BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL
SOUTHERN ZONE BENCH, CHENNAI

Original Application No. 71 of 2021 (SZ)

IN THE MATTER OF
Tribunal on its own motion-SUO MOTU based on the News items in The New Indian Express Newspaper, dated 10.02.2021, "Oil leak from titanium factory hits Thiruvananthapuram coast, public barred from affected stretch"

...Applicant

Versus

The Chief Secretary, Govt. of Kerala & Others ... Respondents

INDEX

Place: Bengaluru
Date: February 18th, 2022

S. Suresh 18/2/2022
(S Suresh)

Counsel for CPCB

S. SURESH
REGIONAL DIRECTOR
CENTRAL POLLUTION CONTROL BOARD
REGIONAL DIRECTORATE (SOUTH)
MIN. OF ENV, FORESTS & CC, GOVT. OF INDIA
BENGALURU - 560 079. MOB : 9480672128

JOINT COMMITTEE REPORT SUBMITTED BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL, SOUTHERN ZONE, CHENNAI IN THE MATTER OF O.A. NO. 71/2021 - TRIBUNAL ON ITS OWN MOTION-SUO MOTU BASED ON THE NEWS ITEMS ON OIL LEAK INTO SEASHORE FROM M/S. TRAVANCORE TITANIUM (P) LTD.

1.0 Preamble:

The Hon'ble NGT moved an application on its own taking SUO MOTU cognizance, based on the News items in The New Indian Express Newspaper, dated 10.02.2021, "Oil leak from titanium factory hits Thiruvananthapuram coast, public barred from affected stretch" and News item in the Hindu, dated: 10.02.2021, "Furnace oil from Titanium Factory spills into sea" and News item in Mathrubhumi, English Edition Dt. 10.02.2021, "Glass furnace pipe bursts at Titanium factory in TVM, oil leaked to sea"

While hearing the matter on 17.02.2021, Hon'ble NGT had issued the following directions:

> *"……In order to ascertain the real nature of issue and damage caused to the environment, we feel it appropriate to appoint a Joint Committee comprising of (1) The District Collector, Thiruvanthapuram District, (2) a Senior Scientist from Kerala State Pollution Control Board (KSPCB), (3) a Senior Officer from Tamil Nadu Coastal Zone Management Authority (TNCZMA) (4) a Senior Scientist from Central Pollution Control Board (CPCB), Regional Office, Bangalore and (5) a Senior Scientist from5 National Institute of Ocean Technology (NIOT), Chennai to inspect the are in question and submit a factual as well asaction taken report including imposition of environmental compensation and the remedial measures for restoring the damage caused to marine ecology and the extent of oil spill in the sea, the nature of damage caused to the aquatic and marine life and the remedial measures to restore the same to its original position and also to assess the environmental compensation, if there is any violation*

found in carrying out the operation by the 10th respondent and whether they are having all safety measures and complying with the conditions imposed in the permissions and consent that has been obtained for this purpose and whether proper maintenance is being done by them and if further improvement is required, suggest the improvement which they will have to carry out for the purpose for avoiding such things happening in future."

Since CPCB, Regional Directorate was identified as the Nodal agency by the Tribunal, in compliance to the directions as above, CPCB, R.D, Bengaluru vide letterNo. F.Tech39/Legal/RDS/2020-21 dated 02/03/2021 requested the concerned Departments/Authorities to nominate senior officials to the Committee for the completion of the task as directed by the Hon'ble Tribunal.

The Hon'ble Tribunal further reconstituted the Joint Committee by order dated 09.07.2021 as per the memo filed by CPCB to resolve the administrative constraints by replacing Tamil Nadu CZMA with Kerala CZMA and instructed the office of the District collector for nominating concerned official at the earliest. Accordingly nominations were again sought from the remaining members and the Joint Committee was constituted and further actions were planned.

2.0 Site visit by the Joint Committee:

Upon the receipt of nominations from all the members of the Joint Committee, site visit at M/s. Travancore Titanium Products Ltd. (TTPL) and premises was planned and completed at shortest possible time on 15.07.2021. The following members of the Committee were present during the visit;

1. Sh. Suneel Pamidi, IFS, Director DoECC & Member Secretary, KCZMA
2. Sh. Kiran. A. S Scientist E, NIOT, Chennai (representing Dr. (Smt.) Vijaya Ravichandran, Scientist G, NIOT)

3. Sh. P. K. Baburajan, CEE, KSPCB, Thiruvananthapuram
4. Sh. Vineeth T. K, Dy. Collector (Disaster Management), Thiruvanathapuram
5. Sh. Vivek. K, Scientist D/SEE, CPCB, RD, Bengaluru

Additionally, Sh. S Shaji, Tahasildar, Thiruvananthapuram was also present during the visit as part of district administration.

The concerned officials of M/s. TTPL were also present during the visit as under;

1. Sh. George Ninan – Managing Director
2. Sh. P Pradeep Kumar – General Manager (T)
3. Sh. S. Perumal – DGM (P)
4. Sh. R Vinod – HoD (S&E)

The Joint Committee members had detailed deliberations on the oil leakage incident, causes and impact on surrounding environment, preventive actions taken after the incident and on-going actions by other agencies and departments. The Committee members also conducted a detailed inspection of the plant, furnace oil storage section, drains through which the oil leak reached the seashore etc.

The Joint Committee members also visited the confluence of the drain reaching the seashore, through which leaked furnace oil had reached the sea and collected sea shore soil samples (03 locations) and water samples from the drain and coast and the same was handed to KSPCB Central Laboratory, Cochin for required analysis. The TTPL representatives were also requested to provide additional information and documents, including previous EIA study report etc. for the preparation of a detailed report, as desired by the Hon'ble Tribunal. The list attendees of the site visit is placed at **Annexure 1.**

The soil and water samples collected by the Committee were handed over to Kerala SPCB for the analysis of relevant parameters. The analysis of the samples took more time than expected, due to the renovation works which were going on at the Central Lab, KSPCB, Ernakulam. The analysis of the samples were completed finally through a

third party private laboratory and on receipt of the results, the Joint Committee had another meeting on **20.09.2021** to discuss and analyse the results. After the discussions, it was decided by the Committee that a few reference soil samples from little far away distances shall also be collected and analysed for oil & grease parameter so as to correlate with the earlier results. Accordingly, KSPCB was requested to carry out the reference sampling and the same was completed by KSPCB on **18.10.2021.**The analysis of the samples collected at four (**04**) locations were completed by the Central Laboratory, KSPCB and results were provided to the Committee. The details of the site visit and the discussions and inferences of the Joint Committee including the analysis results are given in the following sections.

3.1 Back ground on M/s. Travancore Titanium Products Limited (TTPL):

M/s. TTPL is a public sector company (PSU) under the ownership of State Government of Kerala and established in the year 1946. The production commenced in the year 1952 at a rate of 5 Tonnes per day of Titanium dioxide from ilmenite ore (ilmenite is the titanium-iron oxide mineral) through sulphate process using sulphuric acid. At present, as per the consent issued in the year 2018 by KSPCB, the unit is consented to produce 45 TPD of Anatase grade Titanium dioxide. The major source of water for the unit is tube wells (2 nos.), water supplied by Kerala Water Authority (KWA) and natural canal. The unit consumes approximately 6 MLD of water per day for process, cooling and domestic purpose and generates approximately 3.5 MLD of effluent. Unit has installed an ETP consisting Neutralisation plant, Micro filtration cum Reverse Osmosis plant etc. for recycle of the effluent back in the plant. As per the Consent order issued, unit is still having permission to discharge some part of the treated effluent into sea. Copy of the consent order is placed at **Annexure 1 A.**

CPCB had earlier issued closure direction under section 5 of E (P) Act, 1986 to the unit on May 18, 2017, based on the observations & recommendations made by the inspecting team of CPCB on the inadequacy of effluent treatment system during a public complaint investigation. The directions were temporarily stayed by the Hon'ble

High Court of Kerala and subsequently CPCB had revoked the closure directions, after verifying the compliance status and the action taken report by the unit.

3.2 Details of Oil Spillage incident:

As per the information and records made available, the furnace oil spillage from the unit happened on 10.02.2021 at about 7.40am due to a breakage in the oil pipe line. The furnace oil is pumped from the storage tank, located outside the plant premises, to the boiler in the plant through a pipeline and some part of the pipeline is passing as overhead line within the plant. A leakage happened in the overhead line and the leaked oil reached the underneath drain within the plant, which ultimately meets the drain outside the unit leading to seashore. As per the unit representatives, the leakage was stopped before long, on notice, however till that time, approximately 4750 litres of furnace oil leaked into the internal drains and to the effluent drains and some quantity had spread to the sea shore. The records indicate that approximately 2500 litres of oil were collected from the internal drains of the company and the rest of the quantity had reached to the sea shore.

During the site visit, the Committee members inspected the unit premises including the furnace oil tanks, internal drains, the outside drain reaching the seashore. The internal drains appeared to be cleared of oil spillages. The outside drain connecting to the seashore is passing through a coconut field (acquired by the unit) and traversing below coastal road through culverts, before reaching the seashore. The total distance of the outside drain and the sea shore channel is appropriately 150m. It was observed that the drains has been physically blocked by constructing a temporary wall just after the culvert, before joining the sea shore. A small stream of water was found flowing at this point. The Committee collected samples of this stream, as well as water sample from the sea shore. Further sand samples were collected from the seashore, at the confluence of the drain joining seashore and both North and South side of the confluence point. The relevant photographs taken during the visit are placed at **Annexure 2**. As already detailed above, KSPCB had collected few reference samples

afterwards on **18.10.2021**, as desired by the Committee. The analysis results of the samples collected during the Committee visit and afterwards by KSPCB are depicted below.

a. Water sample results – collected on 15.07.2021

S. No	Name of the Parameter with unit	Sampling locations	
		04 (Stream from drain)	**03 (Sea Water sample)**
1.	pH	6.8	6.7
2.	TSS, mg/L	60.1	92
3.	Acidity, mg/L	256	16
4.	Oil & Grease, mg/L	BDL	BDL
5.	Hexavalent Chromium, mg/L	BDL	BDL
6.	Total Chromium, mg/L	BDL	BDL
7.	Copper, mg/L	BDL	BDL
8.	Cadmium, mg/L	BDL	BDL
9.	Iron, mg/L	3.52	0.27
10.	Manganese, mg/L	0.23	0.06
11.	Nickel, mg/L	BDL	BDL
12.	Lead ,mg/L	BDL	BDL
13.	Zinc, mg/L	0.04	0.07
14.	Arsenic, mg/L	BDL	BDL
15.	Titanium, mg/L	0.02	BDL
16.	Vanadium, mg/L	BDL	BDL

b. Soil sample results - collected on 15.07.2021

S. No	Name of the Parameter with unit	Sampling locations		
		01 (Sediment sample from South side of confluence)	**02 (Sediment sample from confluence)**	**03 (Sediment sample from South side of confluence)**

1.	Oil & Grease, ppm	**135.88**	**154.66**	**180.05**
2.	Hexavalent Chromium, mg/Kg	BDL	BDL	BDL
3.	Total Chromium, mg/Kg	10.8	33.6	20.0
4.	Copper, mg/Kg	3.0	4.4	4.2
5.	Cadmium, mg/Kg	BDL	BDL	BDL
6.	Iron, mg/Kg	**3110.0**	**6220.0**	**4140.0**
7.	Manganese, mg/Kg	7.2	14.2	11.0
8.	Nickel, mg/Kg	BDL	BDL	BDL
9.	Lead , mg/Kg	2.4	13.6	7.0
10.	Zinc, mg/Kg	22.4	5.4	3.6
11.	Arsenic, mg/Kg	BDL	BDL	BDL
12.	Titanium, mg/Kg	**176.4**	**493.0**	**369**
13.	Vanadium, mg/Kg	9.8	19.0	13.2

c. Soil sample results – collected on 18.10.2021

S. No	**Name of the Parameter with unit**	**Sampling locations**			
		SD 01 (Sediment sample, 0.5 km from confluence towards South)	**SD 02 (Sediment sample, 1.0 km from confluence towards South)**	**SD 03 (Sediment sample, 0.5 km from confluence towards North)**	**SD 04 (Sediment sample, 1.0 km from confluence towards North)**
1.	Oil & Grease, mg/Kg	66.9	15.1	12.5	7.7

3.3 Inferences on analysis results:

- The water samples collected during the visit does not contain traces of oil & grease.

- The soil samples collected on 15.07.2021, immediately at the confluence and nearby locations to the South and North sides indicate traces of Oil & Grease content, which might have been percolated due to the porous nature of sand. The soil samples also contain relatively higher values of Heavy metals such as Iron, Titanium etc. which can be attributed to the historical effluent discharge practise, as these elements are expected in the effluent generated by the unit.
- The soil samples collected on 18.10.2021, at little far away distances from the confluence of the channel to sea shore, one km towards the South and North sides also indicate traces of Oil & Grease content, lesser than the confluence points. It indicates that some oil content have been brought back to the shore by the tidal waves and might have percolated in the sand.

Copy of the analysis results are attached as **Annexure 3**.

4.0 Impact of the incident on surrounding environment:

The general impacts of the leakage/spillage of oil waste in shoreline or coast is expected due to interactions with sediments such as beach sand and gravel, rocks and boulders, vegetation, and terrestrial habitats. Beach sand and gravel contaminated with oil may be unable to protect and nurture normal vegetation and populations of the substrate biomass. Waves, water currents, and wind move the oil onto shore with the surf and tide. Oil spills, if reaching deep sea also present the potential for harm to deep sea and coastal fishing and fisheries. The immediate effects of oil waste contamination may be mass mortality and contamination of fish and other food species. Commercial fishing enterprises may also be affected permanently.

The expected hazards for aquatic/marine life include toxic effects of exposure or ingestion, injuries such as smothering and deterioration of thermal insulation, and damage to their reproductive systems and behaviours. Oil waste may also contaminate the sensitive marine and coastal organic substrate, interrupting the food chain on which fish and sea creatures depend, and on which their reproductive

success is based. Long-term ecological effects that contaminate or destroy the marine organic substrate and thereby interrupt the food chain are also harmful to the wildlife, so species populations may change or disappear.

Another expected impact of such incidents are on recreational activities. Coastal areas are usually thickly populated and attract many recreational activities and related facilities that have been developed for fishing, boating, swimming, nature parks and preserves, beaches etc. and other resident and tourist attractions. Oil waste that invades and pollutes these areas and negatively affects human activities can have devastating and long-term effects on the local economy and society.

The furnace oil leaked from M/s. TTPL can be largely categorised as Group 3: Medium Oils (Most Crude Oils, IFO 180) (Ref – Reports by National Oceanic and Atmospheric Administration, US Department of Commerce). As per this categorization, such oil spillages generally exhibits;

- About one-third will evaporate within 24 hours.
- Oil contamination of intertidal areas can be severe and long-term.
- Oil impacts to waterfowl and fur-bearing mammals can be severe.
- Cleanup is most effective if conducted quickly.

In the instant case of oil spillage from M/s. TTPL, the quantity of oil which spilled into the sea shore is considerably less and hence might not lead to much long term impact on the coastal environment. A copy of the report from the Indian Coast Guard Assistant Commandant Station Ops Officer dated 11.02.2021, next day of the incident, indicates that as per the extensive monitoring carried out by Indian Coast Guard vessels at far & close coast proximities, traces of oil were not observed in the sea. It has to be inferred that the spread of furnace oil was majorly limited to the sea shore and much impact on the marine life is not expected. The coast guard report also indicates that Shore/beach cleaning and removal of contaminated sand was in progress during that time. Copy of the report from coast guard is placed at **Annexure 4.**

As far as the impact of lively hood of local fishermen is concerned, it was informed to the Committee that an advisory was issued to the local fisherman by District Administration, not to carry out fishing for two days, immediately after the incident. As per the records available with local administration, fish kill or other immediate impact on the aquatic species were not observed or reported due to the incident.

The oil leakage had resulted in the formation and appearance of oil slurries in the sea shore, extending to few kilometres from the discharge channel and reportedly, the oil slurry and contaminated sand were removed from the sea shore on the next few days the incident and as and when on its appearance, afterwards. However, long term effect on the recreational activities and related facilities of the nearby coastal areas is not reported.

The KSPCB had also carried out some sampling of the bore wells in the vicinity of the plant and seashore during April, 2021 and the reports does not indicate oil contamination in the ground water. However the analysis results of the sea shore samples, collected by the Committee and afterwards by KSPCB, detailed in previous para, indicates the presence of oil & grease particles in the sea shore, even at **1 km** distance from the channel through which oil leakage reached the sea shore. The porous nature of the soil shall result in the capture of some quantity of oil particle, which have not yet evaporated out to the atmosphere.

