CENTRAL KOWLOON ROUTE

APS Performance Monitoring and Contingency Plan

(CONDITION 2.21 OF ENVIRONMENTAL PERMIT, EP-457/2013/D)

(April 2025)

路政署
HIGHWAYS DEPARTMENT
主要工程管理處
MAJOR WORKS PROJECT MANAGEMENT OFFICE

ERM

Environmental Permit No. EP-457/2013/D

Central Kowloon Route

Independent Environmental Checker Verification

Works Contract:	**Buildings, Electrical and Mechanical Works (HY/2019/13)**

Reference Document/Plan

~~Document~~/Plan to be ~~Certified~~/ Verified:	APS Performance Monitoring and Contingency Plan
Date of Report:	-
Date received by IEC:	16 April 2025

Reference EP Condition

Environmental Permit Condition: 2.21

Submission and Measures for Mitigating Operational Air Quality Impact

2.21 The Permit Holder shall, no later than one month before the commencement of operation of the Project, or otherwise approved by the Director, submit to the Director for approval four hard copies and one electronic copy of a APS Performance Monitoring and Contingency Plan, which shall be certified by the ET Leader and verified by the IEC to provide monitoring details of the performance of the APS and the contingency plan for the occasion that the performance of APS during operation could not achieve the removal efficiency specified under Condition 2.18 above. The approved APS Performance Monitoring and Contingency Plan shall be fully and properly implemented.

IEC Verification

I hereby verify that the above referenced ~~document~~/plan complies with the above referenced condition of EP-457/2013/D.

Ms Mandy To Date: 16 April 2025

Independent Environmental Checker

Our ref: 0436942_IEC Verification Cert_BEM_APS Performance Monitoring and Contingency Plan_20250416.docx

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Gammon Construction Limited
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Kwun Tong, Hong Kong

By E-Mail
16 April 2025

Dear Sir / Madam,

Contract No. HY/2019/13
Central Kowloon Route – Buildings, Electrical and Mechanical Works
(Environmental Permit (EP) No. EP-457/2013/D)
Certification of APS Performance Monitoring and Contingency Plan

We refer to the submission of the Air Purification System Performance Monitoring and Contingency Plan received on 15 April 2025 via email.

Regarding Condition 2.21 of the Environmental Permit (EP No.: EP-457/2013/D), the Permit Holder shall, no later than one month before the commencement of operation of the Project, or otherwise approved by the Director, submit to the Director for approval four hard copies and one electronic copy of a APS Performance Monitoring and Contingency Plan, which shall be certified by the ET Leader and verified by the IEC to provide monitoring details of the performance of the APS and the contingency plan for the occasion that the performance of APS during operation could not achieve the removal efficiency specified under Condition 2.18 above. The approved APS Performance Monitoring and Contingency Plan shall be fully and properly implemented.

We have no further comments on the plan. As the ET Leader, I hereby certify this in accordance with Condition 2.21 of the Environmental Permit.

Should you have any queries, please do not hesitate to contact Mr. Dave Chan at 2151 2097 or the undersigned at 2151 2072.

Yours faithfully,

For and on behalf of
Cinotech Consultants Limited

Ms. Betty Choi
Environmental Team Leader

Encl.

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Appendices

1. Introduction

1.1. The final approved EIA Report, AEIAR-171/2013 (hereafter referred as “the EIA report”) studying for the engineering feasibility of Central Kowloon Route (CKR) was completed and approved in Year 2013. The Government has decided to incorporate an Air Purification System (APS) in the CKR project, which will bring enhancement to the air quality of tunnel exhaust before discharging them into the atmosphere.

1.2. The Environmental Permit, EP-457/2013/D (hereafter referred as “the EP”), for the Central Kowloon Route was issued on 15 June 2021. As stipulated in Condition 2.18 of the EP, “an air purification system (APS), with removal efficiency of at least 80% of particulate and at least 80% for NO2, shall be adopted to filter the pollutant inside the CKR tunnel before discharging to the atmosphere via the ventilation buildings.

1.3. As stipulated in Condition 2.21 of the EP, “The Permit Holder shall, no later than one month before the commencement of operation of the Project, or otherwise approved by the Director, submit to the Director for approval four hard copies and one electronic copy of a APS Performance Monitoring and Contingency Plan, which shall be certified by the ET leader and verified by the IEC to provide monitoring details of the performance of the APS and the contingency plan for the occasion that the performance of APS during operation could not achieve the removal efficiency specified under Condition 2.18. The approved APS Performance Monitoring and Contingency Plan shall be fully and properly implemented.”.

1.4. In drafting this plan, references is made to the Air Quality Monitoring Plan for Central-Wan Chai Bypass and Island Eastern Corridor Link (Under Condition 2.9 of EP-482/2013).

2. Principle of Air Purification System (APS)

2.1. The Air Purification System (APS) is a system dedicated to remove the pollutant concentrations before releasing to atmosphere via the three ventilation buildings.

2.2. The APS shall consist two main processes, including the dust filtering part by means of an electrostatic precipitator (ESP) and the NO2 removing part by means of a De-NO2 system.

2.3. In the ESP, an electrostatic field is generated to charge the particles when pass through ionizer plates by means of a power supply unit and captured from the airstream to the collector plate. When the collector plates are covered with dust, they shall be washed down with a water spray.

2.4. In the De-NO2 system, activated carbon gas adsorption shall remove NO_2.

3. Operational Requirements for Air Purification System (APS)

3.1. In order to maintain the performance of the APS, Duplicated Air Monitoring Stations (AMS) are installed in the Air Purification System (APS) to monitor the pollutant concentration levels continuously at the inlet and outlet of the system.

3.2. As part of the tunnel ventilation system operation, the APS is interlocked with Tunnel Ventilation Fan (TVF) during normal mode operation (ie. by switch off the APS, the TVF is turned off as well).

3.3. In addition, the APS will be switched off daily from 01:00 to 06:00 for regular daily maintenance in accordance with the tunnel ventilation system operating principles as described in the EIA report, AEIAR-171/2013, in order to maintain the proper functioning of the APS. Under this maintenance mode operation, the APS is not interlocked with the Tunnel Ventilation System (TVS).

3.4. As contingency plan, as discussed in Section 6, shall be deployed in case the pollutant removal efficiency of the APS were detected lower than the committed 80% for either particulate or NO2.

4. System Design and Standby Arrangement

4.1. Tunnel Ventilation System

4.1.1. The tunnel tubes will be equipped with In-tunnel Air Quality Monitoring and the signals will be used in conjunction with the Central Control and Monitoring System (CCMS) at the Administration Building (ADB) to control the operation of the Air Purification System (APS) and associated Tunnel Ventilation Fan (TVF) at Kai Tak Ventilation Building (KVB), Ho Man Tin Ventilation Building (HVB) and Yau Ma Tei Ventilation Building (YVB), which are formally known as East Ventilation Building (EVB), Central Ventilation Building (CVB) and West Ventilation Building (WVB) respectively on the approved EIA Report.

Ventilation Building	**Number of APS**	**Number of TVF**
Kai Tak Ventilation Building (KVB*Note 1)	3 nos. (2 duty and 1 standby)	6 nos. (4 duty and 2 standby)
Ho Man Tin Ventilation Building (HVB*Note 2)	3 nos. (2 duty and 1 standby)	6 nos. (4 duty and 2 standby)
Yau Ma Tei Ventilation Building (YVB*Note 3)	3 nos. (2 duty and 1 standby)	6 nos. (4 duty and 2 standby)

* Remarks:
Note 1: KVB formally known as EVB on the approved EIA Report
Note 2: HVB formally known as CVB on the approved EIA Report
Note 3: YVB formally known as WVB on the approved EIA Report

The configuration of APS and TVF at ventilation building is showed below:

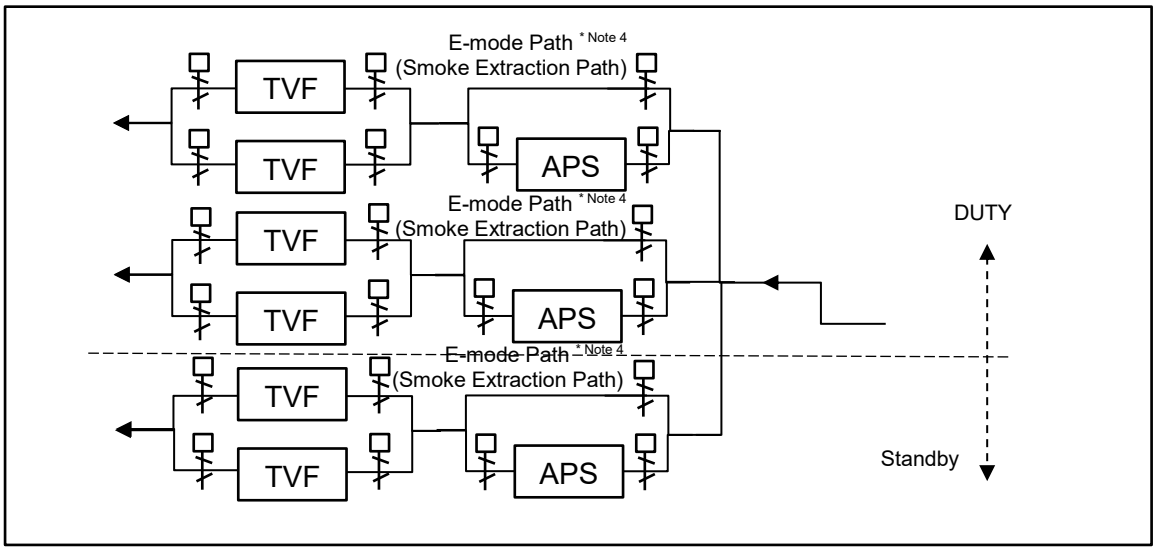


Figure 1: Configuration of APS and TVF

* Remarks:
Note 4: Smoke Extraction Path during fire mode operation will by-pass the APS and discharge the smoke to the atmosphere via the ventilation buildings in case of emergency situation.

4.1.2. The Operation Module for Air Purification System (APS) and Tunnel Ventilation Fan (TVF)

In the current detailed design, the tunnel ventilation system maintain operation to maintain the total air flow emitted via the Ventilation buildings of tunnel while maintaining smaller than or equal to 10% at tunnel portals.

As a result, max. 2 nos. of modules (each module consisting of 1 APS and 2 TVFs) are designed to operate on each ventilation building to regulate both the in tunnel air quality and air volume flow distributions within the tunnel.

In addition, the APS will be switched off daily from 01:00 to 06:00 for regular daily maintenance, in order to maintain the proper functioning of the APS. The tunnel ventilation system maintain operation in accordance with the EIA report, AEIAR-171/2013.

The operation schedule of tunnel ventilation system is subject to the attainment of maintaining no more than 10% of air flow emitted via tunnel portals.

Referring to Figure 1, each APS will have a designated set of TVFs reserved for its operation during the Normal Mode Operation. The current capacity of each APS is sufficient to handle the maximum flow rate from by the designated set of TVFs. For a complete set of modules (APS with associated TVFs), each set is designed with sufficient capacity to effectively handle and remove the pollutants at the maximum design air flow rate of 250m3/s. The removal efficiency is maintained to conform to at least 80% for particulate and NO2 during operation of module.

4.2. Power Supply to Air Purification System (APS) with associated Tunnel Ventilation Fan (TVF)

4.2.1. Dual source power supply was designed at the upstream of the power supply network for the Motor Control Centres (MCCs) and Low Voltage (LV) switchboards so as to maintain APS with associated TVF in normal operation in case one of the power supply sources is failed.

4.2.2. Uninterruptable power supply (UPS) with batteries was designed to maintain operation of the APS control equipment for the period from the main power source failures to the second power source from CLP is taking up the load.

4.3. Central Control and Monitoring System (CCMS)

4.3.1. Central Control and Monitoring System (CCMS) is provided so that the operator can monitor the operation of APS at Administration Building (ADB).

4.4. Others

4.4.1. The design of the ESP filters are vertically subdivided into five(5) sub-assemblies. Each sub-assembly can be isolated from the airstream independently in case any individual faults occur within the sub-assembly. In the event that the TVF/APS module is required to operate when any ESP sub-assemblies of that APS module are isolated, the capacity of the TVF under normal operations shall be restricted proportionally to the available ESP area.

4.4.2. A combination of resilience and redundancy within the design of individual sub-systems of the APS i.e. wash water pump system, sump pump system, pneumatic system and etc. are considered on the APS to maintain the operation with any single point of failure.

4.4.3. Duplicated Air Monitoring Stations (AMS) with 1 duty and 1 standby are provided and installed in different locations inside the APS plenum.

5. APS Performance Monitoring Plan

5.1. Air Monitoring Stations (AMS)

5.1.1. Duplicated Air Monitoring Stations (AMS) with 1 duty and 1 (hot) powered up sensors for NO_2 and PM_{10} are installed at in and out of the APS plenum to record the performance of each APS module, ensuring that it meets the design criteria.

5.1.2. The selected Air Monitoring Stations (AMS), Sapiens MAS-AF300 serial, is equipped with a NO_2 concentration sensor and a particulate sensor for PM_{10}. which will continuously monitor the air quality before and after the APS.

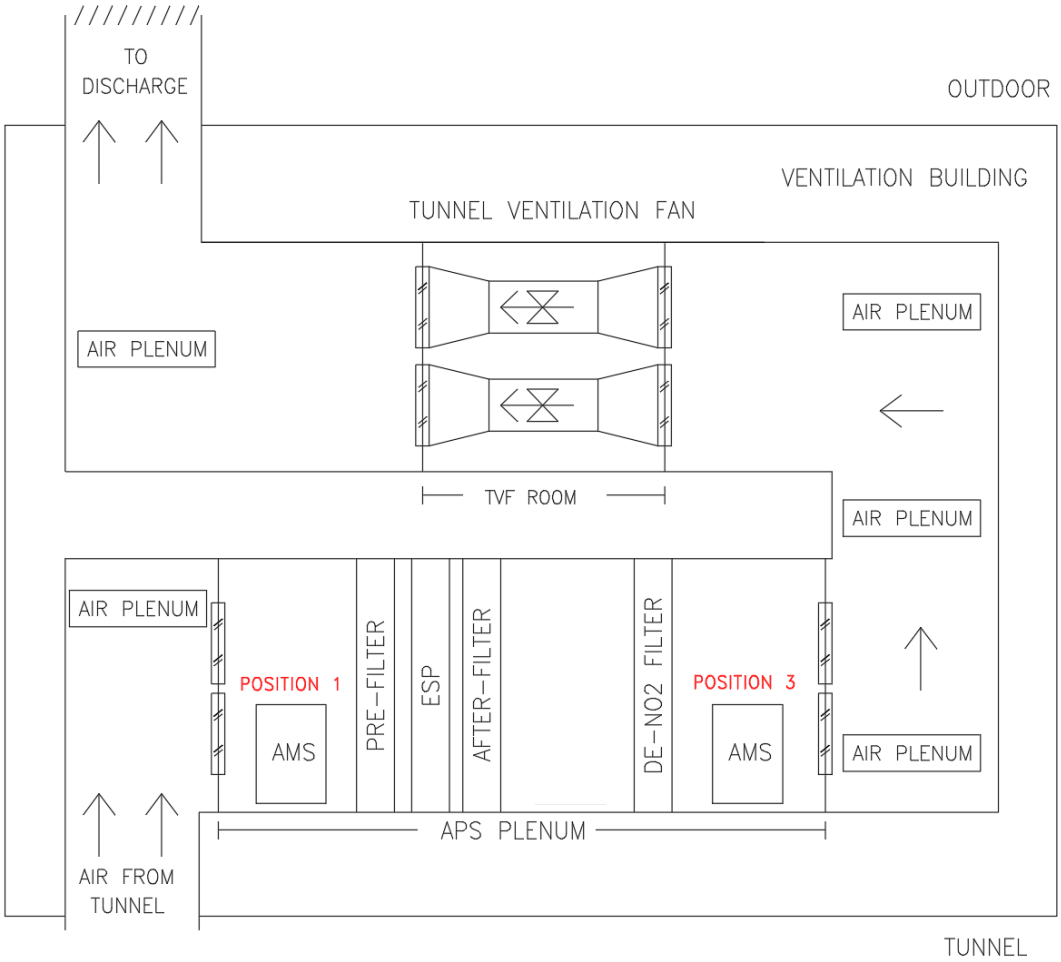
	Sensors related to the plan	Model of AMS
Position 1 (duty)	PM Mass Monitor for **PM10 & NO2** Measurement	MAS-AF300 SAP-G3W5
Position 1 (standby)	PM Mass Monitor for **PM10 & NO2** Measurement	MAS-AF300 SAP-G1W0
Position 3 (duty)	PM Mass Monitor for **PM10 & NO2** Measurement	MAS-AF300 SAP-G2W3
Position 3 (standby)	PM Mass Monitor for **PM10 & NO2** Measurement	MAS-AF300 SAP-G1W0

5.1.3. The accuracy of the sensors is +/-2% for NO_2, and +/-5% for particle size monitors (for 0.1mg/m³ or above measured value for PM_{10}). These sensors are designed to work properly under the environmental condition inside the APS plenum as stipulated in PS Clause 37.16(1). The catalogue and details of the AMS is attached in Appendix 1 for reference.

5.1.4. In order to maintain the accuracy of the sensors, rountine inspection and annual calibration by using standard portable sensor calibration kit with calibrated sample dust kit will be conducted. Detailed calibration arrangement and method will be included in the APS Operation and Maintenance (O&M) Manual, which will be provided to tunnel operator before the tunnel commissioning, to ensure the operation and performance within specifications.

5.1.5. Each APS is equipped with a total of 4 AMS, which are installed at in and out of the APS plenum, with NO_2 concentration sensor and particulate sensor for PM_{10} positioned. The positions of the AMS are as follows:

(i) Position 1 - before the ESP Filter
(ii) Position 3 - after the De-NO_2 Filter



SCHEMATIC DIAGRAM FOR AMS

5.1.6. The APS removal efficiency will be counted by the AMS at Position 1 and 3.

5.1.7. The locations of NO_2 concentration sensor and particulate sensor for PM_{10} are installed according to the contract requirements for HyD's Contract No. HY/2019/13 – Central Kowloon Route – Buildings, Electrical and Mechanical. The location plan of the AMS for Kai Tak Ventilation Building (KVB), Ho Man Tin Ventilation Building (HVB) and Yau Ma Tei Ventilation Building (YVB) with locations are attached in Appendix 2 for reference.

5.2. Criteria for Monitoring the Performance of the APS

5.2.1. Respirable Suspended Particles (RSP) PM_{10} – Removal efficiency

When inlet concentration equal to or greater than 0.5mg/m3 (at Position 1), not less than 80% of RSP/PM_{10} shall be removed (at Position 3); and

When inlet concentration is lower than 0.5mg/m3 (at Position 1), the outlet concentration shall not be greater than 0.1mg/m3 (at Position 3). *Note

5.2.2. NO_2 – Removal efficiency

When inlet concentration equal to or greater than 0.25ppm (at Position 1), not less than 80% of NO_2 shall be removed (at Position 3); and

When inlet concentration is lower than 0.25ppm (at Position 1), the outlet concentration shall not be greater than 0.05ppm (at Position 3). *Note

*Note: According to APS Commissioning Test Plan, the passing criteria at lower inlet concentration levels for PM_{10} and NO_2 will be further reviewed in Second Stage Testing.

5.2.3. The design standard/criteria for relevant air quality parameters were stated according to the contract requirements for HyD's Contract No. HY/2019/13 – Central Kowloon Route – Buildings, Electrical and Mechanical.

5.3. Criteria for Non-compliance (Only apply in tunnel operation)

5.3.1. As part of the tunnel ventilation system operation, the APS is interlocked with TVF in normal mode operation (ie. by switch off the APS, the TVF is turned off as well).

5.3.2. In addition, the APS will be switched off daily from 01:00 to 06:00 for regular daily maintenance in accordance with the tunnel ventilation system operating principles as described in the EIA report, AEIAR-171/2013, in order to maintain the proper functioning of the APS. Under this maintenance mode operation, the APS is not interlocked with the TVS. In such, the non-compliance does not apply during the APS maintenance period.

