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Tulasi Anantharamakrishnan

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Detecting the presence of Hexavalent Chromium in workzones using IoT

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How to detect the presence of Hexavalent Chromium in the Work Zone using IoT based Sensor Systems

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Thank you for the guidance of Dr.N.Gowrishankar, Advisor to IP Rings Ltd and Ms. Malathi, AGM Metallurgical Services IP Rings Ltd in the development of this research paper.

Index

Abstract **–**Electrodeposition of chromium from hexavalent **c**hromic acid is widely used in many industries such as Chrome Plating, Leather Tanneries, Paints etc**.** Industrial processes that involve chromium results in exposure to toxic hexavalent chromium to the employees in the industrial unit. The continuous monitoring of Hexavalent chromium in the workzone still remains a critical challenge for Industries. Hexavalent chromium is one of the top pollutants of concern for the Environmental Protection agencies. A standardized method of continuous monitoring of Hexavalent chromium in the work zone involves the use of laboratory-based methods, such as atomic absorption spectroscopy and mass spectroscopy.
Although these methods are highly selective and sensitive, the experiments are tedious and time consuming, require expensive maintenance, highly trained staff and are offline. We therefore decided to develop a method that will answer the question ' ***How can we detect the presence of Hexavalent Chromium in the work zone using IoT based sensor systems.***'
In **t**his project, the presence of Hexavalent Chromium is evaluated by a color detection method using color detecting sensors which would in turn connect to an alarm system for immediate response. The detection method consists of placing a solution containing chemicals DiPhenyl Carbazide and H_2SO_4 in a glass jar when the solution gets in contact with hexavalent chromium ions the color of the solution changes to pink color. The concept dealt in this project is to make use of the coloration due to the chemical reaction occurring between hexavalent Chromium ions, Diphenyl Cabazide and H_2SO_4 and the Physics principle of Beer Lamberts law for detecting and evaluating the concentration of hexavalent chromium. A light detectable color sensor is attached to the system to evaluate the concentration of the chromic acid. This project can be use**d** for Air quality monitoring of Hexavalent Chromium Cr(VI) in the work zone in plating industries, interfacing of the detected data thru IoT system for swift communication and remedial action. A field study will be conducted in plating industries to validate the concept.

Index Terms- Hexavalent chromium Cr(VI), Diphenyl Carbazide, H_2SO_4, Work zone, monitoring, Health effects, color sensor, IoT-based sensor system.

MY CONTRIBUTION -

INTRODUCTION 2.1

During my internship at IP Rings, a leading auto component manufacturing company in South India, I observed that one of the key processes used was Chrome Plating. Having understood the hazardous nature of Chromic Acid fumes, I noticed that although the company used effective and powerful fume extraction systems, employees had to use Personal Protective Equipment (PPE) by law. Further brainstorming revealed that leakages could occur due to the following reasons:

- Breakdown of extraction fume motors
- Leakages in the Chrome Plating Vat
- Leakages in Chromic acid storage tanks
- Overflow caused due to cooling coil puncture
- The method used to detect the presence of Cr(VI) was qualitative and depended on human skill to notice the change in coloration of the reactant in time and alert the concerned authorities.
- The device was in one area of the chrome plating shop and so if leakage was in one area and wind carried it to another it couldn't be detected.

Therefore, if we were to develop a system that was:

a) On line
b) Was able to give us a quantitative measure
c) Was present in several areas of the work zone
d) Give an automatic alert to the concerned supervisor.
e) Was fool proof and not operator dependent

It would give a much greater level of comfort and confidence to the employees working in this hazardous work zone without any fear that they would be exposed to any carcinogenic fumes.

My suggestions were received positively by the management team at IP Rings and a task force was formed comprising of

Dr. N Gowrishankar – Advisor to IP Rings and My Mentor
Mrs. Malathi – AGM Metallurgical Services

Mr. KV Suresh – Proprietor, Innovative Designs.

Ms. Tulasi. Anantharamakrishnan – Student Researcher

STUDENT'S ROLE 2.2

In order to validate my claims, I carried out the following study.

a) I studied the company's safety records over the past 12 months and found that there had been 3 incidents ofleakage that occurred. *annexure 1.*

b) I observed that the device was in one area of the work zone and therefore a leakage happening in another area or wind carrying fumes to another location might not be captured. To validate this claim, I set up the manual devices in 6 locations of the work zone and monitored the presence of Cr(VI) across 3 shifts over10 days. I observed that this method revealed that there were 2 occurrences during this period. *annexure 2.*
This led to confirming my claim that ***'The present qualitative and manual method of detecting the presence of Cr(VI) in the work zone had to be strengthened.'***

I further studied the following topics under the guidance of my mentor Dr. Gowrishankar and Ms. Malathi :

a) Faraday's Law and the chemistry behind Electrodeposition of Chromium.

b) The chemistry behind the reaction of hexavalent chromium ions with the reagent Diphenyl Carbazide in H2SO4 where the solution turned from colorless to Pink.

c) Beer Lamberts Law in Physics and its application to calorimetry and how length of the light wave can be correlated to concentration of Chromium ions in the reagent thereby arriving at a quantitative measurement of Cr (VI) in the air.

I was also tasked with conducting a primary survey to find Chrome plating units nearby and identify the type ofdetection method that they were using. *Annexure 3*

- I created a format and collected information from the supplier of chromic acid chemicals while continuing to await information from the Tamil Nadu Pollution Control Board on other registered Chrome Platers in Tamil Nadu.
- Out of the 22 units I identified through a primary survey, I visited 3 units and confirmed that the methods used to detect the presence of Cr(VI) in the work zone was quite basic and was prone to the issues I highlighted at IP Rings.

- NOT CONTINOUS
- MANUAL
- QUALITITATIVE
- NOT LOCATED IN ALL AREAS OF THE WORKZONE
- NOT FOOL PROOF

I helped to write the paper under the guidance of Ms. Malathi AGM Metallurgical services.
I was actively involved in all task force meetings as they developed the sensor and integrated it to an alarm system through SMS alerts using a micro controller.
I was also actively involved in deciding the location of these automated devices in the work zone.

ALTERNATE APPROACHES TO AIR QUALITY MONITORING 2.3

The air quality monitoring of Cr VI consists of the following methodology

1) **Ambient Air Quality monitoring as per NISOH (National Institute for Occupational Safety & Health) 7024**: - Collecting the suspended particles from the air for 24 hours and evaluating the hexavalent chrome by atomic absorption spectrometer. This method consists of preparing sample solution from the collected filter paper and interpreting the concentration using a known calibrated Cr(VI) concentration graph. Hence, it's Off line and cannot be used in the shop for on line monitoring and immediate action.

