the Item Number and Drawing Number
- As per Item 1, for all flanges refer to Piping and Valve Specifications
- Flanges to be fitted with holes off center (i.e. 2 holes at top)
- All gaskets to be Full Face 3.0mm Klinger 80 or Equivalent.
- All steel bends to have a R=1.5Dia
- For all Fitting Specifications refer to the Piping and Valve Specification
- For all Screwed Pipes and Fittings specifications refer to the Piping and Valve Specification
- All closures to be supplied 150mm longer than drawing dimensions (i.e. As per Material List Dimensions) with a loose flange to allow for site adjustment.
- Loose flanges should thus be marked
- Fabricator to supply all nuts, bolts and washers, suitably bagged (including 5 spares), labelled and dispatched to site together with piping. Fasteners to be Hot Dip Galvanized (except where piping specification is Stainless Steel as these must be Stainless Fasteners)
- All flushing points to be fitted with 25NB Nipple, with a 25NB Ball Valve and 25NB Quick Release Coupling
- All Pump Suction reducers to be eccentric, top flat.

7.2.5. Electrical

- Low voltage on the plant is to be 380 Volts
- WEG brand motors designed for the environment shall be specified.
- Electrical equipment shall be easily accessible for maintenance.
- Welding and other electrical outlets shall be provided where appropriate.
- All essential equipment is required to be driven by backup generators in the event of incoming power failure.
- All power cables to be blue stripe, low halogen insulated cables
- Local field isolation shall be installed for all low-voltage motors, including local control station that will incorporate a stop/start/E-stop push buttons.
- Switchgear to be utilized should be Schneider supply, with Motor protection relays to be supplied by Schneider as well.

7.2.6. Control

- Control and instrumentation devices shall complement the existing system.
- Supply voltage for instrumentation as well as digital outputs shall be 24V DC. Analog outputs shall be 4-20 mA.
- All computer control equipment to be Schneider supply.

7.2.7. Washdown Systems

- Washdown water supply shall come from the process water system.
- Washdown hoses up to 50mm diameter shall be coupled using the same fittings as currently used on site.
- Wash-down water and associated spillage shall be directed to collection sump pits.
- Floor slopes should be up to 5 degrees where appropriate.

7.2.8. Guarding

- Guarding shall be in accordance with relevant standards,
- Guarding shall comply with Bushveld Vanchem standards.
- Guarding shall be constructed from lightweight, corrosion resistant material.
- Good, practical guarding practice shall be adopted with respect to ease of housekeeping, removal for maintenance, clearing of blockages and minimizing accumulation and build up behind guarding.

7.2.9. Cranes and Lifting Systems

- Lifting equipment shall be in accordance with relevant standards.
- Lifting equipment shall comply with Bushveld VANCHEM standards.
- Separate lifting facilities shall be provided for the installation and removal of equipment.
- Lifting lugs and total mass markings shall be provided on all equipment to be lifted by crane or hoist.
- The crane should be able to remove the Agitator and Gearbox assembly as well as to locate the AmSul bulk bags during normal operation.

7.2.10. Services

The following services are to be allowed for on the plant.

7.2.10.1. Process Water / Potable Water

- Potable Water is being used for both Process and Potable Water Applications.
- Potable water shall be available to tie-in from the existing process water services.
- Potable water is to be utilized for safety shower and eye wash purposes
- Potable water is to be utilized for plant washing and housekeeping purposes, and is to be available at practical positions throughout the plant
- Potable water is to be 25NB or larger to allow for mining hose washdown.

7.2.10.2. Plant Compressed Air

- No Compressed Air had been identified as necessary for the Chemical Plant Expansion.

7.2.10.3. Fire Water

- The client needs to advise on the availability of Fire Water at the new SST Reactors

7.2.10.4. Instrument Compressed Air

- No Compressed Air had been identified as necessary for the Chemical Plant Expansion

7.2.10.5. Raw Water

- The client needs to advise on the availability of Raw Water and if these are different to the Potable Water Supply

7.2.11. Reagents

The following reagents could be utilized in the plant

7.2.11.1. Ammonium Sulphate

- Ammonium Sulfate ($(NH_4)_2SO_4$) is added to the Clearwater in the SST Reactors for AMV precipitation.
- AmSul is added to the contents of the SST Reactors utilizing the overhead crane. The Bulk bags will be hoisted from ground level and positioned into the Bag Breakers.
- The number of Bulk Bags added to the SST's are determined using a table in relation to the amount of Vanadium that is measured.
- After the addition of the $(NH_4)_2SO_4$ to the SST, it is left to stir for a time of approximately two hours for the reaction to be completed. After two hours a sample of the liquid in the SST is taken in order to determine the amount of vanadium that has not reacted. If the concentration of unreacted vanadium is less than 1 g/l the SST is ready to be centrifuged.