5.3.3. The NO2 concentration sensors and particulate sensors for PM10 installed at the ventilation buildings are programmed to log and record one data point every 5-minute-interval-average-data over a 1-hour span at Central Control and Monitoring System (CCMS) at the Administration Building (ADB). In each 1-hour span, 12 readings of removal efficiency (%) will be recorded in with each reading taken at a 5-minute interval.

5.3.4. When there are exceedances of the PM10 or NO2 criteria listed in Section 5.2, the operator shall start to record in the 5-minute average interval readings from the Air Monitoring Stations (AMS) at KVB, HVB and/or YVB. Should there are any non-compliance recorded during the operation of the CKR tunnel, actions in accordance with the Contingency Plan in Section 6.1 shall be implemented.

5.3.5. The Central Control and Monitoring System (CCMS) will alert the operator at the Administration Building (ADB) in the event of an exceedance as cited below in Table 1 being recorded. The operator will start recording on the exceedance reporting template once there is one 5- minute removal efficiency exceeds the exceedance criteria. Non-compliance occurs upon system cross-checking and confirmation by the operator within 30 minutes. The operator will then follow the Event-Action Plan for exceedance as in Appendix 3. Data record sheet for NO2 and PM10 monitoring as recorded in Exceedance Reporting Template are attached in Appendix 4 for reference.

Exceedance Criteria
* Removal efficiency of PM_{10} less than 80% when the inlet concentration equal to or greater than 0.5 mg/m3 Or The outlet concentration greater than 0.1 mg/m3 when the inlet concentration is lower than 0.5 mg/m
** Removal efficiency of NO_2 less than 80% if when the inlet concentration equal to or greater than 0.25 ppm Or The outlet concentration greater than 0.05 ppm when the inlet concentration is lower than 0.25 ppm

Remarks
* Refer to Section 5.2.1 for the criteria of PM_{10}
** Refer to Section 5.2.2 for the criteria of NO_2

Table 1 – Exceedance Criteria for Non-compliance

5.3.6. Sensors could take data every second. When it collects data for 1 minute, it would send this 1-minute-average data to the Programmable Logic Controller (PLC) of APS in HV switch rooms. The APS PLC would collect 5 nos. of this 1-minute-interval-average-data, which computes to a 5-minute-interval-average-data and send to the Central Control and Monitoring System (CCMS) for report.

5.4. Operation and Maintenance Overview

5.4.1. The APS for CKR project operates on a simple on/off principle when the tunnel is opened to traffic. It is remote controlled by CCMS and runs fully automatic once activated without any manning requirement when the tunnel is opened to traffic. The start up and shut down of the APS upon command from the CCMS includes switching on the HV power supply unit to ESP filter, starting up and stopping the duty ventilation fans for drawing the air from the CKR tunnel, and opening the APS isolation dampers for allowing tunnel air to be drawn through the APS filters before exhausted into the ambient air via the tunnel ventilation buildings. As long as the duty ventilation fans are running and the APS equipment is functioning, the APS operates.

5.4.2. The main components of Air Purification System (APS) and Tunnel Ventilation System (TVS) involved in the operation and maintenance of APS and their respective design life are provided in the table below:

Component	**Description**	**Design Life**
TVS	Tunnel Ventilation Fan Motorized Smoke Fire Damper (MSFD) MCC	20 years 25 years 20 years
APS	HV Power Supply Units, Pre-filters, ESP Filter, After Filter, De-NO_2 Filter, Roller shutters, Water Recycling Plant, Wash Down Plant, Pneumatic Plant, Sump pump, etc.	20 years
APS Control Equipment	APS PLC, Air Monitoring Stations, etc.	20 years

Table 2 - The main components of APS and TVS

5.4.3. As part of the system operation, the APS is interlocked with TVF in normal mode operation (ie. by switch off the APS, the TVF is turned off as well).

5.4.4. In addition, the APS will be switched off daily from 01:00 to 06:00 for regular daily maintenance in accordance with the system operating principles as described in the EIA report, AEIAR-171/2013, in order to maintain the proper functioning of the APS. Under this maintenance mode operation, the APS is not interlocked with the TVS.

5.4.5. The Pre-filter is also required to be cleaned when the criteria of the differential pressure across the Pre-filter or the APS running hours have met the preset value. Similar to ESP filter, the pressurized water is sprayed on the Pre-filter to remove the dust particles collected and dried by the pressurized air with natural dry time during the 1-hour cleaning operation.

5.4.6. The design preset value for ESP stated in Section 5.5.6 and De-NO2 filter stated in Section 5.5.7 will be reviewed and adjusted within 1 year Defect Liability Periods (DLP). The APS Operation and Maintenance Manual will include the maintenance arrangement to ensure the operation and performance are within specifications.

5.4.7. During the maintenance hours, the APS needs to be switched off for carrying out regular maintenance / inspection of the APS on monthly, quarterly and annual basis including some other issues such as clearance of large debris, rectification of breakdown of the equipment inside APS plenum etc.

5.4.8. The maintenance works for the major components of the APS required to be conducted regularly are as below:-

Major APS Components	Inspection/maintenance Frequencies (TBC)
General conditions of APS components	Monthly
HV power supply unit	Quarterly
Pre-Filter	Quarterly
ESP Filter	Quarterly
After Filter	Quarterly
De-NO2 Filter	Quarterly
Roller Shutter	Quarterly
APS Control Panel	Quarterly
Air Monitoring Stations	Quarterly
Electric equipment of APS	Yearly
Activated Carbon	3 to 4 years

Table 3 - The major components of APS requiring regular maintenance

5.4.9. An annual review will be conducted to review the duration/frequency of APS shutdown process for regular maintenance/inspection as the operator will be accumulating more practical experience on the maintenance/inspection process.

5.4.10. For any scheduled maintenance works which would result in suspension of APS other than the regular daily maintenance period from 01:00 to 06:00, the standby APS will pick up the operation to avoid any non-compliance. The operator shall inform HyD and EPD of the duration of the maintenance works 2 days in advance.

5.5. Preventative Maintenance Overview

5.5.1. The following preventive maintenance measures will be implemented to safeguard against accidental breakdown or early replacement of individual units of TVF or APS.

5.5.2. Routine maintenance, regular housekeeping, and routine inspection and maintenance of the following components of the APS will be conducted in accordance with the APS Operation and Maintenance (O&M) Manual to ensure the operation and performance of the APS remain within specifications.

i) Pre-Filter
ii) ESP Filter
iii) After Filter
iv) De-NO_2 Filter
v) Air Monitoring Stations
vi) APS Control System
vii) Roller shutters
viii) Water Recycling System
ix) Wash Down System
x) Pneumatic System
xi) Sump pump System
xii) Power Supply System, etc.

5.5.3. Consumables, mainly those required to keep the air monitoring devices within accurate operational limits required for each APS in ventilation buildings, will be in readiness for routine preventive maintenance.

5.5.4. Spare parts of different components will be kept in stock to ensure that they are in readiness for operation.

5.5.5. Training as specified in the prescribed course outline will be provided to all O&M staff.

5.5.6. The ESP is required to be cleaned as scheduled in order to maintain the removal efficiency. The Operator is responsible for monitoring the removal efficiency of ESP. If the removal efficiency of PM10 falls below the initial preset value of 85%, priority cleaning of the ESP will be scheduled during the upcoming maintenance period. During the 4-hour cleaning operation, pressurized water is sprayed on the ESP filter to remove the dust particles collected. The ESP filter will then be dried by pressurized air with natural dry time.

5.5.7. The De-NO2 filter (with the use of activated carbon) is a static element and requires no start-up or control. The activated carbon requires to be replaced regularly (typically every 3 to 4 years subject to the actual traffic condition) to maintain the NO2 removal efficiency. The Operator is responsible for monitoring the pressure drop and verifying the adsorption rate trend of the De-NO2 filter according to the degeneration curve which will be established by APS specialist after twelve (12) months of the commissioning of the APS system. The current preset value for the pressure drop in a carbon replacement program is 850Pa. If the pressure drop across the De-NO2 filter and the adsorption rate exceeds the recommended levels specified by the APS specialist, the operator must initiate a carbon replacement program.

6. APS Contingency Plan

6.1. Non-compliance Situations

6.1.1. When there are exceedances of the PM10 or NO2 criteria listed in Section 5.2, the operator shall start to record in the 5-minute average interval readings from the Air Monitoring Stations (AMS) at KVB, HVB and/or YVB.

6.1.2. Non-compliance occurs upon system cross-checking and confirmation by the operator within 30 minutes, operation of APS with non-compliance will be stopped and the standby APS will pick up the operation in accordance with Event-Action Plan below.

6.1.3. Event-Action Plan for Non-compliance Situations

i. Whenever an the exceedance occurs, Operator will record the data on the exceedance reporting template;
ii. Upon system cross-checking and confirmation by the operator within 30 minutes, the operator to ensure that the operation of APS with non-compliance will be stopped and the standby APS will pick up the operations;
iii. Operator to identify source / investigate reason of exceedance, carry out the maintenance / replacement works and implement recommended preventive action if any;
iv. Operator to resume APS back to Auto Mode after the defect is rectified;
v. Operator to prepare the exceedance report in accordance with the requirements of EPD and HyD and submit the report to Permit Holder within 14 calendar days upon the occurrence of the exceedance *Note 5;
vi. Operator to keep the record of exceedance event; and
vii. Operator to keep monitoring the proper function of the APS after resuming its operations.

The Event-Action flowchart for non-compliance situations is attached in Appendix 3 for reference.

6.1.4. The Event-Action plan under the Contingency Plan would be consulted and agreed by Transport Department (TD), Management Operation and maintenance (MOm), Electrical and Mechanical Services Department (EMSD), and Highways Department (HyD).

* Remarks:
Note 5: Environmental Team (ET) and the Independent Environmental Checker (IEC) should vet the exceedance report during the initial operation period (at least 1 year after CKR tunnel is opened), which should be terminated subject to agreement with EPD.

6.2. Emergency Situations

6.2.1. In the current design, the APS will stop operation and close during the following emergency situations (except for emergency situation (ii)):

i) When an emergency mode of traffic plans such as a fire incident in any part of the tunnel is activated.

ii) When the normal power supply from either one of the feeders from CLP is unavailable.

iii) When there is an emergency, such as fire incident, in the associated ventilation building.

iv) When the environmental conditions i.e. temperature, PM1, PM2.5, PM10 and NO2, Ozone and differential pressure within the APS plenum have exceeded the normal operational conditions (ie. blockage of the APS, abnormal heat generation by ESP filter, generation of toxic gas).

v) When there is an accidental breakdown of the individual component of the APS/TVF or any two(2) sets of the AMS in the same location within APS plenum causing malfunction of the APS and/or the TVF.

In case of emergency situation (i) and (iii), APS will be deactivated and the APS shall be isolated from the TVF by closing the tunnel damper upstream and downstream of the APS. CCMS will switch from normal mode operation to fire mode operation. The interlock between the APS and TVF is overridden. If the associated tunnel ventilation fans are operated in fire mode, the requirement of the removal efficiency of 80% for both RSP and NO2 will not necessarily be achieved.

In case of emergency situation (ii), APS is still required to operate as dual sources of power supply are provided for the APS.

In case of emergency situations (iv) and (v), APS and the associated TVF will be deactivated and the APS shall be isolated from the TVF by closing the tunnel damper upstream and downstream of the APS. If the standby APS and the associated TVF is in normal condition, the standby unit will pick up the operation. In case the standby unit is not ready whatever any reason, the required tunnel ventilation portal emission cannot be achieved. The tunnel air quality may not meet the requirement of the EPD's "Practice Note on Control of Air Pollution in Vehicle Tunnels".

6.2.2. Emergency response for emergency situations including fire incident, power failure, abnormal environmental conditions within the APS Plenum, component breakdown and etc. would be mentioned in the following Section. The emergency response and the APS Operational Procedures enable the Operator to restart the APS as soon as practicable after the above emergency situations have resumed normal. The APS Operation Procedure is attached in Appendix 9 for reference.

6.2.3. The emergency response under the Contingency Plan would be consulted and agreed by Transport Department (TD), Management Operation and maintenance (MOm), Electrical and Mechanical Services Department (EMSD), and Highways Department (HyD).

6.3. Emergency Response and Flowcharts

6.3.1. When there is fire incident happened in the tunnel or any ventilation buildings, the Operator will follow the procedures below to start up tunnel ventilation fans (TVF) and APS as soon as practicable after the fire incident:

i) Operator to inform TD, HyD, EPD, ET and IEC *Note 6;
ii) FSD would be notified of the fire incident by FSCC via Direct line;
iii) FSD will confirm the ventilation buildings/tunnel are safe to operate/reopen;
iv) Operator to check and confirm if any TVFs and APS equipment are damaged in the fire incident;
v) If there is no damaged TVF and APS equipment, Operator to switch APS to auto mode and start up the APS according to the APS Operational Procedures;
vi) If there are damaged TVF and APS equipment, Operator to check the spare part list and repair the damaged equipment with spare parts or procure new parts to replace the damaged equipment;
vii) Operator to switch APS to auto mode and start up the APS according to the APS Operational Procedures after finishing repair/replacing damaged equipment.

The emergency flowchart for fire incident and Recovery is attached in Appendix 5 for reference.

6.3.2. When the normal power supply from either one of the feeders from CLP is not available causing suspension of operation of TVFs and/or APS, APS is still required to operate as dual sources of power supply are provided for the APS. If the switch over of power supply sources is unsuccessful, the Operator will follow the procedures below to start up TVFs and APS as soon as practicable.

i) CLP Power (CLP) has two power supply sources (source A and Source B) for each ventilation building;
ii) When power source A fails to supply electricity to any ventilation building, CLP power supply will be automatically switched to source B to supply electricity to any ventilation building;
iii) Operator to inform CLP, TD, HyD, EPD, ET and IEC *Note 6 on the suspension of power supply and await to resume of power supply by CLP;
iv) If the automatic switch over of power supply source from CKR side is successful, the TVFs and APS will continue to operate;
v) Operator to resume the system after resuming the power source A by CLP;
vi) If the automatic switch over of power supply source from CKR side fails, Operator to conduct inspection and check if any component is damaged during the power supply failure;
vii) If there is no damaged TVF and APS equipment, Operator to start up the TVFs and APS according to the APS Operational Procedures after power supply resumes; and
viii) If there are damaged TVF and APS equipment, Operator to check the spare part list and repair the damaged equipment with spare parts or procure new parts to replace the damaged equipment.

The emergency flowchart for power supply failure is attached in Appendix 6 for reference.

* Remarks:
Note 6: Environmental Team (ET) and the Independent Environmental Checker (IEC) will involve during the initial operation period (at least 1 year after CKR tunnel is opened), which should be terminated subject to agreement with EPD.

6.3.3. When the environmental conditions within the APS plenum measured from the Air Monitoring Stations have exceeded the normal operational conditions, the Operator will follow the procedures below to check and rectify the fault, and then to start up TVFs and APS as soon as practicable.

i) Operator to inform TD, HyD, EPD, ET and IEC *Note 6;
ii) Operator to conduct inspection and identify the root cause of the exceeded normal operational conditions;
iii) If the abnormal environmental conditions within the APS plenum is settled, Operator to check and confirm if any TVFs and APS equipment are damaged in the incident;
iv) If there is no damaged TVF and APS equipment, Operator to switch APS to auto mode and start up the APS according to the APS Operational Procedures;
v) If there are damaged TVF and APS equipment, Operator to check the spare part list and repair the damaged equipment with spare parts or procure new parts to replace the damaged equipment;
vi) Operator to switch APS to auto mode and start up the APS according to the APS Operational Procedures after finishing repair/replace damaged equipment.

The emergency flowchart for abnormal environmental conditions is attached in Appendix 7 for reference.

6.3.4. When there is an accidental breakdown of the individual component of the APS/TVF or any two(2) sets of the AMS in the same APS plenum causing malfunction of the APS and/or the TVF, the Operator will follow the procedures below to resolve the cause of breakdown and then to start up TVFs and APS as soon as practicable.

i) Operator to inform TD, HyD, EPD, ET and IEC *Note 6;
ii) Operator to conduct inspection and identify the root cause of the breakdown;
iii) Operator to check if there is any spare part available for repair;
iv) If there are spare parts available, Operator to repair the broke down component with spare parts;
v) If there is no spare part available, Operator to procure the broke down component for replacement;
vi) Operator to start up the APS according to the APS Operational Procedures after finishing repair/replacing the brokendown component.

The emergency flowchart for breakdown of equipment or any two sets of the AMS in the same location within APS Plenum is attached in Appendix 8 for reference.

6.3.5. The operator should establish and agree the emergency contact / channel with the relevant parties including TD, HyD, EPD, ET and IEC *Note 6.

* Remarks:
Note 6: Environmental Team (ET) and the Independent Environmental Checker (IEC) will involve during the initial operation period (at least 1 year after CKR tunnel is opened), which should be terminated subject to agreement with EPD.

6.4. Conclusion

6.4.1. The APS will cease operation in certain non-compliance situations and emergency situations, including the exceedance criteria for non-compliance, fire incident, abnormally high measurement from the AMS, breakdown of individual components of the APS/TVF or any two(2) sets of the AMS in the same APS plenum causing malfunction of the APS and/or the TVF.

6.4.2. However, in the event of a power supply failure from single power source from CLP, the APS is still required to operate as dual sources of power supply will be provided for the APS.

6.4.3. The emergency response flowcharts and APS Operational Procedures enable the Operator to restart the APS as soon as practicable after recovery from non-compliance and an emergency situation.

Appendix 1:

Catalog of NO_2 Sensor & PM_{10} Monitor

Sapiens MAS-AF300

High performance next generation outdoor air quality monitoring with validated data performance and successful international application cases for research, government, community and industrial users.

Product Description

MAS-AF300 is the flagship model of Sapiens Mini Air Station (MAS) series products for high-performance and long-term outdoor air quality monitoring with integrated autonomous data quality control capabilities. The product can measure criteria air pollutants including particulate matters (PM_1, $PM_{2.5}$, PM_{10}), nitrogen monoxides (NO), nitrogen dioxide (NO_2), ozone (O_3), carbon monoxide (CO), carbon dioxide (CO_2) with near reference data quality under all weather conditions, and total volatile organic compounds (TVOC) at high accuracy. Other important air pollutants are optional.

MAS-AF300 is equipped with the patented Pair Differential Filter (PDF) sensing technology using paired filter for continuous tracking of virtual baseline for the gas sensors signals. Autozero functions are also enabled to track the long-term drift issues for both gas and PM measurements. Data transmission through RS-232 or RS-485 port to user defined control systems or to designated Sapiens cloud server or user designated server through API and direct TCP links are optional.

The intended applications are complementary air quality monitoring with high data performance target needs and near reference data quality requirement for the government agency, communities, air quality researchers and industrial sectors.

Product Features

- Omnidirectional inlet design for gas and PM measurements;
- Stevenson screen protected high performance climatic measurement for ambient temperature and humidity;
- Enclosure materials include Polycarbonate for lightweight application, Aluminum Alloy and Stainless Steel for harsh and corrosive environments;
- IP65 grade waterproof design for all weather condition outdoor monitoring;
- Highly integrated for simultaneous measurement of PM_1, $PM_{2.5}$, PM_{10} with up to 52 size channels from 0.3 μm to 10 μm.
- Sheath flow is enabled for PM counter model for high concentration measurements and long-term performance;
- Correction of laser drift and humidity impact though auto zero function and intelligent heating for PM measurement;
- Up to 6 or 8 gases simultaneous measurements at ppb levels of NO_2, O_3, SO_2, NO and ppm level of CO and CO2, with SO_2, TVOC as optional;
- Pair Differential Filter (PDF) sensing technology is enabled for gas sensors to auto track the virtual baseline of sensor signals;
- Correction of sensor drift impact by auto zero function for NO, NO_2, O_3 and TVOC gases;
- Gas sample pretreatment with condensation trap and humidity stabilization through advanced technology for the fast-varying ambient environments;
- Data transmission via 4G network for continuous and real time monitoring through cloud platforms;
- Versatile installation options of tripod, wall mount and crossarm;
- External smart battery packs are optional for extended outdoor powerless operation for up to 5 days;
- Solar power panels are optional for extended operations in remote outdoor environments.