2) **Standard Test Method for Collection and Analysis of Hexavalent Chromium in Ambient Atmospheres (ASTM D5281-99) :-** This test method covers the collection and measurement of hexavalent chromium [Cr(VI)] in the ambient atmosphere. The test method collects and stabilizes atmospheric hexavalent chromium using an alkaline buffer solution in a wet sampling technique. This test method measures hexavalent chromium using an ion chromatographic separation combined with a post separation reaction with a colorimetric reagent and photometric detection. Hence, it's Offline and cannot be used in the shop for on line monitoring and immediate action.

3) **Determination of chromic acid and chromates by Differential pulse polarography (DPP)**: - An air sample is collected on a 37-mm diameter polyvinyl chloride filter (5-µm pore size) using a calibrated personal sampling pump. The chromium (VI) is extracted from the filter using a carbonate/bicarbonate buffer solution and then analyzed by differential pulse polarography Hence it's Offline and cannot be used in the shop for online monitoring and correcting it

4) PH Method: - This test method covers the collection of sample from the atmosphere air and monitoring the PH ,using the colorimetric principle . The drawback of this technique is the coloration of Diphenyl Carbazide take place only in presence of H2SO4. Hence this method of evaluation of Cr(VI) was dropped.

All the above method consists of requires specialized training to operate it
A simple novel idea was thought to overcome the draw backs of offline monitoring system of CrVI which is hazardous.
In this project, the presence of Hexavalent Chromium Cr(VI) is evaluated by a color detection method using color detecting sensors. On passing the ambient air in the jar containing the chemicals, reaction takes place and changes the color of the solution from colorless to pink. Based on the Physics concept "Beer lamberts law "The light absorbed is proportional to the concentration of the CrVI . The sensors present enables IoT aspects such as alarms and SMS to the Supervisors for immediate action. This system will be a fool proof system and will benefit the environment and worker health a safety.

OVERALL TIMING CHART – GANTT CHART 2.4

You can view the chart here Gantt Chart (V3).xlsx

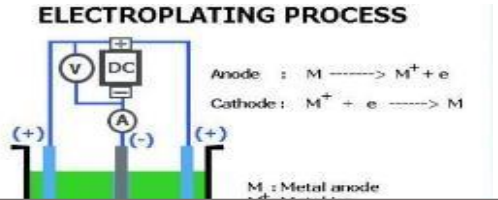
PROBLEMS & CHALLENGES 2.5
Industrial pollution is a very sensitive topic and improper implementation can lead to lawsuits and in some caseseven class – action suits against the organization and its Directors. I therefore found it extremely difficult to collect information on the companies, the number of employees they had in these hazardous areas, the type of Personal protective equipment that they were being given and the type of methodology they had to detect the presence of Cr(VI) in the work zone if it were to occur. However, I was successful invisiting 3 units and validating my claim.

MY LEARNINGS ARE AS FOLLOWS 2.6

1. Teamwork is essential to be able to solve real life issues. This project taught me that without the involvement of various departments and functions in an organization and governmental support, larger environmental and societal issues cannot be solved.
2. Technically unless one can apply their knowledge in a multi-disciplinary and multi/conceptual way one cannot solve real life issues in this instance I had to understand
   A) Faraday's Law for electroplating,
   B) The chemistry behind the reaction between Cr(VI) and Diphenyl Carbazide (DPC)
   C) Had to understand the physics behind Beer Lambert's Law on the absorbance of light proportional to the concentration and length of travel of the light through the liquid which is the principal that the proposed light sensor would use.
3. To make a societal impact government intervention is required to make certain laws mandatory. The Governments stringent pollution control laws helped us achieve this goal.
4. For successful Project management communication and collaboration are very important and if I had consistently communicated the progress with regards to timelines, we might have been able to complete the project as per schedule for each task.
5. Undertaking engineering and technical projects that can make the world a better place for society and environment motivates me to study and participate in. more such projects.

I. INTRODUCTION

Electrodeposition, also called electroplating or simply plating, is an economical technology to protect and enhance the functionality of parts used in many diverse industries including home appliances, jewelry, automotive, aircraft/aerospace, and electronics - in both decorative and engineering applications. Although decorative applications have diminished somewhat primarily due to added expenses and problems associated with plant effluent (pollution) control and waste treatment, its applications in engineering, electroforming, and electronics have increase
Electroplating is the application of a metal coating to a metallic or other conducting surface by an electrochemical process. The article to be plated (the work) is made the cathode (negative electrode) of an electrolysis cell through which a direct electric current is passed. The article is immersed in an aqueous solution (the bath) containing the required metal in an oxidized form either as an aquated cation or as a complex ion. The anode is usually a bar of the metal being plated. During electrolysis metalis deposited on to the work and metal from the bar dissolves as shown in Figure 1



ELECTROPLATING PROCESS

Figure 1 Figure 1

Faraday’s laws of electrolysis govern the amount of metal deposited

Chrome plating is produced by electro-deposition from a chromic acid bath. The Cr(VI) compound chromic acid is used to electroplate chromium onto metal parts to provide a hard protective coating. The chemical reaction taking place in the deposition of Chrome is as given below [12]

Cathode Reaction :

$2Cro_3 + H_2O$ > H_2CrO4 (Chromic Acid)

$2CrO4^{2-}(aq) + 2H^+(aq)$ --------> $Cr_2\ 0_7^- + H_2O$ (Di chromate) Cr_2

$0_7^- + 14H^+ + 12e$ > $2Cr + 7\ H_2O$ (Deposition of Chrome)

$2H^+ + 2e^-$ ------> H_2 (Evolution of Hydrogen Gas)

$Cr_2\ 0_7^- + 14H^+ + 6e$--------> $2Cr^{3+} + 7\ H_2O$ (Formation of Trivalent chrome)

Anode Reaction:

$2H_2O$------- > $O_2 + 4H^+ + 4e^-$ (Evolution of oxygen gas)

$2Cr^{3+} + 6\ H_2O$ --------> $2CrO_3 + 12H^+ + 6e^-$ (Oxidation of Cr^{3+} to Cr^{6+})

$Pb + 2H_20$-------- > $PbO_2 + 4H^+ + 4e^-$ (Formation of Lead Oxide)

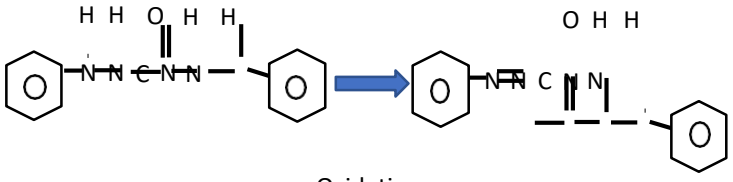
Hexavalent chromium [Cr(VI)] is one of the valence states (+6) of the element chromium and its carcinogenic in nature .Its exposure to humans can result in cancer. In addition, it targets the respiratory system, kidneys, liver, skin and eyes etc. therefore Chromium Plating is classified as a Hazardous Process & calls for strict pollution control measures. The current methodology to detect hexavalent chromium in the work zone is done through a manual system and it is purely qualitative.