7.3. Future Allowances

This design does not allow for the expansion of the plant as discussed with the Project Team. Consideration should be given to such systems in the future. (future tanks, and MCC space)

7.4. Equipment Sparing

Commissioning Spares are smaller spare parts (e.g. Limit Switches, Sensors, PT100, Filters, etc.), which will be needed for the "Cold Commissioning Phase".

A list of Critical Spares to be kept on site for future maintenance shall be supplied by CEMS Consult. Bushveld VANCHEM to procure these spares in advance as needed

7.5. Plant Integration

- Interaction with normal operations, maintenance, traffic and general activities shall be safely managed with disruptions minimized as much as possible.
- Equipment required to be modified as well as interconnections and tie-ins to existing plant shall be identified as part of the design.
- Tie In assemblies must be pre-manufactured to reduce turn around time / down time to allow for such tie ins to be done.

7.6. Critical Protective Systems

- Appropriate risk management processes shall be applied to ensure critical protective systems have been identified and incorporated into design

7.7. Quality Tests

The only quality tests that will be conducted for purposes of this study is the Desilication Filter Press Sampling analysis and filtration tests. Refer to findings in Appendix D – Desilication Filter Press Test Results

7.8. Health, Safety and Environment

- All designs shall comply with the requirements of the specific HSE requirements for the project including Bushveld VANCHEM's specific requirements and protocols.

7.8.1. Waste Water

- The only Waste Water provided for will be the Wash Water when the Filter Plates are being washed / rinsed
- The existing Bund Area and Acid Bricking is in a poor condition and should these be repaired in general prior to installation of the new Filter Press.

7.8.2. Solid Waste

- Solid waste will arise from various activities such as:
    - Maintenance waste;
    - Production Waste (Filter Cakes to be discharge and disposed off into Waste Bins
    - Operational waste (i.e. packaging, empty chemical containers, filter cloths etc.); and
    - Domestic waste.

- The directive for handling & disposal will be dictated by the existing SOP (Standard Operating Procedures) that are implemented by Bushveld VANCHEM. The above does not reflect Construction Waste and shall the latter be disposed of as directed by Bushveld VANCHEM and as indicated by the Construction Contractor during the construction phase.

7.9. Design Software

- As a minimum, all design software shall comply with CEMS Consult standard requirements

7.10. Engineering Procedures

- As a minimum, all engineering procedures shall comply with CEMS Consult standard requirements

7.11. Design References

- Unless noted otherwise, all designs shall comply with the following design references:
    - Relevant regulations, codes and standards noted in 11.2.
    - Reference documents noted in 10.3

7.12. Tank Isolation and Bypass

- All processing related tanks must have the ability to be isolated and bypassed without the primary processing plant needing to be stopped. This will exclude transfer and storage tanks, but should include:
    - Individual SST Reactor
    - Barren Tanks
- The isolation should allow for the tank to be drained and cleaned or maintained as required.
- The bypass should allow for the process to continue sequentially ie. SST 6 can still be used when SST 7 is offline

7.13. Bund Sizing

- All bunds must be sized to accept 110% of the volume of the largest vessel in the bund, if this vessel were to rupture
- It is acceptable to utilize other bunds adjacent to make up a percentage of the required volume – however this must be approved for suitability.

8. Design Assumptions

8.1. Chemical Plant Expansion

An inhouse assessment of the Chemical Plant Expansion had been conducted by Bushveld VANCHEM Engineering and Operations Team. A Concept Level flow schematic and associate process description had been provided for purposes of defining the Scope of Work required for the expansion.

Table 1 - Chemical Plant Expansion

Item	Description	Assumption	Units
	Plant Throughput		
1	Plant Availability	95	
2	Plant Utilization	95	
3	Plant Throughput		
	Desilication Filter Press		
4	Flow Rate		
5	Flow Rate		
6	Percentage Solids		
7	Type of Operation		
8	Operational Hours		
9	Supply Pressure		
10	Supply Temperature		
11	Wash Cycle		
12	Wash Medium		
13	Product Destination		
14	Wash Media Destination		
	SST Reactors		
15	Volume of each SST		
16	Type of Operation		
17	Maximum Fill Height		
18	Decanting Height		
19	Decanting Volume		
20	Decanting Flow Rate		
21	Decanting Density		
22	Decanting Destination		
23	Slurry Flow Volume		
24	Slurry Flow Rate		
25	Slurry Density		
26	Slurry Destination		
	LAROX Filter		
27	Feed Throughput to LAROX Filter		
28	Product Flow Rate		
29	Product / Filter Cake Destination		
30	Wastewater Flow Rate		
31	Waste Water Destination		
	Barron Tanks		
32	Volume of each SST		