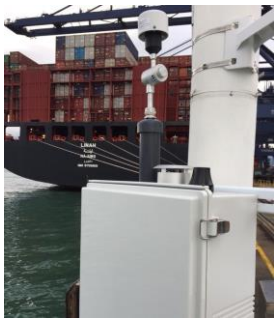
Applications

- Smart city sensor network
- Tunnel air quality monitoring
- Urban air pollution monitoring
- Roadside air quality monitoring
- Industrial fence line monitoring
- Emergency air quality monitoring
- School community monitoring

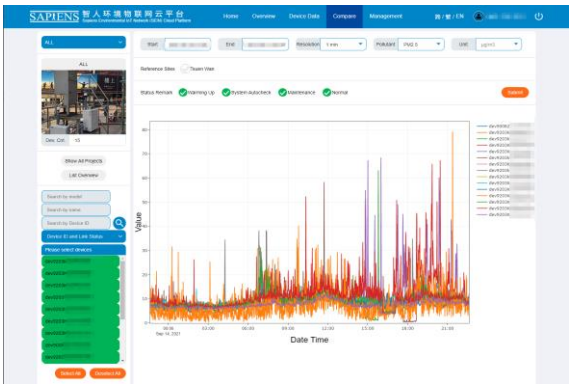
Shanghai expo

Tunnel monitoring

Bus terminal monitoring



Port monitoring



Sapiens Environmental IoT Network cloud platform

Sapiens is an ISO 9001:2015 and GB/T24001-2016/ISO14001:2015 certified company for MAS/NAS/Sirius/PEK series products.

EN 61010:2010+A1:2019
EN 61326-1: 2013
EN 61000-3-2: 2019
EN 61000-3-3: 2013+A1: 2019

SAPIENS 智人環保

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Technical Specification

PM Module	Description	Range	Resolution	Precision	Response Time
PM Counter	Simultaneous output of PM_1, $PM_{2.5}$ and PM_{10}	PM_{10}: 0~30,000 μg/ m^3	1 μg/ m^3	± 5% of measured concentration or ± 5 μg/ m^3	< 1 min
		$PM_{2.5}$: 0~10,000 μg/ m^3	1 μg/ m^3	± 5% of measured concentration or ± 5 μg/ m^3	< 1 min
		PM_1: 0~5,000 μg/ m^3	1 μg/ m^3	± 5% of measured concentration or ± 5 μg/ m^3	< 1 min

Gas Module	Range	Detection Limit	Resolution	Precision
Nitrogen Dioxide (NO_2)	0~5 ppm	1 ppb	≤ 1 ppb	± 2% of measured concentration or ± 5 ppb
Nitrogen Monoxide (NO)	0~ 20 ppm	1 ppb	≤ 1 ppb	± 2% of measured concentration or ± 5 ppb
Ozone (O_3)	0~5 ppm	1 ppb	≤ 1 ppb	± 2% of measured concentration or ± 5 ppb
Carbon Monoxide (CO)	0~20 ppm	0.01 ppm	≤ 0.01 ppm	± 2% of measured concentration or ± 0.02 ppm
Carbon Dioxide (CO2)	0~20,000 ppm	0.05 ppm	≤ 0.05 ppm	± 2% of measured concentration or ± 0.05 ppm

Weather Station	Working Principles	Range	Resolution	Accuracy
Velocity	Ultrasonic anemometer	0 ~ 40 m/ sec	0.1 m/ sec	± 1% of reading
Airflow Direction	Ultrasonic anemometer	0 ~ 359.9°	0.1°	± 3°at 10 m/s
Pressure	Piezo-resistive pressure sensor	300~1100 hPa	0.1 hPa	±0.5 hPa at 25℃ (or better)
Temperature	Precision Thermistor	-40°C ~ +80°C	0.1°C	± 1% of reading
Humidity	Capacitive polymer sensor	0 ~ 100% RH	0.1%RH	± 1% RH at 0 to 90% RH at 20℃

System Specification

Features	Descriptions
Dimension	600 mm × 400 mm × 212.5mm (H x W x D) PM Inlet height: 295mm (without cyclone) 345 mm (with cyclone)
Weight	~ 30 kg
Environmental Operating Range	Temperature: -10 ~ 50°C; Humidity: 0 ~ 99 %; Pressure: 80kPa ~ 120kPa
Installation options	Tripod/ Wall mount/ Cross arm; Enclosure installation: nstalled at a ground within an enclosure
Ingress Protection	IP65 with stainless steel or aluminum alloy or polycarbonate enclosure materials
Power Input	Standard : AC 100~240V 50/60Hz or 20 ~ 28V External DC Input
	Optional: External Smart Battery Packs, Solar Power Panel
Power Consumption	Normal 15W and max 25W
Data Management	RS-232 or RS-485 data output to user defined control systems; Sapiens Environment IoT Network (SEIN) network for remote data browsing, downloading, system condition checking and control, and data management
Data Transmission	4G Module Transmission and Serial Port Connection for Data Streaming
Data Storage	32G Storage or External Serial Port for Data Retrieval using Sapiens MAS Console Program
Gas sampling	Omnidirectional inlet and active sampling with long lifetime pump (>1 year)
PM sampling	Active sampling with long lifetime pump (>1 year)
Sampling Rate	1 minute, 5 minutes
Averaging Interval	1 minute, 5 minutes, 1 hour
Quality Control System	Integrated smart heating inlet with user set threshold of humidity for PM modules (typical 40%)
	Autozero function for PM photometer module to correct for long term drift
	Sheath flow control function for PM counter module for long term performance
	Pair Differential Filter technology for temperature and humidity impact correction on gas sensor signals
	Humidity stabilization function for gas module to control the humidity shock on gas sensors

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POSITION 1 (DUTY)

SAPIENS 智人環保

Technical specification

Equipment: **MAS-AF300**
Model code: **SAP-G3W5**

SAP-G3W5: *PM1, PM2.5, PM10, NO, NO2, NOx, CO, CO2, Ozone. Temperature, Relative humidity, Air pressure, Air direction & Air speed*

MAS-AF300

Dimension：	600mm × 400 mm × 212.5 mm (H x W x D) PM Inlet height: 295mm (without cyclone)
Weight：	~13 kg without battery; 16 kg with battery ~23 kg with stainless steel enclosure without battery
Operating Range：	Temperature: -10 - 50°C; Humidity: 0 - 99 %; Pressure: 80kPa - 120kPa
Installation options：	Tripod/ Wall mount/ Cross arm/ Installed at a ground within an enclosure
Ingress Protection:	IP65 with stainless steel or aluminum alloy or polycarbonate enclosure materials
Power Input：	Standard : AC 100~240V 50/60Hz or 20~28 V DC input as user specified
Power Consumption	Normal 15W and max 25W
Data Management：	RS-232 or RS-485 data output to user defined control systems; Sapiens Environment IoT Network (SEIN) network for remote data browsing, downloading, system condition checking and control, and data management
Data Transmission:	4G Module Transmission and Serial Port Connection for Data Streaming
Data Storage:	32G Storage or External Serial Port for Data Retrieval using Sapiens MAS Console Program
Gas Sampling:	Omnidirectional inlet and active sampling with long lifetime pump (>1 year)
PM Sampling:	Active sampling with long lifetime pump (>1 year)
Sampling Rate:	1 minute, 5 minutes
Averaging Interval：	1 minute, 5 minutes, 1 hour

1. PM Module

Measurement range	PM10 mass concentration:	30,000 μg/m^3
	PM2.5 mass concentration:	10,000 μg/m^3
	PM1 mass concentration:	5,000 μg/m^3
Measurement principle	Fine resolution size bin counting and conversion to PM mass concentration	
Resolution	≤ 1 μg/m^3	
Accuracy	± 5 % of measurement concentration or ±5 μg/m^3	
Precision	± 5% of measurement concentration or ±5 μg/m^3	
Zero drift in 24 hours	≤ 1 μg/m^3	
Lower detection limit	≤ 1 μg/m^3	
Response time	≤ 1 min	
Measurement intervals	1 minute, 5 minutes	
Averaging period	1 minute, 5 minutes, 1 hour	
Baseline correction	Auto zero with filtered zero gas supply	
Drift correction	Every 3 months	
Lower detection limit	<1 μg/m^3	
Active sampling	Yes	
Sampling System	PM inlet: Active heating/sampling	
Quality Control	Active heating to remove water vapor impact on PM measurement	

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EN 61010:2010+A1:2019
EN 61326-1: 2013
EN 61000-3-2: 2019
EN 61000-3-3: 2013+A1: 2019

2. NO sensor module

Measurement range	0-20 ppm
Resolution	≤ 1 ppb
Accuracy	± 2% of measured concentration or ± 5 ppb
Lower detection limit	1 ppb
Response time	≤ 1 min
Drift 24 hour	< 1 ppb
Baseline correction	Auto zero with filtered zero gas supply
Drift correction	Every 3 months
Active sampling	Yes
Quality Control	Both temperature and humidity stabilization module equipped; Also sensor algorithms come with baseline and sensitivity correction for humidity and temperature influences.

3. NO2 sensor module

Measurement range	0-5 ppm
Resolution	≤ 1 ppb
Accuracy	± 2% of measured concentration or ± 5 ppb
Lower detection limit	1 ppb
Response time	≤ 1 min
Drift 24 hour	< 1 ppb
Baseline correction	Auto zero with filtered zero gas supply
Drift correction	Every 3 months
Active sampling	Yes
Quality Control	Both temperature and humidity stabilization module equipped; Also sensor algorithms come with baseline and sensitivity correction for humidity and temperature influences.

4. Ozone sensor module

Measurement range	0-5 ppm
Resolution	≤ 1 ppb
Accuracy	± 2% of measured concentration or ± 5 ppb
Lower detection limit	1 ppb
Response time	≤ 1 min
Drift 24 hour	< 1 ppb
Baseline correction	Auto zero with filtered zero gas supply
Drift correction	Every 3 months
Active sampling	Yes
Quality Control	Both temperature and humidity stabilization module equipped; Also sensor algorithms come with baseline and sensitivity correction for humidity and temperature influences.

5. CO sensor module

Measurement range	0-20 ppm
Resolution	≤ 0.01 ppm
Accuracy	± 2% of measurement concentration or ± 0.02 ppm
Lower detection limit	0.01 ppm
Response time	≤ 1 min
Drift 24 hour	< 5 ppb
Baseline correction	Auto zero with filtered zero gas supply
Drift correction	Every 3 months
Active sampling	Yes
Quality Control	Both temperature and humidity stabilization module equipped; Also sensor algorithms come with baseline and sensitivity correction for humidity and temperature influences.

6. CO2 sensor module

Measurement range	0-20,000 ppm
Resolution	≤ 0.05 ppm
Accuracy	± 2% of measurement concentration or ± 0.05 ppm
Calibration drift	Zero drift1: <0.15 ppm / °C Span drift2 <0.03% / °C Total drift at 370 ppm3: <0.4 ppm / °C
Lower limit of detection	0.05 ppm
Response time (T90)	< 3.5 seconds
Active sampling	Yes
Traceability	Traceable gases to WMO standards from 0 to 3,000 ppm; traceable gases to EPA protocol gases from 3,000 to 20,000 ppm

7. Weather Station (SAP-WS05)

7.1 Temperature

Range:	-40 to 80°C (-40 to 176°F)
Accuracy:	±1% of reading
Resolution:	0.1°C

7.2 Relative Humidity

Range:	0 to 100% RH
Accuracy:	±1% RH at 0 to 90% RH at 20°C
Resolution:	0.1% RH

7.3 Air Pressure

Range:	300 to 1100 hPa
Accuracy:	±0.5 hPa at 25°C (or better)
Resolution:	0.1 hPa

7.4 Air Speed

Range:	0 to 40 m/s (0 to 89 MPH)
Accuracy:	±1% of reading
Resolution:	0.1 m/s
Calculations:	User configurable damping

7.5 Air Direction

Range:	0 to 359.9°
Accuracy:	±3° at 10 m/s
Resolution:	0.1°
Calculations:	User configurable damping

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POSITION 3 (DUTY)

Technical specification

Equipment: **MAS-AF300**
Model code: **SAP-G2W3**

SAP-G2W3: *PM1, PM2.5, PM10, NO, NO2, NOx, CO, CO2, Temperature, Relative humidity, and Air pressure*

MAS-AF300

Dimension：	600 mm × 400 mm × 212.5 mm (H x W x D) PM Inlet height: 295 mm (without cyclone)
Weight：	~13 kg without battery; 16 kg with battery; ~23 kg with stainless steel enclosure without battery
Operating Range：	Temperature: -10 - 50°C; Humidity: 0 - 99 %; Pressure: 80kPa - 120kPa
Installation options：	Tripod/ Wall mount/ Cross arm/ Installed at a ground within an enclosure
Ingress Protection:	IP65 with stainless steel or aluminum alloy or polycarbonate enclosure materials
Power Input：	Standard : AC 100~240V 50/60Hz or 20 ~ 28V External DC Input
Power Consumption	Normal 15W and max 25W
Data Management：	RS-232 or RS-485 data output to user defined control systems; Sapiens Environment IoT Network (SEIN) network for remote data browsing, downloading, system condition checking and control, and data management
Data Transmission:	4G Module Transmission and Serial Port Connection for Data Streaming
Data Storage:	32G Storage or External Serial Port for Data Retrieval using Sapiens MAS Console Program
Gas Sampling:	Omnidirectional inlet and active sampling with long lifetime pump (>1 year)
PM Sampling:	Active sampling with long lifetime pump (>1 year)
Sampling Rate:	1 minute, 5 minutes
Averaging Interval：	1 minute, 5 minutes, 1 hour

1. PM Module

Measurement range	PM10 mass concentration:	30,000 μg/m^3
	PM2.5 mass concentration:	10,000 μg/m^3
	PM1 mass concentration:	5,000 μg/m^3
Measurement principle	Fine resolution size bin counting and conversion to PM mass concentration	
Resolution	≤ 1 μg/m^3	
Accuracy	± 5 % of measurement concentration or ±5 μg/m^3	
Precision	± 5% of measurement concentration or ±5 μg/m^3	
Zero drift in 24 hours	≤ 1 μg/m^3	
Lower detection limit	≤ 1 μg/m^3	
Response time	≤ 1 min	
Measurement intervals	1 minute, 5 minutes	
Averaging period	1 minute, 5 minutes, 1 hour	
Baseline correction	Auto zero with filtered zero gas supply	
Drift correction	Every 3 months	
Lower detection limit	< 1 μg/m^3	
Active sampling	Yes	
Sampling System	PM inlet: Active heating/sampling	
Quality Control	Active heating to remove water vapor impact on PM measurement	

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EN 61010:2010+A1:2019
EN 61326-1: 2013
EN 61000-3-2: 2019
EN 61000-3-3: 2013+A1: 2019

2. NO sensor module

Measurement range	0-20 ppm
Resolution	≤ 1 ppb
Accuracy	± 2% of measured concentration or ± 5 ppb
Lower detection limit	1 ppb
Response time	≤ 1 min
Drift 24 hour	< 1 ppb
Baseline correction	Auto zero with filtered zero gas supply
Drift correction	Every 3 months
Active sampling	Yes
Quality Control	Both temperature and humidity stabilization module equipped; Also sensor algorithms come with baseline and sensitivity correction for humidity and temperature influences.

3. NO2 sensor module

Measurement range	0-5 ppm
Resolution	≤ 1 ppb
Accuracy	± 2% of measured concentration or ± 5 ppb
Lower detection limit	1 ppb
Response time	≤ 1 min
Drift 24 hour	< 1 ppb
Baseline correction	Auto zero with filtered zero gas supply
Drift correction	Every 3 months
Active sampling	Yes
Quality Control	Both temperature and humidity stabilization module equipped; Also sensor algorithms come with baseline and sensitivity correction for humidity and temperature influences.

4. CO sensor module

Measurement range	0-20 ppm
Resolution	≤ 0.01 ppm
Accuracy	± 2% of measured concentration or ± 0.02 ppm
Lower detection limit	0.01 ppm
Response time	≤ 1 min
Drift 24 hour	< 5 ppb
Baseline correction	Auto zero with filtered zero gas supply
Drift correction	Every 3 months
Active sampling	Yes
Quality Control	Both temperature and humidity stabilization module equipped; Also sensor algorithms come with baseline and sensitivity correction for humidity and temperature influences.

5. CO2 sensor module

Measurement range	0-20,000 ppm
Resolution	≤ 0.05 ppm
Accuracy	± 2% of measured concentration or ± 0.05 ppm
Calibration drift	Zero drift1: <0.15 ppm / °C Span drift2 <0.03% / °C Total drift at 370 ppm3: <0.4 ppm / °C
Lower limit of detection	0.05 ppm
Response time (T90)	<3.5 seconds
Active sampling	Yes
Traceability	Traceable gases to WMO standards from 0 to 3,000 ppm; traceable gases to EPA protocol gases from 3,000 to 20,000 ppm

6. Weather Station (SAP-WS03)

6.1 Temperature

Range:	-40 to 80°C (-40 to 176°F)
Accuracy:	±1% of reading
Resolution:	0.1°C

6.2 Relative Humidity

Range:	0 to 100% RH
Accuracy:	±1% RH at 0 to 90% RH at 20°C
Resolution:	0.1% RH

6.3 Air Pressure

Range:	300 to 1100 hPa
Accuracy:	±0.5 hPa at 25°C (or better)
Resolution:	0.1 hPa

POSITION 1 & 3 (STANDBY)

Sapiens Environmental Technology Co Limited
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Email: sales@sapiens-envtech.com

Technical specification

Equipment: MAS-AF300
Model code: SAP-G1W0

SAP-G1W0: *PM1, PM2.5, PM10, NO, NO2, NOx,*

MAS-AF300

Dimension：	600 mm × 400 mm × 212.5 mm (H x W x D) PM Inlet height: 295 mm (without cyclone)
Weight：	~13 kg without battery; 16 kg with battery; ~23 kg with stainless steel enclosure without battery;
Operating Range：	Temperature: -10 - 50°C; Humidity: 0 - 99 %; Pressure: 80kPa - 120kPa
Installation options：	Tripod/ Wall mount/ Cross arm/ Installed at a ground within an enclosure
Ingress Protection:	IP65 with stainless steel or aluminum alloy or polycarbonate enclosure materials
Power Input：	Standard : AC 100~240V 50/60Hz or 20 ~ 28V External DC Input
Power Consumption	Normal 15W and max 25W
Data Management：	RS-232 or RS-485 data output to user defined control systems; Sapiens Environment IoT Network (SEIN) network for remote data browsing, downloading, system condition checking and control, and data management
Data Transmission:	4G Module Transmission and Serial Port Connection for Data Streaming
Data Storage:	32G Storage or External Serial Port for Data Retrieval using Sapiens MAS Console Program
Gas Sampling:	Omnidirectional inlet and active sampling with long lifetime pump (>1 year)
PM Sampling:	Active sampling with long lifetime pump (>1 year)
Sampling Rate:	1 minute, 5 minutes
Averaging Interval：	1 minute, 5 minutes, 1 hour

1. PM Module

Measurement range	PM10 mass concentration:	30,000 μg/m^3
	PM2.5 mass concentration:	10,000 μg/m^3
	PM1 mass concentration:	5,000 μg/m^3
Measurement principle	Fine resolution size bin counting and conversion to PM mass concentration	
Resolution	≤ 1 μg/m^3	
Accuracy	± 5 % of measurement concentration or ±5 μg/m^3	
Precision	± 5% of measurement concentration or ±5 μg/m^3	
Zero drift in 24 hours	≤ 1 μg/m^3	
Lower detection limit	≤ 1 μg/m^3	
Response time	≤ 1 min	
Measurement intervals	1 minute, 5 minutes	
Averaging period	1 minute, 5 minutes, 1 hour	
Baseline correction	Auto zero with filtered zero gas supply	
Drift correction	Every 3 months	
Lower detection limit	<1 μg/m^3	
Active sampling	Yes	
Sampling System	PM inlet: Active heating/sampling	
Quality Control	Active heating to remove water vapor impact on PM measurement	

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EN 61010:2010+A1:2019
EN 61326-1: 2013
EN 61000-3-2: 2019
EN 61000-3-3: 2013+A1: 2019

2. NO sensor module

Measurement range	0-20 ppm
Resolution	≤ 1 ppb
Accuracy	± 2% of measured concentration or ± 5 ppb
Lower detection limit	1 ppb
Response time	≤ 1 min
Drift 24 hour	<1 ppb
Baseline correction	Auto zero with filtered zero gas supply
Drift correction	Every 3 months
Active sampling	Yes
Quality Control	Both temperature and humidity stabilization module equipped; Also sensor algorithms come with baseline and sensitivity correction for humidity and temperature influences.