A new concept can be developed from the qualitative analysis to quantitative by combining the basics of Chemical Reagent causing a color change to the exposure to Chromic acid ions with the Physics of Light absorption by liquids & effect of color & concentration was studied.

The chemical reaction taking place between the chemicals is as follows

$2Cr04^{2-} + 3C_{13}H_{14}N_4O + 8\ H^+$ -------> $(Cr^{+3}(3C_{13}H_{14}N_4O)_2)$

Chromate Ion + DPC + ACID ------- > Cr(III) +DPCA (Complex)



1,5 – Di Phenyl Carbazide(DPC)

Oxidation

DiPhenyl carbazone(DPCA)

The brief explanation of the chemical reaction is

Figure 2
DEPICTING THE COLOUR CHANGE

1. 1,5 DPC reacts in acid medium with hexavalent chromium ions to give a pink color complex.
2. The DPC brings about reduction of hexavalent Cr ions in the solution to form trivalent Cr ions
3. The DPC gets oxidized to DPCA .
4. The pink color solution is Cr(III) – diphenyl Carbazone Complex .

The Physics behind this is Beer-Lamberts law [10], which states that the absorbance of the light is proportional to the concentration & to the length of travel of the light through the liquid as shown in figure 3. So the length of travel has to be standardized.

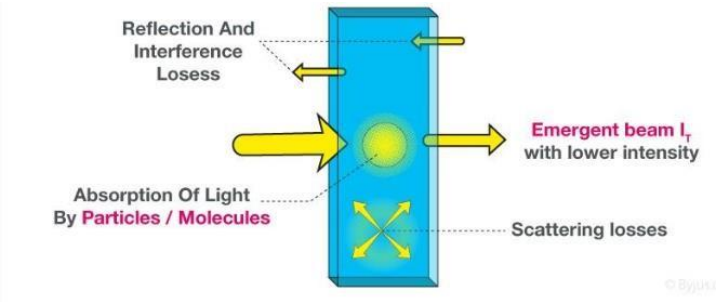


Figure 3
EXPLAINING THE BEER- LAMBERTS LAW

Absorption of energy causes the absorption of light as well usually by electrons. Different forms of light such as visible light and ultraviolet light get absorbed in this process. Therefore, change in the intensity of light due to absorption, interference, and scattering leads to:

$\Delta I = I_0 - IT$

The following equations are necessary for us to obtain our ultimate derivative equation. Transmittance is measured as the ratio of light passing through a substance. It can be calculated as I_T/I_0. To calculate the of transmittance percentage we can do so by:

$$\%T = \frac{100I_T}{I_0}$$

Another key metric is absorbance which is defined as the amount of light absorbed. This is usually calculated as the negative of transmittance and is given by:

$$A = log_{10}\frac{I_0}{I_T} = log_{10}(\frac{1}{T}) = -log_{10}T$$

The rate of decrease in the intensity of light with the thickness of the material of the light is directly proportional to the intensity of the incident light. Mathematically, it can be expressed as:

$$\log \frac{I_0}{I_T} = \frac{k'b'}{2.303} \text{ or } A = \frac{k'b}{2.303}$$

The current project deals with developing a proto type equipment to detect the concentration of the hexavalent Chromium present in the plating atmosphere. The source of light used in the proto type is a LED. The colour of the liquid after reaction will be pink, which is a combination of the basic colours red and blue. Therefore, we use a contrast colour to both red and blue and hence a GREEN LED chosen. The sensing system consists of light source at one side and a light detector at the other side of the container. The sensor used is a single microchip board containing a photo diode, amplifiers and filter. The sensor will measure the light intensity in Lux . The value will be transferred to a microcontroller thru serial communicator. The microprocessor connected to modem which can send SMS messages. The microcontroller will be programmed to sense alert messages to predefined mobile number at different levels based on the alert value set by the user. The alarm setting value is decided based on actual trial with known concentration of chromic acid.

II. METHODOLOGY

The current methodology to detect hexavalent chromium in the work zone is qualitative. The existing system has many gaps like monitoring of the system is person dependent and also, it's a standalone equipment which requires special attention. In the existing system there will be always time lag for remedial action. These gaps have been addressed in the new methodology, for example the process of converting qualitative to quantitative measurements and integrating with IoT based systems for immediate alarms to concerned people.

A glass jar containing water is collected and stored measuring up to 500 ml. To this 10 ml of LR grade sulphuric acid and 0.05 gram of diphenyl carbizide is added and mixed well in the measuring jar. The color of liquid changes when it reacts with hexavalent Cr. The color of the liquid will indicate the concentration level of chromium in the liquid. The principle adapted is Beer Lamberts law, which states that absorbance is directly proportional to the concentration of the absorbing species in the solution and the path length as shown in Figure 4.

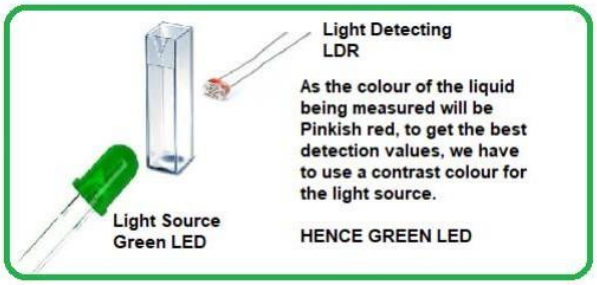


FIGURE04

EXPLAINS THE PRINCIPLE OF PROTOTYPE EQUIPMENT

In the current project, the color value is electronically calibrated with a light sensor and from the sensor value the concentration levels are calculated, if the concentration level exceeds the safe limit, the alarm will be raised. The block diagram of the equipment is shown in Figure 05

BLOCK DIAGRAM OF THE PROTOEQUIPMENT

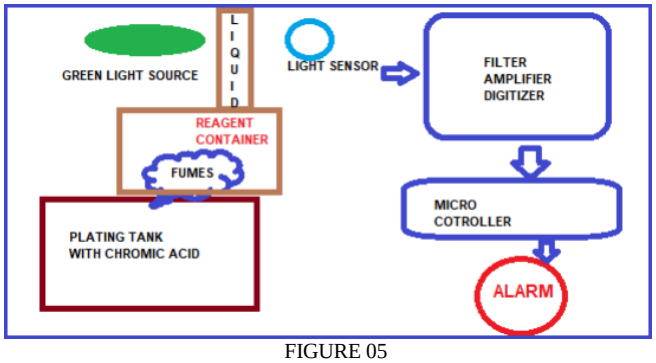


FIGURE 05

This system can be used in plating industries to detect the hexavalent Cr as shown in figure 06