33	Type of Operation
34	Maximum Fill Height
35	Decanting Height
36	Decanting Volume
37	Decanting Flow Rate
38	Decanting Density
39	Decanting Destination
40	Slurry Flow Volume
41	Slurry Flow Rate
42	Slurry Density
43	Slurry Destination

9. Battery Limits

Battery limits and tie-in points for the project has been divided into the following areas:

9.1. Chemical Plant Expansion

9.1.1. Terminal and Tie In Points

- Electrical Feeder Cable from MCC panel from the existing Chemical Plant MCC
- Instrumentation, tie into terminals of the existing PLC
- Tie in to the existing Filter Press Feed Header
- Tie in to the existing Filter Press Product Line to Clear Water Tank
- Tie in to existing SST Feed Header
- Tie in to redundant AmSul feed header (AMV Slurry Return from new SST's)
- Tie in to Feed Line to Settling Tank from new SST Decanting Pumps
- Tie in to Preg Tank Feed Line from new SST Sump Pump
- Services
    - Potable Water - Tie into existing potable water delivery manifold just south of the Ammonia Storage Tanks

9.1.2. By Others

- All reagent addition to remain as per present operation, with addition of AmSul to new SST's as per current protocol
- Suitability/integrity of existing equipment on site including compliance to relevant standards. Refurbish all integrating equipment to support effective utilization of new plant

9.2. Overland Line and LAROX Integration

9.2.1. Terminal and Tie In Points

- Tie in to the existing HDPE Piping (Redundant) on Pipe Rack at Barren Tanks. Piping to be configured and completed up to LAROX Filter Feed Tank Inlet
- Tie in to existing HDPE Piping (Redundant) back to Barren Tanks
- Tie in to existing Barren Tank Feed Header from LAROX Waste Water

9.2.2. By Others

- Suitability/integrity of existing equipment on site including compliance to relevant standards. Refurbish all integrating equipment to support effective utilization of new plant, including LAROX Feed Tank and Feed Pumps, LAROX Waste Water Sump Pumps

9.3. Conversion of Barren Tanks

9.3.1. Terminal and Tie In Points

- Tie in to Decanting Point on Tanks (New)
- Tie in to existing HDPE Piping (Preg Solution to Chemical Plant)
- Tie in to existing Barren Tank Feed Header from LAROX Waste Water

9.3.2. By Others

- Suitability/integrity of existing equipment on site including compliance to relevant standards. Refurbish all integrating equipment to support effective utilization of new plant, including existing APV Slurry Pump Upgrade

10. Plant Numbering System

Currently Bushveld VANCHEM does not have a Plant Equipment and Tagging Standard. For purposes of execution of the Chemical Plant Expansion Project, a Plant Identification and Numbering System had been adopted.

10.1. Plant Identification and Labeling

Plant Sections had been numbered for reference when referring to Tie-In Schedules and process flow description. General numbers such as 'Tank 02' are not specific and cannot be used as positive equipment identification.

All equipment impacted by the Chemical Plant Expansion (existing and new) will be provided with a detailed tag and reference number consisting of Area, Equipment Description and Sequential number.

Where existing equipment already contain a sequential number, i.e. Preg Tank 01, these items (equipment, valves and piping), are to retain their old sequence numbering, while all new equipment and items are to conform to the Project Specific Numbering System

The following unit numbers and descriptions have been assigned for the project:

TABLE 2 - BUSHVELD VANCHEM UNIT NUMBERS

Unit No.	Unit Description	Remarks
010	Ore Preparation	
020	Extraction	
021	Kiln 1 Fume Treatment	
022	Kiln 1 Roasting	
023	Kiln 1 Leach Dams	
024	Kiln 2 Fume Treatment	
025	Kiln 2 Roasting	
026	Kiln 2 Leach Dams	
027	Kiln 3 Fume Treatment	
028	Kiln 3 Roasting	
029	Kiln 3 Leach Dams	
030	AMV Plant	New plant to replace APV
031	LAROX Filter	
032	Deammoniator	
040	Fusion Furnace	
041	SAJV Smelter	
050	HiVox Plant	
051	FeV Smelter	
060	Chemical Plant	
061	Chemical Plant Pregnant Solution	
062	Desilication	
063	Clearwater	
064	Production of AMV	
065	Centrifuging	
070	Barren Treatment	
071	Barren Solution Storage	
072	Filtration	
073	Neutralization	
074	De-Silication	
075	Stripping and Adsorption	
076	Scrubbing	
080	MVR - Mechanical Vapor Recompression Crystallizer	
091	Raw / Fresh Water	
092	Storm Water	
093	Cooling Water	
094	Condensate	
095	Main Plant Boilers	
096	Chemical Plant Boilers	
100	Calcine Dams	
101	Slimes Dam	
102	Sulphuric Acid	
103	Ammonia Storage	
110	Plant/Instrument Air	
111	Fuel System	
112	Fire Systems	
113	Intermediate Storage	
114	Product Storage	

120	Buildings
131	Electrical Distribution
132	Instrument and Control Systems
140	Site Interfaces

10.2. P&ID Coding

P&ID component coding shall comply with the latest specific convention system as defined for the project, noting however that the existing items will be coded according to the old system where practical.

10.3. Equipment Tagging

The basic number is made up of the following 4 parts.

AAA–BB–CCD–EFF

Where:

AAA Unit number (see Table 2 - Bushveld VANCHEM Unit Numbers) e.g. 010 representing Unit 010 – Ore Preparation

BB Equipment identification letters (see 10.3.1 below) e.g. PC representing a centrifugal pump.

CC Sequence number, shall be numbered in the process flow direction for each service or duty based only on the general descriptor and not on the specific descriptor of the equipment identification letters e.g. all pump duties, independent of specific type, shall be numbered in sequence through the unit via either train. A centrifugal pump and a reciprocating pump in the same train will not both have "01" as a sequence numbers.

D Identification letter for equipment in the same service and duty operating in parallel (e.g. standby equipment) or equipment in the same service operating in series but performing a single process duty (e.g. heat exchangers shells in series) if required. Letters, A, B, C, etc. excluding the letters "I" and "O" shall be used.

E Connected/associated equipment identifier if required (see 10.3.1 below). This identifier ensures that closely connected equipment, performing a single process duty, has the same base number. E.g. a pump and its motor shall have the same number except for the last section of the number where an M is added to the pump number to indicate that it is the motor number.

FF Equipment component number, numbered sequentially and is only applicable to air-cooled heat exchangers, cooling towers and heater coils e.g. air-cooled heat exchanger consisting of 12 bundles, 12 fans and 12 motors, the bundles, fans and motors shall be labelled sequentially from 01 to 12.

Note the position of dashes in the composition of the number.

- Indicators D, E and FF may be omitted for equipment numbering where it is not required.

- Wherever possible Equipment shall be numbered in the sequence in which it appears in the direction of main process flow. Equipment numbers shall not be changed to accommodate the addition or deletion of an item during the progress of the contract. Any deleted number shall not be reused.

10.3.1. Equipment Identification Letters

Two describing letters shall identify the equipment. The first letter is a general descriptor and the second letter a specific descriptor. Where a specific descriptor is not required a two letters descriptor shall be used. The following designation letters shall be used to identify particular categories of equipment:

TABLE 3 - EQUIPMENT IDENTIFICATION LETTERS

BF	Boiler, Fired
CC	Compressor Centrifugal
CR	Compressor, Reciprocating
CS	Compressor, Screw
CB	Compressor, Blower/Fan
CX	Compressor, Other
EA	Heat Exchanger, Air cooled
ES	Heat Exchanger, Shell and Tube or Reboiler
EP	Heat Exchanger, Plate and Frame
EC	Heat Exchanger, Cooling Tower
EX	Heat Exchanger, Other (dimple plate, double pipe, etc.)
GE	Generator, Electrical
HF	Heater Fired
HE	Heater Electrical
PC	Pump, Centrifugal
PR	Pump, Reciprocating
PG	Pump, Gear
PD	Pump, Diaphragm
PX	Pump, Other
RF	Relief, Flare
RP	Relief, Pressure Valve
RT	Relief, Temperature Valve
RB	Relief, Busting Disk
TK	Atmospheric Tank or Sump
TP	Tank under positive pressure
VR	Vessel, Reactor
VH	Vessel Hopper or Silo

VC	Vessel, Column or Tower
VD	Vessel, Drum
XA	Miscellaneous Equipment, Agitator
XD	Miscellaneous Equipment, Drier
XF	Miscellaneous Equipment, Filter
XH	Miscellaneous Equipment, Desuperheater
XJ	Miscellaneous Equipment, Ejector
XM	Miscellaneous Equipment, Meter
XP	Miscellaneous Equipment, Package
XS	Miscellaneous Equipment, Silencer
XX	Miscellaneous Equipment, Miscellaneous