3. NO2 sensor module

Measurement range	0-5 ppm
Resolution	≤ 1 ppb
Accuracy	± 2% of measured concentration or ± 5 ppb
Lower detection limit	1 ppb
Response time	≤ 1 min
Drift 24 hour	<1 ppb
Baseline correction	Auto zero with filtered zero gas supply
Drift correction	Every 3 months
Active sampling	Yes
Quality Control	Both temperature and humidity stabilization module equipped; Also sensor algorithms come with baseline and sensitivity correction for humidity and temperature influences.

Appendix 2:

Layout of Ventilation Building with AMS

POSITION 3
AMS (DUTY & STANDBY)

TO ABOVE
TOP R/F OF YVB

DE-NO2 FILTER

ESP FILTER

POSITION 1
AMS (DUTY & STANDBY)

FROM TUNNEL

TO ABOVE
TOP R/F OF YVB

POSITION 3
AMS (DUTY & STANDBY)

DE-NO2 FILTER

ESP FILTER

POSITION 1
AMS (DUTY & STANDBY)

FROM TUNNEL

Arch. Drawing No.	J3883/ARC/YVB/1101/A8
Str. Drawing No.	J3883/STR/YVB/1102/A

NOTES:

1. FOR NOTES, LEGEND AND CABLE SCHEDULE PLEASE REFER TO DRAWING NO. J3883/MEP/APS/GEN/0001 & 0002.
2. FOR DISTRIBUTION DETAIL, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/YVB/1203 & 1204.
3. FOR HV SWITCH ROOM PLANT ROOM DETAIL, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/HVB/3203 & 3204.
4. FOR FILTRATION ROOM PLANT ROOM DETAIL, PLEASE REFER TO DRAWING NO.J3883/MEP/APS/HVB/3303.
5. FOR CONTROL EQUIPMENT, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/HVB/3211.
6. FOR ELECTRICAL EQUIPMENT, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/HVB/3321.
7. FOR TASK VENTILATION DETAIL, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/GEN/4629.
8. FOR INSTALLATION DETAILS OF AMS FINAL DISCHARGE ,PLEASE REFER TO DRAWING NO. J3883/MEP/APS/GEN/4526.

150MM DEPTH SURFACE CHANNEL
150MM DEPTH SURFACE CHANNEL WITH SS316 REMOVABLE SEALED COVER
150MM DEPTH SURFACE CHANNEL WITH SS316 GRATING COVER

Rev.	Description	Date	Arch Rev.	Str Rev.
C	4TH SUBMISSION	24/02/2023	A7	/
B	3RD SUBMISSION	07/01/2023	A7	/
A	2ND SUBMISSION	16/11/2022	A7	/
0	1ST SUBMISSION	26/04/2022	A4	/

Consultant
ARUP MOTT MACDONALD
Arup-Mott MacDonald Joint Venture

Contractor
Gammon
CTA INTERNATIONAL AS CLEAN TUNNEL AIR
JEC

Designer

Project title
Contract No. HY/2019/13

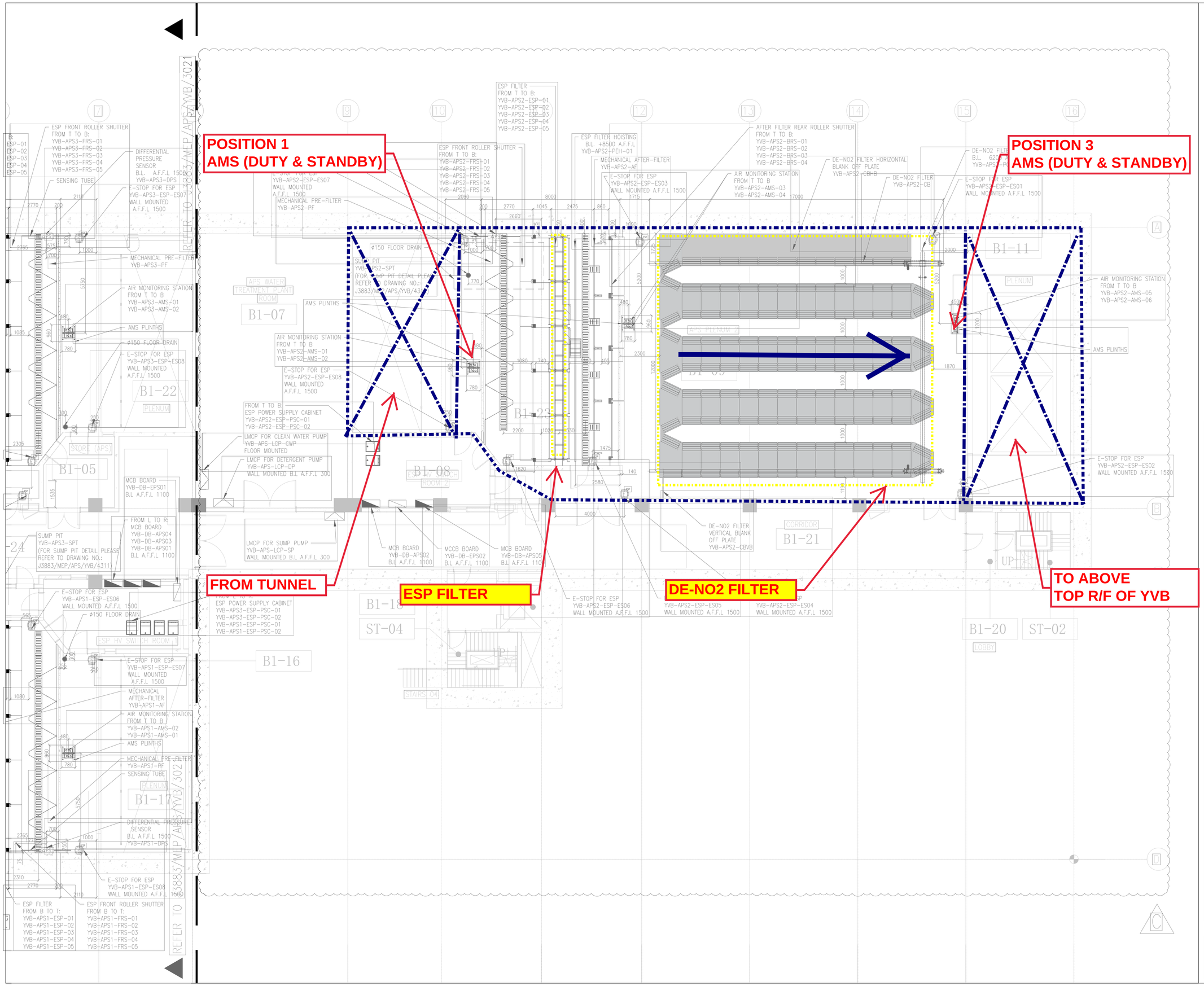
Central Kowloon Route -
Buildings, Electrical and Mechanical

Drawing title
AIR PURIFICATION SYSTEM – EQUIPMENT LAYOUT BASEMENT 1 – YAU MA TEI VENTILATION BUILDING (SHEET 1 OF 2)

Drawing no.	J3883/MEP/APS/YVB/3021
Rev.	C
File name	J3883_MEP_APS_YVB_3021_C.DWG
Scale	1:100 @ A1
Drawn	T. HO
Checked	C. CHEUNG
Approved	F. LEUNG
Authorised Representative	F. HO
Date	24/FEB/23

WORKING DRAWING

路政署
HIGHWAYS DEPARTMENT
主要工程管理處
MAJOR WORKS PROJECT MANAGEMENT OFFICE



Arch. Drawing No.	J3883/ARC/YVB/1101/A8
Str. Drawing No.	J3883/STR/YVB/1102/A

NOTES:

1. FOR NOTES, LEGEND AND CABLE SCHEDULE PLEASE REFER TO DRAWING NO. J3883/MEP/APS/GEN/0001 & 0002.
2. FOR DISTRIBUTION DETAIL, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/YVB/1203 & 1204.
3. FOR HV SWITCH ROOM PLANT ROOM DETAIL, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/HVB/3203 & 3204.
4. FOR FILTRATION ROOM PLANT ROOM DETAIL, PLEASE REFER TO DRAWING NO.J3883/MEP/APS/HVB/3303.
5. FOR CONTROL EQUIPMENT, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/HVB/3211.
6. FOR ELECTRICAL EQUIPMENT, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/HVB/3321.
7. FOR TASK VENTILATION DETAIL, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/GEN/4629.
8. FOR INSTALLATION DETAILS OF AMS FINAL DISCHARGE ,PLEASE REFER TO DRAWING NO. J3883/MEP/APS/GEN/4526.

- 150MM DEPTH SURFACE CHANNEL
- 150MM DEPTH SURFACE CHANNEL WITH SS316 REMOVABLE SEALED COVER
- 150MM DEPTH SURFACE CHANNEL WITH SS316 GRATING COVER

Rev.	Description	Date	Arch Rev.	Str Rev.
C	4TH SUBMISSION	24/02/2023	A7	/
B	3RD SUBMISSION	07/01/2023	A7	/
A	2ND SUBMISSION	16/11/2022	A7	/
0	1ST SUBMISSION	26/04/2022	A4	/

Consultant

ARUP MOTT MACDONALD
Arup-Mott MacDonald Joint Venture

Contractor

Gammon

Designer

CTA INTERNATIONAL AS CLEAN TUNNEL AIR
JEC

Project title

Contract No. HY/2019/13

Central Kowloon Route -
Buildings, Electrical and Mechanical

Drawing title

AIR PURIFICATION SYSTEM – EQUIPMENT LAYOUT BASEMENT 1 – YAU MA TEI VENTILATION BUILDING (SHEET 2 OF 2)

Drawing no.	J3883/MEP/APS/YVB/3022	Rev.	C
File name	J3883_MEP_APS_YVB_3022_C.DWG	Scale	1:100 @ A1
Drawn	T. HO	Checked	C. CHEUNG
Approved	F. LEUNG	Authorised Representative	F. HO
Date	24/FEB/23	Status	WORKING DRAWING

路政署 HIGHWAYS DEPARTMENT
主要工程管理處 MAJOR WORKS PROJECT MANAGEMENT OFFICE

FROM TUNNEL

FROM TUNNEL

FROM TUNNEL

POSITION 1
AMS (DUTY & STANDBY)

POSITION 1
AMS (DUTY & STANDBY)

ESP FILTER

ESP FILTER

ESP FILTER

DE-NO2 FILTER

DE-NO2 FILTER

DE-NO2 FILTER

POSITION 3
AMS (DUTY & STANDBY)

POSITION 3
AMS (DUTY & STANDBY)

TO ABOVE
TOP RR/F OF HVB

TO ABOVE
TOP RR/F OF HVB

Arch. Drawing No.	J3883/ARC/HVB/1103/A10
Str. Drawing No.	J3883/STR/HVB/1104/A

NOTES:

1. FOR NOTES, LEGEND AND CABLE SCHEDULE PLEASE REFER TO DRAWING NO. J3883/MEP/APS/GEN/0001 & 0002.
2. FOR DISTRIBUTION DETAIL, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/HVB/1203 & 1204.
3. FOR HV SWITCH ROOM PLANT ROOM DETAIL, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/HVB/3203 & 3204.
4. FOR FILTRATION ROOM PLANT ROOM DETAIL, PLEASE REFER TO DRAWING NO.J3883/MEP/APS/HVB/3303.
5. FOR CONTROL EQUIPMENT, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/HVB/3211.
6. FOR ELECTRICAL EQUIPMENT, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/HVB/3321.
7. FOR TASK VENTILATION DETAIL, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/GEN/4629.
8. FOR INSTALLATION DETAILS OF AMS FINAL DISCHARGE ,PLEASE REFER TO DRAWING NO. J3883/MEP/APS/GEN/4526.

E CHANNEL
E CHANNEL
E SEALED COVER
150MM DEPTH SURFACE CHANNEL WITH SS316 GRATING COVER

Rev.	Description	Date	Arch Rev.	Str Rev.
B	3RD SUBMISSION	27/02/2023	A83	/
A	2ND SUBMISSION	07/01/2023	A83	/
0	1ST SUBMISSION	15/11/2022	A8	/

Consultant

ARUP MOTT MACDONALD
MacDonald Joint Venture

Contractor

Gammon

Designer

CTA INTERNATIONAL AS CLEAN TUNNEL AIR
JEC

Project title

Contract No. HY/2019/13

Central Kowloon Route -
d Mechanical

M
EQUIPMENT LAYOUT BASEMENT 2 –
HO MAN TIN VENTILATION BUILDING
(SHEET 1 OF 2)

Drawing no.	J3883/MEP/APS/HVB/3041	Rev.	B
File name	J3883_MEP_APS_HVB_3041_B.DWG	Scale	1:100 @ A1
Drawn	T. HO	Checked	C.CHEUNG
Approved	F. LEUNG		
Authorised Representative	F. HO	Date	16/MAR/23
Status	WORKING DRAWING		

HIGHWAYS DEPARTMENT
主要工程管理處
MAJOR WORKS PROJECT MANAGEMENT OFFICE

TO ABOVE
UR/F OF KVB

FROM TUNNEL

ESP FILETER

DE-NO2 FILTER

POSITION 3
AMS (DUTY & STANDBY)

POSITION 1
AMS (DUTY & STANDBY)

POSITION 1
AMS (DUTY & STANDBY)

DE-NO2 FILTER

ESP FILETER

POSITION 1
AMS (DUTY & STANDBY)

FROM TUNNEL

FROM TUNNEL

ESP FILETER

DE-NO2 FILTER

REFER TO J3883/
MEP/APS/KVB/3022

REFER TO J3883/
MEP/APS/KVB/3022

E-STOP FOR ESP
KVB-APS3-ESP-ES07
WALL MOUNTED A.F.F.L 1500

E-STOP FOR ESP
KVB-APS3-ESP-ES08
WALL MOUNTED A.F.F.L 1500

E-STOP FOR ESP
KVB-APS1-ESP-ES03
WALL MOUNTED A.F.F.L 1500

ESP FRONT ROLLER SHUTTER
FROM T TO B:
KVB-APS3-FRS-01
KVB-APS3-FRS-02
KVB-APS3-FRS-03
KVB-APS3-FRS-04
KVB-APS3-FRS-05

ESP FILTER
T TO B:
APS3-ESP-01
KVB-APS3-ESP-02
KVB-APS3-ESP-03
KVB-APS3-ESP-04
KVB-APS3-ESP-05

MECHANICAL AFTER-FILTER
KVB-APS3-AF

AFTER FILTER REAR ROLLER SHUTTER
KVB-APS3-BRS-02
KVB-APS3-BRS-03
KVB-APS3-BRS-04

DIFFERENTIAL PRESSURE SENSOR
WALL MOUNTED A.F.F.L 1500
KVB-APS3-DPS

E-STOP FOR ESP
KVB-APS3-ESP-ES01
WALL MOUNTED A.F.F.L 1500

AIR MONITORING STATION
FROM T TO B
KVB-APS3-AMS-03
KVB-APS3-AMS-04

SENSING TUBE

DE-NO2 FILTER HORIZONTAL
BLANK OFF PLATE
KVB-APS3-CBHB

DE-NO2
KVB-APS

AIR MONITORING STATION
FROM L TO R
KVB-APS1-AMS-05
KVB-APS1-AMS-06

AMS PLINTHS

E-STOP FOR ESP
KVB-APS1-ESP-ES01
WALL MOUNTED A.F.F.L 1500

MECHANICAL PRE-FILTER
KVB-APS3-PF

SUMP PIT
HVB-APS3-SPT
(FOR SUMP PIT DETAIL PLEASE REFER TO DRAWING NO.:
J3883/MEP/APS/KVB/4313)

Ø150 FLOOR DRAIN

AIR MONITORING STATION
FROM T TO B
KVB-APS1-AMS-01
KVB-APS1-AMS-02

MCCB BOARD
KVB-DB-EPS03
B.L. +1100 A.F.F.L

LMCP FOR
SUMP PUMP
KVB-APS-LCP-SP
WALL MOUNTED
B.L +300 A.F.F.L

MCB BOARD
KVB-DB-APS03
B.L. +1100 A.F.F.L

ESP FILTER HOISTING
B.L. +6300 A.F.F.L
KVB-APS3-PEH-01

E-STOP FOR ESP
KVB-APS3-ESP-ES05
WALL MOUNTED A.F.F.L 1500

DE-NO2 FILTER VERTICAL
BLANK OFF PLATE
KVB-APS3-CBVB

E-STOP FOR ESP
KVB-APS3-ESP-ES03
WALL MOUNTED A.F.F.L 1500

E-STOP FOR ESP
KVB-APS2-ESP-ES04
WALL MOUNTED A.F.F.L 1500

DE-NO2 FILTER VERTICAL
BLANK OFF PLATE
KVB-APS2-CBVB

E-STOP FOR ESP
KVB-APS2-ESP-ES06
WALL MOUNTED A.F.F.L 1500

E-STOP FOR ESP
KVB-APS1-ESP-ES05
WALL MOUNTED A.F.F.L 1500

MECHANICAL AFTER-FILTER
KVB-APS1-AF

E-STOP FOR ESP
KVB-APS1-ESP-ES04
WALL MOUNTED A.F.F.L 1500

AMS PLINTHS

MECHANICAL AFTER-FILTER
KVB-APS2-AF

ESP FILTER HOISTING
B.L. +8320 A.F.F.L
KVB-APS2-PEH-01

E-STOP FOR ESP
KVB-APS2-ESP-ES01
WALL MOUNTED A.F.F.L 1500

AIR MONITORING STATION
FROM T TO B
KVB-APS2-AMS-04
KVB-APS2-AMS-03

DE-NO2 FILTER HORIZONTAL
BLANK OFF PLATE
KVB-APS2-CBHB

DE-NO2 FILTER
KVB-APS2-CB

ESP FRONT ROLLER SHUTTER
FROM T TO B:
KVB-APS2-FRS-01
KVB-APS2-FRS-02
KVB-APS2-FRS-03
KVB-APS2-FRS-04
KVB-APS2-FRS-05

ESP FILTER
FROM T TO B:
KVB-APS2-ESP-01
KVB-APS2-ESP-02
KVB-APS2-ESP-03
KVB-APS2-ESP-04
KVB-APS2-ESP-05

AFTER FILTER REAR ROLLER
KVB-APS2-BRS-01
KVB-APS2-BRS-02
KVB-APS2-BRS-03
KVB-APS2-BRS-04

E-STOP FOR ESP
KVB-APS2-ESP-ES08
WALL MOUNTED A.F.F.L 1500

DIFFERENTIAL PRESSURE SENSOR
WALL MOUNTED
B.L. +1500 A.F.F.L
KVB-APS2-DPS

SENSING TUBE

AIR MONITORING STATION
FROM T TO B
KVB-APS2-AMS-01
KVB-APS2-AMS-02

FROM T TO B:
ESP POWER SUPPLY CABINET
KVB-APS1-ESP-PSC-01
KVB-APS1-ESP-PSC-02

DE-NO2 FILTER
KVB-APS1-CB

DE-NO2 FILTER VERTICAL
BLANK OFF PLATE
KVB-APS1-CBVB

E-STOP FOR ESP
KVB-APS2-ESP-ES07
WALL MOUNTED A.F.F.L 1500

E-STOP FOR ESP
KVB-APS1-ESP-ES04
WALL MOUNTED A.F.F.L 1500

AIR MONITORING STATION
FROM L TO R
KVB-APS1-AMS-03
KVB-APS1-AMS-04

E-STOP FOR ESP
KVB-APS1-ESP-ES02
WALL MOUNTED A.F.F.L 1500

ESP FILTER REAR
ROLLER SHUTTER
FROM L TO R:
KVB-APS1-BRS-01
KVB-APS1-BRS-02
KVB-APS1-BRS-03
KVB-APS1-BRS-04

ESP FILTER HOISTING
B.L. +8320 A.F.F.L
KVB-APS1-PEH-01

ESP FILTER
FROM L TO R:
KVB-APS1-ESP-01
KVB-APS1-ESP-02
KVB-APS1-ESP-03
KVB-APS1-ESP-04
KVB-APS1-ESP-05

ESP FRONT ROLLER SHUTTER
FROM L TO R:
KVB-APS1-FRS-01
KVB-APS1-FRS-02
KVB-APS1-FRS-03

B.L. +1500 A.F.F.L
KVB-APS1-DPS

SENSING TUBE

MECHANICAL PRE-FILTER
KVB-APS1-PF

SUMP PIT
HVB-APS1-SPT
(FOR SUMP PIT DETAIL PLEASE REFER TO
J3883/MEP/APS/KVB/4311)

