West Point Oxygen Generation Building - OGADS

Prepared for

King County Department of Natural Resources and Parks

Wastewater Treatment Division

September 28, 2022

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Wastewater Treatment Division
Project Formulation Program

Work Order No. 54
Project Number 5968722

Table 1. Document Revision History				
Version	Summary	Editor	Date Edited	Description of Changes
1	Draft	Jacobs Engineering Group Inc.		
2	Final	Jacobs Engineering Group Inc.	9/28/22	Addressed County comments

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List of Abbreviations

DCS	distributed control system
GOX	gaseous oxygen
HPO	high purity oxygen
HVAC	heating, ventilation, and air conditioning
LOX	liquid oxygen
OGADS	oxygen generation and dissolution system
VSA	vacuum swing adsorption
WPTP	West Point Treatment Plant
WTD	Wastewater Treatment Division

Executive Summary

The oxygen generation system at the King County West Point Treatment Plant provides high-purity oxygen to the secondary aeration tanks, where primary effluent and return-activated sludge are mixed. The current oxygen generation and dissolution system (OGADS) is a vacuum-swing adsorption (VSA) system with a back-up liquid oxygen storage and vaporization system. The existing VSA system is using outdated technology, and various components are reaching or at the end of their useful life. The oxygen generation process is critical to providing secondary treatment and meeting discharge permit limits. King County's Wastewater Treatment Division seeks replace or refurbish the VSA equipment to extend the system's life another 15 to 20 years.

The oxygen generation facility was installed the 1990s and consists of the following major equipment, which are the focus of this scope of work:

- Two VSA trains, each with a capacity of 70 tons per day
- Feed air blower system
- Adsorber system
- Vacuum pump system
- Gaseous oxygen blower system

The system operates reliably, but without turndown, and requires regular and expensive maintenance. In the past 10 years, many components of the oxygen generation system have been approaching the end of their service life. Plans to replace the existing VSA with a new VSA system were advanced as part of the OGADS Modifications Project but were suspended in 2017. The West Point Treatment Plant is currently implementing a separate project to replace all adsorber media to restore oxygen purity, along with any necessary adsorber vessel improvements for maintaining proper media support and adsorber function.

Two options were investigated for the VSA system:

Replacement - installing new, modern VSAs that have vertical, modular adsorbers.

Refurbishment – maintain existing system, replacing individual components, including field panels, local control panels, one feed air blower and motor, both gaseous oxygen blowers, and other items.

King County's preferred option at the formulation phase is Option 1, replacing the existing oxygen generation system with a new, modern VSA system. This option is preferred because the existing system requires significant maintenance time and cost, is energy inefficient, and overly complex to operate.

Section 1

Objectives

The oxygen generation system at the King County West Point Treatment Plant (WPTP) provides high-purity oxygen (HPO) to the secondary aeration tanks where primary effluent and return-activated sludge are mixed. Oxygen is added to maintain an aerobic environment where bacteria consume the organic matter in the mixed liquor. The current oxygen-generation and dissolution system (OGADS) is a vacuum-swing adsorption (VSA) system with a backup liquid oxygen (LOX) storage and vaporization system. Based on work completed as part of the previous OGADS Modifications Project (1116798) for the existing VSA system is using outdated technology, and various components are reaching or at the end of their useful life. The oxygen generation process is critical to providing secondary treatment and meeting discharge permit limits.

King County's Wastewater Treatment Division seeks to replace or refurbish the VSA equipment to extend the system's life at least another 15 to 20 years. This document describes the scope included in a future oxygen generation system replacement or refurbishment, including constructability and schedule impacts.

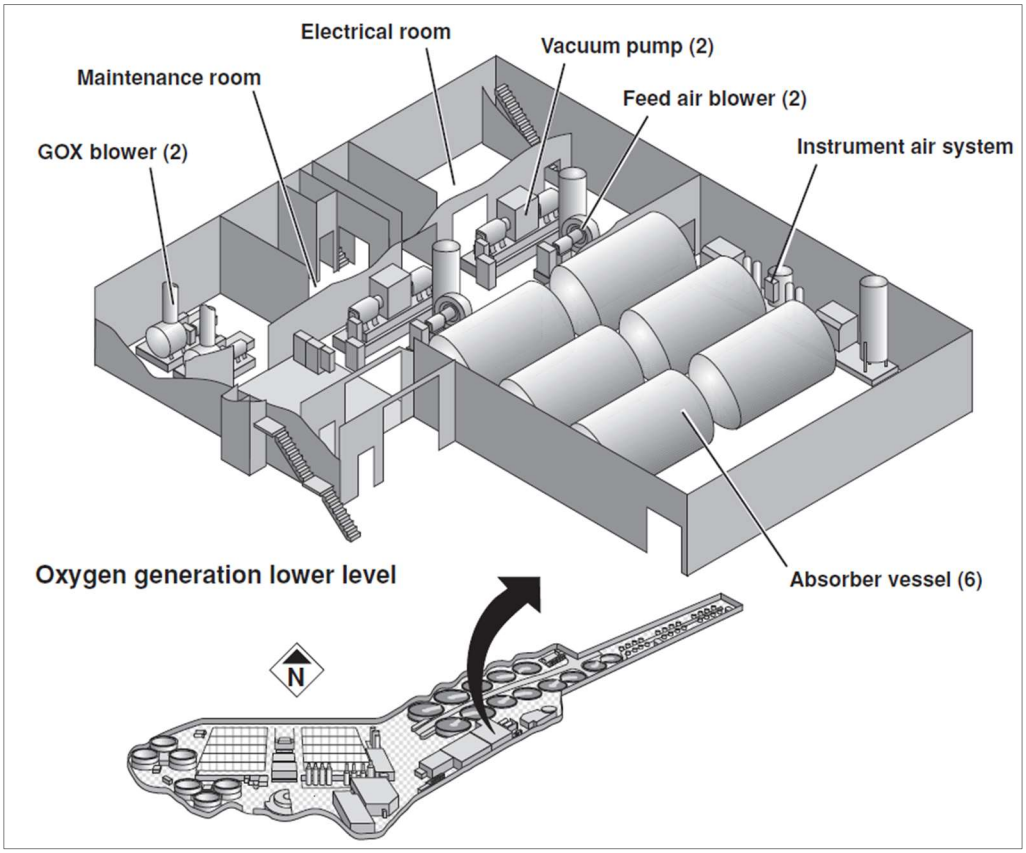
Section 2

Background

2.1 Existing Conditions

The oxygen generation facility was designed and installed by Air Liquide under a design-build contract in the early 1990s. The system consists of two vacuum-swing adsorption (VSA) trains (VSA Trains 1 and 2), each with a capacity of 70 tons per day. Major equipment layout is shown on Figure 1 and includes the following as part of this scope of work:

- Feed air blower system: two feed air blowers, heat exchangers, blower discharge control valves and silencers
- Adsorber system: six adsorber vessels and media, air inlet valve, gaseous oxygen (GOX) outlet valve, vacuum valve, and re-pressurization valves
- Vacuum pump system: two 2-stage vacuum pumps, two separator silencers, inlet strainers, bypass valves, and lubrication system
- GOX blower system: oxygen inlet valve, oxygen bypass/recirculation valve, oxygen vent valve, oxygen discharge valve, and aftercooler



Source: King County.