Connected/associated equipment descriptors shall be as follows:

B	Bundle
C	Heater Coil
D	Diesel Engine
F	Axial Fan
G	Gas Turbine
M	Motor
S	Steam Turbine
T	Transmission/Gearbox

10.3.2. Examples

- **064-VR-01** denotes the equipment number for reactor number 1 in Unit 064 (Chemical Plant AMV Reactors) of Bushveld VANCHEM Production Phase 1.
- **027-CB-01B** denotes the equipment number for the second Axial Fan in parallel service for the first Axial Fan in duty of Kiln 3 in Unit 020 (Extraction) of Bushveld VANCHEM Production Phase 1.
- **031-PC-01A-M** denotes the equipment number for the Duty Feed Pump Motor (Centrifugal Pump) to the LAROX Filter in Unit 031 (LAROX Filter) of Bushveld VANCHEM Production Phase 1

11. Reference Documents

11.1. Previous Study Work

An inhouse assessment of the Chemical Plant Expansion had been conducted by Bushveld VANCHEM Engineering and Operations Team. A Concept Level flow schematic and associate process description had been provided for purposes of defining the Scope of Work required for the expansion.

CEMS Consult has provided a list of **E**nd-**o**f-**J**ob (EOJ) Documents that will be provided as part of the Detail Engineering Design. The specific requirement form Bushveld VANCHEM is to have adequate information to allow the placement of Purchase Orders for the execution of the works.

11.2. Codes, Standards and Specifications

It is noted that specific OEM equipment will be specified to OEM standard. Where standards are not available from Bushveld VANCHEM (Project Specific Specifications), CEMS Consult will apply general design specifications in line with the Operational Data and Chemical Properties of the associated processes.

The installation shall be consistent of a new Bund area and associated equipment, as well as refurbishment and upgrade of existing infrastructure to support the integration of the new equipment and process units. *(No specific Codes and Standards for the existing operations were available during the audit. Applicable Standards that will apply should be identified by the client as reference for any new design work or as when required during expansion of the existing works)*

Table 4 - Codes and Standards

1.0	Codes and Standards		
1.1	Engineering standard	☑	CEMS's Standard ☑ OEM Standard
		☑	Bushveld VANCHEM Standard
1.2	National standard	❑	DIN ❑ AD
		☑	SANS ☑ MHSA
1.3	Material specification	☑	ASTM ☑ BS
		☑	SANS ❑ AD
		❑	API
1.4	Pumps, Compressors and Turbines	❑	API ❑ MHSA
		☑	Manufacturer Standards – use applicable standard for relevant piece of equipment
1.5	Machines (excluding 1.7)	☑	Manufacturer Standards – use applicable standard for relevant piece of equipment

1.6	Piping	☑	ASTM ☑ SANS
		❑	NFPA
1.7	Firefighting and Safety	☑	IEC ☑ MHSA
1.8	Electrical code	☑	SANS ☑ MHSA
		☑	IEC
1.9	Instrumentation	❑	ISA
		☑	SANS
1.10	Civil code	❑	API
		☑	SANS
1.11	Hazardous area classification	☑	SANS
		❑	API
1.12	Tanks	❑	BS ☑ SANS
		☑	API
1.13	Pressure relieving devices	❑	AD / DIN
		☑	SANS
1.14	Steelwork Code	❑	AD / DIN
		☑	SANS
1.15	Noise Regulations	☑	SANS ☑ MHSA

12. Units of Measure

Standard SI units shall apply with particular reference to the Scope of Work document as follows:

TABLE 5 - UNITS OF MEASURE

Property	Unit of Measure
Temperature	°C
Pressure	kPag, kPaa or barg
Vacuum	kPaa
Liquid Flow	m^3/hr (at flowing conditions)
Gas Flow (process units)	Nm^3/hr (0°C at 101.3 kPaa)
Dry gas moisture content	Dew Point (°C)
Gas compositions	Mol% or ppmv
Heat Flow	kW or MW where applicable
Power	kW or MW where applicable
Viscosity	cP
Equipment Dimensions	Mm
Line, valve and nozzle sizes	Inches
Heat transfer coefficient	$W/m^2.^oC$
Conductivity	W/m °C
Time	s, min, h
Specific heat	kJ/kg °C
Latent heat	kJ/kg
Surface tension	mN/m
Mass	kg, tonnes