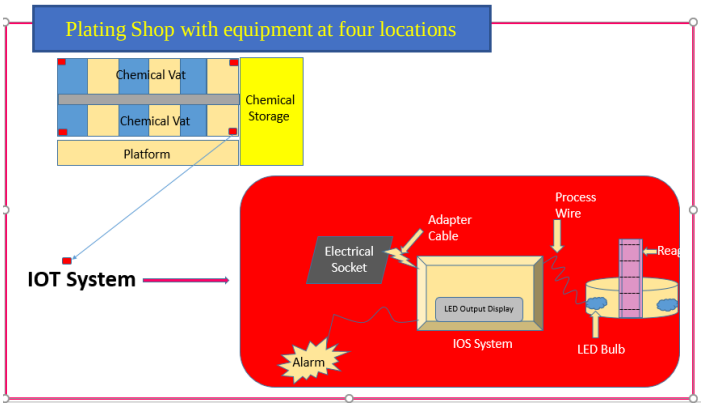
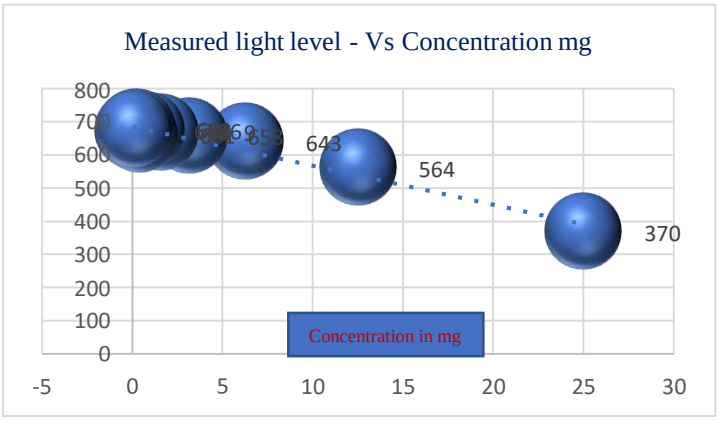


Figure 06

Introduction of newly developed protosystem in the plating shop

III. RESULTS

A prototype instrument was devised to carry out the experiment, and the given below are the results taken in the lab scale and the equipment was able to detect the concentration of hexavalent chromium and able to give alarm. The result obtained is depicted in the graph as shown in Figure 07. The light intensity observed is a inverse exponential function. The results can be captured continuously. In the newly developed system, instrument is able to capture at the first onset of any abnormal situations in the plating shop as there will be momentary increase in concentration of Cr(VI) vapors in air. A measurable change in light intensity level observed whereas in the existing system there will be certain time delay.



The system is able to detect a signal as low as 0.05 mg.

FIGURE 07

LIGHT LEVEL VS THE CONCENTRATION OF CHROMIC ACID

IV. DISCUSSION

The similar prototype equipment can be fixed in the work area for continuous monitoring the hexavalent chromium concentration in the work zone. This methodology appears to be cost effective for implementing from qualitative to quantitative with alarm detection system. A survey was conducted to find similar such chrome plating units in and around Chennai. We could find around 22 chrome plating units currently operating in Chennai. This system will be given to the societyfor simple detection of hexavalent chromium in the work zone and thereby enhancing health and safety of employees. The results of the alarm levels would be shared through messages to the supervisors, safety heads and plant in charges to enable swift necessary measures to control the abnormal condition.

V. CONCLUSION

The gaps in the existing system and the knowledge question has been put in place in the new system which is IOTbased. It has helped in continuous monitoring of air quality in the plating work zone, ensuring timely automated alarmsare sent to key people in the organization.
The project is useful for society since it helps employees feel more comfortable and safer in their work zone. It also helps ensure that air quality in neighborhoods surrounding these industries is also safe.

- The development of a Prototype Sensor System to continuously monitor the leakage of Chromic Acid can be implemented in the work zone
- It was able to capture the surge in Chromic acid concentration & collect digital data
- The digital data will be used to alert & enable immediate redressal of the problem if there are any abnormal situations
- The new method will enable communication of data via internet to designated personnel.
- The new method will enable capturing of Air Quality Data, round the clock.
- The new method is not person dependent
- The new method will be a path-breaking improvement in improving Environmental Quality & promoting Safety.
- The low-cost development will enable other like-minded industries to implement this and improve the Eco Balance.
- This Project is a small step toward creating Wealth without upsetting the Environment.

VI. FUTURE ACTION

1. TO WORK WITH TAMILNADU POLLUTION CONTROL BOARD AND MANDATE THE IMPLEMENTATION OF THIS ON-LINE, CONTINOUS, AUTOMATED, QUANTITATIVE MEASUREMENT SYSTEM FOR ALL PLATERS IN TAMILNADU.
2. TO IDENTIFY ATLEAST 3 ELECTROPLATERS WHO WILL ACCEPT TO IMPLEMENT THIS SYTEM IN THEIR WORKPLACE IMMEDIATELY