Figure 1: Oxygen Generation System General Layout

The system operates reliably, but is inefficient due to lack of turndown and, per County staff, also requires regular and expensive maintenance. In the past 10 years, many components of the oxygen generation system have been approaching the end of their useful service life and plans to replace the existing VSA with a new VSA system were advanced as part of the OGADS Modifications Project (CH2M HILL 2017; WTD Contract No. E00304E13). That effort was suspended as part of budget reprioritization efforts in 2017 after reaching 30 percent design. More recently, County staff documented that oxygen purity was declining in VSA Train 1, VSA Train 2 is no longer operational due to reduced purity, and the plant is currently implementing a separate project to replace all adsorber media in both trains to restore oxygen purity to acceptable levels. That project will be completed during summer 2022, along with any necessary adsorber vessel improvements for maintaining proper media support and adsorber function. County staff have also been rebuilding and refurbishing VSA components on their regular preventive maintenance cycle and as necessary to prolong system life.

The existing VSA system controls rely on outdated programmable logic controller hardware that is no longer offered or serviced by the original equipment manufacturer. While substitute programmable logic controllers are apparently available from other manufacturers, the VSA control system, relies on outdated components that were developed over 25 years ago. In addition, WPTP has standardized on the Emerson Ovation distributed control system (DCS) platform and bringing OGADS into full conformance would provide efficiencies in staff training, better align with common WPTP maintenance capabilities, and improve spare part availability.

2.2 Options Criteria

2.2.1 Replacement

The following criteria were established for the replacement option:

- Two new trains will replace VSA Trains 1 and 2, including appurtenant systems and controls. The new system will meet modern VSA technological standards and functionality.
- New VSA design capacity is based on a 98 tons per day demand. This is the estimated Year 2045 maximum month oxygen demand based on process modeling completed as part of the 2019 OGADS Modifications Project Aerator Upgrades Design, The system would consist of two VSA trains each capable of providing 100 tons per day of high purity oxygen (HPO). HPO needs beyond the maximum month demand would be provided by the redundant VSA and/or existing LOX system.
- Programming and controls are assumed to be manufacturer's standard but will be configured to communicate with and conform to WTD-standard Emerson Ovation DCS.
- Liquid oxygen (LOX) system is not included in the project.
- The heating, ventilation, and air conditioning (HVAC) system will be modified to remove the return air ducting and bypass damper system associated with the feed air system.
- Replacement scope is based on the OGADS Modifications Project 30 percent design from 2017 (CH2M HILL) but with greater capacity VSA units proposed.

2.2.2 Refurbishment

The following criteria were established for the refurbishment option:

- Components identified for replacement are generally based on the recommendations provided in the VSA System Recommendations Memo (Stantec 2022; Appendix B) with additional input from County staff.

- Replacement components will provide the same capacity as the existing system design, where each VSA train provides 70 tons per day of HPO. This system capacity is 30 percent less than Option 1.
- Adsorber vessel media are being addressed as part of the current media replacement project and are not included in the project.
- Programming and controls will be updated to WTD-standard Emerson Ovation DCS and WTD and WPTP component standards.
- The HVAC and LOX systems are not included in the project.

2.3 Documents Received

- Draft VSA System Recommendations Memo (Stantec 2022)
- *West Point Treatment Plant Oxygen Generation and Dissolution Systems Modifications Project Phase 1, Alternatives Analysis Report*. (CH2M HILL 2015a)
- West Point Treatment Plant Oxygen Generation and Dissolution Systems Modifications Project 30% design documents (CH2M HILL 2017)

Section 3

Oxygen Generation System Options

Two options were investigated for the vacuum swing adsorption (VSA) system: replacement and refurbishment.

3.1 Option 1 – Replacement

Option 1 consists of full replacement of the VSA system. The existing Air Liquide VSA system was one of the last of its generation of VSA technology when installed in 1995. The next-generation VSAs transitioned to a two adsorber bed process with buffer tank instead of the older three-bed method. Modern VSAs have moved to smaller, modular vertical adsorbers with valve and control skids typically mounted at grade for ease of access and buffer tank(s).

3.1.1 Scope of Proposed Work

- Replace VSA Trains 1 and 2 with modern equipment, including feed air blowers, adsorbers and media, valve skids, vacuum pumps, gaseous oxygen (GOX) blowers, and buffer tanks with local system controls.
- Upgrade all oxygen generation and dissolution system (OGADS) controls to WTD-standard Emerson Ovation distributed control system (DCS), including configuration and compatibility of local controls with Ovation.
- Wire new equipment from existing motor control centers.
- Modify OGADS building wall to provide access for equipment removal and future equipment installation.
- Design OGADS building wall modifications to meet current seismic building code requirements.
- Install 1-ton bridge crane and access platform in adsorber room.
- Remove the return air ducting and bypass damper system associated with the feed air system.

3.1.2 Constructability

Constructability considerations and potential construction sequencing for this option were addressed in the OGADS Modifications Project's Alternative Analysis Design Documents (CH2M HILL 2015a) and are summarized below.

Given safety concerns with working around high-purity oxygen (HPO) and the large size of the existing adsorbers, the analysis recommended shutting down existing VSA Trains 1 and 2 and relying on the existing liquid oxygen (LOX) system for oxygen generation during the construction period. To better assure a reliable oxygen supply, the existing LOX system should be thoroughly inspected by qualified inspectors and any repairs or upgrades be completed before construction begins. Interrupting LOX delivery during construction is a risk with this option, though not considered a high-probability risk at this time as this risk could be mitigated through development of a contract with guarantees and an established backup source for supplemental LOX delivery. Construction work can also be planned and scheduled to minimize the down time of the VSAs and reliance on only LOX.

Modifications to the OGADS building structure to provide access openings for equipment removal and installation should be completed before VSA construction begins. The size of the building openings will impact the duration of construction, that is, a larger opening could shorten construction time by facilitating equipment in and out of the facility. Construction of Option 1 is not seasonally dependent; however, coordination with WPTP operations, process, and safety will be critical to maintaining safe plant operations during construction.

3.1.3 Future Considerations

The future project design team should consider the following if this option advances:

- Evaluate other potential oxygen generation technologies and alternatives.
- Review system reliance and reliability. This includes the use of LOX for peaking and supplementing normal oxygen supply, including chemical delivery factors and availability of LOX during construction. A defined strategy for how much the plant relies on LOX or simultaneous VSA train operations is needed in order to finalize the number and size of new VSA trains.
- Evaluate and confirm future system design criteria based on current flow and load projections, expected system life, and desired system operation and reliability (e.g. use of LOX for peaking).
- Assess maximum capacity of existing feed air for handling air flows with two larger VSA trains in operation for meeting peak oxygen demands.
- Include equipment performance guarantees and/or extended warranties in contract documents.
- Evaluate energy savings and benefits from improved energy efficiency. A new VSA system could use 7,00,000 kWh annually.

3.2 Option 2 – Refurbishment

Option 2 replaces individual components, based on a condition assessment performed as part of the media replacement project (Stantec 2022) and conversations with County staff. Given the investment in installing all new VSA media, the refurbishment option will consider upgrading associated rotating equipment, components, and controls to align the oxygen generation system's service life with the new media's estimated 15- to 20-year life cycle. System components not included are assumed to have acceptable remaining service life for the 15- to 20-year duration identified. The refurbishment option will also upgrade the VSA control system to achieve standardization with the WTD's Emerson Ovation DCS platform with the additional goal of addressing known existing controls deficiencies in the programming and control components.