E-STOP FOR ESP
KVB-APS1-ESP-ES08
WALL MOUNTED A.F.F.L 1500

Ø150 FLOOR DRAIN

AIR MONITORING STATION
FROM L TO R
KVB-APS1-AMS-01
KVB-APS1-AMS-02

E-STOP FOR ESP
KVB-APS1-ESP-ES07
WALL MOUNTED A.F.F.L 1500

MCCB BOARD
KVB-DB-EPS01
B.L. +1100 A.F.F.L

MCB BOARD
KVB-DB-APS01
B.L. +1100 A.F.F.L

AMS PLINTHS

Ø150 FLOOR DRAIN

SUMP PIT
HVB-APS2-SPT
(FOR SUMP PIT DETAIL PLEASE REFER TO DRAWING NO.:
J3883/MEP/APS/KVB/4312)

FROM T TO B:
ESP POWER SUPPLY CABINET
KVB-APS1-ESP-PSC-01
KVB-APS1-ESP-PSC-02

AIR MONITORING STATION
FROM T TO B
KVB-APS2-AMS-01
KVB-APS2-AMS-02

NOTES:

1. FOR NOTES, LEGEND AND CABLE SCHEDULE PLEASE REFER TO DRAWING NO. J3883/MEP/APS/GEN/0001 & 0002.
2. FOR DISTRIBUTION DETAIL, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/KVB/1203 & 1204.
3. FOR HV SWITCH ROOM PLANT ROOM DETAIL, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/KVB/3203 & 3204.
4. FOR FILTRATION ROOM PLANT ROOM DETAIL, PLEASE REFER TO DRAWING NO.J3883/MEP/APS/KVB/3303.
5. FOR CONTROL EQUIPMENT, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/KVB/3211.
6. FOR ELECTRICAL EQUIPMENT, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/KVB/3321.
7. FOR TASK VENTILATION DETAIL, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/GEN/4629.
8. FOR INSTALLATION DETAILS OF AMS FINAL DISCHARGE ,PLEASE REFER TO DRAWING NO. J3883/MEP/APS/GEN/4526.

150MM DEPTH SURFACE CHANNEL
150MM DEPTH SURFACE CHANNEL WITH SS316 REMOVABLE SEALED COVER
150MM DEPTH SURFACE CHANNEL WITH SS316 GRATING COVER

Arch. Drawing No.	J3883/ARC/KVB/1101/A8
Str. Drawing No.	J3883/STR/KVB/1102/A

Rev.	Description	Date	Arch Rev.	Str Rev.
B	3RD SUBMISSION	21/02/2023	A6	/
A	2ND SUBMISSION	07/01/2023	A6	/
0	1ST SUBMISSION	10/10/2022	A6	/

Consultant
ARUP
MOTT MACDONALD
Arup-Mott MacDonald Joint Venture

Contractor
Gammon
CTA INTERNATIONAL AS CLEAN TUNNEL AIR
JEC

Designer

Project title
Contract No. HY/2019/13
Central Kowloon Route - Buildings, Electrical and Mechanical

Drawing title
AIR PURIFICATION SYSTEM – EQUIPMENT LAYOUT BASEMENT 2 – KAI TAK VENTILATION BUILDING (SHEET 1 OF 2)

Drawing no.	J3883/MEP/APS/KVB/3021	Rev.	B
File name	J3883_MEP_APS_KVB_3021_B.DWG	Scale	1:100 @ A1
Drawn	T. HO	Checked	C. CHEUNG
Approved	F. LEUNG	Authorised Representative	F. HO
Date	16/MAR/23	Status	WORKING DRAWING

路政署
HIGHWAYS DEPARTMENT
主要工程管理處
MAJOR WORKS PROJECT MANAGEMENT OFFICE

DE-NO2 FILTER

TO ABOVE
UR/F OF KVB

POSITION 3
AMS (DUTY & STANDBY)

POSITION 3
AMS (DUTY & STANDBY)

TO ABOVE
UR/F OF KVB

DE-NO2 FILTER

MECHANICAL AFTER-FILTER
KVB-APS3-AF

AFTER FILTER REAR ROLLER SHUTTER
FROM T TO B:
KVB-APS3-BRS-01
KVB-APS3-BRS-02
KVB-APS3-BRS-03
KVB-APS3-BRS-04

E-STOP FOR ESP
KVB-APS3-ESP-ES01
WALL MOUNTED A.F.F.L 1500

AIR MONITORING STATION
FROM T TO B
KVB-APS3-AMS-03
KVB-APS3-AMS-04

DE-NO2 FILTER HORIZONTAL
BLANK OFF PLATE
KVB-APS3-CBHB

DE-NO2 FILTER
KVB-APS3-CB

E-STOP FOR ESP
KVB-APS3-ESP-ES02
WALL MOUNTED A.F.F.L 1500

DE-NO2 FILTER HOISTING
B.L. +13490 A.F.F.L
KVB-APS3-PCH-01

AIR MONITORING STATION
FROM T TO B
KVB-APS3-AMS-05
KVB-APS3-AMS-06

AMS PLINTHS

LMCP FOR CLEAN WATER PUMP
KVB-APS-LCP-CWP
FLOOR MOUNTED

PLEASE REFER TO ESP FILTRATION ROOM PLANT ROOM DETAIL DRAWING NO.:
J3883/MEP/APS/KVB/3303

E-STOP FOR ESP
KVB-APS3-ESP-ES04
WALL MOUNTED A.F.F.L 1500

E-STOP FOR ESP
KVB-APS2-ESP-ES03
WALL MOUNTED A.F.F.L 1500

LMCP FOR DETERGENT PUMP
KVB-APS-LCP-DP
WALL MOUNTED B.L A.F.F.L 300

DE-NO2 FILTER VERTICAL BLANK OFF PLATE
KVB-APS3-CBVB

DE-NO2 FILTER VERTICAL BLANK OFF PLATE
KVB-APS2-CBVB

E-STOP FOR ESP
KVB-APS3-ESP-ES03
WALL MOUNTED A.F.F.L 1500

AIR MONITORING STATION
FROM T TO B
KVB-APS2-AMS-04
KVB-APS2-AMS-03

E-STOP FOR ESP
KVB-APS2-ESP-ES01
WALL MOUNTED A.F.F.L 1500

AFTER FILTER REAR ROLLER SHUTTER
FROM B TO T:
KVB-APS2-BRS-01
KVB-APS2-BRS-02
KVB-APS2-BRS-03
KVB-APS2-BRS-04

REFER TO J3883/MEP/APS/KVB/3021

REFER TO J3883/MEP/APS/KVB/3021

Arch. Drawing No.	J3883/ARC/KVB/1101/A8
Str. Drawing No.	J3883/STR/KVB/1102/A

NOTES:

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2. FOR DISTRIBUTION DETAIL, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/KVB/1203 & 1204.
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5. FOR CONTROL EQUIPMENT, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/KVB/3211.
6. FOR ELECTRICAL EQUIPMENT, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/KVB/3321.
7. FOR TASK VENTILATION DETAIL, PLEASE REFER TO DRAWING NO. J3883/MEP/APS/GEN/4629.
8. FOR INSTALLATION DETAILS OF AMS FINAL DISCHARGE ,PLEASE REFER TO DRAWING NO. J3883/MEP/APS/GEN/4526.

150MM DEPTH SURFACE CHANNEL
150MM DEPTH SURFACE CHANNEL WITH SS316 REMOVABLE SEALED COVER
150MM DEPTH SURFACE CHANNEL WITH SS316 GRATING COVER

Rev.	Description	Date	Arch Rev.	Str Rev.
B	3RD SUBMISSION	21/02/2023	A6	/
A	2ND SUBMISSION	07/01/2023	A6	/
0	1ST SUBMISSION	10/10/2022	A6	/

Consultant
ARUP M MOTT MACDONALD M
Arup-Mott MacDonald Joint Venture

Contractor
Gammon

Designer
CTA INTERNATIONAL AS CLEAN TUNNEL AIR
JEC

Project title
Contract No. HY/2019/13
Central Kowloon Route - Buildings, Electrical and Mechanical

Drawing title
AIR PURIFICATION SYSTEM – EQUIPMENT LAYOUT BASEMENT 2 – KAI TAK VENTILATION BUILDING (SHEET 2 OF 2)

Drawing no.	J3883/MEP/APS/KVB/3022
Rev.	B
File name	J3883_MEP_APS_KVB_3022_B.DWG
Scale	1:100 @ A1
Drawn	T. HO
Checked	C. CHEUNG
Approved	F. LEUNG
Authorised Representative	F. HO
Date	16/MAR/23
Status	WORKING DRAWING

路政署 HIGHWAYS DEPARTMENT
主要工程管理處 MAJOR WORKS PROJECT MANAGEMENT OFFICE

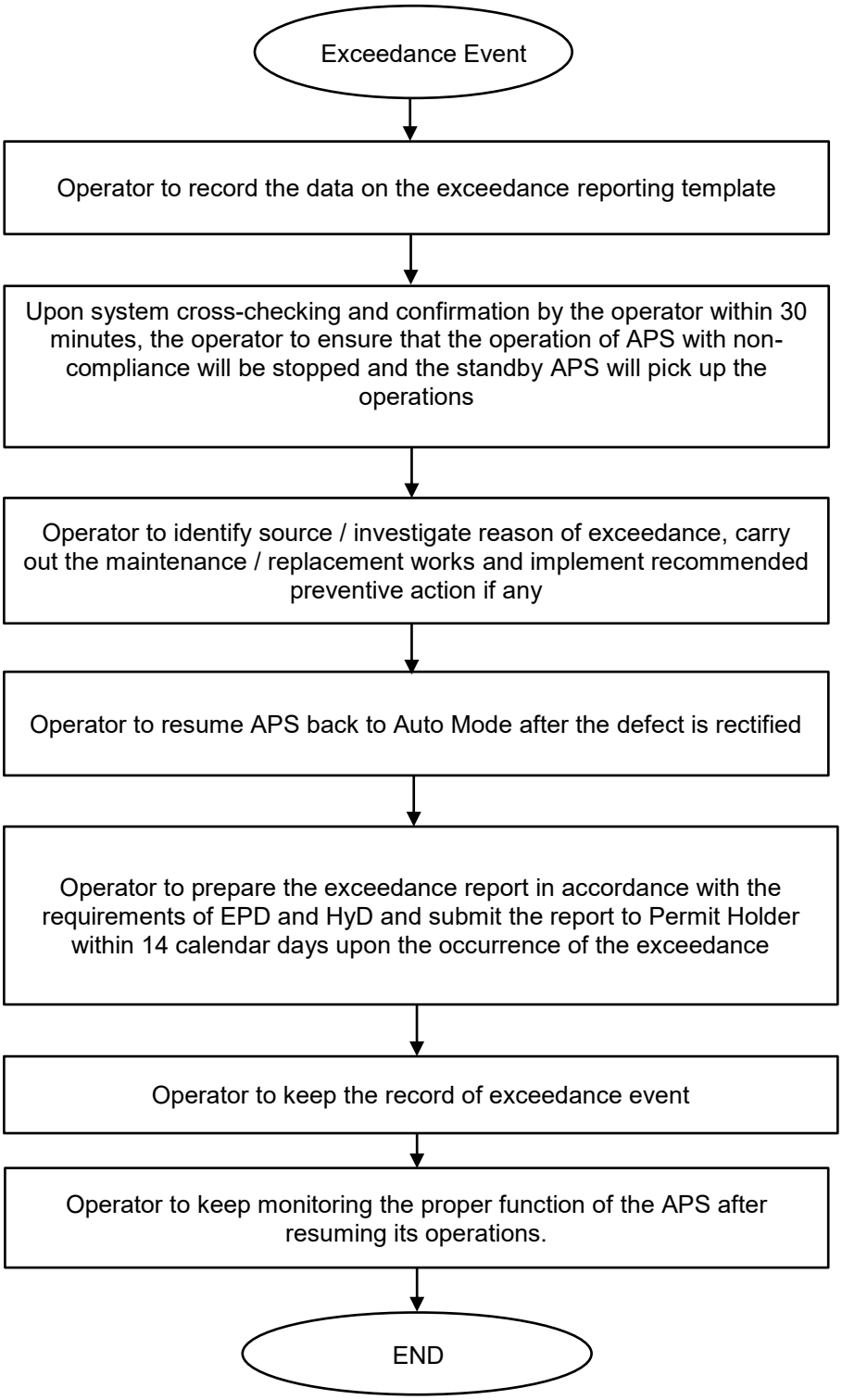
Appendix 3:

Event-Action Plan and Data Record Sheet

Event-Action Plan

Event	Action	
	Operator	**Permit Holder**
Limit Level		
Exceedance of the PM10 or NO2 criteria listed in Section 5.2	1. If the exceedance occurs, Operator record the data on the exceedance reporting template; 2. Upon system cross-checking and confirmation by the operator within 30 minutes, the operator to ensure that the operation of APS with non-compliance will be stopped and the standby APS will pick up the operation; 3.Operator to identify source / investigate reason of exceedance, carry out the maintenance / replacement works and implement recommended preventive action if any; 4. Operator to resume APS back to Auto Mode after the defect is rectified; 5. Operator to prepare the exceedance report in accordance with the requirements of EPD and HyD and submit the report to Permit Holder within 14 calendar days upon the occurrence of the exceedance *Note 5; 6. Operator to keep the record of exceedance event; and 7. Operator to keep monitoring the proper function of the APS after resuming its operations. * Remarks: Note 5: Environmental Team (ET) and the Independent Environmental Checker (IEC) should vet the exceedance report during the initial operation period (at least 1 year after CKR tunnel is opened), which should be terminated subject to agreement with EPD.	1. Submit the exceedance report to the Director of Environmental Protection, within 14 calendar days upon the occurrence of the exceedance.

EVENT-ACTION PLAN FOR THE EXCEEDANCE EVENT



Data Record Sheet for NO_2 and PM_{10} Monitoring

Monitoring Location		
Details of Location		
Date & Time of Sampling		
Elapsed-time	Start (min.)	
	Stop (min.)	
Total Sampling Time (min.)		
Measured NO_2/PM_{10} level (ppm)		
Remarks/Other Observations		

	Name & Designation	Signature	Date
Field Operator:			
Reviewed by:			
Checked by:			

Appendix 4:

Exceedance Reporting Template

Exceedance Reporting Template

NO_2

Date: _____ **Time:** _____

Location[1]: KVB / HVB / YVB **Station ID:** _____

	5-minute-interval-average Inlet concentration (ppm)			5-minute-interval-average Outlet concentration (ppm)			Removal efficiency (%)			Exceedance Level [1, 2]	Non-compliance [1, 3]	Follow up Action
1 Hour	5 min	10 min	15 min	5 min	10 min	15 min	5 min	10 min	15 min	Removal efficiency of less than 80% / outlet concentration greater than 0.05ppm	Yes / No	Possible reason
												Action to be taken
	20 min	25 min	30 min	20 min	25 min	30 min	20 min	25 min	30 min			
												Remarks

1 delete as appropriate

2 When inlet NO2 concentration equal to or greater than 0.25ppm, not less than 80% of NO2 shall be removed; when inlet NO2 concentration is lower than 0.25ppm, the outlet concentration shall not be greater than 0.05ppm.

3 Non-compliance occurs when there are exceedances of NO2 removal efficiency (%) non attainment in any pairs of the monitoring stations' reading at ventilation building.

Exceedance Reporting Template

PM_{10}

Date: _____ Time: _____

Location[1]: KVB / HVB / YVB Station ID: _____

	5-minute-interval-average Inlet concentration (mg/m^3)			5-minute-interval-average Outlet concentration (mg/m^3)			Removal efficiency (%)			Exceedance Level [1, 2]	Non-compliance [1, 3]	Follow up Action
1 Hour	5 min	10 min	15 min	5 min	10 min	15 min	5 min	10 min	15 min	Removal efficiency of less than 80% / outlet concentration greater than 0.1 mg/m^3	Yes / No	Possible reason
												Action to be taken
	20 min	25 min	30 min	20 min	25 min	30 min	20 min	25 min	30 min			
												Remarks

1 delete as appropriate

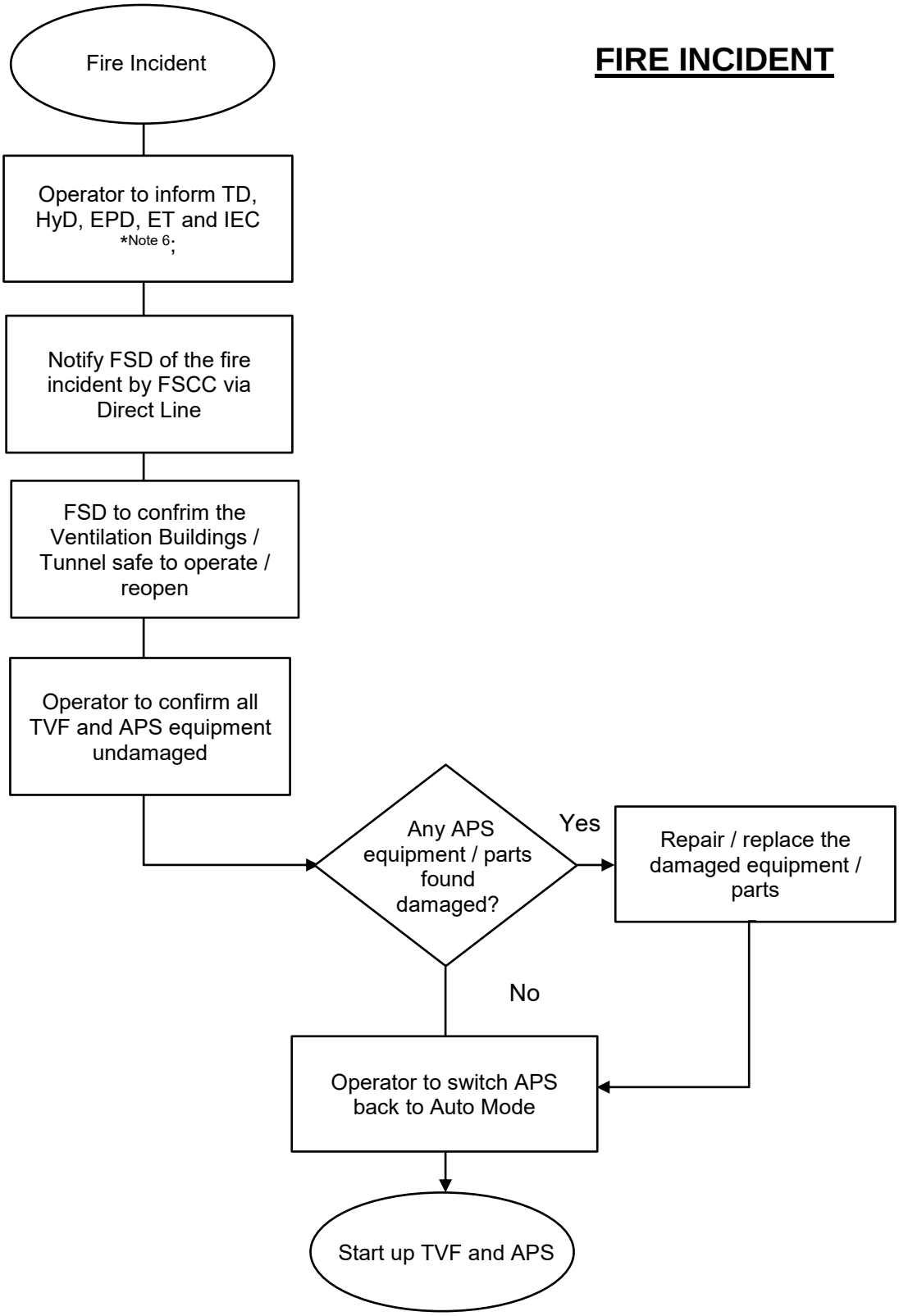
2 When inlet PM10 concentration equal to or greater than 0.5 mg/m3, not less than 80% of PM10 shall be removed; when inlet PM10 concentration is lower than 0.5 mg/m3, the outlet concentration shall not be greater than 0.1 mg/m3.