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IP Rings	Air Quality Monitoring in Workzone(Single Location)				Doc.No.:F/Lab/91 Issue No.:01
Date	**Shift**			**Observation**	**Remarks**
01.10.2021	A	B	C	No colour change	Air quality is within the specified limit
02.10.2021	Leave				
03.10.2021	Leave				
04.10.2021	*	B	C	No colour change	Air quality is within the specified limit
05.10.2021	A	B	C	No colour change	Air quality is within the specified limit
06.10.2021	A	B	C	No colour change	Air quality is within the specified limit
07.10.2021	A	B	C	No colour change	Air quality is within the specified limit
08.10.2021	A	B	C	No colour change	Air quality is within the specified limit
09.10.2021	A	B	C	No colour change	Air quality is within the specified limit
10.10.2021	Leave				
11.10.2021	*	B	C	No colour change	Air quality is within the specified limit
12.10.2021	A	B	C	No colour change	Air quality is within the specified limit
13.10.2021	A	B	C	No colour change	Air quality is within the specified limit
14.10.2021	Leave				
15.10.2021	*	B	C	No colour change	Air quality is within the specified limit
16.10.2021	A	B	C	No colour change	Air quality is within the specified limit
17.10.2021	Leave				
18.10.2021	*	B	C	No colour change	Air quality is within the specified limit
19.10.2021	A	B	C	No colour change	Air quality is within the specified limit
20.10.2021	A	B	C	No colour change	Air quality is within the specified limit
21.10.2021	A	B	C	No colour change	Air quality is within the specified limit
22.10.2021	A	B	C	No colour change	Air quality is within the specified limit
23.10.2021	A	B	C	No colour change	Air quality is within the specified limit
24.10.2021	Leave				
25.10.2021	*	B	C	No colour change	Air quality is within the specified limit
26.10.2021	A	B	C	No colour change	Air quality is within the specified limit
27.10.2021	A	B	C	No colour change	Air quality is within the specified limit
28.10.2021	A	B	C	colour changed in B shift	Due to impellor damage, scrubber failed to work. It is rectified within 4 hours. Production was stopped during correction work.
29.10.2021	A	B	C	No colour change	Air quality is within the specified limit
30.10.2021	A	B	C	No colour change	Air quality is within the specified limit
31.10.2021	Leave				
01.11.2021	*	B	C	No colour change	Air quality is within the specified limit
02.11.2021	A	B	C	No colour change	Air quality is within the specified limit
03.11.2021	A	B	C	No colour change	Air quality is within the specified limit
04.11.2021	Leave				
05.11.2021	*	B	C	No colour change	Air quality is within the specified limit
06.11.2021	A	B	C	No colour change	Air quality is within the specified limit
07.11.2021	Leave				
08.11.2021	*	B	C	No colour change	Air quality is within the specified limit
09.11.2021	A	B	C	No colour change	Air quality is within the specified limit
10.11.2021	A	B	C	No colour change	Air quality is within the specified limit
11.11.2021	A	B	C	No colour change	Air quality is within the specified limit
12.11.2021	A	B	C	No colour change	Air quality is within the specified limit
13.11.2021	A	B	C	No colour change	Air quality is within the specified limit
14.11.2021	Leave				
15.11.2021	*	B	C	No colour change	Air quality is within the specified limit
16.11.2021	A	B	C	No colour change	Air quality is within the specified limit
17.11.2021	A	B	C	No colour change	Air quality is within the specified limit
18.11.2021	A	B	C	No colour change	Air quality is within the specified limit
19.11.2021	A	B	C	No colour change	Air quality is within the specified limit
20.11.2021	A	B	C	No colour change	Air quality is within the specified limit
21.11.2021	Leave				
22.11.2021	*	B	C	No colour change	Air quality is within the specified limit

A	B	C	No colour change	Air quality is within the specified limit

Annexure 1

24.11.2021	A	B	C	No colour change	Air quality is within the specified limit
25.11.2021	A	B	C	No colour change	Air quality is within the specified limit
26.11.2021	A	B	C	No colour change	Air quality is within the specified limit
27.11.2021	A	B	C	No colour change	Air quality is within the specified limit
28.11.2021	Leave				
29.11.2021	*	B	C	No colour change	Air quality is within the specified limit
30.11.2021	A	B	C	No colour change	Air quality is within the specified limit
01.12.2021	A	B	C	No colour change	Air quality is within the specified limit
02.12.2021	A	B	C	colour changed in A shift	Due to suction duct damage, scrubber did not work effectively.
03.12.2021	A	B	C	No colour change	Air quality is within the specified limit
04.12.2021	A	B	C	No colour change	Air quality is within the specified limit
05.12.2021	Leave				
06.12.2021	*	B	C	No colour change	Air quality is within the specified limit
07.12.2021	A	B	C	No colour change	Air quality is within the specified limit
08.12.2021	A	B	C	No colour change	Air quality is within the specified limit
09.12.2021	A	B	C	No colour change	Air quality is within the specified limit
10.12.2021	A	B	C	No colour change	Air quality is within the specified limit
11.12.2021	A	B	C	No colour change	Air quality is within the specified limit
12.12.2021	Leave				
13.12.2021	*	B	C	No colour change	Air quality is within the specified limit
14.12.2021	A	B	C	No colour change	Air quality is within the specified limit
15.12.2021	A	B	C	No colour change	Air quality is within the specified limit
16.12.2021	A	B	C	No colour change	Air quality is within the specified limit
17.12.2021	A	B	C	No colour change	Air quality is within the specified limit
18.12.2021	A	B	C	No colour change	Air quality is within the specified limit
19.12.2021	Leave				
20.12.2021	*	B	C	No colour change	Air quality is within the specified limit
21.12.2021	A	B	C	No colour change	Air quality is within the specified limit
22.12.2021	A	B	C	No colour change	Air quality is within the specified limit
23.12.2021	A	B	C	No colour change	Air quality is within the specified limit
24.12.2021	A	B	C	No colour change	Air quality is within the specified limit
25.12.2021	A	B	C	No colour change	Air quality is within the specified limit
26.12.2021	Leave				
27.12.2021	*	B	C	No colour change	Air quality is within the specified limit
28.12.2021	A	B	C	No colour change	Air quality is within the specified limit
29.12.2021	A	B	C	No colour change	Air quality is within the specified limit
30.12.2021	A	B	C	No colour change	Air quality is within the specified limit
31.12.2021	A	B	C	No colour change	Air quality is within the specified limit
01.01.2022	A	B	C	No colour change	Air quality is within the specified limit
02.01.2022	Leave				
03.01.2022	*	B	C	No colour change	Air quality is within the specified limit
04.01.2022	A	B	C	colour changed in B shift	Due to motor bearing damage, scrubber did not work. It is rectified within an hour. Till that time, production was stopped
05.01.2022	A	B	C	No colour change	Air quality is within the specified limit
06.01.2022	A	B	C	No colour change	Air quality is within the specified limit
07.01.2022	A	B	C	No colour change	Air quality is within the specified limit
08.01.2022	A	B	C	No colour change	Air quality is within the specified limit
09.01.2022	Leave				
10.01.2022	*	B	C	No colour change	Air quality is within the specified limit
11.01.2022	A	B	C	No colour change	Air quality is within the specified limit
12.01.2022	A	B	C	No colour change	Air quality is within the specified limit
13.01.2022	A	B	C	No colour change	Air quality is within the specified limit
14.01.2022	Leave				
15.01.2022	Leave				
16.01.2022	Leave				
17.01.2022	*	B	C	No colour change	Air quality is within the specified limit
18.01.2022	A	B	C	No colour change	Air quality is within the specified limit