3.2.1 Scope of Proposed Work

- Replace all field panels associated with the feed air blower, vacuum pump, and GOX blower systems.
- Provide one spare of each type of instrument and valve for VSA Trains 1 and 2.
- Replace one feed air blower and motor (the other feed air blower and motor are currently being replaced).
- Replace feed air silencer and vacuum pump separator/silencer for VSA Train 1 (these were replaced on VSA Train 2 about 5 years ago).
- Add variable frequency drives to the two feed air blowers.
- Remove feed air heat exchanger subsystems.

- Upsize six adsorber vent valves from 2-inch ball valves to 10-inch high-cycle butterfly valves, including associated piping modifications.
- Replace all oil pumps and motors for vacuum pump system.
- Provide one spare vacuum pump motor.
- Replace two GOX blowers and motors.
- Replace two GOX blower bypass/recirculation valve actuators with electro-pneumatic actuators.
- Upgrade miscellaneous devices and components associated with each of the equipment skids.
- Update programming and controls to WTD I&C standards for the Emerson Ovation platform, communication protocols, I&C hardware, etc. All local control panels (two for feed air blowers, two for vacuum pumps, and one for GOX blowers) and the overall control panel in the control room will be replaced with new control panels conforming to WTD I&C standards. The VSA system will be reprogrammed to conform to WTD I&C standards.
- Replace all uninterruptable power supplies (UPS).
- Refurbish two concrete plenums for vacuum pump exhaust.
- Replace the return air damper and controls that modulate feed air to the oxygen generation system.

3.2.2 Constructability

Construction of Option 2 can largely be completed on one train at a time while the other train maintains oxygen supply for the secondary treatment process. Some component replacements may require short periods of downtime for VSA Trains 1 and 2 during which LOX will be needed to fulfill HPO needs. Construction timing is also dependent on the successful media replacement of both VSA trains, to be completed in 2022. Were this option to be constructed prior to media replacement (expected to be complete in 2022), refurbishment of VSA Train #1 would require increased reliance on LOX. As with Option 1, construction is not seasonally dependent but will require close coordination with WPTP operations, process, and safety.

3.2.3 Future Considerations

The future project team should consider the following if this option advances:

- Process performance is not guaranteed with this option.
- Energy savings and benefits from improved energy efficiency will be evaluated.
- This option requires significant operations and maintenance resources, including training, need for experienced staff, and associated costs. Given the greater complexity of the existing VSA system and the high turnover rate for plant staff, this option is identified as having greater risk of upsets to plant oxygen generation.
- The County, rather than a single equipment vendor, will be responsible for integrating equipment and control system replacement and ensuring process functionality.

Risks and opportunities will be documented, and in some instances monetized, in the Basis of Estimate document. Costs will be prepared at an AACE International Class 5 (0 to 2 percent level of design and planning) using WTD's PRISM model.

Section 4

References

Brown and Caldwell. 2019. *Treatment Plant Flows and Loadings Study*. Prepared for King County, Department of Natural Resources and Parks, Wastewater Treatment Division, Seattle, Washington. November.

CH2M HILL. 2015a. OGADS Modifications Project, Alternative Analysis Design Documents. Prepared for King County, Department of Natural Resources and Parks, Wastewater Treatment Division, Seattle, Washington. January.

CH2M HILL. 2015b. *West Point Treatment Plant Oxygen Generation and Dissolution Systems Modifications Project Phase 1, Alternatives Analysis Basis of Design Report*. Prepared for King County, Department of Natural Resources and Parks, Wastewater Treatment Division, Seattle, Washington. November.

CH2M HILL. 2017. OGADS Modifications Project, 30% Design Documents. Prepared for King County, Department of Natural Resources and Parks, Wastewater Treatment Division, Seattle, Washington. March.

Stantec. 2022. Memo regarding VSA System Recommendations. Draft. Prepared for King County WTD. March 16.

Section 5

Limitations

This document was prepared solely for King County in accordance with professional standards at the time the services were performed and in accordance with the contract between King County and Jacobs Engineering Group Inc. dated September 9, 2019. This document is governed by the specific scope of work authorized by King County; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by King County and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information

Appendix A: Vacuum Swing Adsorption System Information (Air Products)

From: Farmer, Bill
Sent: Friday, August 5, 2022 1:41 PM
To: Eric Benton
Cc: Wu, Melissa
Subject: FW: [External] West Point TP VSA System - Air Products Screening Level Pricing (Updated for 100TD VSA systems - Aug 2022)

Eric – Here's updated quote from Air Products for larger VSAs as per latest County direction; $15,500,000 each. Still waiting on Air Liquide for their requote.
County is still reviewing the BOE/estimate since we updated the TM for the larger VSAs. Stay tuned on that and hold on to this quote for final fixup TBD.
Thanks BF

From: Silver,Garry J. <SILVERGJ@airproducts.com>
Sent: Friday, August 5, 2022 1:33 PM
To: Farmer, Bill <Bill.Farmer@jacobs.com>
Cc: O'Donnell,Mark J. <ODONNEMJ@airproducts.com>; Wu, Melissa <Melissa.Wu@jacobs.com>
Subject: FW: [External] West Point TP VSA System - Air Products Screening Level Pricing (Updated for 100TD VSA systems - Aug 2022)

Hi Bill,

Per your request. We updated the pricing for the much larger sized VSA systems. This should be considered – screening level budget numbers that will need to be firmed up if the project moves forward.

Please keep us in the loop and updated as this process moves forward.

Thanks and Have a nice weekend.

Garry

Garry J. Silver
Business Development Manager
Equipment Sales and Plant Support (ESPS)
Air Products and Chemicals Inc.
Phone: 610-481-3062
www.airproducts.com

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-
Case: 2 x 100 STPDt (2 x M34 VSA), 92% purity, 4.6 psig off plant

-
Capital: $15,500,000 (Screening level budget – same scope as 2016 w/added Controls scope to enable DCS communication)

-

Plant Utilities Needed:
Power: 480V power feeds for EACH plant
Instrument Air (per AP Specifications): 71 Nm3/hr for EACH plant

SOE Scope Included for each plant:
Air Blower and motor/VFD skids
Vacuum Blower and motor/VFD skids
Modular Bed Adsorber Vessels
Switch Valve Skids
O2 Buffer Vessels
Skid Fabrication in Shop
Engineering Labor and T&L

Ocean Freight/Inland Freight to Site
Section 301 Tariffs

Excluded from estimate:

LOX Backup System
Instrument Air System
Electrical Equipment (NO Motor Control Center, NO Control Room in AP Scope of Supply)
Sound Enclosures (95 dBA 3 ft from fenceline)
V111/V112/V194 Silencers EXCLUDED (using existing customer equipment/plenum)
Civil design (APCI will provide loading diagrams only)
Civil construction including foundations
Mechanical and Electrical Construction
Startup and Commissioning Support
Spare Parts (Capital Spares/Startup & Commissioning Spares)
Pipelines to customer
Buildings
Roads, Fencing, etc.
Short Term Interest, Permits

From: Farmer, Bill <Bill.Farmer@jacobs.com>
Sent: Tuesday, August 2, 2022 3:26 PM
To: Silver,Garry J. <SILVERGJ@airproducts.com>
Cc: O'Donnell,Mark J. <ODONNEMJ@airproducts.com>; Wu, Melissa <Melissa.Wu@jacobs.com>
Subject: RE: [External] West Point TP VSA System - Air Products Screening Level Pricing

This email is from an external source. Please exercise caution in opening attachments or links.