4.1 Actions taken by the unit and other local authorities after the incident:

As per the records and information available, some immediate actions were initiated by the unit and in coordination with the local govt. authorities. The internal drain from the unit was blocked to contain further flow of furnace oil to outside drain. The concerned officers from KSPCB, District administration, Fire and Rescue Department, Indian Coast Guard etc visited the site immediately and coordinated for the immediate clean up measures. As informed to the Committee, the shore cleanup activities and removal of oil contaminated sand was initiated on the next day only, as there was

protests from the local fishermen and residents regarding the impact of the incident. It is reported that, a preliminary inquiry revealed that oil spread extended up to 'Thumba' (approximately 4.5 km stretch) from the discharge channel near the unit.

As per the records, soil from the seashore, contaminated with the leaked oil to the tune of **22.27 MT** has been recovered and sent to the TSDF (Treatment, Storage and Disposal facility) located at Kochi for disposal through landfill. As per the analysis report of the contaminated soil, the oil content in the transported contaminated soil is 4.67% by weight, which indicates that approximately 01 tonne of oil has been removed. Further the furnace oil collected from the internal drains of the unit has been sent to the authorised used oil recycler. The amount of oil transported is 2.5 KL approximately, as per HW manifest. The manifests for the transportation of the recovered oil and contaminated sand was verified and copies are attached as **Annexure 5**.

During the visit of the Committee, it was observed that the unit has replaced the pipeline used for transportation of the furnace oil from the storage tank to the boiler. However some of the other recommendations, made by the Committee constituted by the Government of Kerala under the chairmanship of the Principal Secretary, Industries Department and other concerned members are yet to be fully implemented by the unit. It was informed by the unit that the same is in process and shall be completed.

The details of all the actions initiated by the concerned State Government departments including KSPCB has already been reported in detail before the Hon'ble Tribunal and the same are not repeated in the report for the sake of brevity.

4.2 Compliance to the related regulations by the unit:

As per the records made available, the unit was functioning with valid consent/approval from the various departments such as KSPCB, Factories & Boilers,

Local administration etc. An onsite emergency plan with the provisional approval from the Director, Factories & Boilers dated 25.10.2018 is in practise at the unit, as per records. However on going through the onsite emergency plan, it is observed that the scenario/situation of furnace oil leakage into the seashore has not been identified and emergency measures have not been specified. Considering the proximity of the unit to the sea shore and existence of effluent drain, the onsite emergency plan needs to be revisited to incorporate such scenario of leakages of furnace oil or other chemicals into the seashore. Copy of the onsite emergency plan is attached as **Annexure 6**.

As per the coastal regulation zone (CRZ) map of Thiruvananthapuram district, the unit premises comes under CRZ category II. As per the available information, unit has not obtained the required clearance under CRZ rules for the disposal of the effluent into the sea.

4.3 Environmental damage and compensation calculation:

The methodology followed by CPCB, as accepted by the Hon'ble Tribunal for the imposition of environmental compensation based on the formula developed is depending on the period of noncompliance to specified environmental norms and standards. Since the incident at M/s. TTPL was an instant accident, such compensation calculation shall not be relevant and hence not attempted. In such cases the cost of environmental damages and remediation shall be relevant as environmental cost. The environmental damages essentially includes restoration/ rehabilitation expenses, fine/ penalty/ financial deterrent for the activities which caused the environmental damages and the expenses incurred for identifying the extent of environmental degradation.

There a few approached adopted as standard practises for the damage assessment such as the equivalency method where environmental indexes/markers and appropriate restorations methods are used as representative cases. Another method

used is the habitat equivalency analysis (HEA), which represents ecosystem stability assessment and the expenses/ compensation to be recovered for restoration of habitat as a whole as well as the services previously rendered by those areas back to the baseline conditions are calculated according to the relevant economic methodology. However due to the complicated conception of ecosystems and variations in significant indexes or markers of environmental damage and unavailability of baseline data, it is not possible to assess the damages using these practices and hence the same was not attempted. It may also be noted that the quantity of the furnace oil reaching the sea shore is comparatively very less compared to the tanker accidents/ship wreck incidences, for which such damage assessment is done usually.

In the instant case of oil leakage from TTPL, Committee made an assessment of the costs incurred for the immediate clean up and disposal of contaminated sand. As per the copy of statement provided by the unit representative, approximately 9.53 Lakh Rupees has been spent by the unit for the shore clean-up activities, including labour charges, disbursement of amount to local fishermen and hiring of vehicles etc. Copy is placed at **Annexure 7**. Further as per the copy of the manifest provided an amount of Rs. 1.33 lakhs have been paid to the TSDF operator for disposal of contaminated sand.

On account of the loss of livelihood for the local fisherman community, the District Administration had convened a meeting on 26/02/2021 with the representatives of fishermen and M/s TTPL, whereby it was decided that as the District Administration had prohibited the fishermen to go to the Sea following the oil spill for two days, it had caused economic loss to the fishermen whose livelihood solely depend on fishing and allied activities, and hence they had to be adequately compensated for the loss of work on the days of prohibition. M/s Travancore Titanium Products Ltd agreed to compensate 902 fishermen at the rate of Rs. 200 per person based on the compensation amount fixed by the Government during the loss of livelihood on account of natural calamities. Later the union representatives of fishermen claimed that the compensation amount was meagre and demanded for higher amount as

compensation, following which, the District Administration discussed the matter with the Office of the Deputy Director of Fisheries. The Deputy Director of Fisheries conveyed that a compensation of Rs. 700 per person per day would suffice. District Administration has asked M/s Travancore Titanium Products Ltd to consider the payment of aforementioned sum (6.3 Lakh Rupees approax.) to the fishermen at the earliest and the same is in process.

The committee also feels that the long term monitoring of the impact on coast line including marine ecosystem due to the incident, as well the historical practice of effluent discharge, shall be taken up by the unit in consultation with reputed institutes. Under these circumstances, it is felt by the Committee that fixing of an arbitrary penalty for the negligence which led to the accident shall be left to the wisdom of the Hon'ble Tribunal.

5.0 Recommendations for avoiding such incidents and improvement of environment management:

Based on the observations made by the Committee, records verified and the analysis results of the sample collected during the visit, the Committee comes up with the following conclusions and recommendations;

A. With respect to the incident of oil leakage which happened due to negligence in assessing the pipeline for damages, as part of routine safety audits, the following steps needs to be implemented by the unit to avoid such incidents in future;
    - The periodic assessment of Pipe Integrity (including internal crack, corrosion and erosion) has to be made at least once in five years, so that the status of the pipeline shall be known and accordingly replacement period for the pipe shall be decided.
    - The onsite emergency plan needs to be revisited to incorporate such scenarios of leakages of furnace oil or other chemicals into the seashore

considering the proximity of the unit to the sea shore and existence of effluent drain.

- The unit shall install automatic leak detection and cut-off systems to avoid such leakages and should implement the recommendations made by the Committee constituted by Govt. of Kerala, without further delay.

B. With respect to the overall improvement in environment management and assessment of long term impact of the oil leakage as well the historical practise of effluent discharge on the coast line including marine ecosystem, the unit shall take up a detailed long term study in consultation with reputed institutes in this field (Fisheries & Marine ecology) in line with the internationally accepted systematic methods for surveying an affected shoreline after an oil spill such as Shoreline Clean up and Assessment Technique (SCAT).

C. The analysis results indicate presence of traces of oil & Grease still in the sea shore sand samples and a detailed investigation and risk assessment study for remediation of sea shore shall be carried out to assess the impacts occurring from activities handling oil and grease, acid etc. and extent of damage (spatial) to environment, ecology and livelihoods estimated. Based on these estimates, emergency response procedures (ERP) shall be developed and costs assigned in the annual budget for monitoring the ERP. In this regard, the entire expenditure for the investigation, risk assessment study and remediation shall be borne by the unit.

D. Considering that the unit has installed systems such as MFRO which facilitates reuse of treated effluent, the practise of discharge of effluent to the sea shore shall be discontinued by the unit. KSPCB may consider amendment of the Consent conditions to this extent after ensuring that reject management systems are installed by the unit to achieve Zero Liquid Discharge status.

E. The unit shall comply with the CRZ notifications and obtain the necessary clearances from KCZMA as per the regulations.

Suneel Pamidi, IFS
Director DoECC &
Member Secretary, KCZMA

Vineeth T. K, Dy. Collector
(Disaster Management)
Thiruvanathapuram.

P. K. Baburajan,
Chief Environmental Engineer,
KSPCB, Thiruvananthapuram.

Dr. (Smt.) Vijaya Ravichandran,
Scientist G, NIOT, Chennai

Vivek, K,
Senior Environmental Engineer/Sc.
D, CPCB, Bangalore

Annexure 1

NGT COMMITTEE ATTENDANCE SHEET

Venue: TTPL Lounge **Date: 15/07/2021**

Sl No.	Name	Organization	Designation	Contact No.	Email ID	Signature
1.	Suneel Pamidi	Director, DoECC, Member Secretary, KCZMA		8281625134	pamidisuneel@gmail.com	
2.	VIVEK.K, S	CPCB, R.D, Bengaluru	SEE/SCD	9990300758	vivek.cpcb@gov.in	
3.	Kiran.A.S	NIOT Chennai	Scientist E	8807561490	kiran.niot@gov.in	
4.	Vineeth.T.K.	Dy. Collector (DM) DDMA	Dy. Collector (DM)	8547610015	vineethtke gmail.com	
5.	S. SHAJI		Tahasildar Tvpm.	9446441098	Shaji revenue bb@gm	
6.	George Niram	TTPL	Managing Director	9496012574	md@ttpltd.in	
7.	P PRADEEP KUMAR	TTPL	GM(T) I/C	9072865023	pradeep.kumar@ttpltd.in	
8.	S.PERUMAL	TTPL	DGM(P)	9048505628	Perumal@gmail.com	
9.	Baburajan P.K	KSPCB	Chief Envtl. Engineer	9447975732	baburajanpk@gmail.com	
10.	R. Vinod	TTPL	HoD (SEE)	9048505345	vinodr@ttpltd.in	

Annexure 1 A

KERALA STATE POLLUTION CONTROL BOARD

FILE NO. :PCB/HO/TVM/ICO/18/2009
Date of issue :18/09/2018

INTEGRATED CONSENT TO OPERATE - RENEWAL

Consent No : PCB/HO/TVM/ICO-R/10/2018 **Valid upto 30.06.2023**

Ref : As per consent no.PCB/HO/TVM/ICO-R/05/2017 dated 29/06/2017 valid up to 30/06/2018.

The ' Integrated Consent to Operate' issued as per reference above to M/s .TRAVANCORE TITANIUM PRODUCTS LTD,POST BOX No: 1, KOCHUVELI, THIRUVANATHAPURAM-695021, is hereby renewed up to 30/06/2023 and issued to M/s .TRAVANCORE TITANIUM PRODUCTS LTD,POST BOX No: 1, KOCHUVELI, THIRUVANATHAPURAM-695021. The consent(s)/ variation order(s) cited under reference are integral part of this renewal order and this order is subject to the conditions stipulated therein and the following modifications/ additions.

I. GENERAL

S.No.	Items	Description
1	Annual Fees	Rs.317945/-
2	Fee remitted	Rs.1589725/-
3	Validity	30/06/2023
4	Date of application	22/06/2018
5	Product	Titanium Dioxide pigment-45 TPD
6	Category	Red
7	Capital Investment	Rs.12863.41 lakh

II. Stack Details

Stack No.	Source of Emission	Emission Rate(Nm3/Hr)	Stack Height above		Control Equipment
			Ground Level(In Meters)	Roof Level(In Meters)	
As per previous consent details					

III. CONDITIONS

(1)Steam condensate now being discharged into equalization tank of Effluent Treatment Plant shall be utilized for heat recovery in plant process so as to avoid the shock load of hot water directly into the Effluent treatment plant.

(2) The drain leading from canteen shall be completely closed and the water shall be treated for achieving percolation/ gardening standards.

(3) Automatic pH correction shall be done at the authorized outlet and discharge point of storm water drain just before letting out from the plant premises.

(4)A dyke wall shall be constructed around the caustic/lime storage/facilitating area at Effluent Treatment Plant to ensure that no spillage of caustic occurs into the storm water drain.

(5) More number of RO modules shall be incorporated so that the effluent can be completely reused in the plant process itself.

All other conditions of the Integrated Consent to Operate issued as per reference above remain unchanged.

K SAJEEVAN Digitally signed by K SAJEEVAN
Date: 2018.09.18 16:23:21 +05'30'

DATE :18/09/2018

SIGNATURE & SEAL OF ISSUING AUTHORITY
CHAIRMAN

KERALA STATE POLLUTION CONTROL BOARD

To
M/s.TRAVANCORE TITANIUM PRODUCTS LTD,
POST BOX No: 1, KOCHUVELI,
THIRUVANATHAPURAM-695021.

KERALA STATE POLLUTION CONTROL BOARD

FILE NO. : PCB/HO/TVM/ICO/18/2009
Date of issue :29/06/2017

INTEGRATED CONSENT TO OPERATE - RENEWAL

Consent No : PCB/HO/TVM/ICO-R/05/2017

Ref : Consent No. PCB/HO/TVM/ICO/14/2009 dated 20/7/2009 valid up to 30.06.2012

The ' Integrated Consent to Operate' issued as per reference above to M/s TRAVANCORE TITANIUM PRODUCTS LTD, KOCHUVELI,THIRUVANATHAPURAM is hereby renewed up to 30/06/2018 and issued to M/s TRAVANCORE TITANIUM PRODUCTS LTD, KOCHUVELI,THIRUVANATHAPURAM, for a period of one year for trial run,in full compliance with the directions of the Hon'ble High Court and Central Pollution Control Board and is subject to the final decision of the Hon'ble High Court in WP(C) No.18315/2017. The consent(s)/ variation order(s) cited under reference are integral part of this renewal order and this order is subject to the conditions stipulated therein and the following modifications/ additions.

I. GENERAL

S.No.	Items	Description
1	Fees remitted	Rs. 9,10,000/-
2	Annual Fee	Rs.1,40,000/-
3	Validity	30.06.2018
4	Capital Investment	Rs. 128.63 crores
5	Occupier details	Sri. Georgee Ninan, Managing Director
6	Products	Titanium Dioxide - 30tonnes per day

II. Stack Details

Stack No.	Source of Emission	Emission Rate(Nm3/Hr)	Stack Height above		Control Equipment
			Ground Level(In Meters)	Roof Level(In Meters)	
1A,1B,1C,1D, 1E,1F,1G,1H	New Plant Digestor	3000	25	-	

KERALA STATE POLLUTION CONTROL BOARD

2A,2B.2C.2D, 2E.2F	Old Plant Digestor	16000	20.7	-	-
4A	Gas Cleaning Plant 2	10200	24.3	-	Scrubbing & Electrostatic Precipitator
5A	Gas Cleaning Plant 3 & 4	24600	24.3	-	Scrubbing & Electrostatic Precipitator
6A	Acid Plant	27000	25	-	Alkali Scrubber
7A,7B,&7C	Package Boilers, Smoke Tube-Oil Firing Type,3 No.s	10745	20.7	-	
8A,8B	Mukund Mill	6800	20.7	-	Bag Filter
9A,B,C	BP Mill	3400	274	-	Bag Filter
1000 KVA D.G.Set-3 No.s	-	-	-	5	Accoustic Enclosure

III. CONDITIONS

3.1The effluent treatment plant consisting of neutralisation system, filtration system and reverse osmosis shall be operated continuously.

3.3. The 70 % of treated effluent shall be utilised and the rest shall be discharged to the Lakshawdeep sea after achieving the standards specified in condition 3.4 of reference.

4.4 Automatic continuous emission monitoring and recording facilities shall be provided for all stacks within 6 months.

5.11. The unit shall provide proper facility for the storage of Hazardous waste.

5.12.The provisions of Hazardous and Other Waste Management, Rules 2016 shall be complied with.

All other conditions of the Integrated Consent to Operate issued as per reference above remain unchanged.

DATE :29/06/2017

STATE POLLUTION CONTROL BOARD KERALA OFFICE SEAL

SIGNATURE & SEAL OF ISSUING AUTHORITY

CHAIRMAN

To

TRAVANCORE TITANIUM PRODUCTS LTD

POST BOX No: 1,KOCHUVELI, THIRUVANATHAPURAM- 695021.