3 Non-compliance occurs when there are exceedances of PM10 removal efficiency (%) non attainment in any pairs of the monitoring stations' reading at ventilation building.

Appendix 5:

Emergency Flowchart for Fire Incident

FIRE INCIDENT

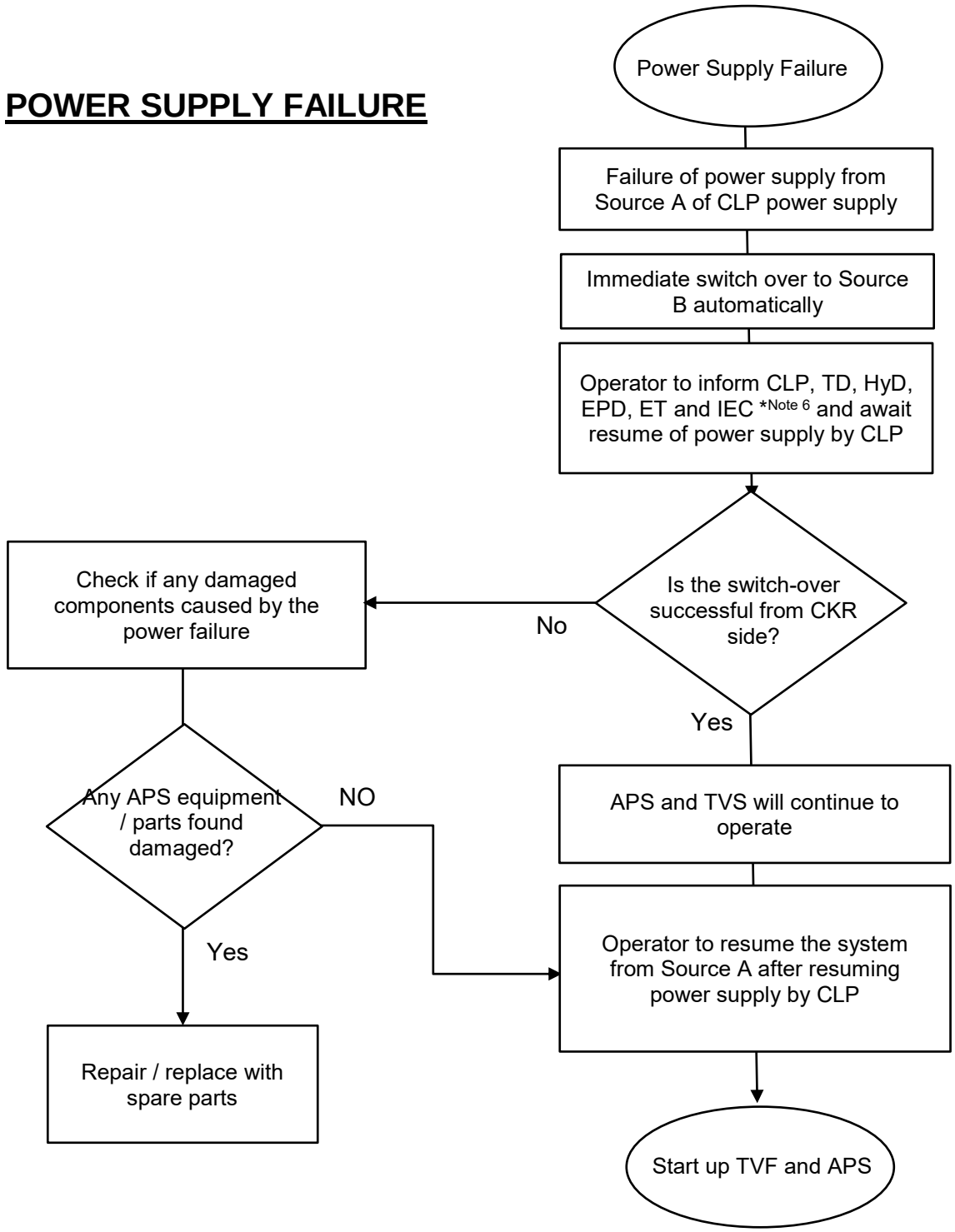


Note 6: Environmental Team (ET) and the Independent Environmental Checker (IEC) will involve during the initial operation period (at least 1 year after CKR tunnel is opened), which should be terminated subject to agreement with EPD.

Appendix 6:

Emergency Flowchart for Power Supply Failure

POWER SUPPLY FAILURE

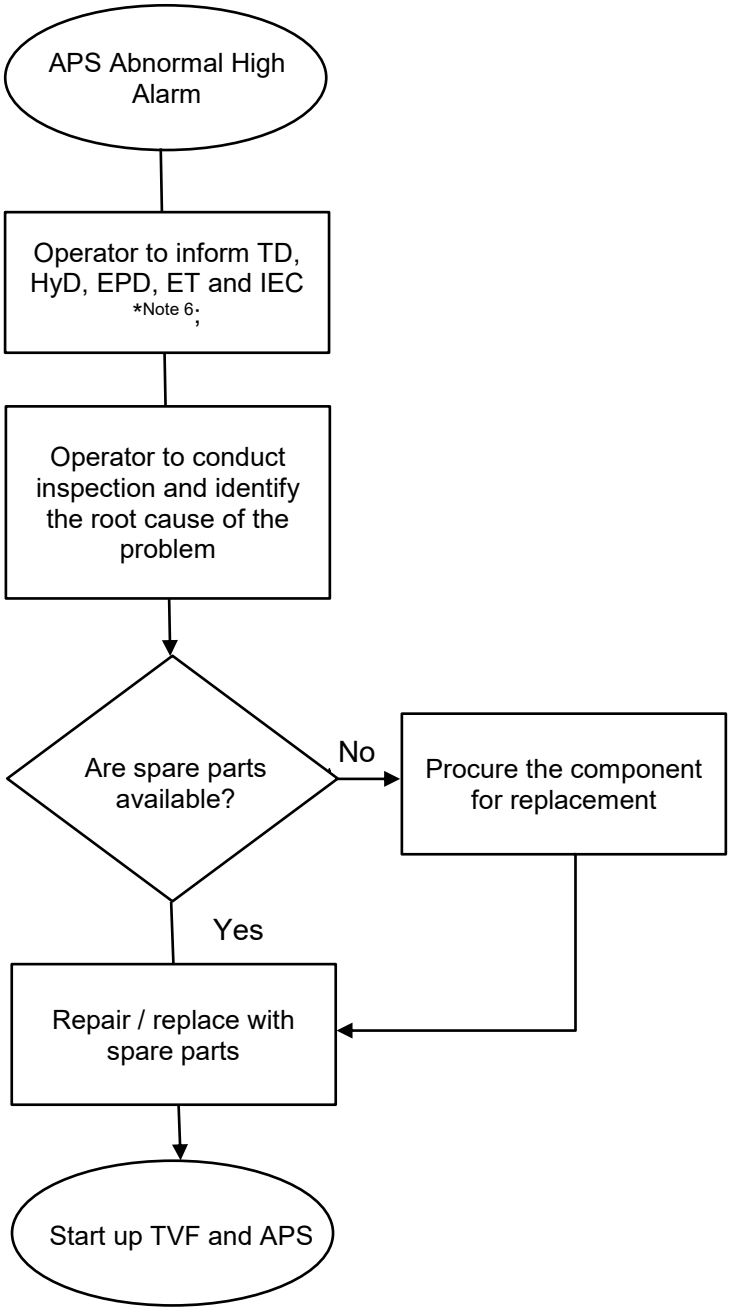


Note 6: Environmental Team (ET) and the Independent Environmental Checker (IEC) will involve during the initial operation period (at least 1 year after CKR tunnel is opened), which should be terminated subject to agreement with EPD.

Appendix 7:

Emergency Flowchart for APS Abnormal High Alarm

APS Abnormal High Alarm

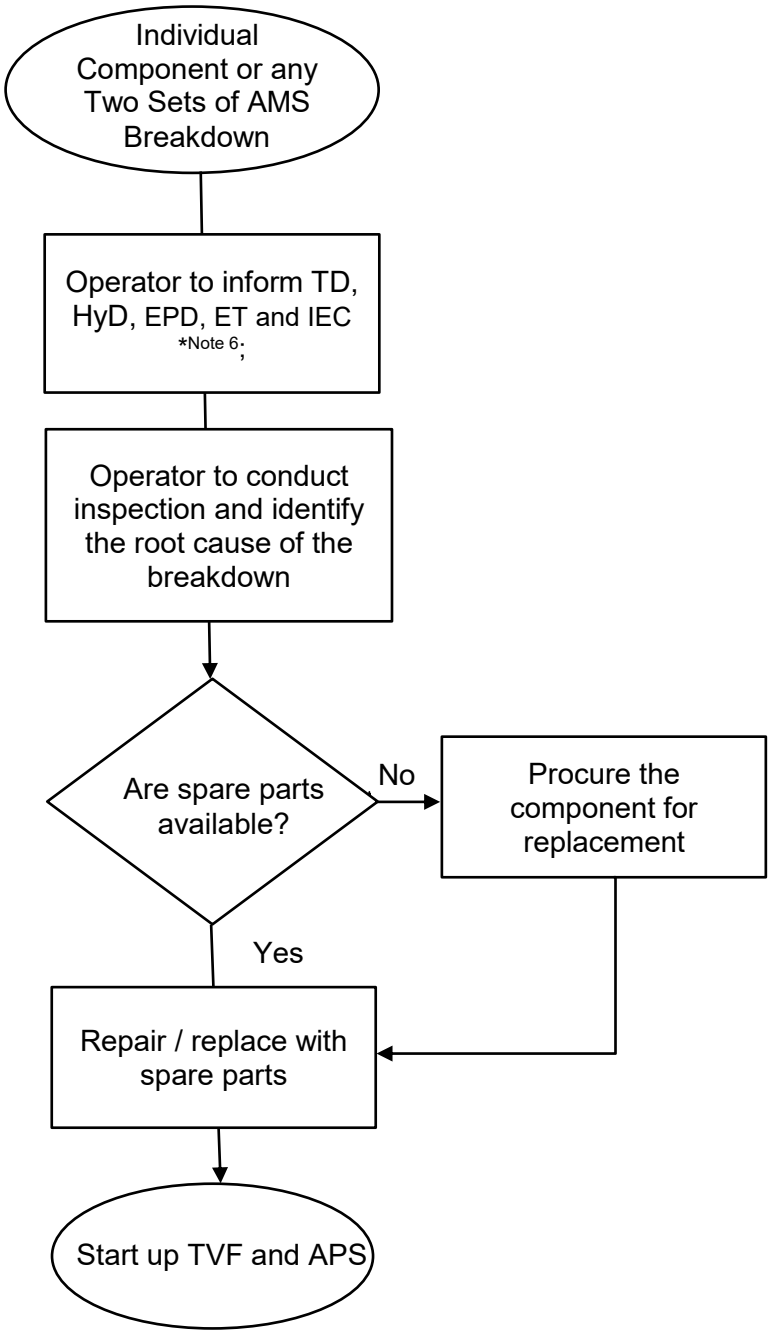


Note 6: Environmental Team (ET) and the Independent Environmental Checker (IEC) will involve during the initial operation period (at least 1 year after CKR tunnel is opened), which should be terminated subject to agreement with EPD.

Appendix 8:

Emergency Flowchart for Breakdown of Equipment or any Two sets of the AMS in the same location within APS Plenum

Breakdown of Equipment or any Two sets of the AMS in the same location within APS Plenum



Note 6: Environmental Team (ET) and the Independent Environmental Checker (IEC) will involve during the initial operation period (at least 1 year after CKR tunnel is opened), which should be terminated subject to agreement with EPD.

Appendix 9:

APS Operation Procedures

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CENTRAL KOWLOON ROUTE

Air Purification System (APS)
Operation Procedures

R0	1st draft
R1	
R2	

Prepared by: _____ Date : _____

Position:

Approved by: _____ Date : _____

Position:

Table of Content

1. APS OPERATIONS

1.1. Operations Overview

This document contains the procedures that must be implemented by the Operator to enable operation of the Mechanical and Electrical Equipment for the Air Purification System (APS).

1.2. Operation Procedures

Operation Procedures will provide the Operator with instructions to operate the equipment in accordance with the design intent. For the detailed information, please refer to updated APS Operation and Maintenance (O&M) Manual.

1.3. Operational Staff Roles and Responsibilities

The specific roles and responsibilities of operational staff are summarised in the following table:

Table 1: Operational Staff Roles & Responsibilities

Staff Personnel Description	Role	Responsibility
Traffic Control Room Supervisor	Overall management of the day-to-day operations, staff, assets and resources.	• Keep the tunnel open and running smoothly Sufficient experienced staff, assets and resources
Traffic Control Room Operator	Operation of the CCMS, monitoring actions, reporting alarms, faults and emergencies	• Tunnel is open and running efficiently that all systems are monitored and all faults, alarms and emergencies are correctly actioned
APS Operator	Operation of the remote APS	• Keep APS operate under normal and high volume traffic flow. • Attend and report all faults, alarm and emergency
APS Maintenance	Personnel To undertake schedule and routine plant maintenance, attend essential and emergency repairs	• Keep APS under operational condition and ready to operate when required

2. OPERATION PROCEDURES

The following section lists the procedures that will provide guidance for the operation of the Electrical and Mechanical Equipment for the APS.

2.1. Listing of Operating Procedures

Table 2: Operating Procedures

System	Assets Items	Procedure
ESP Filter	ESP filter Operation Procedures	Please refer to updated APS O&M Manual
Wash Down System	Automatic Wash down and air drying for ESP Filter Operating Procedure	Please refer to updated APS O&M Manual
	Automatic Wash down and air drying for Pre-Filter Operating Procedure	Please refer to updated APS O&M Manual
	Sump Pump System Operating Procedure	Please refer to updated APS O&M Manual
	Water Recycling System Operating Procedure	Please refer to updated APS O&M Manual
	Wash down System Operating Procedure	Please refer to updated APS O&M Manual
	Pneumatic System Operating Procedure	Please refer to updated APS O&M Manual
	Front/Rear Roller Shutter Operating Procedure	Please refer to updated APS O&M Manual
De-NO2 Filter	Activated Carbon	Please refer to updated APS O&M Manual
Air Monitoring Station	Air Monitoring System (AMS) Operating Procedure	Please refer to updated APS O&M Manual
LV Electrical System	Electrical Distribution System Operating Procedure	Please refer to updated APS O&M Manual
HV Electrical System	ESP HV Power Supply Units Operating Procedures	Please refer to updated APS O&M Manual
APS Control System	ASP Control System Operating Procedures	Please refer to updated APS O&M Manual

2.2. Operating Systems Failure /Degradation

This section outlines possible operator responses to deal with a system failure or degradation. Responses are to be initiated by reference to the guidelines in the Failure Type Matrix under APS Operator discretion.

- At all times safety of users comes first, containment of the impacts of the failure second, protection of the APS asset third, and re-establishment of normal operating conditions fourth.

- Record the nature and location of the incident; recall source, and other relevant information using an Incident Log. Advise the Maintenance Team, CKR CCMS Management of failure.

- If incident is not verified as a failure or degradation, return to previous operating state after checking for control of the system.

- Refer to Table 3 Failure Type Matrix to assess impact of the failure on operation of the APS and/or the control of the equipment. Note that the matrix contains guidelines only as it addresses single failure of each element of the APS. It does not consider failure of all combinations of equipment types. The actual response in each case will be at the discretion of the Operator in conjunction with CKR CCMS Management, EMSD and Highways Department.

- Always ensure that the operator has total control of the system. Advice the Maintenance Team of any alarms or loss of control identified.

- If the systems are operating in a degraded state, advise Maintenance Team, CKR CCMS Management and EMSD of failures and ensure that they are kept up to date.

Unsafe to Operate

- If CKR CCMS has lost control of APS systems or it is unsafe to continue operation of the APS, shutdown the APS using the appropriate emergency stop facilities, contact CKR CCMS Management, Maintenance Team, EMSD and Highways Department immediately.

- Dispatch appropriate resources as required.

Repair Works

- Perform repair work completely or up to a point such that APS management responses are not required, or system fall back arrangements are no longer required.
- Confirm that it is safe to re-introduce APS to operation.
- Return all systems to the pre-incident state or normal state as appropriate.
- Log incident in the incident database.
- Conduct de-brief with EMSD, agencies and subcontractors if requested.

The following is a Matrix of critical equipment failure mode and response required. Most of the following scenarios will generate various critical/warning system alarms and should be read in conjunction with the Alarms created by the APS PLC.