Hey Garry – Can you update your quote for larger VSAs? King County has decided they want full redundancy and for a future worst case condition that's a little larger. So we need cost for (2) 100 tpd systems. As for controls, I think we had previously assumed that Air Products would provide their standard control system but it would need to be compatible with interfacing with the plant's Emerson Ovation DCS controls platform for overall plant monitoring and control. This is all very high level budgeting at this point so details will be figured out if and when this gets back into design.
Thanks BF

Bill Farmer, PE
Process Mechanical Engineer
~~D 425-233-3551~~
M 206-518-1906

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From: Farmer, Bill/SEA
Sent: Wednesday, June 1, 2022 12:57 PM
To: Silver,Garry J. <SILVERGJ@airproducts.com>
Cc: O'Donnell,Mark J. <ODONNEMJ@airproducts.com>; Wu, Melissa/SEA <Melissa.Wu@jacobs.com>
Subject: RE: [External] West Point TP VSA System - Air Products Screening Level Pricing

My bad Garry, you are right! I had not looked back at the RFP and we do state (2) 40 tpd systems so your quote is good to go. We had considered both the VSAs and the LOX system in assessing full capacity and for meeting redundancy and the ability to meet oxygen req'ts with the largest piece of equipment (LOX vaporizer) out of service.
The VSA spec also required system controls so we're good on that for quoting purposes. Similarly, the spec states GOX delivered at 4 psig to the pipeline so if you can do that with your configuration, we don't need to include additional blowers just because that's what they have now.
Thanks BF

Bill Farmer, PE
Process Mechanical Engineer

Appendix B: Stantec Memo (March 16, 2022)

Stantec

Memo

To:	Jack Launit, PMP	From:	Ayman Shawwa, PE, PMP, Ph.D.
	King County WTD		Walnut Creek
Project/File:	VSA System Recommendations – Draft Memo	Date:	March 16, 2022

Objectives

As part of Work Order#10, WPTP OGADS Media Replacement, the Stantec team in consultation with the WTD staff, developed long term recommendations for Vacuum Swing Adsorption (VSA) system (Task 500) based on the condition assessment and evaluation of Train 1 and 2 performance after substantial completion of media replacement project (Task 400).

The recommendations presented in this technical memorandum (TM) are based on condition assessment performed by the Stantec team on August 17-18, 2021. The condition assessment included site investigation of VSA system deficiencies and interviews with WPTP O&M staff. Based on the condition assessment, the Stantec team developed recommendations regarding potential future modifications of the VSA system, which included equipment refurbishment or replacement, controls modifications or upgrades, and system tuning suggestions.

This TM documents the recommendations for essential assets in the VSA system ranked by risk priority, as established by Stantec in consultation with the WTD staff. These recommendations are required to mitigate the risk of failure of essential assets in the VSA system, which could impact oxygen production at West Point WWTP. They will also help King County to plan for a second phase of design and construction procurement services for the VSA system for the purpose of extending the life of Trains 1 and 2.

In this memo, a brief description of the five subsystems of the VSA system along with the associated essential assets, is provided. This is followed by brief discussion of the condition assessment and a summary of key observations for each VSA subsystem. The Risk-Based Mitigation methodology used to rank the recommendations will be presented and the ranking criteria along with recommended mitigations will be discussed. Tabulated summary of ranked recommendations for each VSA subsystem will be presented. Finally, mark-ups to the VSA system manual (Section 4 in WPTP O&M manual) will be provided to reflect assessment findings, observations, or changes needed to improve VSA system performance.

Description of VSA System

The VSA system include two trains, each capable of producing 70 tons a day of high-purity oxygen. Each train includes the following five subsystems with associated assets (more information on the VSA subsystems is included in **Appendix A**):

- Feed air blower – supplies ambient air to the adsorbers. This subsystem includes a blower, a blower discharge control valve, and two heat exchangers.

- Adsorbers – there are three adsorbers per train. In this subsystem, feed air enters an adsorber and passes through an adsorbent bed containing layers of alumina and molecular sieve. Moisture and carbon dioxide are removed by alumina and nitrogen is adsorbed by the molecular sieve.
- Vacuum pump – regenerates adsorbent beds in each adsorber by removing the nitrogen, carbon dioxide, and moisture from the adsorber media. This subsystem includes a two-stage pump and a silencer/moisture separator.
- Gaseous oxygen (GOX) blower – draws the high-purity oxygen from the adsorbers and feeds it to the secondary aeration tanks via the GOX header located in the south gallery. This subsystem includes a blower, aftercooler, bypass/recirculation valve, and vent valve.
- Electrical and Control System – VSA system operates automatically through a programmable logic controller (PLC). Any system fault shuts down the entire VSA system.

WTD provided Stantec with a list of all the assets in the OGADS, including the VSA system. Stantec in consultation with WTD staff identified essential assets in each of the VSA subsystem described above. The "OGADS Master Assets List" and the "VSA System Assets List" are included as separate tabs in an Excel spreadsheet titled "**VSA System Assets Risk Mitigation**", which is submitted with this memo.

Condition Assessment of VSA System

A detailed condition assessment of the VSA system was performed by Adsorptech on August 17th and 18th, 2021. A report titled "King County OGADS site visit and O2 VPSA condition assessment" was submitted to Stantec on September 16, 2021. The condition assessment revealed design problems and weaknesses for the VSA system. Key observations were summarized in a draft memo titled "Summary of West Point's O2 VPSA Condition Assessment" which was submitted to King County on November 30, 2021. A copy of the draft memo and Adsorptech report are included in **Appendix B**.

VSA Systems' Recommendations

Based on the results of the condition assessment, numerous recommendations for the refurbishment, replacement, or upgrades of the VSA system were provided by Adsorptech. These recommendations are required to mitigate the risk of failure of essential assets in the VSA system. The recommendations for the five VSA subsystem, which were not ranked, are summarized in **Table C.1** and presented in **Appendix C**.

Stantec, in consultation with the WTD staff, developed a Risk-Based Mitigation methodology in which the recommendations were ranked based on their risk of failure and their impact on oxygen production at West Point WWTP. Three ranking levels were identified: Critical, High, and Low. The risk criteria for each ranking level were developed and the primary and secondary mitigations for each ranking level were defined, as shown in **Table 1**.

Table 1. Ranking Criteria and Recommended Primary/Secondary Mitigations

Ranking Level	Risk Criteria	Primary Mitigation	Secondary Mitigation
Critical	• Single Point of failure for both trains • Failure would cause outage for a train longer than 3 months • Permit required information and reporting • Causes safety issues	Fix/Replace Assets - Now	Purchase Spares - Now
High	• Single point of failure for a redundant system • Failure would cause outage for a train longer than 1 month • Long lead times for a replacement item (30 days) • Obsolete Equipment no longer available	Purchase Spares Rebuild/Refurbish	Replace in 2+ years out
Low	• Spare parts readily available • Does not shut system • No process or safety issues	Spares	Identify sources for procurement

Summary of Ranked Recommendations

Stantec in consultation with WTD staff assigned ranking level for each essential asset in the five VSA subsystems based on the risk criteria defined in **Table 1**. Once the assets are ranked, primary and secondary mitigations were added to each asset in each VSA subsystem.