Copy To

1. The Environmental Engineer, District Office, Thiuvanathapuram
2. Stock File

Annexure 2

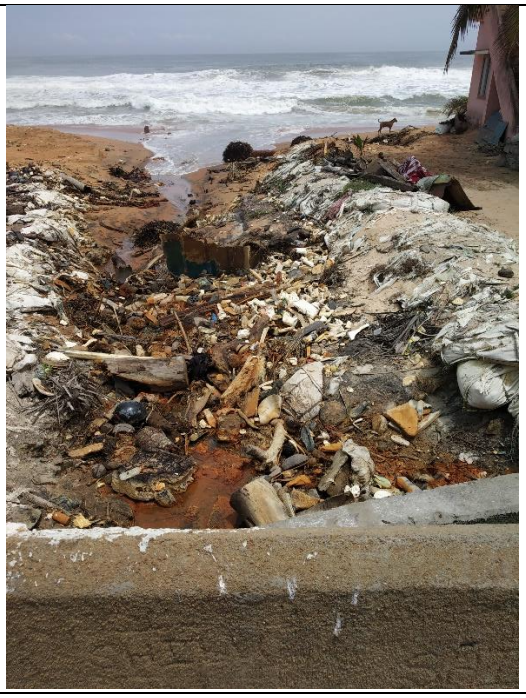
Photographs taken during the visit:

Overhead pipeline and the drain underneath through which oil leakage happened

Furnace oil storage tanks and Acid storage tanks outside plant premises

Internal drains of the unit, temporarily blocked, and joining outside drain

Sea shore and sample collection



Drain reaching the seashore found temporarily blocked by wall construction

Effluent channel reaching the sea shore

Collection of sea shore soil samples

Telephone: 0471-2306644
email: kspcbdetvpm@gmail.com

KERALA STATE POLLUTION CONTROL BOARD
കേരള സംസ്ഥാന മലിനീകരണ നിയന്ത്രണ ബോർഡ്

DISTRICT OFFICE, THIRUVANANTHAPURAM
ജില്ലാ ഓഫീസ്, തിരുവനന്തപുരം

T. C. 12/96 (4,5), PLAMOODU JN., PATTOM P.O. THIRUVANANTHAPURAM - 695 004
ടി.സി. 12/96 (4,5), പ്ലാമൂട് ജംഗ്ഷൻ, പട്ടം പി.ഒ, തിരുവനന്തപുരം - 695 004

ANALYSIS REPORT

No: 202244

Date: 06/09/2021

Source	TTPL, VELI, TRIVANDRUM		
Sample received from	NAMP	Date of sample collection	15/07/2021
Date of Receipt (Central Laboratory)	19/07/2021	Ref. No.	04,05

Sl. No.	Parameter	Unit	Value		Detection Limit
			04 (Sample from Outlet-Effluent)	05 (Sample from Sea)	
1	pH		6.8	6.7	*6.5-8.5
2	Total Suspended Solids	mg/L	60.1	92.0	*100mg/L
1	Acidity	mg/L	256	16	1mg/L
2	Hexavalent Chromium	mg/L	BDL	BDL	0.03mg/l
3	Cadmium	mg/L	BDL	BDL	0.01mg/l
4	Total Chromium	mg/L	BDL	BDL	0.03mg/L
5	Copper	mg/L	BDL	BDL	0.02mg/L
6	Iron	mg/L	3.52	0.27	0.05mg/L
7	Manganese	mg/L	0.23	0.06	0.05mg/L
8	Nickel	mg/L	BDL	BDL	0.05mg/L
9	Lead	mg/L	BDL	BDL	0.05mg/L
10	Zinc	mg/L	0.04	0.07	0.02mg/L
11	Arsenic	mg/L	BDL	BDL	0.01mg/L
12	Oil & Grease	mg/L	BDL	BDL	5mg/L
13	Titanium	mg/L	0.02	BDL	0.03mg/L
14	Vanadium	mg/L	BDL	BDL	0.02mg/L

Remarks:- BDL-Below Detection Limit, *Permissible Limit
Analysis report forwarded from Central Laboratory, Ernakulum. Decoded and issued by District Laboratory, Trivandrum (Effluent outlet & Sea water including consented parameters)

Scientist-in-charge of analysis

ASSISTANT ENVIRONMENTAL SCIENTIST

Telephone: 0471-2303844
email: kspcbdotvpm@gmail.com

KERALA STATE POLLUTION CONTROL BOARD
കേരള സംസ്ഥാന മലിനീകരണ നിയന്ത്രണ ബോർഡ്

DISTRICT OFFICE, THIRUVANANTHAPURAM
ജില്ലാ ഓഫീസ്, തിരുവനന്തപുരം
T. C. 12/96 (4,5), PLAMOODU JN., PATTOM P.O, THIRUVANANTHAPURAM – 695 004
ടി.സി. 12/96 (4,5), പ്ലാമൂട് ജംഗ്ഷൻ, പട്ടം പി.ഒ, തിരുവനന്തപുരം – 695 004

ANALYSIS REPORT

No: 202244 **Date: 03/09/2021**

Source	TTPL, VELI, TRIVANDRUM		
Sample received from	NAMP	Date of sample collection	15/07/2021
Date of Receipt (Central Laboratory)	19/07/2021	Ref. No.	04,05

Sl. No.	Parameter	Unit	Value		Detection Limit
			04 (Sample from Outlet-Effluent)	05 (Sample from Sea)	
1	Acidity	mg/L	256	16	1mg/L
2	Hexavalent Chromium	mg/L	BDL	BDL	0.03mg/L
3	Cadmium	mg/L	BDL	BDL	0.01mg/L
4	Total Chromium	mg/L	BDL	BDL	0.03mg/L
5	Copper	mg/L	BDL	BDL	0.02mg/L
6	Iron	mg/L	3.52	0.27	0.05mg/L
7	Manganese	mg/L	0.23	0.06	0.05mg/L
8	Nickel	mg/L	BDL	BDL	0.05mg/L
9	Lead	mg/L	BDL	BDL	0.05mg/L
10	Zinc	mg/L	0.04	0.07	0.02mg/L
11	Arsenic	mg/L	BDL	BDL	0.01mg/L
12	Oil & Grease	mg/L	BDL	BDL	5mg/L
13	Titanium	mg/L	0.02	BDL	-
14	Vanadium	mg/L	BDL	BDL	-

Remarks:- BDL-Below Detection Limit.
Analysis report forwarded from Central Laboratory, Ernakulum. Decoded and issued by District Laboratory, Trivandrum (samples from:- Outlet & Sea water)

Scientist-in-charge of analysis

03/09/2021

ASSISTANT ENVIRONMENTAL SCIENTIST

Telephone: 0471-2303844
email: kspcbdotvpm@gmail.com

KERALA STATE POLLUTION CONTROL BOARD
കേരള സംസ്ഥാന മലിനീകരണ നിയന്ത്രണ ബോർഡ്

DISTRICT OFFICE, THIRUVANANTHAPURAM
ജില്ലാ ഓഫീസ്, തിരുവനന്തപുരം
T. C. 12/96 (4.5), PLAMOODU JN., PATTOM P.O. THIRUVANANTHAPURAM – 695 004
ടി.സി. 12/96 (4.5), പ്ലാമൂട് ജംഗ്ഷൻ, പട്ടം പി.ഒ, തിരുവനന്തപുരം – 695 004

ANALYSIS REPORT

No: 202244 (1) **Date: 03/09/2021**

Source	TTPL, VELI, TRIVANDRUM		
Sample received from	NAMP	Date of sample collection	15/07/2021
Date of Receipt (Central Laboratory)	19/07/2021	Ref. No.	01,02,03

Sl. No.	Parameter	Unit	Value			Detection Limit
			01 Sediment Sample from South side	02 Sediment Sample from Centre (West)	03 Sediment Sample from North side	
1	Manganese	mg/Kg	7.2	14.2	11.0	0.05 mg/Kg
2	Iron	mg/Kg	3110.0	6220.0	4140.0	0.05 mg/Kg
3	Vanadium	mg/Kg	9.8	19.0	13.2	
4	Titanium	mg/Kg	176.4	493.0	369.0	
5	Cadmium	mg/Kg	BDL	BDL	BDL	0.01 mg/ Kg
6	Lead	mg/Kg	2.4	13.6	7.0	0.05 mg/ Kg
7	Zinc	mg/Kg	22.4	5.4	3.6	0.02 mg/ Kg
8	Total Chromium	mg/Kg	10.8	33.6	20.0	0.03 mg/ Kg
9	Hexavalent Chromium	mg/Kg	BDL	BDL	BDL	0.03 mg/ Kg
10	Copper	mg/Kg	3.0	4.4	4.2	0.02 mg/ Kg
11	Nickel	mg/Kg	BDL	BDL	BDL	0.05 mg /Kg
12	Arsenic	mg/Kg	BDL	BDL	BDL	0.01 mg/ Kg
13	Mercury	mg/Kg	17	30.2	21.2	

Remarks:- BDL-Below Detection Limit
Analysis report forwarded from Central Laboratory, Ernakulum. Decoded and issued by District Laboratory, Trivandrum (Soil samples)

Scientist-in-charge of analysis

ASSISTANT ENVIRONMENTAL SCIENTIST

KERALA STATE POLLUTION CONTROL BOARD
CENTRAL LABORATORY
കേരള സംസ്ഥാനമലിനീകരണ നിയന്ത്രണ ബോർഡ്
കേന്ദ്ര പരീക്ഷണശാല
An Environmental Laboratory recognised under E(P)A 1986
Certificate No. TC 8525

No.PCB/CL/NGT-OUTSOURCING/2020 Date: 30.09.2021

From
The Chief Environmental Scientist

To
The Environmental Engineer,
Kerala State Pollution Control Board
District office,
Thiruvanathapuram

Sub: Forwarding of Analysis Report of Sediments TTPL Veli
Ref: That office letter no. KSPCB/DO/TVM/Lab/TTPL samplings/2018 with dated 16/07/2021

Sir,

I am enclosing herewith the analysis report (Oil & Grease) of the sludge samples received from that office as per reference cited above.

01- Sample from the south side - PCB 01
02- Sample from center (west) - PCB 02
03- Sample from north side - PCB 03

Yours faithfully,

for CHIEF ENVIRONMENTAL SCIENTIST

Encl: As above.

GANDHI NAGAR, KOCHI – 682 020 ഗാന്ധിനഗർ, കൊച്ചി – 682 020
Ph : 0484 220 7781, EPABX: 0484 220 7783 – 86, Fax: 0484 – 220 7781, Mob: 9447975741

COCHIN TEST HOUSE

ANALYTICAL SERVICES & TESTING LABORATORY

V / 78, Kollanpady, Murungeliparambu Road, Irumpanam P.O., Kochi - 682 309
Mob.: 9446332556, 9846551014, 9387381780. Tel. : 0484 - 2782672
E-mail: cochintesthouse1@gmail.com, info@cochintesthouse.in. Web : www.cochintesthouse.in

Laboratory Approved by Kerala State Pollution Control Board ('A' Grade)

KERALA STATE POLLUTION CONTROL BOARD CENTRAL LABORATORY COCHIN-20

TEST REPORT

Report No : CTH/LR/21/NN/1802 Issue Date: September 30, 2021

Name and Address of customer : **M/s. Kerala State Pollution Control Board, Central Laboratory, Gandhi Nagar, Kochi – 682 020**

Sample Drawn By : Customer

Sample code : 21/NN/1802, 21/NN/1803 & 21/NN/1804

Date of receipt of sample : 29.09.2021

Dates of Analysis : 30.09.2021

Description of the sample by the customer : **PCB – 01, PCB – 02 & PCB – 03**

Sl.No.	Parameters	Unit	Method	Result		
				21/NN/1802	21/NN/1803	21/NN/1804
				PCB – 01	PCB – 02	PCB – 03
1	Oil & Grease	ppm	CTH/CH/SOP/630	135.88	154.66	180.05

End of Report

AES 82 30/9/21

2780 30/9/21

COCHIN TEST HOUSE Kochi

Verified By

Authorised Signatory
Chemical
COCHIN TEST HOUSE

☎ 04 1-2307844
e-mail: kspcbdotvpm@gmail.com
kspcb.dotvm@yahoo.com

KERALA STATE POLLUTION CONTROL BOARD

കേരള സംസ്ഥാന മലിനീകരണ നിയന്ത്രണ ബോർഡ്

DISTRICT OFFICE, THIRUVANANTHAPURAM
ജില്ലാ ഓഫീസ്, തിരുവനന്തപുരം
T. C. 12/961(4.5), PLAMOODU JN., PATTOM P.O, THIRUVANANTHAPURAM – 695 004
ടി.സി. 12/961 (4. 5), പ്ലാമൂട് ജംഗ്ഷൻ, പട്ടം പി.ഒ, തിരുവനന്തപുരം - 695 004

KSPCB/DO/TVM/LAB/TTPL Sampling/2018 09/11/2021

From

The Assistant Environmental Engineer

To

The Chief Environmental Engineer,
Regional Office,
Thiruvananthapuram

Sub:- Forwarding the Analysis Report (**Oil & Grease**) of the Soil Samples collected from TTPL, Veli in connection with **O.A 71/2021** -reg:

Ref:- 1. PCB/CL/AR/2009 dated 08/11/2021.
2. KSPCB/DO/TVM/LAB/TTPL Sampling/2018 dated 18/10/2021.
3. E-mail from Regional Office,TVM dated 13/10/2021.

Sir,

I am enclosing herewith the decoded analysis report of Oil &Grease content of the soil samples (4Nos) collected from the sea shore near the outlet of Travancore Titanium Products Ltd, Veli on 18/10/2021 in connection with **O.A 71/2021** which were handed over to the Central Laboratory for the analysis on 18/10/2021. This is for favour of kind information and further necessary action.

Yours faithfully,

ASSISTANT ENVIRONMENTAL ENGINEER

Telephone: 0471-2303844
email: kspcbdotvpm@gmail.com

KERALA STATE POLLUTION CONTROL BOARD
കേരള സംസ്ഥാന മലിനീകരണ നിയന്ത്രണ ബോർഡ്

DISTRICT OFFICE, THIRUVANANTHAPURAM
ജില്ലാ ഓഫീസ്, തിരുവനന്തപുരം
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ANALYSIS REPORT

No:202251 **Date: 09/11/2021**

Source	TTPL, VELI, TRIVANDRUM		
Sample received from	NAMP	Date of sample collection	18/10/2021
Date of Receipt (Central Laboratory)	20/10/2021	Ref. No.	SD 01,02,03,04 (Soil samples)

Sl. No.	Parameter	Unit	Value				Permissible Limit
			SD 01	SD 02	SD 03	SD 04	
1	Oil & Grease	mg/Kg	66.9	15.1	12.5	7.7	-

Remarks:- SD 01-0.5 Km from final outlet towards South
SD 02-1 Km from final outlet towards South
SD 03-0.5 Km from final outlet towards North
SD 04- 1 Km from final outlet towards North
Test Method-PCB/CL/SOP/TM/5.4.2/18-1 SOIL
Analysis report forwarded from Central Laboratory, Ernakulum. Decoded and issued by District Laboratory, Trivandrum

Scientist-in-charge of analysis

09/11/21

ASSISTANT ENVIRONMENTAL SCIENTIST

Email : cgs-vzm@indiancoastguard.nic.in
Tele : 0471-2486484

The Commanding Officer

ICGS Vizhinjam
Harbour Road
Vizhinjam P.O
Thiruvananthapuram
Kerala – 695 521

Quoting: 758/1

11 Feb 21

The District Collector
Thiruvananthapuram

OIL SPILL FROM TRAVANCORE TITANIUM PRODUCTS LTD

Dear Mam

1. Refer to District Collector Thiruvananthapuram letter DDMA/01/2021/Oil Spill dated 10 Feb 21.

2. Representatives of this station along with KSPCB officials visited the discharge site AM 11 Feb 21. KSPCB was impressed upon to undertake shoreline cleanup i.a.w article 3.1.2 of NOSDCP-2015 (copy of relevant page enclosed).

3. Shore/beach cleaning is in progress. Removal of contaminated sand in progress. Cleaning/removal of sand from the discharge site held up due to resistance/agitation from local fisher folks.

4. Indian Coast Guard Ship (ICGS) C- 441 and CG Dornier carried out extensive monitoring of the area on 10 Feb 21 and found no traces of oil in the ocean. On 11 Feb 21, ICGS C-427 carried out extensive far/close coast monitoring (300 meters from shore) and gemini of C-427 inspected 15-20 meters close to the beach. Nil traces of oil observed at sea.

5. This is for your information only.

Regards

(Ramandeep Singh)
Assistant Commandant
Station Ops Officer
for Commanding Officer

Annexure 5

AM VSHE 32

KERALA ENVIRO INFRASTRUCTURE LTD.

Common TSDF Project, Inside FACT CD Campus, Ambalamedu, Kochi - 682 303
Phone: 0484-2722141, 241, 341, E-mail: drnkpillai@gmail.com
GSTIN: 32AACCK6979P1ZS, CIN: U24129KL2005PLC017973

23/6/21

KEIL/AC/20-21/ BL-23

Friday, 18 June 2021

Mgr (C).

Kindlt Att:Mr Vinod .R
Asst General Manager (S&E)
Travancore Titanium Products Ltd.
P B No:1,
Thiruvananthapuram
PIN:695021

Sub: Original Invoice for the month of march 2021

Dear Sir;

We are submitting the Invoice Nos: KEIL/20-21/G2267 dated: 06th March 2021 for an amount of Rs:1,33,807 /-(One lakhs Thirty Three Thousand Eight Hundred and Seven Only) towards the disposal charges of 22.270 MT of Furnace oil contaminated sand Waste from Travancore Titanium Products Ltd which was disposed at KEIL landfill .