13. Control Philosophy

2.1. Plant Control in Automatic Position

2.2. Plant Control in Manual Position

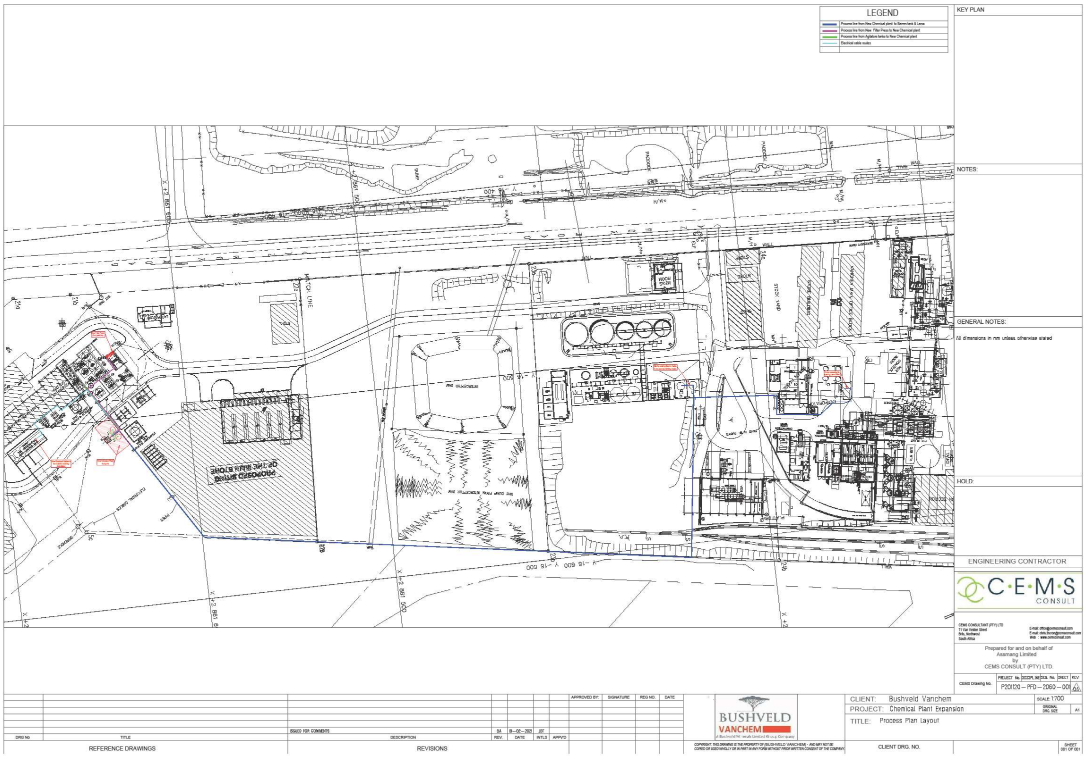
2.3. Plant Control in Maintenance Position

TABLE 6 - CONTROL PHILOSOPHY

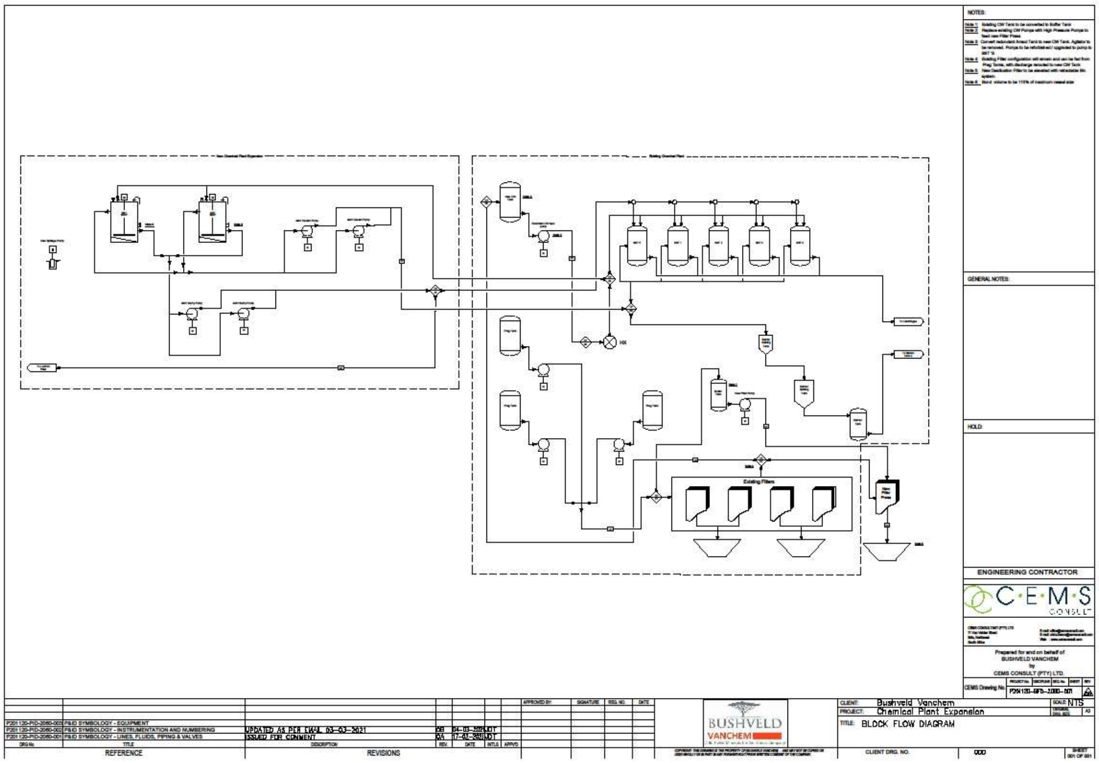
NAME	Chemical Plant Control Philosophy	
PURPOSE		
INSTRUMENTS		
CONTROL		
INTERLOCKS / PERMISSIVES	**Flow Start up if:**	
	Start up if:	
STOP IF	**Flow Shutdown**	
	Stop if:	
ALARMS		
INDICATIONS		