The ranked recommendations with mitigations for all essential asset in the VSA system were tabulated and saved in an Excel spreadsheet titled "**VSA System Assets Risk Mitigation**", which is submitted with this memo. There is a separate tab in the Excel spreadsheet for each VSA subsystem. The ranked recommendations for VSA subsystems are presented in the following pages and tabulated as follows:

- Feed Air Blower Assets (**Table 2**)
- Adsorbers Assets (**Table 3**)
- Vacuum Pump Assets (**Table 4**)
- GOX Blower Assets (**Table 5**)
- Electrical and Control Assets (**Table 6**)

Ok

Stantec

- Assume only one spare per equipment type is purchased (i.e. no multiple spares)

Memo

Replace field panels with new; no spares needed for panels.

Table 2. Recommendations for Feed Air Blower System Assets

Asset Name	Asset No	Risk to O2 Production	Primary Mitigation	Secondary Mitigation
Field Panel Train 1	711-FP1111	Critical	purchase & install F	~~Purchase spare~~
Field Panel Train 2	711-FP1121	Critical	purchase & install	~~Purchase spare~~
Flow Indicator Transmitter Train 1	711-FIT11DO111	Critical	Purchase spare	
Flow Indicator Transmitter Train 2	711-FIT11DO211	Critical	~~Purchase spare~~	
Pressure Indicator Transmitter Train 1	711-PIT11DH111	Critical	Purchase spare	
Pressure Indicator Transmitter Train 2	711-PIT11DH211	Critical	~~Purchase spare~~	
Temperature Element Transmitter Train 1	711-TET11DG111	Critical	Purchase spare	
Temperature Element Transmitter Train 2	711-TET11DG211	Critical	~~Purchase spare~~	
Temperature Element Transmitter (Foxboro) Train 1	711-TET11DJ111	Critical	Purchase spare	
Temperature Element Transmitter (Foxboro) Train 2	711-TET11DJ211	Critical	~~Purchase spare~~	
Temperature Switch High Train 1	711-TSH11DI111	Critical	Purchase spare	
Temperature Switch High Train 2	711-TSH11DI211	Critical	~~Purchase spare~~	
Temperature Switch High High Train 1	711-TSHH11DI111	Critical	Purchase spare	
Temperature Switch High High Train 2	711-TSHH11DI211	Critical	~~Purchase spare~~	
Temperature Switch High High Train 1	711-TSHH11AI111	Critical	Purchase spare	
Temperature Switch High High Train 2	711-TSHH11AI211	Critical	~~Purchase spare~~	
Vibration Switch High Train 1	711-VSH11DI111	Critical	Purchase spare	
Vibration Switch High Train 2	711-VSH11DI211	Critical	~~Purchase spare~~	
Vibration Switch High Monitor Train 1	711-VSH11AI111	Critical	Purchase spare	
Vibration Switch High Monitor Train 2	711-VSH11AI211	Critical	~~Purchase spare~~	
Vibration Switch High High Train 1	711-VSHH11DI111	Critical	Purchase spare	

Provide 1 spare instrument of each type for both trains

F = assume upgrade all controls to Emerson Ovation DCS; reprogram all

Reference: VSA System Recommendations

Asset Name	Asset No	Risk to O2 Production	Primary Mitigation	Secondary Mitigation
Vibration Switch High High Train 2	711-VSHH11DI211	Critical	Purchase spare	
Vibration Switch High High Monitor Train 1	711-VSHH11AI111	Critical	Purchase spare	
Vibration Switch High High Monitor Train 2	711-VSHH11AI211	Critical	Purchase spare	
Timing Valve 18" Train 1	711-FV11AK111	High	Refurbish	Purchase spare
Timing Valve 18" Train 2	711-FV11AK211	High	Refurbish	Purchase spare
Air Blower Temperature Switch High High Train 1	711-TSHH11AB111	High	Purchase spare	Replace in 2+ years
Air Blower Temperature Switch High High Train 2	711-TSHH11AB211	High	Purchase spare	Replace in 2+ years
Air Blower Motor Train 1	711-MTR11AB111	High	Refurbish	Purchase spare
Air Blower Motor Train 2	711-MTR11AB211	High	purchase & install	Refurbish
Air Blower Train 1	711-B11AB111	High	Refurbish	Replace blower in 2+ years
Air Blower Train 2	711-B11AB211	High	purchase & install	Replace blower in 2+ years
Timing Valve 2 (Cold Water) Train 1	711-TCV11AG112	High	Refurbish	Purchase spare
Timing Valve 2 (Cold Water) Train 2	711-TCV11AG212	High	Refurbish	Purchase spare
Flow Valve (Jamesbury) Train 1	711-FV11DN111	High	Refurbish	Purchase spare
Flow Valve 1 (Jamesbury) Train 2	711-FV11DN211	High	Refurbish	Purchase spare
Flow Valve 2 (ASCO) Train 1	711-FV11DN112	High	Refurbish	Purchase spare
Flow Valve (Jamesbury, BC20) Train 2	711-FV11DN212	High	Refurbish	Purchase spare
Timing Valve 1 (Hot Water) Train 1	711-TCV11AG111	High	Refurbish	Purchase spare
Timing Valve 1 (Hot Water) Train 2	711-TCV11AG211	High	Refurbish	Purchase spare
Temperature Element Transmitter (HVAC) Train 1	711-TET11AD111	High	Purchase spare	
Temperature Element Transmitter (HVAC) Train 2	711-TET11AD211	High	Purchase spare	
Pressure Switch Low Low Train 2	711-PSLL11DH111	High	Purchase spare	
Pressure Switch Low Low Train 1	711-PSLL11DH211	High	Purchase spare	

A

A

Provide 1 spare of each type for both trains

A = refurbish not in formulation; assume already covered by WP PMs

Reference: VSA System Recommendations

Asset Name	Asset No	Risk to O2 Production	Primary Mitigation	Secondary Mitigation
Temperature Element Transmitter 2 Train 2	711-TET11AG212	High	~~Purchase spare~~	
Temperature Element Transmitter 1 Train 1	711-TET11AE111	High	Purchase spare	
Temperature Element Transmitter 1 Train 2	711-TET11AE211	High	~~Purchase spare~~	
Temperature Element Transmitter 1 Train 1	711-TET11AG111	High	Purchase spare	
Temperature Element Transmitter 1 Train 2	711-TET11AG211	High	~~Purchase spare~~	
Heat Exchanger Aftercooler Train 1	711-HX11DB111	Low	Remove	
Heat Exchanger Aftercooler Train 2	711-HX11DB211	Low	Remove	
Air Blower Skid Train 1	711-ME11SK111	Low	Inspect/Repairs	
Air Blower Skid Train 2	711-ME11SK211	Low	Inspect/Repairs	
Heat Exchanger Train 1	711-HX11AA111	Low	Remove	
Heat Exchanger Train 2	711-HX11AA211	Low	Remove	
Hot Water Pump Motor 1 Train 1	711-MTR11SA111	Low	Remove	
Hot Water Pump Motor 1 Train 2	711-MTR11SA211	Low	Remove	
Hot Water Pump 1 Train 1	711-P11SA111	Low	Remove	
Hot Water Pump 1 Train 2	711-P11SA211	Low	Remove	
Hot Water Pump 2 Motor Train 1	711-MTR11SA121	Low	Remove	
Hot Water Pump 2 Motor Train 2	711-MTR11SA221	Low	Remove	
Hot Water Pump 2 Train 1	711-P11SA121	Low	Remove	
Hot Water Pump 2 Train 2	711-P11SA221	Low	Remove	