Kindly acknowledge and release the payment at the earliest.

Thanking you,

Yours faithfully
For KERALA ENVIRO INFRASTRUCTURE LTD.

Madhu. P.M,
Sr. Officer. (A & A)

KERALA ENVIRO INFRASTRUCTURE LTD. AMBALAMEDU 682 303 TSDF PROJECT

License : D08/EKM/03/535/2008
CB No : PCB/HO/EKM/IC/CO/26/08

KERALA ENVIRO INFRASTRUCTURE LIMITED

TSDF, Inside FACT (CD) Campus,
Ambalamedu,Ernakulam Dist.
Cochin - 682 303
Ph : 0484 - 2722141,241,341
CIN:U24129KL2005PLC017973
MSME Reg NO:UDYAM-KL-02-0000573
GSTIN/UIN: 32AACCK6979P1ZS
State Name : Kerala, Code : 32
E-Mail : drnkpillai@gmail.com

Invoice No : KEIL/20-21/G2267 Date : 6-Mar-2021
Order No :

G Billing Period
From Date : 26-Feb-2021
To Date : 26-Feb-2021

To: M/sTravancore Titanium Products Ltd
P.B. No. 1,, Thiruvananthapuram --695021., Work Order No:104/20-21 Dt :19.08.2020
GSTIN/UIN : 32AAACT8543J1Z9

SlNo	MF Sl No	Details , MF No & Vechile. No.	HSN Cod	U.Price	Qty	Total
		Operating Charges				
1		57473 / KL 02 BN 4683 / 26-Feb-2021 /FURNACE OIL CONTAMINATED SAND COLLECTED FROM BEACH	999432	1,872.00	22.270 MTs	41,689.44
2		Analysis Charges KEIL/QA/HW/2021/039 Dt :05.03.21	998346	6,500.00	1.000 nos	6,500.00
		Grand Total				48,189.44

Stabilisation Charge	65,206.56
CGST	10,205.64
SGST	10,205.64
Round Off	(-)0.28
	1,33,807.00

In words: - Indian Rupees One Lakh Thirty Three Thousand Eight Hundred Seven only

HSN/SAC	Taxable Value	Central Tax		State Tax		Total
		Rate	Amount	Rate	Amount	Tax Amount
999432	1,06,896.00	9%	9,620.64	9%	9,620.64	19,241.28
998346	6,500.00	9%	585.00	9%	585.00	1,170.00
Total	**1,13,396.00**		**10,205.64**		**10,205.64**	**20,411.28**

1. Terms & conditions as per agreement
2. Payment Advance
3. Subject to Cochin Jurisdiction.
4. PAN No. AACCK6979P
5. SERVICE TAX No. AACCK6979PSD001

Company's Bank Details
Bank Name: **HDFC BANK Ltd**
A/c No. : **50200041290250**
Branch & IFS Code: **Main Branch ChoiceTowers Ernakulam & HDFC0001218**

Being disposal charges for 22.270 MTs @Rs 1872/-. Stabilisation charges @ Rs 2928/-. Materials transported by the party

For KERALA ENVIRO INFRASTRUCTURE LIMITED

HOD (S&E) / Mgr (C)

E & OE

Authorised Signatory

The work has completed Satisfactorily and the Bill amount of Rs-133,807/- (Including Taxes) may be passed for payment.
23/6/21
Am (S&E)

KERALA ENVIRO INFRASTRUCTURE LTD. AMBALAMEDU 682 303 TSDF PROJECT

KERALA ENVIRO INFRASTRUCTURE LIMITED

TSDF, Inside FACT (CD) Campus,
Ambalamedu,Ernakulam Dist.
Cochin - 682 303
Ph : 0484 - 2722141,241,341
CIN:U24129KL2005PLC017973
MSME Reg NO:UDYAM-KL-02-0000573

Travancore Titanium Products Ltd

Bill-wise Details

P.B. No. 1,
Thiruvananthapuram –695021.
WO NO:47/19-20 Dt :28.05.2019
1-Apr-2021 to 16-Jun-2021

Date	Ref. No.	Opening Amount	Pending Amount	Due on	Overdue by days
6-Mar-2021	KEIL/20-21/G2267	1,33,807.00 Dr	**1,33,807.00 Dr**	6-Mar-2021	*102*
31-Mar-2021	KEIL/20-21/G2475	4,85,219.00 Dr	**4,85,219.00 Dr**	31-Mar-2021	*77*
		6,19,026.00 Dr	**6,19,026.00 Dr**		

KEIL

KERALA ENVIRO INFRASTRUCTURE LTD.

Common TSDF Project, Inside FACT CD Campus, Ambalamedu, Kochi - 682 303
Phone: 0484-2722141, 241, 341, E-mail: drnkpillai@gmail.com
GSTIN: 32AACCK6979P1ZS, CIN: U24129KL2005PLC017973

KEIL/AC/20-21/ BL-23A Friday, 21 May 2021

Kindlt Att:Mr Vinod .R
Asst General Manager (S&E)
Travancore Titanium Products Ltd.
P B No:1,
Thiruvananthapuram
PIN:695021

Sub: Original Invoice for the month of march 2021

Dear Sir;

We are submitting the Invoice Nos: KEIL/20-21/G2473&2475 dated: 31th March 2021 for an amount of Rs:6,89,859 /-(Six lakhs Eighty Nine Thousand Eight Hundred and Fifty Nine Only) towards the disposal charges of 180.26 MT of Waste from Travancore Titanium Products Ltd which was disposed at KEIL landfill .

Kindly acknowledge and release the payment at the earliest.

Thanking you,

Yours faithfully
For KERALA ENVIRO INFRASTRUCTURE LTD.

Madhu. P.M,
Sr. Officer. (A & A)

KERALA ENVIRO INFRASTRUCTURE LTD. AMBALAMEDU 682 303 TSDF PROJECT

Factory License : D08/EKM/03/535/2008
KSPCB No : PCB/HO/EKM/IC/CO/26/08

KERALA ENVIRO INFRASTRUCTURE LIMITED

TSDF, Inside FACT (CD) Campus,
Ambalamedu,Ernakulam Dist.
Cochin - 682 303
Ph : 0484 - 2722141,241,341
CIN:U24129KL2005PLC017973
MSME Reg NO:UDYAM-KL-02-0000573
GSTIN/UIN: 32AACCK6979P1ZS
State Name : Kerala, Code : 32
E-Mail : drnkpillai@gmail.com

Invoice No : KEIL/20-21/G2473
Order No :

Date : 31-Mar-2021

G Billing Period
From Date : 6-Mar-2021
To Date : 6-Mar-2021

To: M/sTravancore Titanium Products Ltd
P.B. No. 1,, Thiruvananthapuram --695021., WO NO:104/20-21 Dt :19.08.2020
GSTIN/UIN : 32AAACT8543J1Z9

SlNo	MF Sl No	Details , MF No & Vechile. No.	HSN Cod	U.Price	Qty	Total
		Operating Charges				
1		57474 / KL 02 BN 4683 / 6-Mar-2021/OIL Contaminated Sludge	999432	1,872.00	36.130 MTs	67,635.36
		Grand Total				67,635.36

Stabilisation Charge		1,05,788.64
CGST		15,608.16
SGST		15,608.16
Round Off		(-)0.32
	36.130 MTs	2,04,640.00

In words: - Indian Rupees Two Lakh Four Thousand Six Hundred Forty only

HSN/SAC	Taxable Value	Central Tax		State Tax		Total
		Rate	Amount	Rate	Amount	Tax Amount
999432	1,73,424.00	9%	15,608.16	9%	15,608.16	31,216.32
Total	**1,73,424.00**		**15,608.16**		**15,608.16**	**31,216.32**

1. Terms & conditions as per agreement
2. Payment Advance
3. Subject to Cochin Jurisdiction.
4. PAN No. AACCK6979P
5. SERVICE TAX No. AACCK6979PSD001

Company's Bank Details
Bank Name : **HDFC BANK Ltd**
A/c No. : **50200041290250**
Branch & IFS Code: **Main Branch ChoiceTowers Ernakulam & HDFC0001218**

Being disposal charges for 36.130 Mts @Rs 1872/-. Stabilisation charges @Rs 2928/-. Materials transported by the party

HOD (S&E) / Mgr (C)

Work has Completed Satisfactorily and the payments may be given as per Work order conditions.
Asst (S&E) 11/04/21

For KERALA ENVIRO INFRASTRUCTURE LIMITED

Authorised Signatory

KERALA ENVIRO INFRASTRUCTURE LTD ★ AMBALAMEDU 682 303 ★ TSDF PROJECT

E & OE

FORM 10 *[See rule 19 (1)]*

MANIFEST FOR HAZARDOUS AND OTHER WASTE

1.	Sender's Name & Mailing Address (including Phone No. and e-mail)	Travancore Titanium Products Kochuveli., TVM, 695021.
2.	Sender's authorisation No.	applied
3.	Manifest Document No.	534
4.	Transporter's Name & Address (including Phone No. & e-mail)	T
5.	Type of Vehicle	(Truck / Tanker / Special Vehicle)
6.	Transporter's Registration No.	
7.	Vehicle Registration No.	KL 41 H 7225
8.	Receiver's Name & Mailing Address (including Phone No. and e-mail)	**CEE JEE LUBRICANTS** VI / 592, Industrial Development Area, Edayar, BINANIPURAM - P.O., ALWAYE - 683 502
9.	Receiver's authorisation No.	B-29016 / 279 / 1(Reg.) / 07 / HWMD dt. 11/10/2007
10.	Waste Description	Furnace oil waste
11.	Total Quantity	2.465 ..... ~~K.L./~~m^3 ~~or MT~~
	No. of containers	~~one~~ 11 .....Nos
12.	Physical Form	(Solid / Semi-Solid / Sludge / Oily / Tarry / Slurry / Liquid)
13.	Special handling instructions & additional information	Do not spill in transit
14.	Sender's Certificate :	I hereby declare that the contents of the consignment are fully and accurately described above by proper shipping name and are categorised, packed, marked, and labeled, and are in all respects in proper conditions for transport by road according to applicable national government regulations.
	Name & Stamp :	Signature : Month 09 Day 29 Year 2021
15.	Transporter's acknowledgement of receipt of Waste	
	Name & Stamp : Shajan K.C Manager Cee Jee Lubricants IDA, Edayar, Alwaye	Signature : Month 09 Day 29 Year 2021
16.	Receiver's certification of receipt of hazardous and other waste	
	Name & Stamp :	Signature : Month 09 Day 29 Year 2021

Copy 1 (White) - To be forwarded by the sender to the State Pollution Control Board after signing all the seven copies.
Copy 2 (Yellow) - To be retained by the sender after taking signature on it from the transporter and the rest of the five signed copies to be carried by the transporter.
Copy 3 (Pink) - To be retained by the receiver (actual user or treatment storage and disposal facility operator) after receiving the waste and the remaining four copies are to be duly signed by the receiver.
Copy 4 (Orange) - To be handed over to the Transporter by the receiver after accepting waste.
Copy 5 (Green) - To be sent by the receiver to the State Pollution Control Board.
Copy 6 (Blue) - To be sent by the receiver to the sender.
Copy 7 (Grey) - To be sent by the receiver to the State Pollution Control Board of the sender in case the sender is in another State.

Titanium

TRAVANCORE TITANIUM PRODUCTS LIMITED

(A Government of Kerala Undertaking)
THIRUVANANTHAPURAM

03rd July 2021

TTPL/S&E/21/286

To,

The Environmental Engineer
Kerala State Pollution Control Board
District Office, Pattom Palace P.O
Thiruvananthapuram.

Sir/ Madam,

Sub: Submission of Hazard Waste Manifest (Form-10)

We have handed over 2.465 KL (11 Barrels) of Waste Oil (Used Furnace ~~Lubrication~~ Oil) to authorized processing party , M/s CEE JEE LUBRICANTS, Alwaye on 29/06/2021.

Corresponding Hazardous Waste Manifest (Form 10) of the same is attached herewith.

This is for your kind information and updation of records.

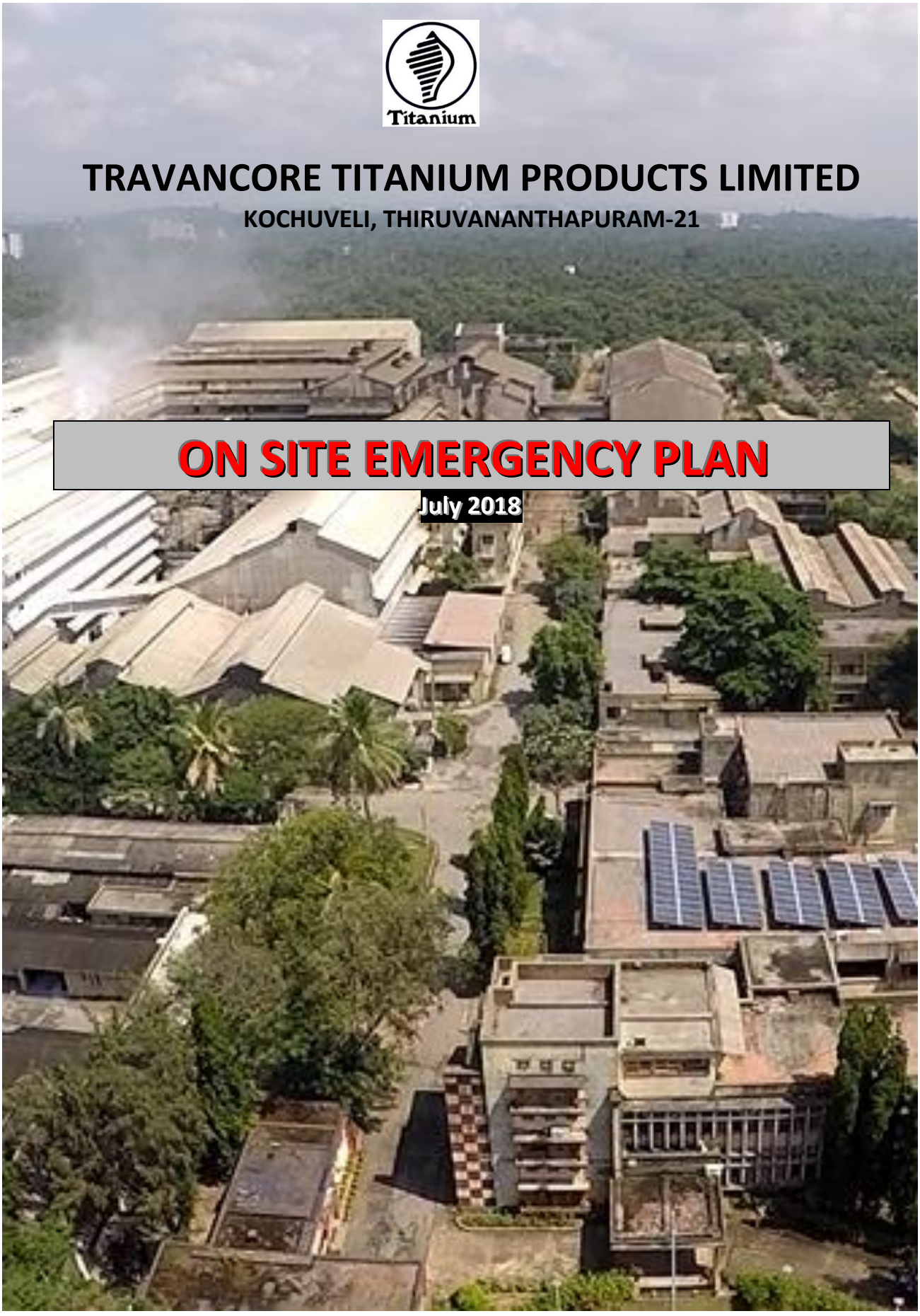
For Travancore Titanium Products Limited,

Received
Jayalalal

Thiruvananthapuram
Pin: 695004

Head of the Department
Safety & Environment Department

REGD. OFFICE : KOCHUVELI, THIRUVANANTHAPURAM - 695 021, KERALA, INDIA
Phone : 0471 - 2502748, 2508621, 2500221 Fax : 0471 - 2502724, 2501533, 2501127
CIN : U13209KL1946SGC001214, GST No: 32AAACT8543J1Z9
E - mail : mkting@travancoretitanium.com md@ttpltd.in purchase@ttpltd.in
Visit us on : www.travancoretitanium.com
Adding Life to Colours


