

**CENTRAL KOWLOON ROUTE**

# **APS Commissioning Test Plan**

(CONDITION 2.19 OF  
ENVIRONMENTAL PERMIT, EP-457/2013/D)

(April 2025)

## Environmental Permit No. EP-457/2013/D

### Central Kowloon Route

### Independent Environmental Checker Verification

Works Contract:	Buildings, Electrical and Mechanical Works (HY/2019/13)
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#### Reference Document/Plan

Document/Plan to be Certified/ Verified:	APS Commissioning Test Plan
Date of Report:	-
Date received by IEC:	15 April 2025

#### Reference EP Condition

Environmental Permit Condition:	2.19
Submission and Measures for Mitigating Operational Air Quality Impact	
2.19 The Permit Holder shall, no later than three months before the commencement of operation of the Project, submit to the Director for approval four hard copies and one electronic copy of a APS Commissioning Test Plan, which shall be certified by the ET Leader and verified by the IEC, to provide schedule and methodology for the commissioning test of the adopted APS described under Condition 2.18 above.	

#### 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 Commissioning Test Plan\_20250416.docx

Our ref.: MA20024/Corres/Out/EP2.19/DC250416

**Gammon Construction Limited**  
22/F, Tower 1 and 2, The Quayside  
77 Hoi Bun Road,  
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 Air Purification System Commissioning Test Plan**

We refer to the submission of the Air Purification System Commissioning Test Plan received on 15 April 2025 via email.

Regarding Condition 2.19 of the Environmental Permit (EP No.: EP-457/2013/D), the Permit Holder shall, no later than three months before the commencement of operation of the Project, submit to the Director for approval four hard copies and one electronic copy of a APS Commissioning Test Plan, which shall be certified by the ET Leader and verified by the IEC, to provide schedule and methodology for the commissioning test of the adopted APS described under Condition 2.18 above.

We have no further comments on the plan. As the ET Leader, I hereby certify this in accordance with Condition 2.19 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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## 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 2.19 of the EP, the Permit Holder shall, no later than three months before the commencement of operation of the Project, submit to the Director for approval four hard copies and one electronic copy of APS Commissioning Test Plan, which shall be certified by the ET Leader and verified by the IEC, to provide schedule and methodology for the commissioning test of the adopted APS described under Condition 2.18 of the EP.

As stipulated in Condition 2.20 of the EP, the Permit Holder shall, in accordance with the submission schedule as stipulated in the approved APS Commissioning Test Plan described in Condition 2.19 of the EP, or otherwise approved by the Director, deposit with the Director four hard copies and one electronic copy of the APS Commissioning Test Report, which shall be certified by the ET Leader and verified by the IEC as conforming to the removal efficiency specified under Condition 2.18 of the EP.

- 1.3. In drafting this plan, references is made to the APS Commissioning Test Plan for Central-Wan Chai Bypass and Island Eastern Corridor Link (Under Condition 2.7 of EP-482/2013/A).

## **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 NO<sub>2</sub> removing part by means of a De-NO<sub>2</sub> 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-NO<sub>2</sub> system, activated carbon gas adsorption shall remove NO<sub>2</sub>.

### 3. Testing Schedule and Methodology

- 3.1. The testing of APS at three different ventilation buildings will be carried out in 2 stages for monitoring the performance of the APS below:-

#### Respirable Suspended Particles (RSP) PM10 – Removal efficiency

When inlet concentration equal to or greater than 0.5mg/m<sup>3</sup>, not less than 80% of RSP/PM10 shall be removed; and

When inlet concentration is lower than 0.5mg/m<sup>3</sup>, the outlet concentration shall not be greater than 0.1mg/m<sup>3</sup>. \*Note

#### NO2 – Removal efficiency

When inlet concentration equal to or greater than 0.25ppm, not less than 80% of NO2 shall be removed; and

When inlet concentration is lower than 0.25ppm, the outlet concentration shall not be greater than 0.05ppm. \*Note

\*Note: The passing criteria at lower inlet concentration levels for PM10 and NO2 will be further reviewed in Second Stage Testing.