Provide allowance for misc. items on skid

Provide 1 spare of each type for both trains

Table 3. Recommendations for Adsorber Assets

Asset Name	Asset No	Risk to O2 Production	Primary Mitigation	Secondary Mitigation
Adsorber Vessel 1 Train 1	711-ADS11BA111	Critical	Inspect/Repair	
Adsorber Vessel 2 Train 1	711-ADS11BA121	Critical	Inspect/Repair	
Adsorber Vessel 3 Train 1	711-ADS11BA131	Critical	Inspect/Repair	
Adsorber Vessel 1 Train 2	711-ADS11BA211	Critical	Inspect/Repair	
Adsorber Vessel 2 Train 2	711-ADS11BA221	Critical	Inspect/Repair	
Adsorber Vessel 3 Train 2	711-ADS11BA231	Critical	Inspect/Repair	
Oxygen Sensor Transmitter Train 1	711-AET11TB021	Critical	Purchase 1 spare per train	
Oxygen Sensor Transmitter Train 2	711-AET11TB022	Critical	Purchase 1 spare per train	
Pressure Indicator Transmitter Vessel 1 Train 1	711-PIT11BH111	Critical	Purchase spare	
Pressure Indicator Transmitter Vessel 2 Train 1	711-PIT11BH121	Critical	Purchase spare	
Pressure Indicator Transmitter Vessel 2 Train 1	711-PIT11BH131	Critical	Purchase spare	
Pressure Indicator Transmitter Vessel 1 Train 2	711-PIT11BH211	Critical	Purchase spare	
Pressure Indicator Transmitter Vessel 2 Train 2	711-PIT11BH221	Critical	Purchase spare	
Pressure Indicator Transmitter Vessel 2 Train 2	711-PIT11BH231	Critical	Purchase spare	
Flow Control Valve Vessel 1 Train 1	711-FV11BG111	High	Refurbish	Purchase 1 spare per train
Flow Control Valve Vessel 2 Train 1	711-FV11BG121	High	Refurbish	Purchase 1 spare per train
Flow Control Valve Vessel 3 Train 1	711-FV11BG131	High	Refurbish	Purchase 1 spare per train
Flow Control Valve Vessel 1 Train 2	711-FV11BG211	High	Refurbish	Purchase 1 spare per train
Flow Control Valve Vessel 2 Train 2	711-FV11BG221	High	Refurbish	Purchase 1 spare per train
Flow Control Valve Vessel 3 Train 2	711-FV11BG231	High	Refurbish	Purchase 1 spare per train

B

A

Provide 1 spare of each type for both trains

A = refurbish not in formulation; assume already covered by WP PMs

B = not in formulation; adsorber inspections & repairs covered by media project

Reference: VSA System Recommendations

Asset Name	Asset No	Risk to O2 Production	Primary Mitigation	Secondary Mitigation
Timing Valve 24" Vessel 1 Train 1	711-KV11BB111	High	Refurbish	Purchase 1 spare ~~per train~~
Timing Valve 24" Vessel 2 Train 1	711-KV11BB121	High	Refurbish	Purchase 1 spare ~~per train~~
Timing Valve 24" Vessel 3 Train 1	711-KV11BB131	High	Refurbish	Purchase 1 spare ~~per train~~
Timing Valve 24" Vessel 1 Train 2	711-KV11BB211	High	Refurbish	~~Purchase 1 spare per train~~
Timing Valve 24" Vessel 2 Train 2	711-KV11BB221	High	Refurbish	~~Purchase 1 spare per train~~
Timing Valve 24" Vessel 3 Train 2	711-KV11BB231	High	Refurbish	~~Purchase 1 spare per train~~
Timing Valve GOX 20" Vessel 1 Train 1	711-KV11BC111	High	Refurbish	Purchase 1 spare ~~per train~~
Timing Valve GOX 20" Vessel 2 Train 1	711-KV11BC121	High	Refurbish	Purchase 1 spare ~~per train~~
Timing Valve GOX 20" Vessel 3 Train 1	711-KV11BC131	High	Refurbish	Purchase 1 spare ~~per train~~
Timing Valve GOX 20" Vessel 1 Train 2	711-KV11BC211	High	Refurbish	~~Purchase 1 spare per train~~
Timing Valve GOX 20" Vessel 2 Train 2	711-KV11BC221	High	Refurbish	~~Purchase 1 spare per train~~
Timing Valve GOX 20" Vessel 3 Train 2	711-KV11BC231	High	Refurbish	~~Purchase 1 spare per train~~
Timing Valve Depressurizing 14" Vessel 1 Train 1	711-KV11BD111	High	Refurbish	Purchase 1 spare ~~per train~~
Timing Valve Depressurizing 14" Vessel 2 Train 1	711-KV11BD121	High	Refurbish	Purchase 1 spare ~~per train~~
Timing Valve Depressurizing 14" Vessel 3 Train 1	711-KV11BD131	High	Refurbish	Purchase 1 spare ~~per train~~
Timing Valve Depressurizing 14" Vessel 1 Train 2	711-KV11BD211	High	Refurbish	~~Purchase 1 spare per train~~
Timing Valve Depressurizing 14" Vessel 2 Train 2	711-KV11BD221	High	Refurbish	~~Purchase 1 spare per train~~
Timing Valve Depressurizing 14" Vessel 3 Train 2	711-KV11BD231	High	Refurbish	~~Purchase 1 spare per train~~
Timing Valve Vacuum Relief 30" Vessel 1 Train 1	711-KV11BE111	High	Refurbish	Purchase 1 spare ~~per train~~
Timing Valve Vacuum Relief 30" Vessel 2 Train 1	711-KV11BE121	High	Refurbish	Purchase 1 spare ~~per train~~
Timing Valve Vacuum Relief 30" Vessel 3 Train 1	711-KV11BE131	High	Refurbish	Purchase 1 spare ~~per train~~
Timing Valve Vacuum Relief 30" Vessel 1 Train 2	711-KV11BE211	High	Refurbish	~~Purchase 1 spare per train~~
Timing Valve Vacuum Relief 30" Vessel 2 Train 2	711-KV11BE221	High	Refurbish	~~Purchase 1 spare per train~~
Timing Valve Vacuum Relief 30" Vessel 3 Train 2	711-KV11BE231	High	Refurbish	~~Purchase 1 spare per train~~