Titanium
TRAVANCORE TITANIUM PRODUCTS LIMITED
KOCHUVELI, THIRUVANANTHAPURAM-21
ON SITE EMERGENCY PLAN
July 2018

PROVISIONAL APPROVAL

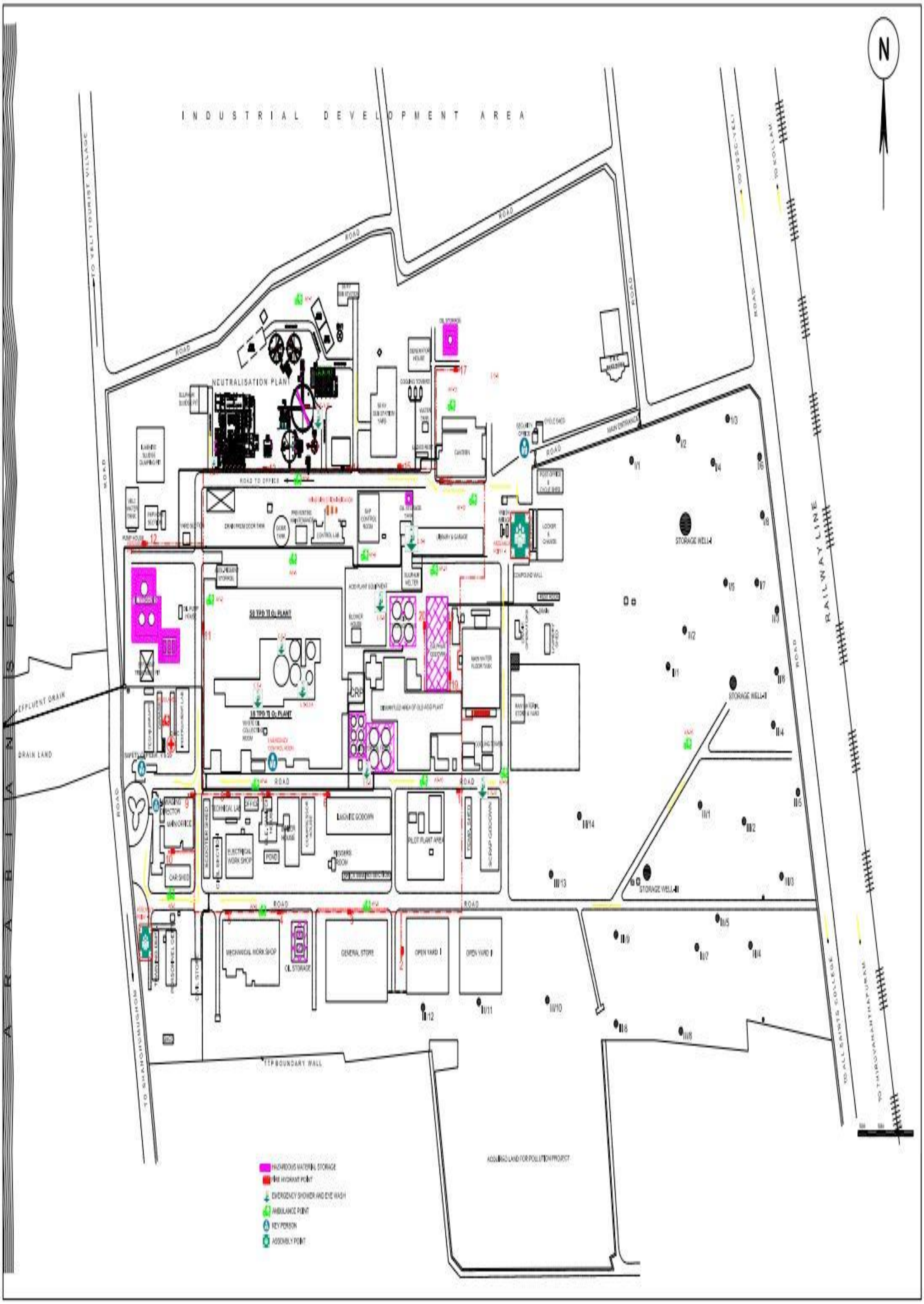
ORDER NO. GA-10583/2017/F&B DATED 25/10/2018

The Onsite Emergency plan of Travancore Titanium Products Ltd, Thiruvananthapuram is provisionally approved vide order No. GA/10583/2017/F&B dated 25/10/2018 of The Director of Factories & Boilers, Kerala State.

OFFICE OF THE DIRECTOR OF FACTORIES & BOILERS * KERALA *

Director of Factories & Boilers
Kerala State.

TTP/HSE/OEP/02



INDEX

8	Chapter 7 **Emergency actions on Hazardous Items** Sulphur Sulphur Dioxide Sulphur Trioxide Sodium Hydroxide Glyceryl Monostearate Sulfated Castor Oil (Turkey Oil) Aluminium Powder Potassium Sulphate Zinc Dust Zinc Oxide	30 31 32 33 34 35 36 37

LIST OF ANNEXURE

SAFETY POLICY

We, at Travancore Titanium Products Limited recognise that the safety of our employees, contractor workers, third parties and visitors is vital to our business success. Safety is integrated with our business processes spanning people, processes, systems, technologies and facilities. SAFETY is driven through top management commitment and Visible Leadership across all levels. Our main objectives are to:

1. Provide safe and Healthy Working environment to all employees and maintain high degree of safety standards in all the factory installations right from the design stage to the disposal stage.
2. Create and maintain Safety conscious among the employees and neighboring citizens by way of safety education, training, safety awareness programs and all other possible means.
3. Take all possible steps to prevent any potential disaster likely to occur in the course of employment apart from being vigilant and prepared for emergencies and maintain a healthy environment.
4. Ensure strict compliance of all rules and regulations with respect to safety, health and environment protection.

WORK PLACE SAFETY

All operations are required systematically to implement a series of fatality prevention directives. The directives are based upon major causes of fatalities and encompass hazard identification, risk assessment and controls, training, and maintenance and emergency procedures.

Our health and safety policy has been rolled out across all operations and has been included as a key responsibility in line management and business performance. Clear organisational accountabilities are supported by a robust program of training, communication and Risk Management processes. A systematic reporting system enables the top management to evaluate the overall direction and efficiency of the health and safety system and develop strategies for improving it.

Regular audits (both internal and external) ensure that all legal regulations/standards are implemented and complied with.

Cardinal Rules

1. Protective Equipment Personal Protective Equipment (PPE) rules, applicable to a given task, must be adhered to, at all times.

2. Lock-Out Procedure Isolation & lock-out procedures must always be followed.

3. No Alcohols or Drugs No Person may work, if under influence of alcohol/drug.

4. Reporting Culture All injuries and incidents must be reported.

5. Compliance of applicable legal and other requirements.

6. Involve all employees in the implementation of this Policy and provide appropriate training.

7. Adopting safe operating practices with an emphasis on social accountability.

8. Inculcate safety as a personal value through behavioral intervention at all levels, recognition of positive behavior and continuous correction of unsafe behavior.

The company expects all employees to co-operate and ensure active involvement in all activities connected with the different accident prevention programs and to co-operate with the neighboring society and extend all possible efforts to prevent and contain any disaster in case of occurrence in the factory, in spite of all safety precautions and measures. As a matter of safety policy, employees are also expected to shoulder personal as well as collective responsibilities in order to achieve our safety objectives towards an accident free work environment.

MANAGING DIRECTOR

CHAPTER 1

PREFACE

1.1 The enclosed On-site Emergency Plan is made for Travancore Titanium Products Limited, Thiruvananthapuram.

1.2 The plant has a manufacturing facility to produce bulk chemicals and pigments.

1.3 The plant is designed and equipped to handle hazardous chemicals and to carry out various processes and operations on these chemicals. The plant is provided with partial Fire Hydrant system, Fire extinguishers and Scrubber system. In addition to this, numerous Personal Protective Equipments, First Aid Boxes, Eye washers, Ventilation systems has been adequately provided.

1.4 Considering the types of operations carried out in the plant and the nature, extent of hazards existing, the management of Travancore Titanium Products Ltd thought it is necessary to have a system for tackling an emergency.

1.5 The formulation of this document is an outcome of the above thought process.

PREAMBLE

In spite of various preventive and precautionary measures taken in the plant, the possibility of a mishap cannot be totally ruled out. Hence, the need to prepare a Contingency Plan for dealing with incidences which may still occur and are likely to affect LIFE and/or PROPERTY, both within the plant and in the immediate neighborhood.

Such an emergency could be the result of malfunction of the Plant & Equipment or non-observance of operating instructions. It could, at times, be the consequence of acts outside the control of plant management like severe storm, earthquake, flooding, or deliberate acts of arson or sabotage.

A Major Emergency in the plant is one that may cause serious injury or loss of life and damage to the property.

This On Site Emergency Plan (OEP) explains the code of conduct of all personnel in the plant along with the actions to be carried out in case of an Emergency. This plan gives the guidelines for employees, contractors, transporters, etc. It not only defines responsibilities but also informs about prompt rescue operations, evacuations, rehabilitation, co-ordination and communication.

Factory Details		
Name of Factory	Travancore Titanium products Ltd.	
Name of Occupier	Shri.Georgee Ninan	
Name of Manager	Shri. Prabhakaran	
Name of Medical Officer	Shri. Victor S	
Name of Welfare Officer	Smt. Nirmala M	
License No	6655	
Present Strength	710	
Shifts timing	First shift	06.00 to 14.00 hrs
	Second Shift	14.00 to 22.00 hrs
	Third Shift	22.00 to 06.00 hrs
	General Shift	08.00 to 16.00 hrs

Key Personalities		**Internal Phone Number**
Occupier	**Managing Director**	**2200**
Factory Manager	**DGM (HR)**	**2188**
Safety Officer	**AGM (S&E)**	**2111**
Security Officer	**V & SS**	**2049**
OHC	**Chief Medical Officer**	**2090**
Emergency Control Room	**Manager (Prodn)**	**2085**
Main Gate Security	**Head Guard**	**2011**

CHAPTER 2

ON-SITE PLAN

1. EMERGENCY:

An Emergency is a situation, which may lead to or cause large-scale damage or destruction of life, property or environment within or outside the Factory. Such an unexpected situation may be too difficult to handle for the normal work force within the plant.

2. NATURE OF EMERGENCY:

The emergency specified in the **OEP** refers to occurrence of one or more of the following events: -

a. Fire/Explosion.

b. Major accident such as structural or building collapse, overturning of road tanker containing flammable substances.

c. Natural calamities like storm, flood, earthquake, etc.

d. Sabotage; act of terrorism, civil commotion, air raid etc.

3. PROCESS DESCRIPTION:

A brief description of the Manufacturing Process is given in 'Annexure A'.

4. IDENTIFICATION OF HAZARDOUS AREAS:

HAZARD	AREA	PROBABLE CAUSE OF THE ACCIDENT
Explosion	Boilers / Transformers / Receivers for the Air compressors.	Malfunctioning of the Safety Valve, rupture of vessels
	Flammable Petroleum Product Storage Tank / Drum Storage area (Waste oil)	External fire causing pressure built up in the tanks / barrels
Fire	H.S.D. / FO Storage Area/ Sulphur storage / Sulphur Melting pit / Acid Dilution tank / Sulphuric acid Storage.	Flammable vapor / air mixture and source of ignition.
	Flammable Petroleum Product - Storage Tank / Drum Storage Shed (Waste oil) / Pumping Area	Formation on pool in the dyke wall and source of ignition.
		External fire → Built up of internal pressure → Failure of the top cover → Tank on Fire
Spillage	Acid Storage Area	Spillage of Acid due to rupture of the pipe line, collapse of the storage tank

5. OBJECTIVES OF THE PLAN

a) To provide resources and methods for effective control of emergencies arising out of leakage, explosion and fire due to hazardous chemicals.

b) To prevent emergency turning into a disaster.

c) To minimize damage to property, people and environment.

d) Effective rescue operation and treatment of the causalities.

e) To train the people to act effectively in an emergency.

f) To provide authoritative information to the media and government agencies.

g) Not to create panic among general public and to hinder exploitation or exaggeration of the situation by any agency.

h) To restore normalcy in the least possible time.

i) To preserve records and to take steps to prevent recurrence.

6. EMERGENCY CONTROL CENTRE:

For the purpose of handling emergency, the following Emergency Control Center has been identified as **The Office of Manager (Production), TiO_2 Plant**

All communications to and from will originate at this **CONTROL CENTRE**.

The Emergency Control Center will have the following: -

a) A copy of ON-SITE EMERGENCY PLAN.

b) List of important telephone numbers such as Police, Fire Brigade, Hospitals, and other outside Emergency Services, etc.

c) List of key Personnel with addresses and telephone numbers.

d) Plant layout indicating storage of hazardous materials

e) List Fire Extinguisher.

7. ASSEMBLY POINTS

In case of an **EMERGENCY** the employees should assemble near the defined Assembly Points, as indicated below: -

- Assembly point (1) – near Time Office.
- Assembly point (2) – near Training Department Building

Wind direction to be determined by the WIND SOCKS installed on top of the Process control lab building.

THE EMPLOYEES SHOULD RUN PERPENDICULAR TO THE WIND DIRECTION AND NOT AGAINST / ALONG THE WIND DIRECTION.

8. CODIFICATION OF SIRENS

Sr.	SIRENS	INDICATES	AUTHORITY
1.	30 SECOND CONTINUOUS	ON SITE EMERGENCY (ALERT)	MANAGER (Prodn)
2.	1 MINUTE CONTINOUS	EMERGENCY CONTROLLED (ALL CLEAR)	MANAGER (Prodn)

NOTE: 1) EMERGENCY SIREN TO BE SOUNDED ONLY IF REQUIRED

2) NO EMERGENCY ORGANIZATION MEMBER WILL LEAVE THE EMERGENCY SPOT UNLESS `ALL CLEAR' SIREN BLOWN.

9. TRAINING AND EDUCATION

Experience with on site –emergency planning has proved the need of training and rehearsal. Major emergency procedure should be laid down clearly and convincingly to everyone on site particularly Key Personnel and Essential workers.

In-House Training

TTPL give in-house refreshment training in safety every month for approx 50 employees, covering all employees every year.

First - Aid training

There are about 30 first aid trained employees in the factory. They are trained by St. Johns Ambulance.

Fire drill

Fire drills with live fire were conducted every month during in-house training.

Mock Drills

Mock drills on various emergency situations were conducted once in every 3 months.

10. MOCK REHEARSAL:

- Inform all the employees about mock drill.
- Fix the date for mock drill.
- Observers will not be involved in the exercise. They will monitor the Mock drill.
- Emergency Siren / alarm will be raised.
- After hearing the Siren / alarm, Emergency procedure will be followed as mentioned in the OEP.
- Observer will note down the activities with respect to the time.

11. UPDATING THE PLAN:

As and when required the On Site Emergency Management plan will be updated. After each drill the plan will be thoroughly received to take account of shortcoming and accordingly plan will be updated.

CHAPTER - 3

EMERGENCY ORGANISATION

Responsibility will be automatically delegated in absence of concern person/s in following manner.

SITE CONTROLLER:	**Manager (Production)**
INCIDENT CONTROLLER:	**Officer in charge of the site**
SAFETY COORDINATOR:	**AGM(S&E)**
ADVISORY COMMITTEE:	**Safety Committee**
COMMUNICATION COMMITTEE:	**HR Department**

CHAPTER - 4

KEY PERSONNEL & THEIR RESPONSIBILITIES

Key Personnel's Responsibility during normal working hours :-

1. **Site Controller - Manager (Production) (on duty):**

He will retain overall responsibility for the factory and its personnel. As soon as he is informed of the emergency he shall proceed to the control room**.** His duties shall be:

i) Assess the magnitude of the situation and decide if staff needs to be evacuated from their assembly points.

ii) Exercise direct operational control over areas other than those affected.

iii) Maintain a continuous review of possible development and assess in consultation with Incident Controller and other Key personnel as to whether shutting down of the plant or any section of the plant and evacuation of persons is required.

iv) Liaison with Senior Officials of Police, Fire Brigade, Directorate of Industrial Safety, provide advice on possible effects on areas outside the factory premises.

v) Control rehabilitation of affected areas on discontinuation of emergency.

vi) Issue authorized statements to news media, and ensure that evidence is preserved for inquiries to be conducted by statutory authorities.

2. **Incident Controller:**

During emergency he will rush to the scene of the occurrence and take overall charge and report to Site Controller. On arrival he will assess the scale of emergency and decide if major emergency exists or is likely and inform the Communication Officer accordingly.

(1) Direct all operations within the affected areas with the priorities for safety of personnel minimize damage to the plant, property and minimize loss of materials.

(2) Pending arrival of Site Controller, assume the duties of his post and, in particular.

(3) (a) Direct the shutting down and evacuation of plant and areas likely to be adversely affected by the emergency.

(b) Ensure that all Key personnel and outside help are called in.

(4) Provide advice and information to the Security Officer and the local fire service as and when they arrive.

(5) Ensure that all non-essential workers/staff of the areas affected are evacuated to the appropriate assembly points, and the areas are searched for casualties.

(6) In the event of failure of electric supply and internal telephones, set up communication point and establish contact with Emergency Control Centre.

(7) Report on all significant developments to the HR manager.

(8) Have regard to the need for preservation of evidence so as to facilitate any inquiry into the causes and circumstances, which caused or escalated the emergency.