Table 3: Critical Equipment Failure Matrix and Response *

Item	APS equipment	Event	Communication	Alarm	APS's action	TVS's action
1	Washdown system interlock	Dirty water tanks high water level	• APS PLC to pump control panel	High level Alarm	• Stop sump pump operation	• No action
2		Dirty water tanks low water level	• APS PLC to pump control panel	Low level Alarm	• Stop water recycling system	• No action
3		Clean water tanks high water level	• APS PLC to pump control panel	High level alarm	• Stop dirty water feed pump	• No action
4		Clean water tanks low water level.	• APS PLC to pump control panel	Low level alarm	• Wash cycle not available	• No action
5		Main washdown/air drying valve fault	• APS PLC to pump control panel	Main valve fault alarm	• Wash down sequence aborted.	• No action
6		Branch washdown/air drying valve fault	• APS PLC to pump control panel	Branch valve fault alarm	• Wash down sequence continue with error	• No action
7		Washdown system switched to local manual mode	• APS PLC to CCMS	Washdown system local manual alarm	• APS not ready	• TVS stop •
8		Sump pit high water level	• APS PLC to pump control panel	Sump pit high level alarm	• Wash cycle not available	• No action
9		Sump pump malfunctions	• APS PLC to pump control panel	Duty pump fault alarm	• Switch to standby sump pump	• No action
10		Low pressure pump malfunctions	• APS PLC to pump control panel	Duty pump fault alarm	• Switch to standby low pressure pump	• No action
11		High pressure pump malfunctions	• APS PLC to pump control panel	Duty pump fault alarm	• Switch to standby high pressure pump	• No action
12		Detergent pump malfunctions	• APS PLC to pump control panel	Duty pump fault alarm	• Switch to standby detergent pump	• No action
13	Air compressor system interlock	Air compressor malfunctions	• APS PLC to air compressor	Duty air compressor fault alarm	• Switch to standby air compressor	• No action
14		Air dryer malfunctions	• APS PLC to air dryer	Air dryer fault alarm	• No action	• No action

Table 3: Critical Equipment Failure Matrix and Response (Cont'd) *

Item	APS equipment	Event	Communication	Alarm	APS's action	TVS's action
15	ESP filter interlock	ESP cell fault	• APS PLC to CCMS	ESP column 'X' fault	• Relevant ESP front roller shutter close, APS on (when conditions allow) • APS switch off (airflow rate has exceeded the remaining ESP face area) • APS standby with condition	• TVS stop • CCMS select the standby TVS/APS to operate
16		ESP sub-assembly roller shutter failed to open	• APS PLC to CCMS	Sub-assembly screen failed to open	• APS switch off (airflow rate has exceeded the remaining ESP face area) • APS standby with condition	• TVS cannot start • CCMS select the standby TVS/APS to operate
17		ESP sub-assembly roller shutter Alarm and failed to close	• APS PLC to CCMS	Sub-assembly screen failed to close	• APS not ready	• TVS cannot start • CCMS select the standby TVS/APS to operate
18		Emergency stop pressed	• APS PLC to CCMS	Emergency stop alarm	• APS not ready	• TVS cannot start • CCMS select the standby TVS/APS to operate
19	After-filter rear roller shutters system interlock	After-filter rear roller shutters failed to open	• APS PLC to CCMS	After-filter rear roller shutters failed to open alarm	• APS off • APS not ready	• TVS cannot start • CCMS select the standby TVS/APS to operate
20		After-filter rear roller shutters failed to close	• APS PLC to CCMS	After-filter rear roller shutters failed to close alarm	• Washdown sequence abort • Washdown not ready	• No action
21	AMS interlock	Ozone higher than the pre-set value	• APS PLC to door lock system	Ozone abnormal high alarm	• ESP access doors locked	• No action

Table 3: Critical Equipment Failure Matrix and Response (Cont'd) *

Item	APS equipment	Event	Communication	Alarm	APS's action	TVS's action
22		AMS detected PM10 value higher than the pre-set value	• APS PLC to CCMS	PM10 abnormal high alarm	• APS off • APS not ready	• TVS stop • CCMS select the standby TVS/APS to operate
23		AMS detected NO2 value higher than the pre-set value	• APS PLC to CCMS	NO2 abnormal high alarm	• APS off • APS not ready	• TVS stop • CCMS select the standby TVS/APS to operate
24		AMS detected temperature higher than the pre-set value	• APS PLC to CCMS	Temperature abnormal high alarm	• APS off • APS not ready	• TVS stop • CCMS select the standby TVS/APS to operate
25		AMS detected pressure drop higher than the pre-set value	• APS PLC to CCMS	Pressure abnormal high alarm	• APS off • APS not ready	• TVS stop • CCMS select the standby TVS/APS to operate
26		ESP/De-NO2 efficiency drops below 80% (complying requirement in PS37.02)	• APS PLC to CCMS	Low removal efficiency alarm	• No action. • Operator shall follow the procedures in the approved APS Performance Monitoring and Contingency Plan to take actions	• No action.
27	Access control interlock	APS plenum door opened	• APS PLC to CCMS	APS plenum door opened alarm	• APS off • APS not ready	• TVS cannot start
28	Water recycling system interlock	Dirty water feed pump failure	• PLC of the water recycling system to APS PLC • APS PLC to CCMS	Water recycling system common fault alarm	• No action	• No action
29		Back wash pump failure	• PLC of the water recycling system to APS PLC • APS PLC to CCMS	Water recycling system common fault alarm	• No action	• No action

Table 3: Critical Equipment Failure Matrix and Response (Cont'd) *

Item	APS equipment	Event	Communication	Alarm	APS's action	TVS's action
30	Incoming power interlock	APS feed power failure longer than 10 seconds	• APS PLC to CCMS	APS power outage alarm	• APS not ready	• TVS stop • CCMS select the standby TVS/APS to operate
31		APS feed power failure but resumed with 10 (adjustable) seconds	• APS PLC to CCMS	APS power outage alarm	• Resume ESP power supply	• No action
32	Fire alarm interlock	Fire alarm in APS plenum detected (from CCMS)	• APS PLC to CCMS	APS plenum fire alarm	• APS not ready	• TVS stop • CCMS select the standby TVS/APS to operate
33		Fire alarm tunnel detected (from CCMS)	• APS PLC to CCMS	APS emergency alarm	• APS off	• TVS emergency operation
34	APS local control	APS switched to local manual mode	• APS PLC to CCMS	APS local alarm	• APS off	• TVS stop • CCMS select the standby TVS/APS to operate

* Please refer to updated APS O&M Manual on detailed Critical Equipment Failure Matrix and Response

3. APS OPERATION OVERVIEW

The Air Purification System will normally be controlled under CCMS automatically without tunnel operator input. In order to have automatic control by CCMS, the selection switch of all corresponding LMCPs should be in the remote control condition, also the APS touch panels are required to be under remote control condition.

For manual control at CCMS, which mean override CCMS automatic control, operators are required to switch the individual equipment from “Auto” to “Manual”. According to priority of control, the selection switch of corresponding LMCPs is also required in remote control condition, and the APS touch panels are required to be under remote control condition.

All APS Touch Panel will be in the same control level, first-in-first serve based, means only one control panel can be used once the first touch panel requested local mode. Other panels will be unable to take control right.

The LMCPs will have the highest priority of control. Any operation of such equipment can be controlled by setting the selection switch to “local” control mode and then be controlled manually by the operator, equipment under local mode cannot be controlled by CCMS nor APS Touch Panel anymore, whatever the equipment is under Auto or Manual under CCMS or APS control. Emergency Stop push button of local manual override switch will be provided for each motor unit, which override all other levels of control. This signal will be sent back to CCMS to notify tunnel operator.

Level of control in descending order of priority

Priority	Source	Location
Highest	LMCPs	APS Plenum / APS Filtration / ESP HV Switch Room
↓	APS Touch Panel	APS Main Control Panel in ESP HV Switch Room 1
		APS Remote Input/ Output Panel in ESP HV Switch Room 2
Lowest		CCMS Operation Panel in CCMS Control Room
	CCMS Workstation	ADB 2/F Control Room

Table 3: System Control Priority

The highest level of control has the highest priority, that is individual motor start / stop control and valve open / close control at LMCP have the highest priority (i.e. can override control from touch panel). Similarly, this priority of control also applies to other equipment under APS (e.g. Roller shutters, Air compressors, etc.)

Please refer to updated APS O&M Manual on detailed APS Control Flowchart.

3.1. APS Normal Operation

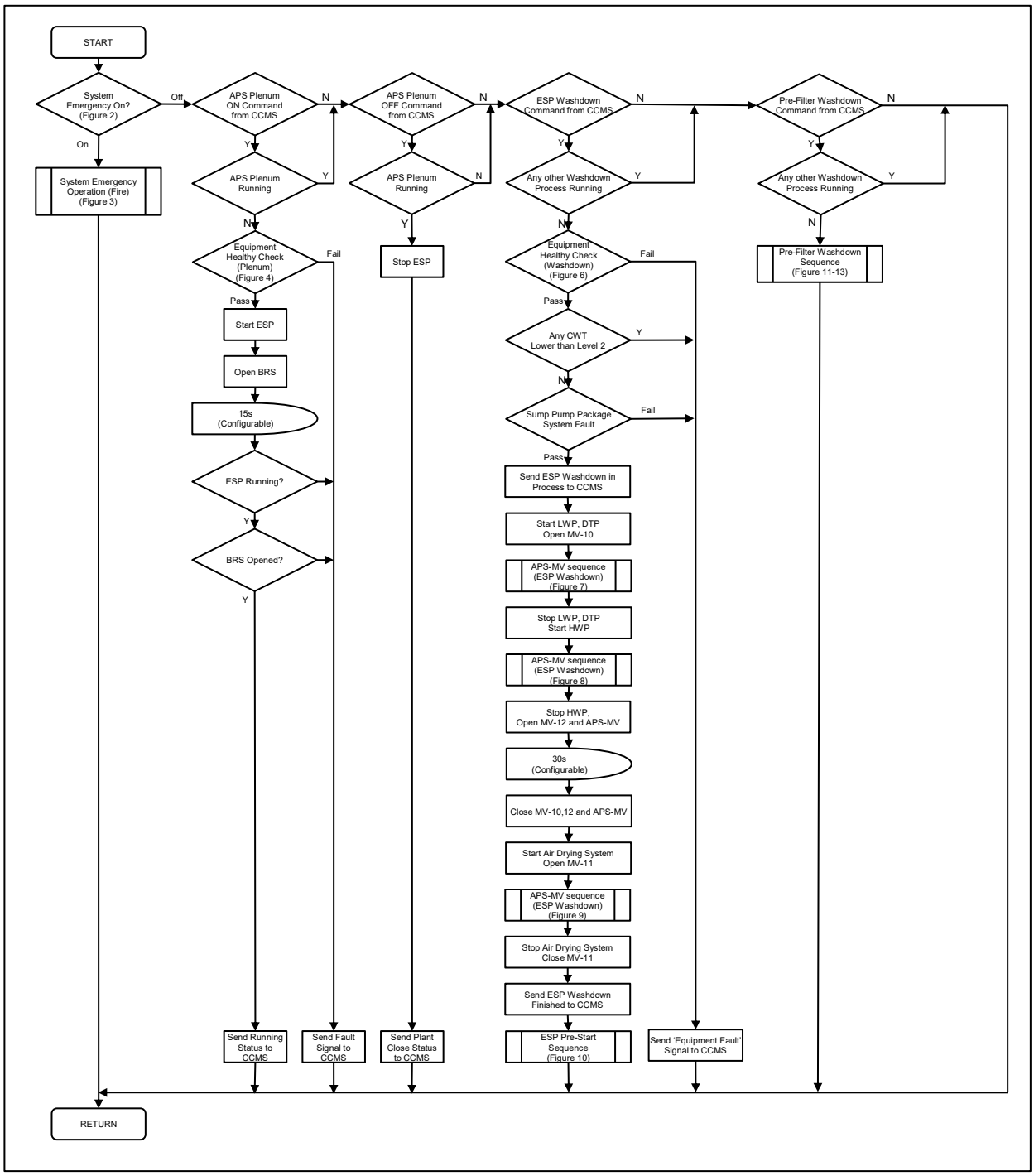

Figure 1 : Normal Operation Mode Control Logic

Normal Operation Mode Control Logic

- The system safety check always run.
- If the Emergency Mode is On, APS will switch to Emergency Operation.
- If the Emergency Mode is Off, the APS program check if there is ON Control Command from CCMS.
- If ON control exists, system healthy check of the APS Plenum will be carried out.
- If the system healthy check passed, PSU supplying for the ESP of the APS Plenum will be commanded ON and BRS of the APS Plenum will be commanded open.
- After a configurable delay (default 15s), the current status of the ESP and BRS will be checked. If any the PSU supplying the ESP is running and all BRS are fully opened, Running Status of the APS Plenum will be sent to CCMS.
- If either the system healthy check failed, or none of the PSU supplying the ESP is not in operation after the configurable delay, or any BRS are not fully opened after the configurable delay, fault signal will be sent to CCMS.
- If there is no ON control of any APS Plenum from CCMS, the program will check if there is OFF control Command from CCMS.
- If OFF control exists, after a configurable delay (default 15s), all PSU suppling the ESP will be command stop and Plant Close status of the APS Plenum will be sent to CCMS.
- If there is no OFF control of any APS Plenum from CCMS, the program will check if there is start control of ESP washdown sequence of any APS Plenum.
- If start control of ESP washdown sequence exist, the washdown equipment healthy check will be carried out.
- If the ESP washdown equipment healthy check passed, and All CWT higher than level 2, the sump pit equipment healthy check will be carried out.
- If the sump pit equipment healthy check passed, the ESP washdown sequence will be carried out, and ESP washdown in process status will be sent to CCMS.
- First the clean water pump (low pressure) and detergent pump will be started, and the MV-10 will be opened. Then the MV to each ESP sub-assembly will be opened in sequential to apply detergent to each ESP sub-assembly, after each ESP sub-assembly is washed, clean water pump (low pressure) and detergent pump will be stopped.
- Then the clean water pump (high pressure) will be started, and the APS-MV to each ESP sub-assembly will be opened in sequential to rinse each ESP sub-assembly, after each ESP sub-assembly is rinsed, clean water pump (high pressure) will be stopped.
- MV-12, APS-MV-01 to 10 and APS-MV-11 (for KVB only) will be opened to drain the water from the pipes for 30 seconds, then MV-10 and fore-mentioned MVs will be closed.
- Finally, the air drying system will be started, and MV-11 will be opened, and the APS-MV to each ESP sub-assembly will be opened in sequential to apply air-blow drying to each ESP sub-assembly, after each ESP sub-assembly is dried, air drying system will be stopped, and MV-11 will be closed.
- Then ESP Washdown Finished Status will be sent to CCMS and the ESP Pre-Start Sequence will be started.
- If start control of Pre-filter Washdown exist while start control of ESP washdown sequence is not exist, the Pre-Filter washdown Sequence will be carried out.

3.2. Plenum Emergency Operation

When any of the measurements from the air monitoring stations is abnormally high, APS control system shall stop the ESP system and isolate the APS Plenum from the tunnel ventilation system automatically. An alarm shall be sent for the APS controller to CCMS to notify the operator.

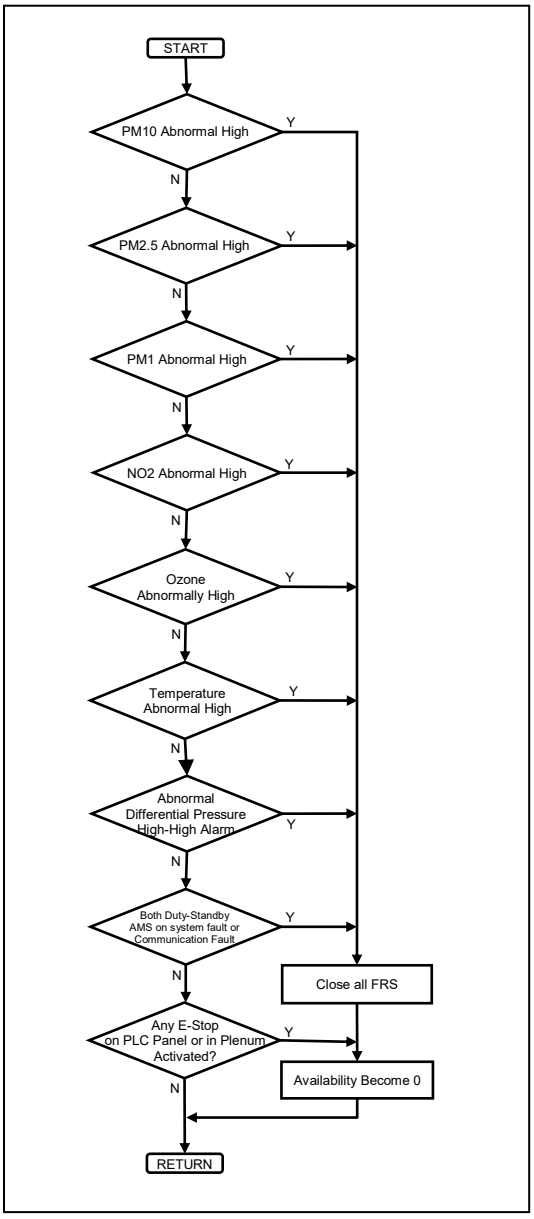

Figure 2 : Emergency Situation in APS Plenum

3.3. System Emergency Operation (Fire)

Once the system going into the Emergency Operation, program will check if there are any APS Plenum running and will send OFF command to those running APS Plenum.

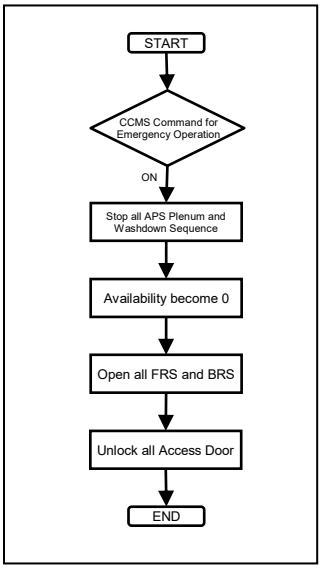

Figure 3 : Emergency Operation (Fire)

3.4. Equipment Healthy Check (Plenum)

To check if the equipment in the APS plenum is suitable for running, the APS Plenum will not be allowed to run if the checking is not passed.

Plenum Equipment Healthy Check Logic

Plenum Equipment Healthy Check will be considered as fail if any following condition is met.

- If Emergency Operation is running
- If any Removal Efficiency less than 80% (Configurable).
- If any Roller shutter is not fully opened and disabled (Not including the front roller shutter closed due to ESP subassembly fault.).
- If all access override key switches on panels are switched to normal state, and any APS or ESP access Door Contact is opened.

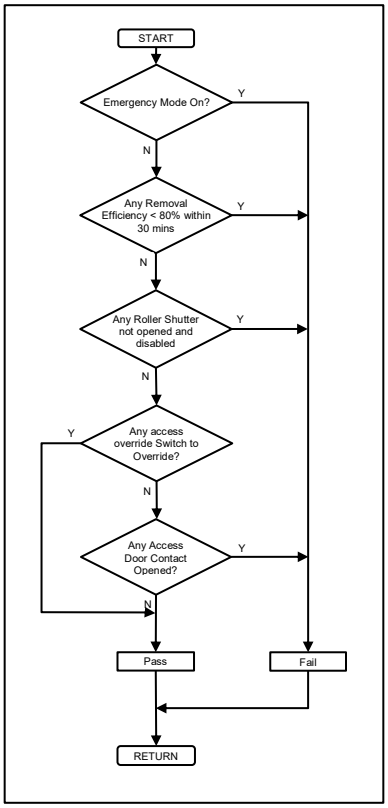

Figure 4 : APS Plenum Equipment Healthy Check

3.5. ESP Washdown Operation

3.5.1. Equipment Preparation (refilling the Clean Water Tanks) Timer

Schedule Time is available to be set between 00:00 to 23:59 for start refilling the Clean water tank every day. The default timer is a 21:00.

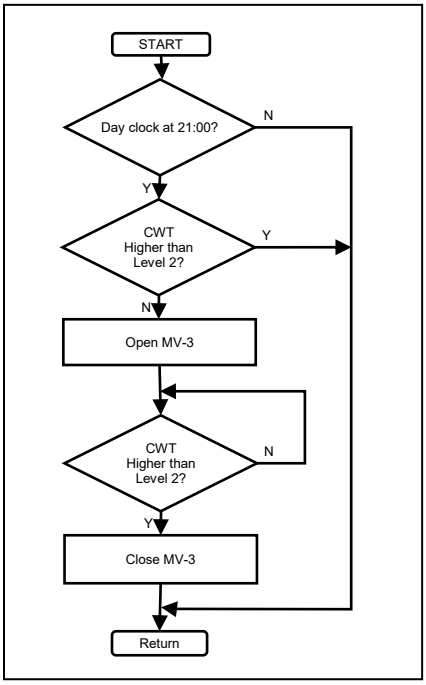

Figure 5 : Washdown Equipment Preparation

3.5.2. Equipment Healthy Check (Washdown)

To check the common equipment used in the APS Washdown sequence is suitable to operate, the APS washdown will not be allowed to start if the checking is not passing, also the running APS washdown sequence will be terminated.