#### First Stage Testing

- 3.2. The tests of the first stage will involve the Factory Acceptance Test (FAT), the material test of the denitrification media for De-NO2 filter and the Site Acceptance Test (SAT). Details refer to Section 4 of this report.

#### Second Stage Testing

- 3.3. The tests of the second stage will involve the Post-commissioning Efficiency Tests of the APS for all three ventilation buildings and review the passing criteria at low inlet concentration level for PM10 and NO2 after the CKR tunnel is commissioned. Details refer to Section 5 of this report.

#### 4. First Stage Testing

##### 4.1. Factory Acceptance Test (FAT)

For the FAT, it includes the performance test of the Electrostatic Precipitator (ESP) using the accepted ESP HV Power Supply Units, the adsorption test of the De-NO<sub>2</sub> filter and the performance of the integrated ESP and De-NO<sub>2</sub> filters prior to manufacturing and delivery to Hong Kong.

- 4.1.1. For the factory performance test of electrostatic precipitator (ESP) using the accepted ESP HV Power Supply Units, it will be conducted under the contract requirements for HyD's Contract No. HY/2019/13 – Central Kowloon Route – Buildings, Electrical and Mechanical Works.

The tests will be carried out inside the factory by the APS specialist at conditions similar to the tunnel environment and the PM<sub>10</sub> concentration will be measured before and after the ESP modules. 10 nos. of ESP filters with stainless steel supporting framing will be assembled to overall size not less than 2m(W) x 2m(W).

The removal efficiency for ESP filter will be performed in 3 different stages: 1) PM<sub>10</sub> alone, 2) PM<sub>10</sub> and PM<sub>2.5</sub> and 3) PM<sub>10</sub>, PM<sub>2.5</sub> and PM<sub>1</sub> at concentrations which simulate concentrations in the tunnel exhaust environment. The testing parameters and testing values are listed in the below table 1.

Table 1 - Testing Parameter and Test Values for the factory performance test of electrostatic precipitator (ESP) using the accepted ESP HV Power Supply Units

Testing Condition / Environment	Inlet PM <sub>10</sub> Concentration	ESP Air Velocity	Temp. / R.H.	Ionizer / Collector Voltage	Passing Criteria		
PM <sub>10</sub>	<0.5 mg/m <sup>3</sup> (Range start at value at 0.2-0.4 mg/m <sup>3</sup> stably)	5.37 + 0.5 m/s	50°C ± 2°C / 95% ± 5%	14 kV / 6.5 kV	PM <sub>10</sub> level ≤ 0.1 mg/m <sup>3</sup>		
PM <sub>10</sub> & PM <sub>2.5</sub>							
PM <sub>10</sub> , PM <sub>2.5</sub> & PM <sub>1</sub>							
PM <sub>10</sub>	≥0.5 mg/m <sup>3</sup> (Range start at value at 0.6-0.9 mg/m <sup>3</sup> stably)	5.37 + 0.5 m/s			50°C ± 2°C / 95% ± 5%	14 kV / 6.5 kV	≥ 80% PM <sub>10</sub> Removed
PM <sub>10</sub> & PM <sub>2.5</sub>							
PM <sub>10</sub> , PM <sub>2.5</sub> & PM <sub>1</sub>							

Note:

1. The design ESP air velocity is 5.37m/s.
2. The measurement results for PM<sub>10</sub> from Air Monitoring Station is based on 1-minute rolling averaging

The removal efficiency for ESP filters should achieve 80% or more when inlet PM<sub>10</sub> concentration is equal to or greater than 0.5 mg/m<sup>3</sup> and achieve less than or equal to 0.1 mg/m<sup>3</sup> when inlet concentrations is lower than 0.5 mg/m<sup>3</sup>.