3. **Safety Coordinator, AGM(S&E)**

During emergency he will approach the emergency site and assess the situation and will consult with the incident controller. He will also be consulting with the advisory committee. Instructions will be given to the main Incident controller. Communication with top management and government authorities are his responsibility. The decision for evacuation and blowing of ALL CLEAR siren will be up to him after his evaluation on the situation.

4. **Human Resources Manager (DGM, HR)**:

He will also work as liaison Officer and will be stationed at the Main Entrance (Security Office near Main Gate) during the emergency. He will under the direction of the site Controller handle police, press and other inquiries, receive reports from roll-call leaders from assembly points and pass on the absentee information to the Incident Controller. His responsibilities shall include -

(1) To ensure that casualties receive adequate attention, to arrange additional help if required and information relatives.
(2) To control traffic movements into the factory and ensuring that alternative transport is available when need arises.
(3) When emergency is prolonged, arrange for the relief of personnel and organise refreshments / catering facility.
(4) From information received, advise the Site Controller of the situation, recommending (if necessary) evacuation of staff from assembly points.
(5) Recruit suitable staff to act as runners between the Incident Controller and himself if the telephone and other system of communication fails due to whatsoever reasons.
(6) Maintain prior agreed inventory in the control centre.

(7) In case of prolonged emergency involving risk to outside areas by wind-blown materials, contact local Meteorological Office to receive early notification of changes in weather conditions.

5. **Security Officer:**

On hearing alarm advice fire squad and security staff in the factory of the incident zone and cancel the alarm. He will also announce through telephone or messengers to the HR Manager, Incident Controller and Site Controller that incident has occurred in such and such zone. He will open the gates nearest to the incident and stand by to direct the emergency service.

6. **Departmental Heads:**

The Departmental head where in the incident has taken place will report to Incident Controller and provide assistance as required. They will decide which members of their staff they require at the scene.

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CHAPTER - 5

EMERGENCY ACTION PLAN

ANY ONE NOTICING EMERGENCY SITUATION LIKE FIRE, EXPLOSION, TOXIC GAS LEAKAGE ETC

DO's

- Attract the nearby person/employee by shouting "FIRE – FIRE – FIRE. "
- Seek help from the persons working nearby.
- Try to control the incident at its initial stage with available means/sources quickly.
- Inform Shift In-charge / Duty Officer (In Night Shift) about the Incident.

DON'Ts

- Do not be panicky.
- Do not run – Walk fast.

SITE CONTROLLER (MANAGER PRODUCTION ON DUTY)

DO's

A. IF FIRE / OTHER INCIDENTS ARE CONTROLLABLE

- Approach the emergency site immediately taking note of wind direction.
- Assess the situation.
- Inform Security Officer, Tell – NAME, TYPE OF INCIDENT, ACTION TAKEN, HELP NEEDED and Order Security Officer/Guard to inform all KEY persons.
- Take lead in controlling emergency until such time concerned Section Manager takes over the charge.

DON'TS

- Do not be panicky.
- Do not lose temperament.

B. IF FIRE/OTHER INCIDENTS ARE NOT CONTROLLABLE

In Addition to Above (A)

- Order to blow emergency `ALERT' Siren (30 second continuous).
- Organize Fire fighting / rescue team members to control the Incident.
- Take stock of situation if required shut down the plant / process in affected area.
- Call Fire Brigade if situation demands.
- Evacuate affected area.
- Organize head count of the plant.
- Act as INCIDENT CONTROLLER till such time senior person takes charges as indicated in Emergency organization.

NOTE: 1) Messenger will wait until such time Security Officer arrives.

2) Also inform Telephone Operator.

SECURITY OFFICER

DO's

- Do not allow any vehicle to come inside the factory.
- Do not entertain any outside call except for emergency purpose.
- Do not allow visitors to move around.
- Inform all key persons about location and type of emergency.
- Follow this sequence – Inform concerned HOD/Section Head, Site Controller, Incident Controller & Safety Officer and other KEY persons.
- Inform Main Site Controller about Government visitors, if any.

DON'Ts

- Do not entertain any outside call except for emergency purpose.

- Do not allow visitor to move around, from reception.

SECURITY GUARDS

DO's

- Immediately report at Security Gate in shortest possible time.
- Follow instructions of Officer In-charge.
- Assist in controlling emergency.
- Assist in controlling contractors, vehicle movement and mob.
- Assist in cordoning off the area.
- Take note of wind direction while approaching emergency site.
- Render all possible help for controlling overall situation.

DON'Ts

- Do not leave the site unless asked to do so.

EMERGENCY VEHICLE DRIVER

DO's

- Immediately start vehicle and reach rescue squad assembly point.
- Rescue squad members to emergency site.
- Take vehicle near to emergency site as directed.
- Take note of wind direction.
- Reverse the emergency vehicle for quick transports of injured, if any.
- Keep vehicle engine running.
- Always be on Driver's seat of the vehicle.
- Take the injured to the hospital as directed.

DON'Ts

- Do not leave the vehicle.
- Do not take the vehicle very near to the site.

SAFETY COORDINATOR,AGM(S&E)

DO's

- Will approach emergency site immediately / assess the situation.
- Consult Incident Controller.
- Consult advising Committee Members.
- Instruct Main Incident Controller.
- Communicate to higher ups and Govt. authorities, if required.
- Decide upon need for evacuation and blow `Disaster Siren'.
- After getting satisfied with the situation, give instruction to blow ALL CLEAR Siren

DON'Ts

- Do not instruct to blow ALL CLEAR siren unless the situation is fully under control.
- Don't evacuate the entire plant unless the situation demands.

ALL GENERAL EMPLOYEES EXCEPT THOSE WHO ARE IN EMERGENCY ORGANIZATION ON HEARING SIREN

DO's

- Be alert and be available if required.
- Wait for further instructions.
- Bring down the process/plant/equipment in SAFE CONDITION in case of DISASTER siren as per instructions from Incident Controller.
- Approach respective safe assembling points route as taking note of wind direction.
- Help in taking roll call.
- After hearing ALL CLEAR, go back to the departments.
- Start the work again after setting instruction from Incident controller.

DON'Ts

- Do not be panicky. Do not run.
- Do not approach emergency site unless asked for.

- Do not engage telephone except for emergency purpose. Keep lines free.

GENERAL INTRUCTIONS

DO'S

- Stop work at height. / Stop all hot works.
- Stop all vessel entry.
- Take note of wind direction.
- On hearing Disaster Siren evacuates as per evacuation route without running and panicky and assembles at respective safe Assembly Points.

DON'Ts

- Do not use telephone except for emergency purpose.
- Do not start work at height, vessel entry, hot work unless permit conditions are verified.
- Do not allow unauthorized person to approach emergency site.

EMERGENCY ACTIONS ON HAZARDOUS SITUATIONS

1. Failure of Sulphuric Acid Storage Tanks

In case of failure to the storage tanks that hold Sulphuric acid, it is likely to endanger the life of employees and property and can develop to such an extent that the duty personnel and the facilities available within the facilities available within the factory cannot control it.

Properties of Sulphuric acid

Sulphuric acid is not flammable but is highly reactive and capable of charring when in contact with materials. It is a very powerful acidic oxidizer. Many materials (eg: Acetic acid, nitrates, carbides, chlorates etc) can ignite or even explode on contact with sulphuric acid.

Possible hazards of Sulphuric acid

Acid will get into the drains and spread to the surrounding area with evolution of heat and acid fumes. Sulphur dioxide poisoning, asphyxiation and acid burns are possible. Hazards can spread to the beach area surrounding the drain channels outside the factory premises and can affect inhabited areas outside the factory premises.

Precautions

Acid storage tanks are provided with built-in-safety arrangements. Instead of having a single storage tank of high capacity,8 tanks with lesser capacity are installed to minimize the damages in case of failure. These tanks are arranged at two different locations with each having a set of 4 tanks of 1500MTs of capacity. One tank in each set will be kept on standby. No tank is kept full, so that there is a spare storage capacity available for transferring acid from leaky tank. Dyke walls are provided to each setoff tanks to contain the acid when there is leak.

Emergency Actions

1) Level off the storage tanks(Personnel directed to operate valves within the Dyke walls should wear protection equipments such as PVC suit, gum boots, chemical goggles and gas mask).
2) Transfer acid from the punctured tank to the standby tanks.
3) Neutralize the acid flowing through the drain with quick lime or washing soda.
4) Shutdown the Sulphuric acid Plant .If the Plant cannot be stopped locally, get it stopped from the electrical switch house.

Shutdown procedures of Sulphuric Acid Plant

1) Stop the Sulphur pump.
2) Stop the air blower.
3) Stop all dilution water.
4) Stop product acid.
5) Close the blow down valves of boilers.
6) Stop acid circulation, if necessary.
7) Inform Steam users.

First Aid Treatment

a) Skin Contact:

Get under an emergency shower immediately. Remove all contaminated clothing as rapidly as possible while under the shower. If an Emergency shower is not available, flush the affected area with large quantity of running water, at least for 15 minutes.

b) Inhalation of Fumes

1. Remove the victim to an uncontaminated area.
2. If the victim is unconscious, check for breathing and pulse.
3. If breathing has ceased, start artificial respiration immediately.
4. If the victim is conscious, make him lie or sit down calmly.
5. If the breathing becomes rapid, place the victim in the sitting up position and give oxygen (oxygen should be administered by an authorized person only).

2. Fire and Explosion of Fuel oil and Storage tanks

Inflammable liquids like kerosene, HSD and furnace oil used in the manufacture of Titanium dioxide and for boiler operations. The fuels are stored in the factory premises under license from the Department of explosives.

Fire to fuel oil storages can lead to bursting of storage vessels. The consequences are shock wave, damage to buildings, falling of structures, flying debris, heat radiation and smoke. It is likely to endanger the lives of employees, loss of property and it can develop to such an extent that it cannot be controlled by the facilities and personnel available in the factory.

Kerosene oil stored in a vertical mild steel tank of 500 Kl capacity and furnace oil stored in a vertical mild steel tank of 310 Kl capacity. There are three more horizontal Mild steel tanks of 32 Kl capacity, each mounted on concentrate pillar to store furnace oil and kerosene oil. All tanks are located adjacent to each other in the oil storage area. Fuel pumping station is also provided in the storage area.

Precautions and Fire Fighting Facilities

Electrical equipments and motors used in the oil pumping station are fire proof. The storage tanks are adequately grounded and dyke walls are provided to contain the liquid in case of leakage or spillage. A portable foam type fire extinguisher of 50 liters capacity is placed in the storage area. Hydrant points are provided at four corners of the area. In case of fire on any of the tanks, the nearby tanks and building are to be cooled using the hydrant points provided.

Availability of Water

Within the premises, water is stored in the floor tanks. The main floor tank, near the Sulphuric acid plant has a capacity of 4800m^3 and the one near the fuel oil storage area has a capacity of 1875$m^{3.}$

3. Sulphur Dioxide leakage from Sulphur dioxide plant

On detection of uncontrolled leakage of Sulphur Dioxide leakage from Sulphuric acid plant, decision for evacuating the plant and to inform the locality persons should be taken by Site controller in concurrence from DGM (Production).

Safety Hints on Sulphur dioxide

1) It has no colour. So we cannot see it.
2) It has a pungent smell and is suffocating.
3) It settles near the ground.
4) At high concentration, the gas can be incapacitating.
5) It does not catch fire.
6) To avoid inhalation of gas move at right angles to the wind direction.
7) If you are near to the gas, use wet cloth to cover the face.
8) Wash eyes, nose and throat with lot of water.
9) Breath through a wet cloth

Method of declaring Emergency

The declaration of emergency is done by Site controller by operating emergency siren for one minute duration and declaring emergency through the Public Address System (PAS). The assembly point to be used should be communicated analysing the wind direction by monitoring wind socks.

Lifting of Emergency

The lifting of emergency will be declared by operating siren communicating same through Public Address System.

Action	Personnel Responsible
1. Blow emergency siren continuously for 1 minute and declare emergency through PAS.	Manager (Prodn) on shift duty
2. Direct safe shutdowns of the concerned sections and instruct control measures to section head	Manager (Prodn) on shift duty
3. Arrange for evacuation / fire fighting squad. All security personnel except those posted in main gate will engage.	Manager (Prodn) on shift duty
4. Direct personnel to assembly point-1 (Near Main Gate) or assembly point-2 (Near Time Office), depending on the wind Direction. Employees should leave to assembly points in right angle to the wind direction.	

SAFETY HINTS AND EMERGENCY ACTIONS ON HAZARDOUS ITEMS

Based on the reactions involved during the production process and the raw material involved the possible hazards are indentified. The action for the emergency situation is given.

Production: Concentrated Sulphuric Acid			
Process: Double Contact Double Absorption Process			
NO	**Critical Raw Material**	**Possible hazards**	**Actions**
1	**SULPHUR**	Solid and molten sulphur can be ignited; burning sulphur produces **SULPHUR DIOXIDE**. Dust particles may be irritating to the eyes, nose, throat, and skin. Molten sulphur can cause thermal burns. Molten sulphur may evolve **HYDROGEN SULPHIDE** (toxic gas) which may accumulate in storage container vapor space. Hydrogen sulphide causes eye irritation.	EYE CONTACT: Immediately flush eyes with plenty of water for at least 15 minutes INHALATION: Move exposed personnel to uncontaminated area. If not breathing, administer artificial respiration. INGESTION: Do not induce vomiting. Do not give liquids. Obtain immediate medical attention. If spontaneous vomiting occurs, lean victim forward to reduce the risk of aspiration. Monitor for breathing difficulties. Small amounts of material which enter the mouth should be rinsed out until the taste is dissipated.

2	**SULPHUR DIOXIDE**	Irritation and/or burns to the cornea that may lead to vision impairment or loss. Corrosive and irritating to the respiratory tract and mucous membranes. Chemical burn similar to one that is caused by an inorganic acid.	EYE CONTACT: Immediately flush eyes with plenty of water for at least 15 minutes INHALATION: Move exposed personnel to uncontaminated area. If not breathing, administer artificial respiration. SKIN CONTACT: Flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. **Get immediate medical attention**
3	**SULPHUR TRIOXIDE**	Very hazardous in case of skin contact (corrosive, irritant, permeator), of eye contact (irritant, corrosive), of ingestion, of inhalation. Liquid or spray mist may produce tissue damage particularly on mucous membranes of eyes, mouth and respiratory tract. Skin contact may produce burns. Inhalation of the spray mist may produce	EYE CONTACT: Immediately flush eyes with plenty of water for at least 15 minutes INHALATION: Move exposed personnel to uncontaminated area. If not breathing, administer artificial respiration. SKIN CONTACT: Flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes.

		severe irritation of respiratory tract, characterized by coughing, choking, or shortness of breath. Severe over-exposure can result in death	**Get immediate medical attention**
4	**SODIUM HYDROXIDE**	Very hazardous in case of skin contact (corrosive, irritant, permeator), of eye contact (irritant, corrosive), of ingestion, of inhalation. The amount of tissue damage depends on length of contact. Eye contact can result in corneal damage or blindness. Skin contact can produce inflammation and blistering. Inhalation of dust will produce irritation to gastro-intestinal or respiratory tract, characterized by burning, sneezing and coughing.	EYE CONTACT: Immediately flush eyes with plenty of water for at least 15 minutes INHALATION: Move exposed personnel to uncontaminated area. If not breathing, administer artificial respiration. SKIN CONTACT: Flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. **Get immediate medical attention**
5	**GLYCERYL MONOSTEARATE**	Irritating to eyes and skin	EYE CONTACT: Immediately flush eyes with plenty of water for at least 15 minutes SKIN CONTACT: After contact with skin, wash

			immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Cover the irritated skin with an emollient. If irritation persists, seek medical attention. INGESTION: Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If not breathing, give artificial respiration. **Get immediate medical attention**
6	**SULFATED CASTOR OIL (TURKEY RED OIL)**	Irritating to eyes and skin	EYE CONTACT: Immediately flush eyes with plenty of water for at least 15 minutes SKIN CONTACT: After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Cover the irritated skin with an

			emollient. If irritation persists, seek medical attention. INGESTION: Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If not breathing, give artificial respiration. **Get immediate medical attention**
Process : Precipitation			
7	**ALUMINIUM POWDER**	Combustible solid, Irritating to skin	EYE CONTACT: Immediately flush eyes with plenty of water for at least 15 minutes SKIN CONTACT: After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Cover the irritated skin with an emollient. If irritation persists, seek medical attention. INGESTION: Do not induce vomiting. Loosen tight clothing such as a collar, tie,

			belt or waistband. If not breathing, give artificial respiration. **Get immediate medical attention**
8	**POTTASSIUM SULPHATE**	Hazardous in case of inhalation. Slightly hazardous in case of skin contact (irritant) and of eye contact (irritant).	EYE CONTACT: Immediately flush eyes with plenty of water for at least 15 minutes SKIN CONTACT: After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Cover the irritated skin with an emollient. If irritation persists, seek medical attention. INGESTION: Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If not breathing, give artificial respiration. **Get immediate medical attention**

9	**ZINC DUST**	Hazardous in case of inhalation. Slightly hazardous in case of skin contact (irritant) and of eye contact (irritant). **Dangerous When Wet, Spontaneously Combustible** - (Can evolve gaseous hydrogen in contact with water or damp air. The heat of the reaction may be sufficient to ignite the hydrogen produced)	EYE CONTACT: Immediately flush eyes with plenty of water for at least 15 minutes SKIN CONTACT: After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Cover the irritated skin with an emollient. If irritation persists, seek medical attention. INGESTION: Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If not breathing, give artificial respiration. **Get immediate medical attention**
10	**ZINC OXIDE**	Hazardous in case of inhalation. Slightly hazardous in case of skin contact (irritant) and of eye contact (irritant).	EYE CONTACT: Immediately flush eyes with plenty of water for at least 15 minutes SKIN CONTACT: After contact with skin, wash immediately with plenty of

			water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Cover the irritated skin with an emollient. If irritation persists, seek medical attention. INGESTION: Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If not breathing, give artificial respiration. **Get immediate medical attention**

ANNEXURE 'A'

BRIEF DESCRIPTION OF THE MANUFACTURING PROCESS

MANUFACTURING PROCESS OF TITANIUM DIOXIDE

Ilmenite, a mixed oxide of Titanium, ferrous iron and ferric iron is ground in ball mills to fine powder and is reacted with concentrated Sulphuric acid in specially designed digesters. The porous cake obtained as product is dissolved in water. Titanium goes into the solution as Titania Sulphate. The ferric iron present/is reduced to ferrous which is easily washable, using scrap iron.