Washdown Equipment Healthy Check Function

If either a following condition is violated, the APS washdown equipment check is considered as failed, and the washdown shall be terminated:

- All pump in Auto Mode
- At least one pump in DTP system, LWP System, HWP System, Air Compressor System, one of air path for Air Receiver and Air dryer are under health conditions
- DTP, LWP, HWP, Air Compressor System Power Supply Normal
- Valve in Pneumatic System open / close as required
- CWT, DWT, MWT not overflow (under Level 1)
- Water exists in CWT (higher than Level 4)
- Detergent exists in DT (higher than Level 2)
- No MV fail to Open or Close under the Washdown Sequence

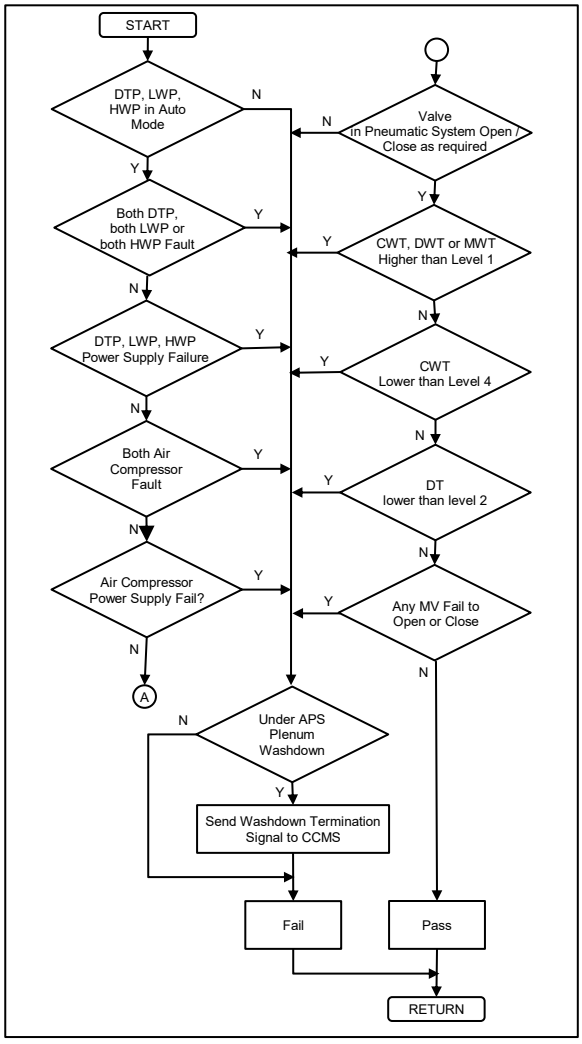

Figure 6 : APS Plenum Washdown Equipment Check

3.5.3. APS-MV Sequence

In APS-MV Sequence, water pipe to each ESP subassemblies are controlled with two APS-MV with parallel setup, both APS-MV will be opened and closed in sequence and thus those ESP subassemblies are washed and blowed in sequence. The duration of each ESP subassemblies can be set individually for each process.

APS-MV to ESP sub-assemblies will be opened in the sequence of “A”, “B”, “C”, “D” and “E”, the delay of opening of APS-MV in each phase can be configured individually to fit the usage of different stage.

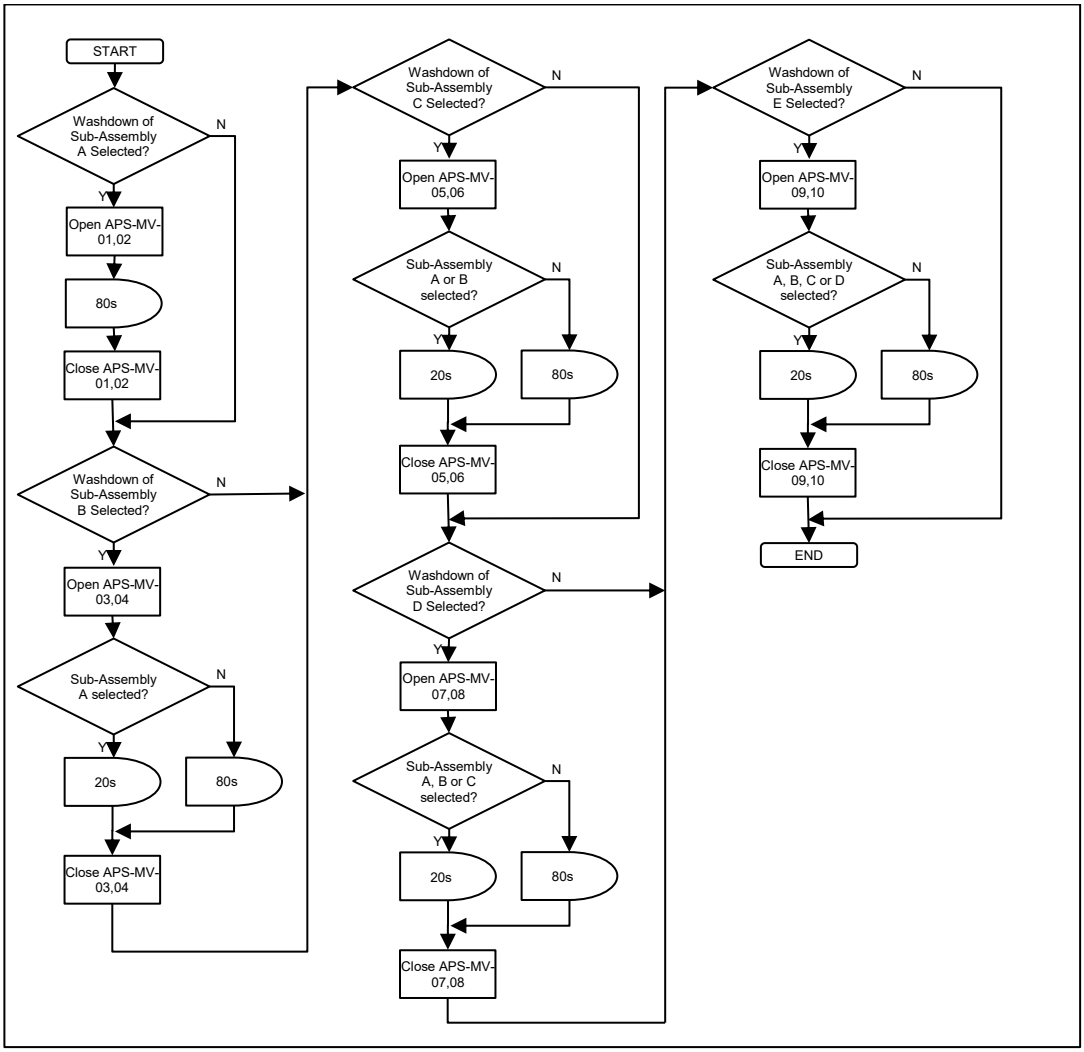

Figure 7 : APS-MV Sequence Flowchart for applying detergent / Rinsing

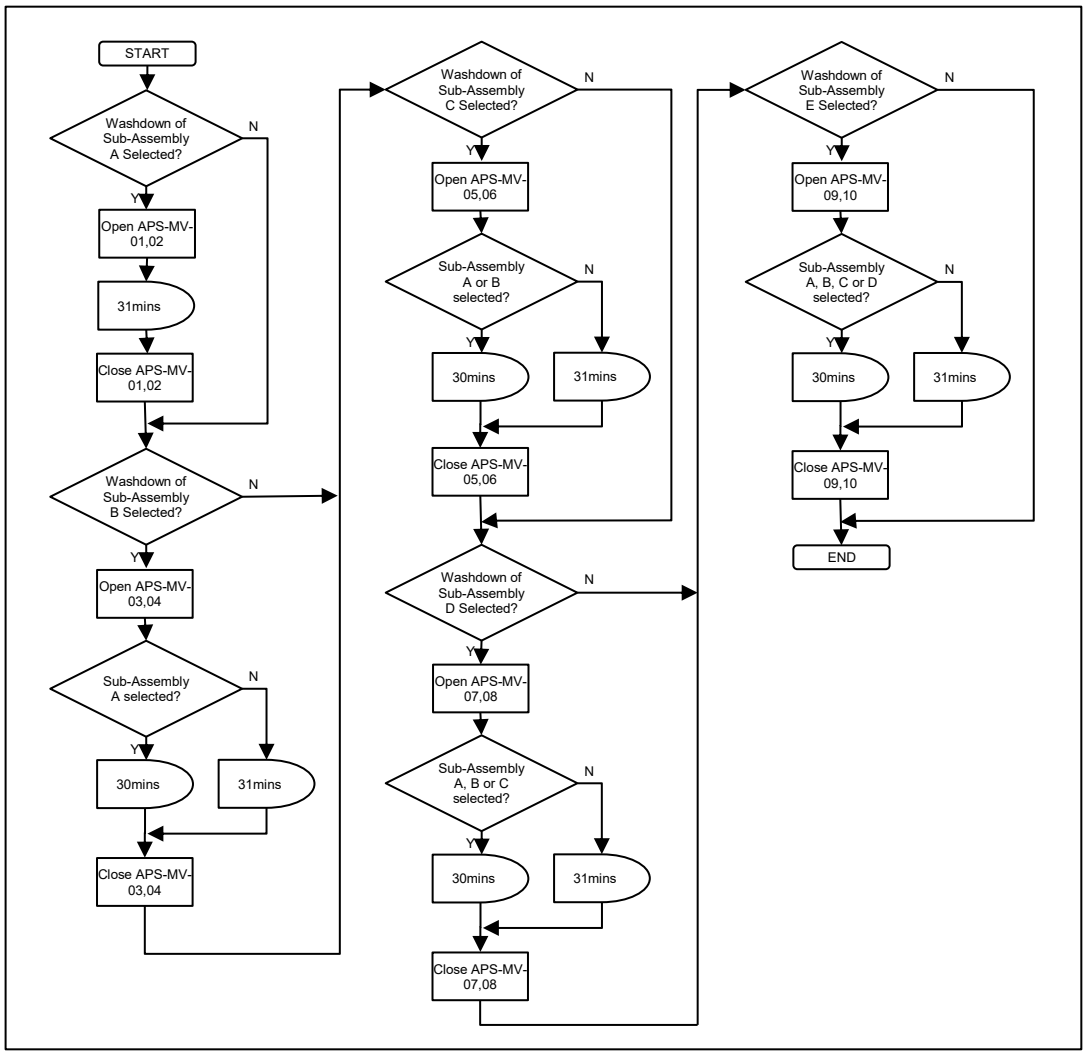

Figure 8 : APS-MV Sequence Flowchart for applying detergent / Rinsing

3.5.4. System Safety Interlock (Air Drying)

To ensure the Air Drying System still function under fault conditions on the air tank and/or air dryer, bypass valve are provided in the system. Air drying system will be started during the APS Plenum Washdown process. Air tank will be considered as leakage if pressure is lower than 7 bar and abnormal when pressure exceed 8.5 bar, as the opening pressure of the air relief valve is 8.8bar. 20s will be given after receiving the start signal as Tank require 10s to fill up.

- If pressure inside air tank exceed 8.5 bar after 20s of receiving the Start command, High level alarm will be sent to CCMS.
- If pressure inside air tank lower than 1 bar after 20s of receiving the Start command, Low Level alarm will be sent to CCMS.
- 3. If there is either High Level alarm or Lower Alarm for the air tank, MV-4, MV-5 will be closed, and MV-6 will be opened.
- Otherwise MV-4 and MV-5 will remain open, and MV-6 will be closed.
- If air dryer is fault, MV-7 and MV-8 will be closed and MV-9 will be opened.
- Otherwise MV-7 and MV-8 will remain open, and MV-9 will be closed.

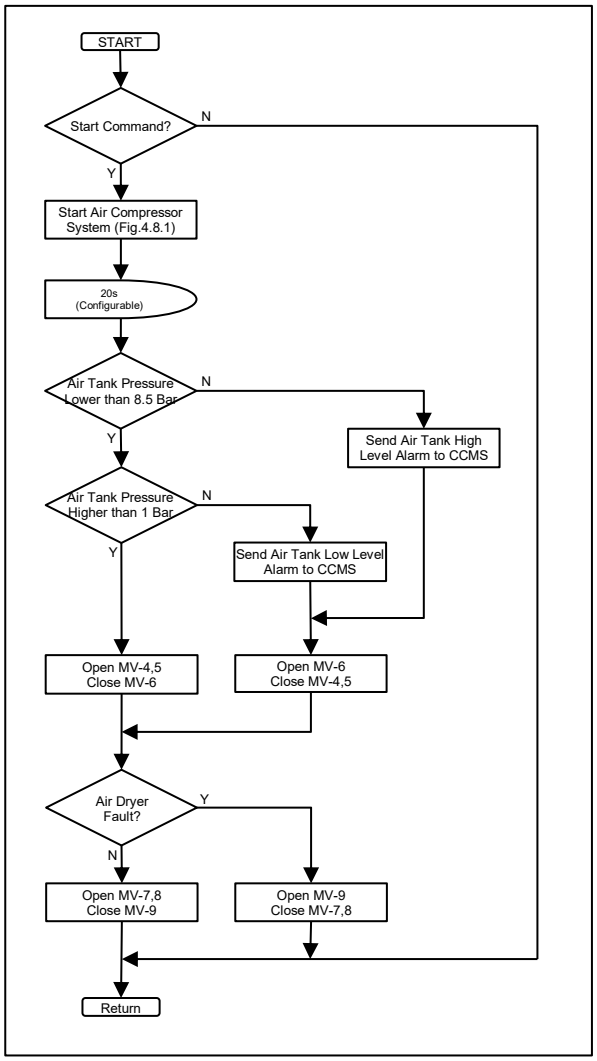

Figure 9 : Air Drying System Safety Interlock

3.5.5. **Pre-Starting of ESP after APS Plenum Washdown #**

PSU for ESP ionizer will be switched on for 1 hour gradually increasing from 10kV to 12kV to dry the ESP filter at 3 hours 50 minutes after the APS Plenum Washdown Process, which will be 05:00 to 06:00 if the APS Plenum Washdown Process started at 01:10.

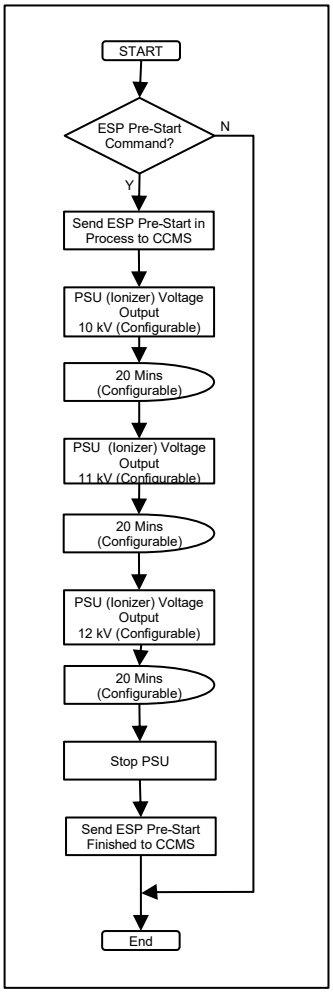

Figure 10 : ESP Pre-Starting Sequence

3.6. Pre-Filter Washdown Sequence

- Washdown equipment healthy check will be carried out.
- If the washdown equipment healthy check passed, and All CWT higher than level 2, the sump pit equipment healthy check will be carried out.
- If the sump pit equipment healthy check passed, the Pre-Filter washdown sequence will be carried out.
- First the clean water pump (high pressure) will be started, and the MV-10 will be opened. Then the MV to Pre-Filter will be opened wash the Pre-filter. After Pre-Filter is washed, clean water pump (high pressure) will be stopped.
- MV-12, APS-MV-13 and 14 and APS-MV-11 (for KVB only) will be opened to drain the water from the pipes for 30 seconds, then MV-10 and fore-mentioned MVs will be closed.
- Finally, the air drying system will be started, and MV-11 will be opened, and the APS-MV to Pre-Filter will be opened in sequential to apply air-blow, after Pre-Filter is dried, air drying system will be stopped and MV-11 will be closed.
- If either the washdown equipment healthy check failed, or the sump pit equipment healthy check failed, or none of the clean water tank reach level 2 after the configurable delay, equipment fault signal will be sent to CCMS.

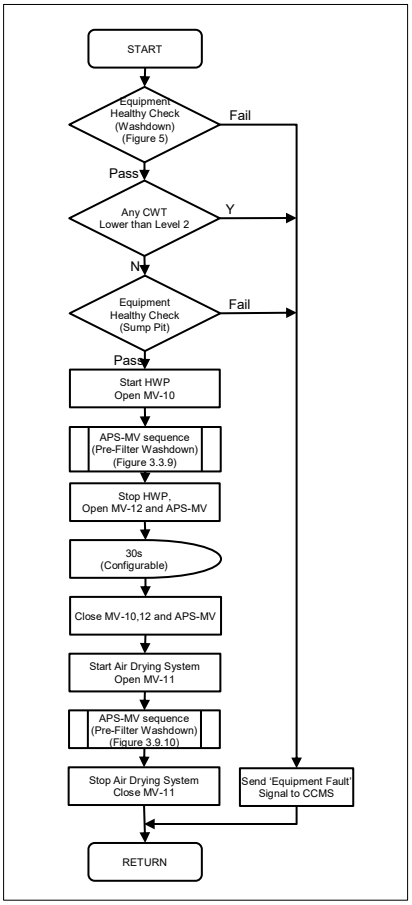

Figure 11 : APS-MV Sequence Flowchart for applying detergent / Rinsing

For the APS-MV Sequence in the Pre-Filter washdown Sequence, APS-MV-13 and 14 will be opened, for washing process, valve will be opened for 80s and 20s respectively for air blowing process, valve will be opened for 31 and 30 minutes respectively instead.

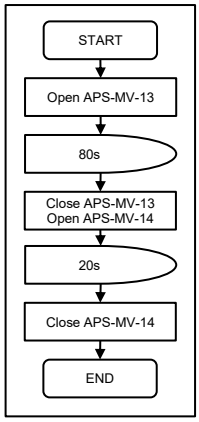

Figure 12 : APS APS-MV Sequence Flowchart for applying Rinsing in Pre-Filter Washdown Sequence

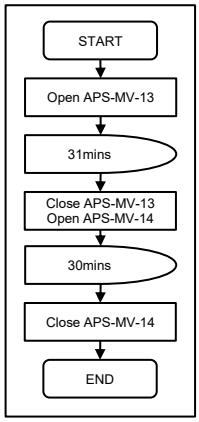

Figure 13 : APS-MV Sequence Flowchart for Air Blowing Process in Pre-Filter Washdown Sequence

3.7. Requirement of requesting ESP Washdown and Pre-filter Washdown

When any of following criteria met, ESP Request washdown signal will be send to CCMS to arrange ESP washdown under schedule setting in CCMS:

- ESP Usage Time without Washdown exceed 57 hours (Configurable)
- PM1 Removal Efficiency below 85% (Configurable)
- PM2.5 Removal Efficiency below 85% (Configurable)
- PM10 Removal Efficiency below 85% (Configurable)

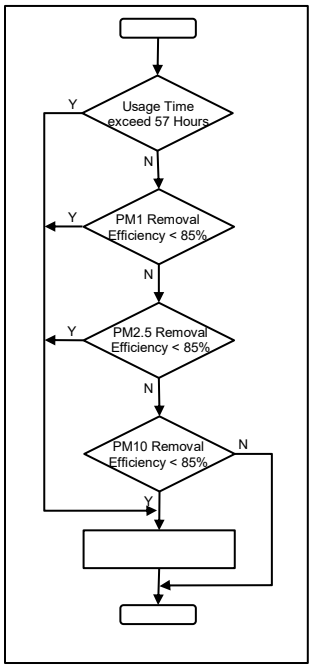

Figure 14 : Requirement of Requesting ESP and Pre-filter Washdown

When any of following criteria met, Pre-filter Request washdown signal will be send to CCMS to arrange Pre-filter washdown under schedule setting in CCMS:

1. Pre-filter Usage Time without Washdown exceed half years (Configurable)
2. Pressure drop across the Pre-filter above 90Pa (Configurable)

Annex A – Equipment Operation

Annex A – Equipment Operation

ESP HV Power Supply Unit

(For the Detail information, please refer to the updated O&M Manual)

Annex A – Equipment Operation

Air Monitoring Station (AMS)

(For the Detail information, please refer to the updated O&M Manual)