19.01.2022	A	B	C	No colour change	Air quality is within the specified limit
20.01.2022	A	B	C	No colour change	Air quality is within the specified limit
21.01.2022	A	B	C	No colour change	Air quality is within the specified limit
22.01.2022	A	B	C	No colour change	Air quality is within the specified limit
23.01.2022	Leave				
24.01.2022	*	B	C	No colour change	Air quality is within the specified limit
25.01.2022	A	B	C	No colour change	Air quality is within the specified limit
26.01.2022	Leave				
27.01.2022	A	B	C	No colour change	Air quality is within the specified limit
28.01.2022	A	B	C	No colour change	Air quality is within the specified limit
29.01.2022	A	B	C	No colour change	Air quality is within the specified limit
30.01.2022	Leave				
31.01.2022	*	B	C	No colour change	Air quality is within the specified limit
01.02.2022	A	B	C	No colour change	Air quality is within the specified limit
02.02.2022	A	B	C	No colour change	Air quality is within the specified limit
03.02.2022	A	B	C	No colour change	Air quality is within the specified limit
04.02.2022	A	B	C	No colour change	Air quality is within the specified limit
05.02.2022	A	B	C	No colour change	Air quality is within the specified limit
06.02.2022	Leave				
07.02.2022	*	B	C	No colour change	Air quality is within the specified limit
08.02.2022	A	B	C	No colour change	Air quality is within the specified limit
09.02.2022	A	B	C	No colour change	Air quality is within the specified limit
10.02.2022	A	B	C	No colour change	Air quality is within the specified limit
11.02.2022	A	B	C	No colour change	Air quality is within the specified limit
12.02.2022	A	B	C	No colour change	Air quality is within the specified limit
13.02.2022	Leave				
14.02.2022	*	B	C	No colour change	Air quality is within the specified limit
15.02.2022	A	B	C	No colour change	Air quality is within the specified limit
16.02.2022	A	B	C	No colour change	Air quality is within the specified limit
17.02.2022	A	B	C	No colour change	Air quality is within the specified limit
18.02.2022	A	B	C	No colour change	Air quality is within the specified limit
19.02.2022	A	B	C	No colour change	Air quality is within the specified limit
20.02.2022	Leave				
21.02.2022	*	B	C	No colour change	Air quality is within the specified limit
22.02.2022	A	B	C	No colour change	Air quality is within the specified limit
23.02.2022	A	B	C	No colour change	Air quality is within the specified limit
24.02.2022	A	B	C	No colour change	Air quality is within the specified limit
25.02.2022	A	B	C	No colour change	Air quality is within the specified limit
26.02.2022	A	B	C	No colour change	Air quality is within the specified limit
27.02.2022	Leave				
28.02.2022	*	B	C	No colour change	Air quality is within the specified limit
01.03.2022	A	B	C	No colour change	Air quality is within the specified limit
02.03.2022	A	B	C	No colour change	Air quality is within the specified limit
03.03.2022	A	B	C	No colour change	Air quality is within the specified limit
04.03.2022	A	B	C	No colour change	Air quality is within the specified limit
05.03.2022	A	B	C	No colour change	Air quality is within the specified limit
06.03.2022	Leave				
07.03.2022	*	B	C	No colour change	Air quality is within the specified limit
08.03.2022	A	B	C	No colour change	Air quality is within the specified limit
09.03.2022	A	B	C	No colour change	Air quality is within the specified limit
10.03.2022	A	B	C	No colour change	Air quality is within the specified limit
11.03.2022	A	B	C	No colour change	Air quality is within the specified limit
12.03.2022	A	B	C	No colour change	Air quality is within the specified limit
13.03.2022	Leave				
14.03.2022	*	B	C	No colour change	Air quality is within the specified limit
15.03.2022	A	B	C	No colour change	Air quality is within the specified limit
16.03.2022	A	B	C	No colour change	Air quality is within the specified limit
17.03.2022	A	B	C	No colour change	Air quality is within the specified limit
18.03.2022	A	B	C	No colour change	Air quality is within the specified limit
19.03.2022	A	B	C	No colour change	Air quality is within the specified limit
20.03.2022	Leave				

21.03.2022	*	B	C	No colour change	Air quality is within the specified limit
22.03.2022	A	B	C	No colour change	Air quality is within the specified limit
23.03.2022	A	B	C	No colour change	Air quality is within the specified limit
24.03.2022	A	B	C	No colour change	Air quality is within the specified limit
25.03.2022	A	B	C	No colour change	Air quality is within the specified limit
26.03.2022	A	B	C	No colour change	Air quality is within the specified limit
27.03.2022	Leave				
28.03.2022	A	B	C	No colour change	Air quality is within the specified limit
29.03.2022	A	B	C	No colour change	Air quality is within the specified limit
30.03.2022	A	B	C	No colour change	Air quality is within the specified limit
31.03.2022	A	B	C	No colour change	Air quality is within the specified limit
01.04.2022	A	B	C	No colour change	Air quality is within the specified limit
02.04.2022	A	B	C	No colour change	Air quality is within the specified limit
03.04.2022	Leave				
04.04.2022	*	B	C	No colour change	Air quality is within the specified limit
05.04.2022	A	B	C	No colour change	Air quality is within the specified limit
06.04.2022	A	B	C	No colour change	Air quality is within the specified limit
07.04.2022	A	B	C	No colour change	Air quality is within the specified limit
08.04.2022	A	B	C	No colour change	Air quality is within the specified limit
09.04.2022	A	B	C	No colour change	Air quality is within the specified limit
10.04.2022	Leave				
11.04.2022	*	B	C	No colour change	Air quality is within the specified limit
12.04.2022	A	B	C	No colour change	Air quality is within the specified limit
13.04.2022	A	B	C	No colour change	Air quality is within the specified limit
14.04.2022	Leave				
15.04.2022	*	B	C	No colour change	Air quality is within the specified limit
16.04.2022	A	B	C	No colour change	Air quality is within the specified limit
17.04.2022	Leave				
18.04.2022	*	B	C	No colour change	Air quality is within the specified limit
19.04.2022	A	B	C	No colour change	Air quality is within the specified limit
20.04.2022	A	B	C	No colour change	Air quality is within the specified limit
21.04.2022	A	B	C	No colour change	Air quality is within the specified limit
22.04.2022	A	B	C	No colour change	Air quality is within the specified limit
23.04.2022	A	B	C	No colour change	Air quality is within the specified limit
24.04.2022	Leave				
25.04.2022	*	B	C	No colour change	Air quality is within the specified limit
26.04.2022	A	B	C	No colour change	Air quality is within the specified limit
27.04.2022	A	B	C	No colour change	Air quality is within the specified limit
28.04.2022	A	B	C	No colour change	Air quality is within the specified limit
29.04.2022	A	B	C	No colour change	Air quality is within the specified limit
30.04.2022	A	B	C	No colour change	Air quality is within the specified limit
01.05.2022	Leave				
02.05.2022	*	B	C	No colour change	Air quality is within the specified limit
03.05.2022	A	B	C	No colour change	Air quality is within the specified limit
04.05.2022	A	B	C	No colour change	Air quality is within the specified limit
05.05.2022	A	B	C	No colour change	Air quality is within the specified limit
06.05.2022	A	B	C	No colour change	Air quality is within the specified limit
07.05.2022	A	B	C	No colour change	Air quality is within the specified limit
08.05.2022	Leave				
09.05.2022	*	B	C	No colour change	Air quality is within the specified limit
10.05.2022	A	B	C	No colour change	Air quality is within the specified limit
11.05.2022	A	B	C	No colour change	Air quality is within the specified limit
12.05.2022	A	B	C	No colour change	Air quality is within the specified limit
13.05.2022	A	B	C	No colour change	Air quality is within the specified limit
14.05.2022	A	B	C	No colour change	Air quality is within the specified limit
15.05.2022	Leave				
16.05.2022	*	B	C	No colour change	Air quality is within the specified limit
17.05.2022	A	B	C	No colour change	Air quality is within the specified limit
18.05.2022	A	B	C	No colour change	Air quality is within the specified limit
19.05.2022	A	B	C	No colour change	Air quality is within the specified limit