A

Provide 1 spare valve of each type for both trains

A = refurbish not in formulation; assume all already covered by WP PMs

Reference: VSA System Recommendations

Asset Name	Asset No	Risk to O2 Production	Primary Mitigation	Secondary Mitigation
Timing Valve Repressurizing 14" Vessel 1 Train 1	711-KV11BF111	High	Refurbish	Purchase 1 spare ~~per train~~
Timing Valve Repressurizing 14" Vessel 2 Train 1	711-KV11BF121	High	Refurbish	Purchase 1 spare ~~per train~~
Timing Valve Repressurizing 14" Vessel 3 Train 1	711-KV11BF131	High	Refurbish	Purchase 1 spare ~~per train~~
Timing Valve Repressurizing 14" Vessel 1 Train 2	711-KV11BF211	High	Refurbish	~~Purchase 1 spare per train~~
Timing Valve Repressurizing 14" Vessel 2 Train 2	711-KV11BF221	High	Ref A sh	~~Purchase 1 spare per train~~
Timing Valve Repressurizing 14" Vessel 3 Train 2	711-KV11BF231	High	Ref sh	~~Purchase 1 spare per train~~
Timing Valve 14" Train 1	711-KV11BI111	High	Refurbish	Purchase 1 spare ~~per train~~
Timing Valve 14" Train 2	711-KV11BI211	High	Refurbish	~~Purchase 1 spare per train~~
Timing Valve 12" Train 1	711-KV11BJ111	High	Refurbish	Purchase 1 spare ~~per train~~
Timing Valve 12" Train 2	711-KV11BJ211	High	Refurbish	~~Purchase 1 spare per train~~
Adsorber Skid Train 1	711-ME11SK141	Low	Inspect/Repairs	
Adsorber Skid Train 2	711-ME11SK241	Low	Inspect/Repairs	

Provide allowance for misc. items on skid

A = refurbish not in formulation; assume already covered by WP PMs

Provide 1 spare valve of each type for both trains

Table 4. Recommendations for Vacuum Pump System Assets

Asset Name	Asset No	Risk to O2 Production	Primary Mitigation	Secondary Mitigation
Vacuum Pump Motor Train 1	711-MTR11CA111	Critical	Refurbish C	Purchase C re
Vacuum Pump Motor Train 2	711-MTR11CA211	Critical	Purchase spare	Refurbish
Oxygen Sensor Transmitter 1 Train 1	711-AET11TB031	Critical	Purchase 1 spare per train	
Oxygen Sensor Transmitter 2 Train 1	711-AET11TB032	Critical	Purchase 1 spare per train	
Oxygen Sensor Transmitter 1 Train 2	711-AET11TB041	Critical	Purchase 1 spare per train	
Oxygen Sensor Transmitter 2 Train 2	711-AET11TB042	Critical	Purchase 1 spare per train	
Field Panel Train 1	711-FP1113	Critical	purchase & install F	Purchase spare
Field Panel Train 2	711-FP1123	Critical	purchase & install	Purchase spare
Vent Valve 18" Train 2	711-KV11AK111	High	Refurbish	Purchase spare per train
Vent Valve 18" Train 1	711-KV11AK211	High	Refurbish A	Purchase spare per train
Second Stage Bypass Valve 24" Train 1	711-KV11CG111	High	Refurbish	Purchase spare per train
Second Stage Bypass Valve 24" Train 2	711-KV11CG211	High	Refurbish	Purchase spare per train
Silencer Train 1	711-ME11AC111	High	purchase & install	Purchase parts
Silencer Train 2	711-ME11AC211	High	Inspect/Repairs	Purchase parts
Separator Silencer Train 1	711-ME11CH111	High	purchase & install	Purchase parts
Separator Silencer Train 2	711-ME11CH211	High	Inspect/Repairs	Purchase parts
Vacuum Pump Train 1	711-P11CA111	High	Refurbish C	Purcha C pare
Vacuum Pump Train 2	711-P11CA211	High	Refurbish	Purchase spare
Pressure Indicator Transmitter Train 1	711-PIT11CH111	High	Purchase spare	
Pressure Indicator Transmitter Train 2	711-PIT11CH211	High	Purchase spare	
Oil Pump Motor 1 Train 1	711-MTR11CB111	High	purchase & install	Purchase spare

Provide 1 spare of each type for both trains

A = refurbish not in formulation; assume already covered by WP PMs

D = silencer replaced in 201?; replace 2nd silencer >> CONFIRM which silencer(s) were replaced

C = vacuum pumps already rebuilt in 2014 and 2016/2017; no spares in formulation

F = assume upgrade all controls to Emerson Ovation DCS; reprogram all

Reference: VSA System Recommendations

Asset Name	Asset No	Risk to O2 Production	Primary Mitigation	Secondary Mitigation
Oil Pump Motor 1 Train 2	711-MTR11CB211	High	purchase & install	~~Purchase spare~~
Oil Pump Motor 2 Train 1	711-MTR11CB212	High	purchase & install	~~Purchase spare~~
Oil Pump Motor 2 Train 2	711-MTR11CB221	High	purchase & install	~~Purchase spare~~
Oil Pump 1 Train 1	711-P11CB111	High	purchase & install	~~Purchase spare~~
Oil Pump 2 Train 1	711-P11CB121	High	purchase & install	~~Purchase spare~~
Oil Pump 1 Train 2	711-P11CB211	High	purchase & install	~~Purchase spare~~
Oil Pump 2 Train 2	711-P11CB221	High	purchase & install	~~Purchase spare~~
Pressure Indicator Transmitter Train 1	711-PIT11CE111	High	Purchase spare	
Pressure Indicator Transmitter Train 2	711-PIT11CE211	High	~~Purchase spare~~	
Temperature Element Transmitter Train 1	711-TET11CD111	High	Purchase spare	
Temperature Element Transmitter Train 2	711-TET11CD211	High	~~Purchase spare~~	
Bypass Valve 30 " Train 1	711-KV11CF111	High	~~Refurbish~~ A	Purchase spare ~~per train~~
Bypass Valve 30 " Train 1	711-KV11CF211	High	~~Refurbish~~	~~Purchase spare per train~~
Vacuum Pump Skid Train 1	711-ME11SK131	Low	Inspect/Repairs	
Vacuum Pump Skid Train 2	711-ME11SK231	Low	Inspect/Repairs	