Reduced crude liquor is dosed with settling agents and sent through settling tanks to remove the sludge consisting mainly of un-reacted illmenite and silica. The clear overflow from the settlers is concentrated to a specific extent and then charged into precipitation tanks. On boiling by injecting live steam, the Titanium contents get precipitated as hydrated titanium oxides.

It is then filtered over the drum rotary vacuum filters. Any ferric iron still present is reduced to washable ferrous form by leaching the pulp with concentrated Sulphuric acid and aluminium powder. It is washed further and then treated with small quantities of certain chemicals which help to develop the pigmentary properties. The treated pulp is dewatered to 40% solids and fed into big Furnace oil fired rotary kilns.

The moisture gets first removed and then the occluded Sulphuric acid decomposes and the oxides of the Sulphur escape out. At the final stages of heating in the Kiln, crystalline properties get fully developed. The discharge from the kiln is cooled slowly and pulverized to very fine particles of average size from 0.4 microns. The Titanium dioxide (TiO_2) is packed as such and sold.

ANNEXURE 'B'

TELEPHONE NUMBERS OF POLICE, FIRE BRIGADE, HOSPITALS, AND OTHER OUTSIDE EMERGENCY SERVICES

POLICE	
Police Control Room	100
Shangumukham Police Station	2501801
Police Station, Pettah	2743195
Police Station, Valiyathura	2501833
FIRE BRIGADE	
Fire Station, Chackai	2501255
Fire Station, Chengalchoola	2333101
K.S.E.B. OFFICE: -	
K.S.E.B Sub Station, Veli	2502315
K.S.E.B Sub Station, Chackai	2502562
K.S.E.B Control Room	2461391
AGENCIES TO BE INFORMED	
Inspector of Factories, Trivandrum	2431458
Director of Factories and Boilers	2440974
District Collector, Thiruvananthapuram	2731200
HOSPITALS	
Medical College Hospital	2444270
General Hospital	2303870
Govt. Fort Hospital	2471766
Sree Chithra Medical Centre	2443152
Regional Cancer Centre	2442541
Cosmopolitan Hospital	2448182
SUT Hospital	2446220
KIMS Hospital	2448585
Lords Hospital	2742323
S.P. Fort Hospital	2450540
P.R.S Hospital	2344443
Jubilee Hospital	2334561

TELEPHONE NUMBERS AND ADDRESSES OF KEY PERSONNEL

LIST OF KEY PERSONS

NAME	INTERNAL PHONE	ADDRESS	CONTACT
MD (Occupier of Factory)	2200	Shri. Georgee Ninan Plavilakandathil, Kadappakada, Kollam.	
GM (TECHNICAL)	2038	Shri. Royson Luke	8593936611
DGM (PRODUCTION)	2028	Shri. S. Perumal	9048505628
DGM(HR) (Factory Manager)	2188	Shri. Prabhakaran TC- 30/70(1), Niharika, Kudavoor, Anayara P.O, Trivandrum -29.	9048505624
AGM(S&E) (Safety Officer)	2111	Shri.Vinod R Kailasam, TC 19/2108-8, Poojapura, TVM 695012	9048505345
MANAGER (PRODUCTION)	2085	-	9048505942
SECURITY OFFICER(V&SS)	2049	Shri. Harikumar IPS	9072858650
CHIEF MEDICAL OFFICER	2090	Dr.Victor S	9846481627
MAIN GATE SECURITY	2011	-	0471 - 2500784

ANNEXURE 'D'

MUTUAL AID SCHEME MEMBERS

MUTUAL AID RESPONSE GROUP

NAME	OFFICE PHONE
VSSC	**2564292**
Airport Domestic Terminal	**2501237**
Airport International Terminal	**2702600**

ANNEXURE 'E'

FIRE EXTINGUSHER

List of Fire Extinguishers

The company has trained personnel for fire fighting and its intends to improve the fire fighting skills of their employee by conducting training on Fire fighting. There are 172 portable fire extinguishers, the break-up of which is as under: -

Sr.No.	Location	Type & Numbers
1	Main Gate	CO_2-3
2	Time Office	Water-1, DCP-1
3	Crane Section	Water-1
4	Cooling Tower	DCP-1
5	Pilot Plant	DCP-1,CO_2-1
6	Acid Plant	Mechanical Foam-3
7	Substation no:3	CO_2-8
8	Compressor House	CO_2-2
9	General Store	Mechanical Foam-2, Water-2
10	Boiler House	Mechanical Foam-3, CO_2-3,DCP-1
11	Substation no:2	CO_2-1
12	Substation-Generator House	CO_2-3
13	Electrical Workshop	CO_2-3,DCP-3
14	Planning Section	CO_2-1,Water-1
15	Civil Section	Water-1, DCP-1
16	Mechanical Workshop	Water-1, CO_2-3,DCP-1
17	Carpentry Section	Water-1
18	Smithy Section	DCP-1, Water-1
19	Rubber Lining Section	DCP-1 CO_2,-1
20	TS Old Lab	DCP-1, Water-1
21	3 Shift Maintenance	DCP-3, Water-2
22	PM & APM Office	DCP-1, Water-1
23	Old Digester Section	CO_2-1,Mechanical Foam-1
24	New Digester Section	Mechanical Foam-1,Water-1, CO_2-1,DCP-1
25	Leaching and Treatment	Mechanical Foam-1, CO_2-5,DCP-3
26	Filter Section	CO_2-1
27	White End	Mechanical Foam-3
28	Calciner 3 & 4	Mechanical Foam-5, CO_2-1

29	Calciner Old Plant	Mechanical Foam-3, CO_2-2,DCP-3
Sr.No.	**Location**	**Type & Numbers**
30	Sub-Station 1	CO_2 -2,DCP-1
31	Inner Gate	DCP-1
32	Main Office Building	DCP-4 , CO_2-4,Water-6
33	Training Department	CO_2-2,DCP-1
34	Personnel Department	CO_2-1,DCP-1,Water-2
35	Security & Vigilance Department	CO_2-1
36	Safety Department	DCP-1, CO_2 -1
37	Technical Library	DCP-1, Water-1
38	Medical Room	Water-1, CO_2 -1
39	Instrument Section	DCP-1, Water-1
40	Oil Storage & Pumping Station	DCP-4, Mechanical Foam-4, CO_2 -1
41	FRP Section	DCP-1, CO_2 - 1
42	Preventive Maintenance Section	CO_2-1
43	Process Control Lab	DCP-1, Mechanical Foam-1, CO_2 -1
44	66 KV Sub-station	DCP-5, CO_2 -1
45	Generator House & Oil Storage	DCP-6, CO_2 -2,Mechanical Foam-1
46	Canteen Building	CO_2 -4,DCP-2,Water-2
47	TRC Library	CO_2 -1,DCP-1,Water-1
48	SAP Maintenance	DCP-1

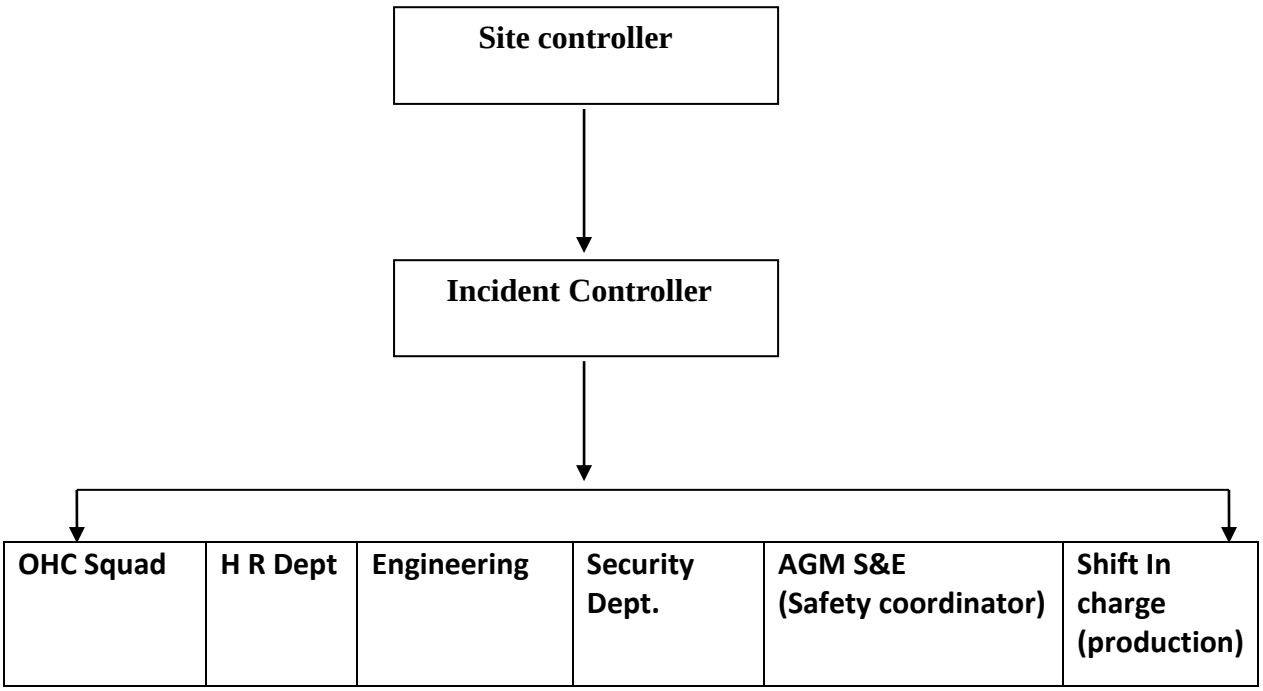
Total Number of Fire Extinguishers:

Sr. No	**Types of Extinguisher**	**Total Nos.**
1	DCP	51
2	CO_2	63
3	Foam	28
4	Water	30

Total Number of Sand Buckets: **70 Nos**

ANNEXURE 'H'

EMERGENCY ORGANIZATION CHART



ANNEXURE 'I'

Maximum Storage facility for Materials in the factory

Name of chemicals materials	Storage
Ilmenite	10000 MT
Sulphur	4000 MT
Scrap Iron	300 MT
Furnace oil	393 KL
Kerosene oil	92 KL
High Speed Diesel	90 KL
Sulphuric acid	10000 MT
Titanium Dioxide	3000 MT
Calcium Carbonate	400 MT
Sodium Hydroxide	400 MT

Safety equipments / PPE

No	ITEM
1	Fire buckets
2	Fire extinguishers
3	Emergency showers
4	Eye washes
5	Apron(leather)
6	Apron(PVC)
7	Safety Belt
8	Safety Helmet(IS)
9	Helmet for welders
10	Hand shield for welders
11	Gum boots
12	Safety shoes
13	Chrome leather gloves
14	Leather gloves for welders
15	Leather gloves for riggers
16	PVC gloves
17	Cotton gloves
18	Rubber gloves, for electricians
19	Anti gasmask
20	Asbestos Suit with hood
21	PVC coat
22	PVC hood
23	PVC pants
24	Ear muff
25	Ear Plug
26	Panorama goggles, splash proof
27	Coloured goggles for welders
28	Nose mask
29	Filtering mask
30	Wind socks

TTP/HSE/OEP/02

LIST OF FIRST AID TRAINED EMPLOYEES

SL NO	NAME	DEPT./SECTION	EMP:CODE	CONTACT NUMBER
1	Anjana. P.M	R&D	1729	9495688645
2	Saji. K	R&D	1538	9495832643
3	Deepu. B	Canteen(H.R)	1623	9447700075
4	Pradeepan. E.K	Medical(OHC)	1932	9633086890
5	Hailan. T.S	Production	1549	9447396115
6	Joseph Jude Rose	Production	1570	9446271926
7	Suresh Kumar. S	Safety & Environment	1420	9447856594
8	Dileesh. S. Das	Production	1827	9447403306
9	Prajin Chandran. C	Production	7028	9496343234
10	Subhash .C	Engineering	1504	9388667725
11	Jishnu K Surendran	Production	1925	7736806118
12	Deepuraj. B.S	Production	1845	8281658551
13	Anoop. S.S	Production	7021	9567222140
14	Ajish. A.J	Production	1599	9495718975
15	Anand. B.S	Production	1739	9746706746

SL NO	NAME	DEPT./SECTION	EMP:CODE	CONTACT NUMBER
16	Nelson Michael	Production	1547	9605662982
17	Boosiri. B	Engineering	1934	8086256505
18	Debhi. H.D'silva	Engineering	1942	9995736331
19	Gopakumar .S	Engineering	1649	9388293300
20	Thomas. V	Engineering	1448	9567448809
21	Johnson. A	Engineering	1874	9656978278
22	Sreenath. S	Engineering	1881	9497533109
23	Sangeeth. P.S	Engineering	1938	8589026466
24	Albert. M	Engineering	1473	9605289901
25	Babu. V.B	Engineering	1467	9496224852
26	Joseph Patrick. T	Engineering	1508	9447560897
27	Sebastian. J	Engineering	1443	9495521233
28	Rajesh. J	Engineering	1507	9447321291
29	James. T.J	Engineering	1352	9446748389
30	Joy. J	Engineering	1337	9447699594

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ADVISORY • RESEARCH • TRAINING

Quantitative Risk Assessment Report

Titanium

Travancore Titanium Products Limited

Report title: **Quantitative Risk Assessment Report**
Date: 21st February 2018

Customer: Travancore Titanium Products Limited (TTPL)
Customer Purchase Order No.: 394/17-18

Consultivo Business Solutions Pvt. Ltd.
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Report no: CBS/ASRN/17-18/013/QRA
Consultivo project ID: 20118013

Report prepared by: Ujjwal K Kundu

Report reviewed by: Saikat Basu

Contents

1.0 Introduction:

Travancore Titanium Products Limited (TTPL) was incorporated on 18th of December 1946, to produce pigment grade Titanium dioxide from ilmenite which is abundantly available as placer deposits on beaches near Kollam, 65 Kms north of the capital city, Thiruvananthapuram in the coastal state of Kerala, India. The unit was promoted by the then princely state of Travancore in collaboration with the British Titan Products (BTP) Company Limited, U.K.(now known as Tioxide Group Limited).The administrative control of the company was with a managing agency, Indian Titan Products Company.

The Company which started production at a modest rate of 5 tonnes per day, increased its capacity in stages to the present level of 40-45 tonnes per day. Till recently, Travancore Titanium Products Ltd., was the only unit producing Anatase grade Titanium Dioxide pigment, in India. TTPL, became a State Public sector unit in 1960, with the Government of Kerala owning 97.55% of the shares.

Production of titanium dioxide commenced in the year 1951,and the capacity was raised to 10 tonnes per day in 1960, the year in which the management of the Company was taken over by the Govt. of Kerala. The Company also installed its own sulphuric acid plant to produce acid for captive consumption. In 1963 the capacity of Titanium Dioxide produced was further increased to 18 tonnes per day wuth a commensurate addition to the sulphuric acid production also.

Subsequently, a modern sulphuric acid plant was commissioned in 1996, which utilizes the tail gas recycling DCDA (Double Catalysis Double Absorption) technology. The alkali scrubbing system incorporated therein helps to keep sulphur dioxide emissions well within permissible limits and helps in maintaining a clean environment.