******Note1 Tag Numbers to be supplied by BV***

Appendix A – Process Layout Diagram



Appendix B – Process Flow Diagram (PFD)



Appendix C – Battery Limit Interface Table (BLIT)

Appendix D – Desilication Filter Press Test Results

1. Filtration test

Volume (L)	Elapsed Time min	Pressure (Bar)	Flux rate l/m²/h	Average flux rate
20,00	3,00	2,00	2208,00	2208,00
45,00	7,00	2,00	2070,00	2129,14
70,00	12,00	2,00	1656,00	1932,00
95,00	18,00	2,00	1380,00	1748,00
120,00	25,00	2,00	1182,86	1589,76
145,00	33,00	2,00	1035,00	1455,27
170,00	43,00	3,00	828,00	1309,40
195,00	53,00	4,00	828,00	1218,57
220,00	65,00	5,00	690,00	1120,98
245,00	80,00	6,00	552,00	1014,30
270,00	98,00	6,50	460,00	912,49
295,00	116,00	6,50	460,00	842,28
320,00	137,00	6,50	394,29	773,61
345,00	161,00	6,50	345,00	709,71
370,00	190,00	6,50	285,52	644,97

2. Filter Press Sizing

Slurry description		
Test number	no	1
Solution SG	sg	1.15-1.2
Slurry PH	Ph	8,11
Slurry Temperature	C	75-80
Solids loading	w/w%	0.39%
Solids PSD	d	Not measured
Slurry SG	SG	1,28
Filtration cycle		
Chamber thickness used	mm	20
Filter cloth	type	877x
Chamber type	Recess/Membrane	Membrane
Precoat	yes/no	No
Recycle time	minutes	no
Precoat grade		NA
Precoat thickness	mm	NA

Initial feed pressure	kPa	150
Final feed pressure	kPa	650
Filtrate volume	Litres	370
Filtration time	minutes	03:10:00
Average filtration flux rate	$L/m^2/h$	644
Cake wash cycle		
Cake wash liquor	water/other	water
Wash water temp	C	Ambient
Cake wash pressure	kPa	700
Cake wash flow rate	$l/m^2/h$	264
Cake wash time	minutes	10
Cake wash volume	litres	2,5
Cake drying cycle		
Air dry pressure	kPa	600
Air dry time	minutes	3
Membrane inflation pressure	kPa	700
Membrane inflation time	minutes	3
Wet bulk density cake	SG	1,55
Cake moisture	%	30
Total dry cake weight	kg	2,42
Filter cake volume	l	1.990
Dry cake weight	kg	1,694
Wet bulk density	sg	1.21