- 4.1.2. For the factory adsorption test of De-NO<sub>2</sub> filter, it will be conducted under the contract requirements for HyD's Contract No. HY/2019/13 – Central Kowloon Route – Buildings, Electrical and Mechanical Works.

The tests will be carried out inside Trane Air Conditioning System (China) Laboratory by the APS specialist at an environment similar to the APS plenum in terms of temperature, humidity and the design airflow velocity. The specimen size 400(L) x 400(H) x 430mm(D) of the De-NO<sub>2</sub> filters will be assembled for adsorption test.



The removal efficiency for De-NO<sub>2</sub> filter will be performed in 3 different stages: 1) NO<sub>2</sub> alone, 2) NO<sub>2</sub> and O<sub>3</sub>, 3) NO<sub>2</sub> and Toluene at concentration which simulate concentrations in the tunnel exhaust environment. The testing parameters and testing values are listed in the below table 2.

Table 2 - Testing Parameter and Test Values for the factory adsorption test of De-NO<sub>2</sub> filters

Testing Condition / Environment	NO <sub>2</sub> Concentration criteria	Face Velocity	Temp. / R.H.	Passing Criteria
NO <sub>2</sub> alone	≥0.25 ppm, (Range start at value at 0.3-0.6ppm stably)	0.5 +0.05m/s	50°C ± 2°C / 95% ± 5%	≥ 80% NO <sub>2</sub> Removed
NO <sub>2</sub> alone	<0.25 ppm (Range start at value at 0.05- 0.2ppm stably)			NO <sub>2</sub> ≤ 0.05ppm
NO <sub>2</sub> / O <sub>3</sub>	NO <sub>2</sub> ≥0.25 ppm + ozone 0.5ppm ±5% (NO <sub>2</sub> range start at value at 0.3-0.6ppm stably)			≥ 80% NO <sub>2</sub> Removed
NO <sub>2</sub> / Toluene	NO <sub>2</sub> ≥0.25 ppm + toluene 10 ppm ±5% (NO <sub>2</sub> range start at value at 0.3-0.6ppm stably)			≥ 80% NO <sub>2</sub> Removed

Note:

1. The design face velocity is 0.5/s.
2. The measurement results from NO<sub>2</sub> sensors (Air Monitoring Station) is based on 1-minute rolling averaging

The measured NO<sub>2</sub> adsorption rates should achieve 80% or more when inlet NO<sub>2</sub> concentration is equal to or greater than 0.25ppm and less than or equal to 0.05ppm when inlet concentration is lower than 0.25ppm.

- 4.1.3. For the integrated test of the ESP and De-NO<sub>2</sub> filters, it will be conducted under the contract requirements for HyD's Contract No. HY/2019/13 – Central Kowloon Route – Buildings, Electrical and Mechanical Works.

The tests will be carried out inside the factory by the APS specialist at conditions similar to the tunnel environment and measured the PM<sub>10</sub> and NO<sub>2</sub> concentration before and after the system. 10 nos. of ESP cells and 55 nos. of carbon boxes with a stainless steel supporting framing will be assembled.

The performance tests of an integrated ESP and De-NO<sub>2</sub> filters will be performed in different inlet concentration for PM<sub>10</sub> and NO<sub>2</sub>, injected voltages for ESP ionizer and collector plates which in an environment similar to the APS plenum of 50°C / 40% RH and 50°C / 95% RH under design face velocity of ESP filter in 5.37 m/s. The testing parameters and testing values are listed in the below table 3.