20.05.2022	A	B	C	No colour change	Air quality is within the specified limit
21.05.2022	A	B	C	No colour change	Air quality is within the specified limit
22.05.2022	Leave				
23.05.2022	*	B	C	No colour change	Air quality is within the specified limit
24.05.2022	A	B	C	No colour change	Air quality is within the specified limit
25.05.2022	A	B	C	No colour change	Air quality is within the specified limit
26.05.2022	A	B	C	No colour change	Air quality is within the specified limit
27.05.2022	A	B	C	No colour change	Air quality is within the specified limit
28.05.2022	A	B	C	No colour change	Air quality is within the specified limit
29.05.2022	Leave				
30.05.2022	*	B	C	No colour change	Air quality is within the specified limit
31.05.2022	A	B	C	No colour change	Air quality is within the specified limit
01.06.2022	A	B	C	No colour change	Air quality is within the specified limit
02.06.2022	A	B	C	No colour change	Air quality is within the specified limit
03.06.2022	A	B	C	No colour change	Air quality is within the specified limit
04.06.2022	A	B	C	No colour change	Air quality is within the specified limit
05.06.2022	Leave				
06.06.2022	*	B	C	No colour change	Air quality is within the specified limit
07.06.2022	A	B	C	No colour change	Air quality is within the specified limit
08.06.2022	A	B	C	No colour change	Air quality is within the specified limit
09.06.2022	A	B	C	No colour change	Air quality is within the specified limit
10.06.2022	A	B	C	No colour change	Air quality is within the specified limit
11.06.2022	A	B	C	No colour change	Air quality is within the specified limit
12.06.2022	Leave				
13.06.2022	*	B	C	No colour change	Air quality is within the specified limit
14.06.2022	A	B	C	No colour change	Air quality is within the specified limit
15.06.2022	A	B	C	No colour change	Air quality is within the specified limit
16.06.2022	A	B	C	No colour change	Air quality is within the specified limit
17.06.2022	A	B	C	No colour change	Air quality is within the specified limit
18.06.2022	A	B	C	No colour change	Air quality is within the specified limit
19.06.2022	Leave				
20.06.2022	*	B	C	No colour change	Air quality is within the specified limit
21.06.2022	A	B	C	No colour change	Air quality is within the specified limit
22.06.2022	A	B	C	No colour change	Air quality is within the specified limit
23.06.2022	A	B	C	No colour change	Air quality is within the specified limit
24.06.2022	A	B	C	No colour change	Air quality is within the specified limit
25.06.2022	A	B	C	No colour change	Air quality is within the specified limit
26.06.2022	Leave				
27.06.2022	*	B	C	No colour change	Air quality is within the specified limit
28.06.2022	A	B	C	No colour change	Air quality is within the specified limit
29.06.2022	A	B	C	No colour change	Air quality is within the specified limit
30.06.2022	A	B	C	No colour change	Air quality is within the specified limit
01.07.2022	A	B	C	No colour change	Air quality is within the specified limit
02.07.2022	A	B	C	No colour change	Air quality is within the specified limit
03.07.2022	Leave				
04.07.2022	*	B	C	No colour change	Air quality is within the specified limit
05.07.2022	A	B	C	No colour change	Air quality is within the specified limit
06.07.2022	A	B	C	No colour change	Air quality is within the specified limit
07.07.2022	A	B	C	No colour change	Air quality is within the specified limit
08.07.2022	A	B	C	No colour change	Air quality is within the specified limit
09.07.2022	A	B	C	No colour change	Air quality is within the specified limit
10.07.2022	Leave				
11.07.2022	*	B	C	No colour change	Air quality is within the specified limit
12.07.2022	A	B	C	No colour change	Air quality is within the specified limit
13.07.2022	A	B	C	No colour change	Air quality is within the specified limit
14.07.2022	A	B	C	No colour change	Air quality is within the specified limit
15.07.2022	A	B	C	No colour change	Air quality is within the specified limit
16.07.2022	A	B	C	No colour change	Air quality is within the specified limit
17.07.2022	Leave				
18.07.2022	*	B	C	No colour change	Air quality is within the specified limit
19.07.2022	A	B	C	No colour change	Air quality is within the specified limit