Provide allowance for misc. items on skid

Provide 1 spare of each type for both trains

A = refurbish not in formulation; assume all already covered by WP PMs

Table 5. GOX System Assets

Asset Name	Asset No	Risk to O2 Production	Primary Mitigation	Secondary Mitigation
Oxygen Blower Field Panel Train 1	711-FP1112	Critical	purchase & install	~~Purchase spare~~
Oxygen Blower Field Panel Train 2	711-FP1122	Critical	purchase & install	~~Purchase spare~~
Oxygen Sensor Monitor Transmitter	711-AET11TB051	Critical	Purchase spare	
Oxygen Blower Discharge Transmitter Train 1	711-AIT11DM111	High	Purchase spare	
Oxygen Blower Discharge Transmitter Train 1	711-AIT11DM211	High	~~Purchase spare~~	
Oxygen Blower Train 1	711-B11DA111	High	purchase & install	~~Replace blower in 2+ years~~
Oxygen Blower Train 2	711-B11DA211	High	purchase & install	~~Replace blower in 2+ years~~
Oxygen Blower Motor Train 1	711-MTR11DA111	High	purchase & install	~~Purchase spare~~
Oxygen Blower Motor Train 2	711-MTR11DA211	High	purchase & install	~~Refurbish~~
Timing Valve 8" Oxygen Blower Discharge Train 1	711-FV11DP111	High	Refurbish	Purchase spare
Timing Valve 8" Oxygen Blower Discharge Train 2	711-FV11DP211	High	Refurbish	~~Purchase spare~~
Timing Valve 10" Oxygen Blower Inlet Train 1	711-FV11DQ111	High	Refurbish	Purchase spare
Timing Valve 10" Oxygen Blower Inlet Train 2	711-FV11DQ211	High	Refurbish	~~Purchase spare~~
Timing Valve 4" Oxygen Recirculation for Pressure Control Train 1	711-PCV11DH111	High	A	Purchase spare
Timing Valve 4" Oxygen Recirculation for Pressure Control Train 2	711-PCV11DH211	High	Refurbish	~~Purchase spare~~
Timing Valve Oxygen Vent for Pressure Control Train 1	711-PCV11DN111	High	Refurbish	Purchase spare
Timing Valve Oxygen Vent for Pressure Control Train 1	711-PCV11DN211	High	Refurbish	~~Purchase spare~~
Flow Valve Instrument Air Isolation Train 1	711-FV11DF111	High	Refurbish	Purchase spare
Flow Valve Instrument Air Isolation Train 1	711-FV11DF211	High	Refurbish	~~Purchase spare~~

Provide 1 spare valve of each type for both trains

A = refurbish not in formulation; assume all already covered by WP PMs

Table 6. Electrical and Control System Assets

Asset Name	Asset No	Risk to O2 Production	Primary Mitigation	Secondary Mitigation
Switchgear 1 Load Disconnect for A-Side Main Feed	711-CB1A	Critical	Purchase spare	
Switchgear 1 Load Disconnect for B-Side Main Feed	711-CB1B	Critical	Purchase spare	
Switchgear Feed to MCC 3	711-SWGR01-3	Critical	Purch E spare	
Switchgear Feed to MCC 1	711-SWGR01-4	Critical	Purchase spare	
Switchgear Feed to MCC 4	711-SWGR01-7	Critical	Purchase spare	
Switchgear Feed to MCC 2	711-SWGR01-8	Critical	Purchase spare	
Switchgear Feed Tie Breaker	711-SWGR01-T	Critical	Purchase spare	
PLC for Train 1	711-T1	Critical	purchase & install F	~~Purchase spare~~
PLC for Train 2 & LOX	711-T2	Critical	purchase & install	~~Purchase spare~~
Local Control Panel 1101	711-LCP1101	High	purchase & install F	~~Replace – 2+ years out~~
Local Control Panel 1102	711-LCP1102	High	purchase & install	~~Replace – 2+ years out~~
Uninterruptable Power Supply OGADS FACP	711-UPS01	High	purchase & install	~~Replace – 2+ years out~~
Motor Control Center 1	711-MCC01	High	Inspect/Refurbish	~~Replace – 2+ years out~~
Motor Control Center 2	711-MCC02	High	Inspect/Refurbish	~~Replace – 2+ years out~~
Motor Control Center 3	711-MCC03	High	Inspect/Refurbish	~~Replace – 2+ years out~~
Motor Control Center 4	711-MCC04	High	Inspec E furbish	~~Replace – 2+ years out~~
Motor Control Center 5	711-MCC05	High	Inspect/Refurbish	~~Replace – 2+ years out~~
Motor Control Center 6	711-MCC06	High	Inspect/Refurbish	~~Replace – 2+ years out~~
Main Switchgear for Vacuum Pump	711-MSG01	High	Inspect/Refurbish	~~Replace – 2+ years out~~

E = refurbish not in formulation; assume already covered by WP PMs; no spares

F = assume upgrade all controls to Emerson Ovation DCS; reprogram all

Reference: VSA System Recommendations

Asset Name	Asset No	Risk to O2 Production	Primary Mitigation	Secondary Mitigation
Oxygen PRODION Switchgear	711-SWGR01	High	Inspect, Refurbish E	Replace – 2+ years out
Uninterruptable Power Supply WCNW00001	711-UPS02	High	purchase & install	Replace – 2+ years out
Uninterruptable Power Supply LCP1101A	711-UPS1101A	High	purchase & install	Replace – 2+ years out
Uninterruptable Power Supply LCP1101B	711-UPS1101B	High	purchase & install	Replace – 2+ years out
Uninterruptable Power Supply LCP1101C	711-UPS1101C	High	purchase & install	Replace – 2+ years out
Transformer, Square D DPL01	711-XFMR01	High	purchase & install	Replace – 2+ years out
Transformer, Square D DPL03	711-XFMR03	High	purchase & install	Replace – 2+ years out
Local Control Panel for Oxygen Production 1102 Loop	711-LP1102	High	purchase & install F	Replace – 2+ years out
Oxygen PRODION Distribution Panel DPL01	711-DPL01	High	Inspect, Refurbish E	Replace – 2+ years out
Oxygen PRODION Distribution Panel DPL03	711-DPL03	High	Inspect, Refurbish	Replace – 2+ years out
Oxygen Production Loop Power Panel LCP1102	711-LP1102	High	REPEAT?	Replace – 2+ years out

E = refurbish not in formulation; assume already covered by WP PMs; no spares

F = assume upgrade all controls to Emerson Ovation DCS; reprogram all

Stantec

Memo

VSA System Manual Mark-Ups

This section will be completed after the substantial completion of media replacement project and the evaluation of performance of Train 1 and 2. The marked-up manual will be included as **Appendix D** in the Final TM.

Conclusions

- Ranked recommendations should be implemented after the media in Trains 1 and 2 have been replaced and both trains are operational. The only exception would be the inspection of the interior of the vessels and any necessary repairs. King County could perform these activities during the media replacement project in coordination with the contractor.

Already addressed

adsorber vessel work as part of media replacement

- In addition to the recommendations presented in **Table 2** for the Feed Air Blower system**,** changing the air blower motor to variable frequency drive (VFD) driven would allow contro the air blower which would increase process flexibility and eliminate surge issue

Add VFDs for (2) Feed Air Blowers

- In addition to the visual inspection of the empty adsorbers during the media replacement project, it is highly recommended to perform X-ray inspection of circumferential, longitudinal welds, and nozzle welds.

Already addressed

- In addition to the recommendations presented in **Table 4** for the Vacuum Pump system, adding time delay on the injection water flow switch would provide process flexibility. Internal inspection of vacuum train piping for excessive corrosion is recommended. Also, changing the 2" automated ball valves to 6 or 10" high cycle butterfly would all This would increase the operational flexibility.

Add upsizing (6) vent valves to 10" high-cycle BTVs with piping upsizing

- In addition to the recommendations presented in **Table 5** for the GOX Blower system, replacement of existing valve positioners with electro-pneumatic positione

Replace (2) GOX bypass/recirc valve actuators to electro-pneumatic

- In addition to the recommendations presented in **Table 6** for the Electrical and Control system, it is recommended to replace the existing PLC control system which is an antiquated TI-505 and has not been supported by the manufacturer for many years. Also, PLC changes will be required for changing the 2" automated ball valves to 6 or 10" high cycle butterfly.

Already addressed

Regards,

Stantec Consulting Services Inc.

Include cost to refurbish concrete plenum for vacuum pump purge

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