Table 3 - Testing Parameters and Test Values for integrated test of the ESP and De-NO2 filters

Testing Condition / Environment	Inlet Concentration	ESP Air Velocity	Ionizer / Collector Voltage	Temp. / R.H.	Passing Criteria
PM10	<0.5 mg/m3 (Range start at value at 0.2-0.4 mg/m3 stably)	5.37 + 0.5 m/s	Case 1 14 kV / 6.5 kV  Case 2 13 kV / 6 kV	50°C ± 2°C / 95% ± 5%	PM10 level ≤ 0.1 mg/m3
NO2	<0.25 ppm (Range start at value at 0.05-0.2ppm stably)				NO2 ≤ 0.05ppm
PM10	≥0.5 mg/m3 (Range start at value at 0.6-0.9 mg/m3 stably)				≥ 80% PM10 Removed
NO2	≥0.25 ppm, (Range start at value at 0.3-0.6ppm stably)				≥ 80% NO2 Removed

Note:

1. The design ESP air velocity is 5.37m/s and the design face velocity is 0.5/s.
2. The measurement results from PM10 & NO2 sensors (Air Monitoring Station) is based on 1-minute rolling averaging.

4.1.4. The above tests for the FAT will be inspected and accepted by relevant parties including the Contractor, Resident Site Staff, and witnessed by representatives of EMSD and HyD to ensure the tests would meet the performance requirements.

#### 4.2. Material Test of the Denitrification Media

- 4.2.1. For the material test of the denitrification media (activated carbon) for De-NO<sub>2</sub> filter, it will be carried out during the manufacturing process of the denitrification media by an accredited independent laboratory.
- 4.2.2. Material test of the denitrification media (activated carbon) for De-NO<sub>2</sub> filter will be conducted under the contract requirements for HyD's Contract No. HY/2019/13 – Central Kowloon Route – Buildings, Electrical and Mechanical Works.

The tests shall be carried out for the denitrification media (activated carbon) at a rate of one (1) 1.5 kg sample of the denitrification media (sample) per 25,000kg of the denitrification media (material) by the independent laboratory. To ensure consistency, the independent laboratory, in association with the APS specialist, will verify the details of the material content of De-NO<sub>2</sub> media and compare the result with the specification. The sample will be tested in accordance with the following standards.

Test Requirement	Relevant Standard
Carbon Tetrachloride Adsorption CTC	ASTM D3467
Moisture	ASTM D2867
Hardness	ASTM D3802
Bulk Density	ASTM D2854
Ignition Temp.	ASTM D3466
Ash Content	ASTM D2866
Surface Area	GB/T 7702
Particle size	ASTM D2862

#### 4.3. Site Acceptance Test (SAT)

- 4.3.1. Upon completion of the installation, the SAT will be conducted for two crucial equipment components: the ESP HV Power Supply Units and the ESP System (ESP Ionizer and Collector).
- 4.3.2. For the Site Acceptance Test of ESP HV Power Supply Units and ESP System, the start-up of the HV power supply units and ESP System will be checked on site at the respective ventilation buildings.
- 4.3.3. Efficiency test for the APS at all three ventilation buildings will be conducted to show compliance with criteria in Section 3.1.
- 4.3.4. The intergraded test of ESP and De-NO<sub>2</sub> filters will be conducted during the Site Acceptance Test (SAT).
- 4.3.5. The performance integrate test to demonstrate the operation schedule of Module (APS with associated TVF) to maintain smaller than or equal to 10% of air flow emitted via tunnel portals of tunnel will be conducted during the Site Acceptance Test (SAT).
- 4.3.6. The tests will be inspected by relevant parties including the Contractor, Resident Site Staff, and witnessed by representatives of EMSD and HyD to ensure the installed components of APS are properly functioned according to contract requirements for HyD's Contract No. HY/2019/13 – Central Kowloon Route – Buildings, Electrical and Mechanical Works and the EMSD's CoP requirement.