20.07.2022	A	B	C	No colour change	Air quality is within the specified limit
21.07.2022	A	B	C	No colour change	Air quality is within the specified limit
22.07.2022	A	B	C	No colour change	Air quality is within the specified limit
23.07.2022	A	B	C	No colour change	Air quality is within the specified limit
24.07.2022	Leave				
25.07.2022	*	B	C	No colour change	Air quality is within the specified limit
26.07.2022	A	B	C	No colour change	Air quality is within the specified limit
27.07.2022	A	B	C	No colour change	Air quality is within the specified limit
28.07.2022	A	B	C	No colour change	Air quality is within the specified limit
29.07.2022	A	B	C	No colour change	Air quality is within the specified limit
30.07.2022	A	B	C	No colour change	Air quality is within the specified limit
31.07.2022	Leave				
01.08.2022	*	B	C	No colour change	Air quality is within the specified limit
02.08.2022	A	B	C	No colour change	Air quality is within the specified limit
03.08.2022	A	B	C	No colour change	Air quality is within the specified limit
04.08.2022	A	B	C	No colour change	Air quality is within the specified limit
05.08.2022	A	B	C	No colour change	Air quality is within the specified limit
06.08.2022	A	B	C	No colour change	Air quality is within the specified limit
07.08.2022	Leave				
08.08.2022	*	B	C	No colour change	Air quality is within the specified limit
09.08.2022	A	B	C	No colour change	Air quality is within the specified limit
10.08.2022	A	B	C	No colour change	Air quality is within the specified limit
11.08.2022	A	B	C	No colour change	Air quality is within the specified limit
12.08.2022	A	B	C	No colour change	Air quality is within the specified limit
13.08.2022	A	B	C	No colour change	Air quality is within the specified limit
14.08.2022	Leave				
15.08.2022	Leave				
16.08.2022	*	B	C	No colour change	Air quality is within the specified limit
17.08.2022	A	B	C	No colour change	Air quality is within the specified limit
18.08.2022	A	B	C	No colour change	Air quality is within the specified limit
19.08.2022	A	B	C	No colour change	Air quality is within the specified limit
20.08.2022	A	B	C	No colour change	Air quality is within the specified limit
21.08.2022	Leave				
22.08.2022	*	B	C	No colour change	Air quality is within the specified limit
23.08.2022	A	B	C	No colour change	Air quality is within the specified limit
24.08.2022	A	B	C	No colour change	Air quality is within the specified limit
25.08.2022	A	B	C	No colour change	Air quality is within the specified limit
26.08.2022	A	B	C	No colour change	Air quality is within the specified limit
27.08.2022	A	B	C	No colour change	Air quality is within the specified limit
28.08.2022	Leave				
29.08.2022	*	B	C	No colour change	Air quality is within the specified limit
30.08.2022	Leave				
31.08.2022	Leave				
01.09.2022	*	B	C	No colour change	Air quality is within the specified limit
02.09.2022	A	B	C	No colour change	Air quality is within the specified limit
03.09.2022	A	B	C	No colour change	Air quality is within the specified limit

Note: * - Plant Maintenance activity will be carried out during start up like Anode cleaning, Tank cleaning etc.,

Annexure 2

Air Quality Monitoring in Workzone (Multiple Location)					
Date	**Shift**			**Observation**	**Kit Location**
16.8.2022	A	B	C	Colour change in 'C' shift	East
17.8.2022	A	B	C	No colour change	-
18.8.2022	A	B	C	No colour change	South East
19.8.2022	A	B	C	No colour change	-
20.8.2022	A	B	C	No colour change	North
21.8.2022	Sunday				
22.8.2022	*	B	C	No colour change	South East
23.8.2022	A	B	C	No colour change	-
24.8.2022	A	B	C	Colour change in 'B' shift	-
25.8.2022	A	B	C	No colour change	South
26.8.2022	A	B	C	No colour change	South

* - Plant Maintenance activity will be carried out during start up like Anode cleaning, Tank cleaning etc.,

Annexure 3

CHROME PLATING SHOP ASSESSMENT

A primary assessment was conducted in the plating shops highlighted and observed the air quality monitoring is with similar kind of manual kit . Because of the confidentiality of the process and sensitivity in meeting the statutory norms ,the visit was restricted to three units

1	SHREE RAANN HARD CHROME	C-42, SSIOA, Vanagaram-Ambattur Rd, Athipet, Natesan Nagar, Industrial Estate, Chennai, 600058	
2	GNANAM HARD CHROME INDUSTRIES	11-A, Vanagaram Road, Vanagaram Road, Chennai, Tamil Nadu 600058	
3	SOUTHERN CHROME PLATERS	323, Triplicane High Rd, Ellis Puram, Padupakkam, Triplicane, Chennai, Tamil Nadu 600005	
4	IP RINGS LTD	D11/12, Industrial Estate, Maraimalai Nagar, Tamil Nadu 603209	Qualitative detection only
5	INDIA PISTONS LTD	Huzur Gardens, Simpsons Sembiyam Estate, Sembiyam, Perambur, Chennai, Tamil Nadu 600011	Qualitative detection only
6	SUNRISE ELECTRO PLATERS	No 246, 10th Street, SIDCO Industrial Estate,, Pattaravakkam, Chennai, Tamil Nadu 600098	
7	SURYA HARD CHROME	Shop No. 96, Sidco Industrial Estate, Ambattur, Chennai, Tamil Nadu 600098	
8	SUPER PLATERS	399AA, 13TH STREET, AAVIN DAIRY ROAD, NORTHERN AVENUE ROAD, Chennai, Tamil Nadu 600098	Qualitative detection only
9	MECK ENGINEERING SERVICES	Old No. 247/3, New, No. 11/a, PKM Rd, Athipet, Ambattur, Chennai, Tamil Nadu 600058	
10	KWALITY ELECTRO PLATERS	13th Main Rd, Industrial Estate, Thirumudivakkam, Tamil Nadu 602109	
11	PNG METAL FINISHERS	5, Kamaraj 10th Street, Vanchi Nagar, Sidco Industrial Estate, Ambattur Industrial Estate, Chennai, Tamil Nadu 600098	
12	MADRAS ELECTRO PLATERS	SHED NO: 112, 13Th main road, SIDCO INDUSTRIAL ESTATE, THIRUMUDIVAKKAM, Chennai, Tamil Nadu 600044	
13	SUPERIOR INDUSTRIAL ENGINEERING	NO.54, PHASE V, SIDCO, Kakkalur Industrial Estate, Thiruvallur, Tamil Nadu 602003	
14	SAI INDUSTRIES	1/93, Mangadu Rd, Mangala Nagar, Paraniputhur, Iyyappanthangal, Chennai, Tamil Nadu 600122	
15	SR PLATING	24, Gandhi St, Guduvancheri, Tamil Nadu 603202	
16	JAYAM HARDCHROME INDUSTRIES	NO.20/232, Nageswara Rao Road, Ambattur, Athipet, Periya Colony, Chennai, Tamil Nadu 600058	
17	METCHEM INDUSTRIES	86E, second Main Road Ambattur Industrial Estate, Chennai, Tamil Nadu 600058	
18	PLATE METALS PRIVATE LIMITED	165, 161, SH 49, Pandian Nagar, Vettuvankeni, Chennai, Tamil Nadu 600041	
19	SHINE INTERNATIONALS	Thandalam, Tamil Nadu 600069	
20	SURTECH ENGG PVT LTD	No.95, 5 TH STREET, 3 RD LANE, Godrej Rd, Pattravakkam, Ambattur, Chennai, Tamil Nadu 600098	
21	EVERSHINE ELECTRO PLATING	7/1A , Abdul Kalam Road Light Leather Ground, 44th St, Nagalkeni, Chromepet, Chennai, Tamil Nadu 600044	
22	BALAJI ELECTRO PLATING WORKS	9, W Mada St, Tiruvottiyur, Chennai, Tamil Nadu 600019	