3. Filter Plant Sizing

Option 1- Peak flow rate condition

- $400m^3$ per 24 hours
- 6g/l solids loading
- 42m3/ peak flow rate

Option 2- High solid condition

- $400m^3$ per 24 hours
- 15g/l solids loading

4. Option 1 – Peak Flow Rate

Estimated Cycle times based on 0.6 % solids loading	
Description	Minutes
Close press	3
Recirculation for clarity check	5
Feed press	310
Cake wash if required	10
Membrane squeeze air blow	5
Open press	3
Discharge press	15
Cycle time	361
Online filtration time	310
Total filtration time per day	1110.42 (18.507 hours)
Technical non filtration time	41
Total cycles per 24 hours	3.98
Assume further 10% for plant stoppages and maintenance	3.582
Sizing based on flux rate	
Design plant throughput m3/day	400 m^3/day
Cycles per day	3.582
Normal plant production rate 400/18.507	21.61 m^3/h
Peak max flow design	42 m^3/h
Average flux rate from test work	632 l/m^2/h
Allowance for cloth performance degradation due to blinding over cloth life	30%
Design flux rate	442.4 l/m^2/h
Total filtration required 42/442.4	94.93 m^2
Filtration area of 1000mmx1000mmx20mm filter plate	1.52m2
Total number of chambers required	62.45
Therefore use	64 chambers
Total press filtration area	97.28 m^2
Total press cake volume	1056 litres

5. Option 2 – High Solid Condition

Daily production (l)	Solids loading ww%	Cake volume produced (l)	Comment
400000	0,39	2151,00	Test data
400000	0,5	2758,00	
400000	1	5516,00	
400000	1,5	8274,00	Design
400000	2	11032,00	
400000	2,5	13790,00	
400000	3	16548,00	

Estimated Cycle times based on 1.5 % solids loading	
Description	Minutes
Close press	3
Recirculation	5
Estimated filtration cycle	80
Cake wash if required	10
Membrane squeeze air blow	5
Open press	3
Discharge press	15
Cycle time	121
Onlin e filtration time	80
Technical non filtration time	41
Total cycles per 24 hours	11.9
Allowance for further 10% for plant stoppages and maintenance	10.71
Total filtration time per day	952 (15.866 hours)
Allowance for further 10% for plant stoppages and maintenance	856 (14.28 hours)
Sizing based on 1,5% solids loading	
Design plant throughput m3/day	400 m^3/day
Filter cake produced per day based on 1% solids loading	8274l
Number of cycles available	10.71
Total cake volume per cycle	772 litres
Allowance for membrane compression	20%
Total filter press volume	965 litres
Volume of 1000x1000x20mm	17.6 litres
Therefore 965/17.6	54.82
Therefore use	56 chambers
Total filtration area	85.12 m^3
Total volume	985.6 litres

Flux rate design check based on 1.5% solids loading	
Total volume per day	400 m^3
Available filtration time	14.28 hours
Total filtration rate per hour required	28.001
Proposed filtration area	85.12
Therefore, average flux rate	328.959 $l/m^2/h$

6. Recommendation

Based on the above design calculation used for the max flow rate of 42m3/h and the 1.5% maximum solids loading we recommend the option for the 64-chamber unit

7. Incoming Service Requirements

Membrane inflation	
Total press volume	1056 Litres
Compression	20%
Therefore 1056 multiply 0.2	211.2 Litres required at 8 bar working pressure
Air Blow Requirements	
Total press area	97.28 m^2
Air blow rate from design manual	0.07m^3 per m^2
Therefore 97.28 multiply 0.07	6.805 m^3 per minute @ 600kpa
Instrument air	
9 valves at 4 litres per valve	36 litres per cycle per press @ 600kpa

8. Feed Pump Selection

Volume (L)	Elapsed Time min	Pressure (Bar)	Flux rate l/m²/h	Average flux rate	Comment
20,00	3,00	2,00	2208,00	2208,00	
45,00	7,00	2,00	2070,00	2129,14	
70,00	12,00	2,00	1656,00	1932,00	
95,00	18,00	2,00	1380,00	1748,00	
120,00	25,00	2,00	1182,86	1589,76	
170,00	43,00	3,00	828,00	1309,40	Start-up duty flow rate
195,00	53,00	4,00	828,00	1218,57	
220,00	65,00	5,00	690,00	1120,98	
245,00	80,00	6,00	552,00	1014,30	
270,00	98,00	6.50	460,00	912,49	Final pump duty flow rate
295,00	116,00	6,50	460,00	842,28	
320,00	137,00	6,50	394,29	773,61	
345,00	161,00	6,50	345,00	709,71	
370,00	190,00	6,50	285,52	644,97	

Feed pump sizing	
Filtration area	97.28 m²
Filtration rate at 6.5 bar	460 l/m²/h
Therefore, pump duty required	44.748 m³ @ 6.5 bar flange pressure
Allowance for frictional and head loses	10%
Pump duty required	49.72 m³/h at 6.5 bar
Initial pump delivery duty	100 m³/h @ 2 bar