## 5. Second Stage Testing

### 5.1. Post-commissioning Efficiency Tests

- 5.1.1. The second stage testing will include the Post-commissioning Efficiency Tests of the APS for all three ventilation buildings. The Efficiency Test for each APS module shall be conducted over a continuous thirty (30) calendar day period after the CKR tunnel is commissioned according to contract requirements for HyD's Contract No. HY/2019/13 – Central Kowloon Route – Buildings, Electrical and Mechanical Works. The Efficiency Tests for APS modules in different ventilation buildings shall occur simultaneously to verify the performance efficiency of the APS. During this test period, the APS shall operate under both manual and automatic operating modes and the change-over of operating priority of the individual TVF/APS modules will be tested.
- 5.1.2. Before the road commissioning, the accredited independent laboratory with experience in measuring air quality will be engaged to verify the installation and calibration of the installed air monitoring stations.
- 5.1.3. Based on the installation and calibration of the installed air monitoring stations and the site constraint, the accredited independent laboratory shall propose additional air quality measurement in the air stream before and after passing through the ESP and De-NO2 filter for the Efficiency Test for each APS in each ventilation building. The result of the additional air quality measurement shall be used as one of the references in the test report.
- 5.1.4. The accredited independent laboratory shall also witness the air quality measurements, certifying their results and efficiency over the duration of Efficiency Test as conforming to the removal efficiency in compliance with the criteria in Section 3.1.
- 5.1.5. The passing criteria at lower inlet concentration levels for PM10 and NO2 will be further reviewed after the CKR tunnel is commissioned.

## 6. Submission Schedule

- 6.1. The first stage APS Commissioning Test Report, which includes the Factory Acceptance Test (FAT), the material test of the denitrification media for the De-NO<sub>2</sub> filter, and the Site Acceptance Test (SAT), will be submitted to the Director of Environmental Protection before the CKR tunnel is opened.
- 6.2. The second stage APS Commissioning Test Report will include the Efficiency Tests for each APS module, which will be conducted continuously for a period of thirty (30) calendar days after the CKR tunnel is commissioned. These Efficiency Tests will be completed no later than six months after the tunnel commissioning according to contract requirements for HyD's Contract No. HY/2019/13 – Central Kowloon Route – Buildings, Electrical and Mechanical Works. To allow two months for preparation of the report and verification of the test results, the second stage APS Commissioning Test Report will be submitted to the Director of Environmental Protection approximately eight months after the CKR tunnel is opened.
- 6.3. In order to maintain the precise performance of the air monitoring stations, the routine preventative maintenance and annual calibration of Air Monitoring Station (AMS) will be conducted within the timeframe as recommended by AMS specialist.

Table 4 - Tentative Submission Schedule for APS Commissioning Test Report

APS Commissioning Test Report		Tentative Submission Schedule
First Stage Testing	<ul style="list-style-type: none"> <li>(i) Factory Acceptance Test (FAT)               <ul style="list-style-type: none"> <li>- performance test of the Electrostatic Precipitator (ESP) filters</li> <li>- adsorption test for De-NO<sub>2</sub> filter</li> <li>- performance tests of an integrated ESP and De-NO<sub>2</sub> filters</li> </ul> </li> <li>(ii) Material Test of the Denitrification Media (activated carbon)</li> <li>(iii) Site Acceptance Test               <ul style="list-style-type: none"> <li>- ESP HV Power Supply Units and ESP System</li> <li>- Intergraded test of ESP and De-NO<sub>2</sub> filters</li> <li>- Performance integrate test of Module (APS with associated TVF) with air flow emitted via tunnel portals of tunnel</li> </ul> </li> <li>- Efficiency Tests for the APS</li> </ul>	before the CKR tunnel is opened
Second Stage Testing	<ul style="list-style-type: none"> <li>(iv) Calibration of the installed air monitoring stations</li> <li>(v) Post-commissioning Efficiency Test for each APS module over a continuous thirty calendar day period</li> <li>(vi) Review of passing criteria at lower inlet concentration levels for PM<sub>10</sub> and NO<sub>2</sub></li> </ul>	Approximately eight months after the CKR tunnel is opened