The chronological events leading to growth of the company is as mentioned below:

- Incorporated in 18th Dec. 1946 in collaboration with British Titan Products, UK.
- Commercial production started in 1950 with an installed capacity of 5 tpd.
- First expansion programme to 10 tpd to produce anatase and rutile grades in 1957.
- Management of TTP taken over the Govt. of Kerala in 1960. Second expansion to 18 tpd in 1963.
- Third expansion to 18 tpd in 1973.
- KSIPTC was appointed sole selling Agents in 1979.
- Upgradation of Sulphuric acid plant technology to DCDA in 1980.
- New DCDA Sulphuric acid plant incorporating technology for air pollution abatement of 300 tpd in 1996.
- Production of rutile by in-house technology in 2002.
- Direct marketing again by TTP from 2003.
- ISO 9001:2000 Company in 2004.
- All time records in Sales and Production in 2004.
- ISO 9001:2008 Company in 2010.

2.0 Background:

TTPL Corporation Ltd. is engaged in manufacturing Titanium Di-oxide pigment from the mineral Ilmenite abundantly available in beaches Kerala. The processes use different chemicals , high temperature, different types of fuel etc. The processes involve risks at various level of operation. Hence, the company was interested to carry out Quantitative risk Assessment /HAZOP study of some of their facilities. TTPL Corporation Ltd. , Thiruvanathapuram, Kerala entrusted the job of carrying out QRA / HAZOP study of different units to Consultivo , Kolkata.

3.0 Scope of work

The detail scope of work is mentioned below.

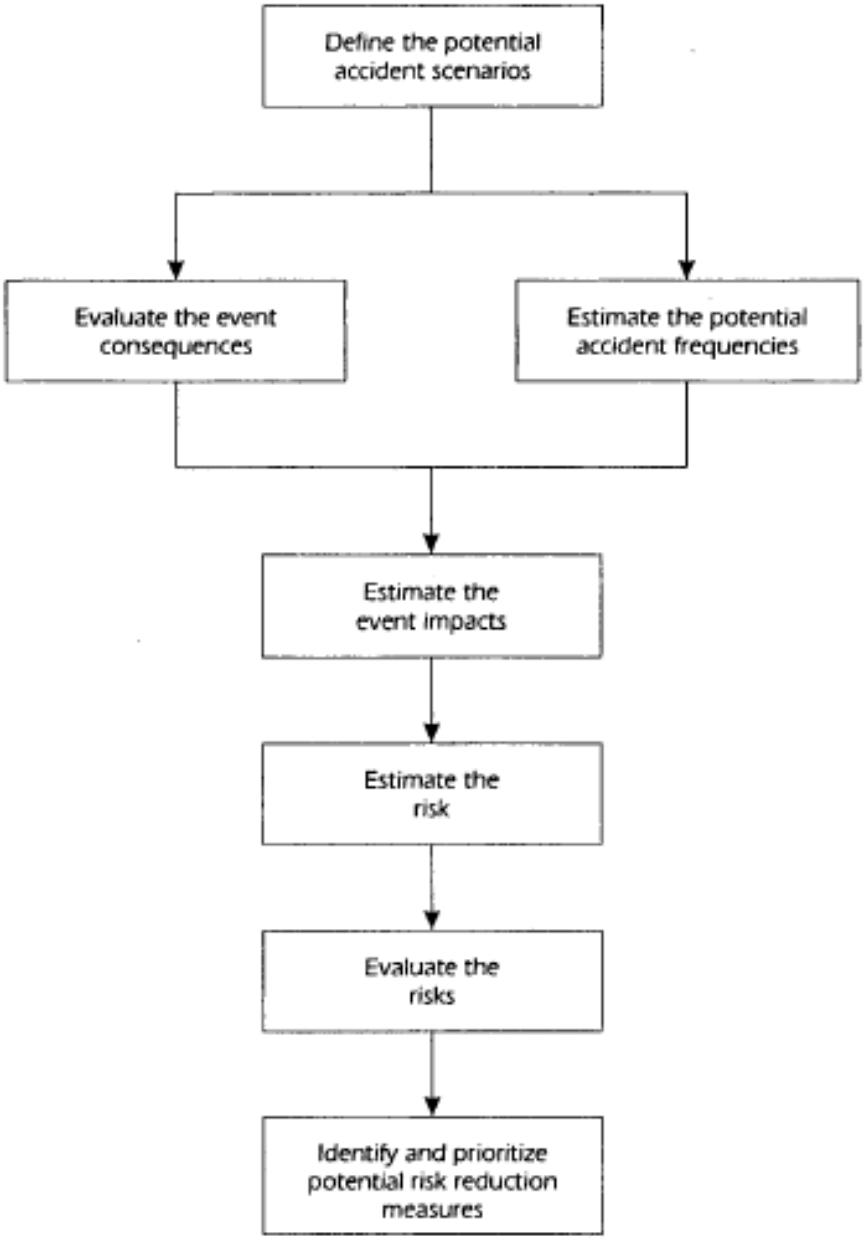
Conduct a HAZOP and QRA of TiO2 plant and Acid plant at TTPL and submit a report with recommendations for reducing / eliminating the hazards and operationality problems.

4.0 Objective

The objective of the study is to identify the potential risk, assessment of the risk and suggest remedial measures.

5.0 Methodology:

The methodology followed for the study is as follows:



6.0 Risk scenarios:

Major chemicals / hydrocarbon :

Sl. No	Material	Scenario	Effect
1.	HSD	i) Hose rupture during unloading.	a) No fire, only vapour cloud.
		ii) Leakage from unloading pump	a) No fire, only vapour cloud.
		iii) Tank drain valve not closed properly	a) No fire, only vapour cloud.
		iv) Leakage from tank body	a) Vapour and fire inside dyke b) With fire.
		v) Leakage in supply line to consumers	a) Vapour
		vi) BLEVE	b) Thermal radiation effect.
2.	SKO	i) Hose rupture during unloading.	a) No fire, only vapour cloud.
		ii) Leakage from unloading pump	a) No fire, only vapour cloud.
		iii) Tank drain valve not closed properly	a) No fire, only vapour cloud.
		iv) Leakage from tank body	a) Fire case
		v) Leakage in supply line to unit	a) No fire, only vapour cloud. b) Vapour and fire
3)	Sulphuric Acid	i) Leakage from storage	Vapour cloud in case of huge leak
		ii) Leakage from pumps	-Do-
		iii) Leakage in Pump suction line (hot liquid at 330 0C	Vapour cloud in case of huge leak
		iv) Leakage in pump discharge line	do
		v) Leak in furnace coil	Hot liquid spill
		vi) Rupture of furnace coil	do
4)	FO	i) Hose rupture during unloading.	
		ii) Leakage from unloading pump	
		iii) Tank drain valve not closed properly	
		iv) Leakage from tank body	
5)	SO_2 & SO_3	i) Release from scrubber of TiO_2 plant	Vapour cloud
		ii) Release from acid plant	Vapour cloud
6)	Sulphuric Acid	i) Leakage in unit	Vapour cloud
		ii) Leakage in storage	

7. Consequence Analysis:

7.1 HSD:

Chemical Data Sheet:

HSD

Chemical Identifiers | Hazards | Response Recommendations | Physical Properties | Regulatory Information | Alternate Chemical Names

Chemical Identifiers			
CAS Number	UN/NA Number	DOT Hazard Label	USCG CHRIS Code
none	1202	Flammable Liquid	GOC

NFPA 704

Diamond	Hazard	Value	Description
	Health	0	No hazard beyond that of ordinary combustible material.
	Flammability	2	Must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.
	Instability	0	Normally stable, even under fire conditions.
	Special		

General Description

A straw yellow to dark liquid with a petroleum-like odor. Flash point between 73.4-142°F. Boiling range 450-800°F. Less dense than water and insoluble in water. Hence floats on water. Vapors are heavier than air.

Hazards

Reactivity Alerts

- Highly Flammable

Air & Water Reactions

Highly flammable. Insoluble in water.

Fire Hazard

[Flammable Liquids (Water-Immiscible)]:

HIGHLY FLAMMABLE: Will be easily ignited by heat, sparks or flames. Vapors may form explosive mixtures with air. Vapors may travel to source of ignition and flash back. Most vapors are heavier than air. They will spread along ground and collect in low or confined areas (sewers, basements, tanks). Vapor explosion hazard indoors, outdoors or in sewers. Those substances designated with a (P) may polymerize explosively when heated or involved in a fire. Runoff to sewer may create fire or explosion hazard. Containers may explode when heated. Many liquids are lighter than water. Substance may be transported hot.

Health Hazard

INHALATION: causes irritation of upper respiratory tract; stimulation, then depression; dizziness, headache, in coordination, anesthesia, coma, respiratory arrest; irregular heartbeat is a complication. ASPIRATION: causes severe coughing, gagging, distress, rapid development of pulmonary edema. INGESTION: causes irritation of throat and stomach; stimulation, then depression.

Reactivity Profile

Saturated aliphatic hydrocarbons, which are contained in GAS OIL, may be incompatible with strong oxidizing agents such as nitric acid. Charring may occur followed by ignition of unreacted hydrocarbon and other nearby combustibles. In other settings, mostly unreactive. Not affected by aqueous solutions of acids, alkalis, most oxidizing agents, and most reducing agents. When heated sufficiently or when ignited in the presence of air, oxygen or strong oxidizing agents, burns exothermically.

Belongs to the Following Reactive Group(s)

- Hydrocarbons, Aliphatic Saturated

Potentially Incompatible Absorbents

Response Recommendations

Isolation and Evacuation

[Flammable Liquids (Water-Immiscible)]:

As an immediate precautionary measure, isolate spill or leak area for at least 50 meters (150 feet) in all directions.

LARGE SPILL: Consider initial downwind evacuation for at least 300 meters (1000 feet).
FIRE: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (½ mile) in all directions; also, consider initial evacuation for 800 meters (½ mile) in all directions. *(ERG, 2016)*

Firefighting

[Flammable Liquids (Water-Immiscible)]:

CAUTION: All these products have a very low flash point: Use of water spray when fighting fire may be inefficient. CAUTION: For mixtures containing alcohol or polar solvent, alcohol-resistant foam may be more effective.

SMALL FIRE: Dry chemical, CO_2, water spray or regular foam.

LARGE FIRE: Water spray, fog or regular foam. Do not use straight streams. Move containers from fire area if you can do it without risk.

FIRE INVOLVING TANKS OR CAR/TRAILER LOADS: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Non-Fire Response

Flammable Liquids (Water-Immiscible)]:

ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). All equipment used when handling the product must be grounded. Do not touch or walk through spilled material. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. A vapor-suppressing foam may be used to reduce vapors. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. Use clean, non-sparking tools to collect absorbed material.

LARGE SPILL: Dike far ahead of liquid spill for later disposal. Water spray may reduce vapor, but may not prevent ignition in closed spaces.

First Aid

Get medical attention.

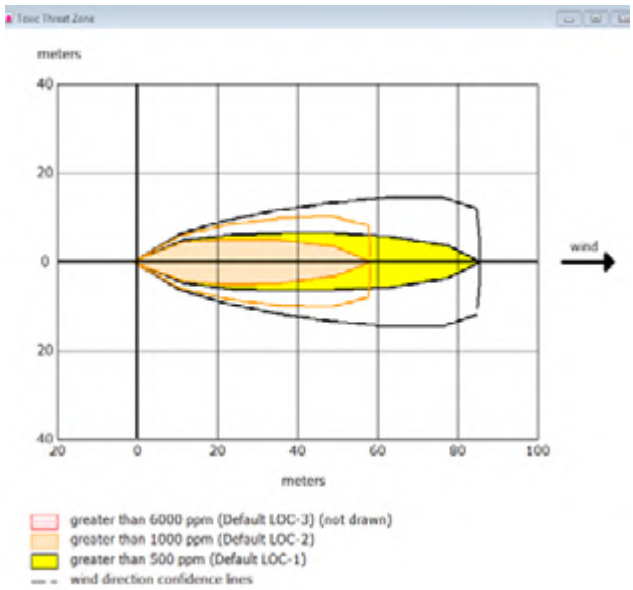
INHALATION: maintain respiration; administer oxygen if needed.

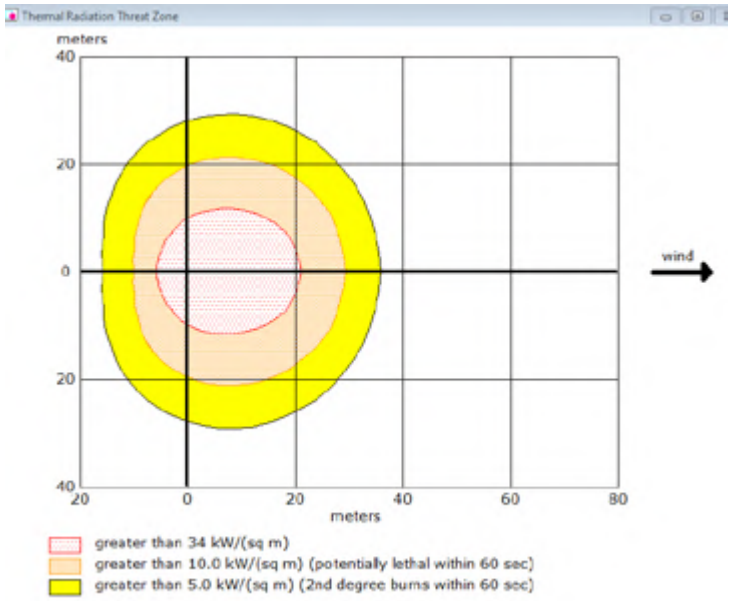
ASPIRATION: enforce bed rest and administer oxygen.

INGESTION: give victim water or milk; do NOT induce vomiting; guard against aspiration into lungs.

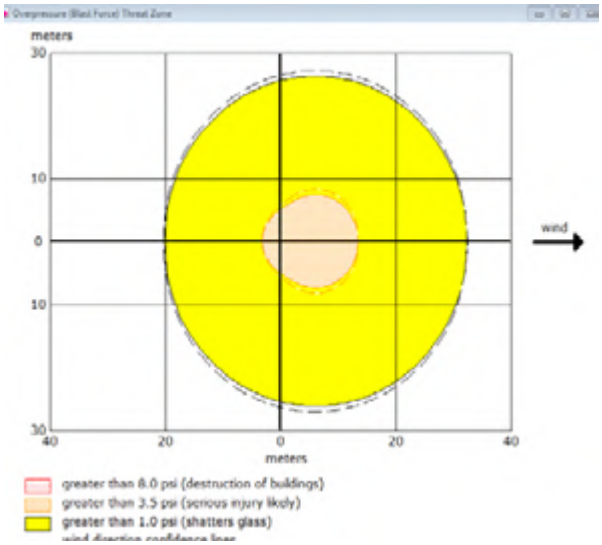
EYES: wash with copious quantity of water.

SKIN: remove by wiping, then wash with soap and water.

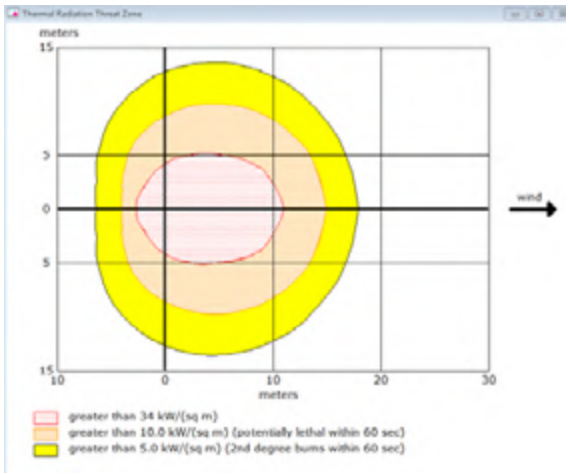
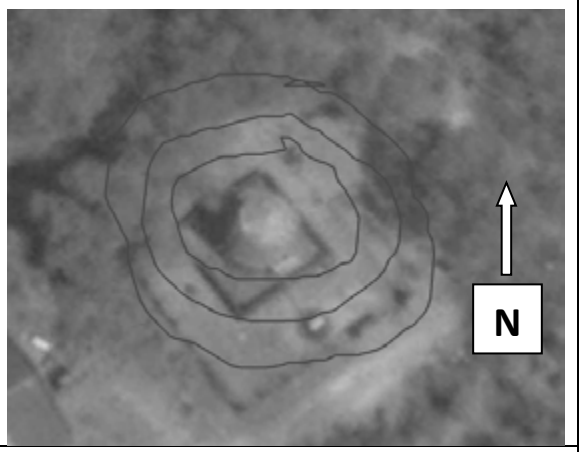
Sl. No	Risk Scenario	Effect	Figure
1.	Toxic threat zone- leak at 2 Kg/sec for 1 hr. Leak may occur during unloading, tank body leak, leak in transfer line from tank area.	Concentration of vapour : Red : 20 meters --- (6000 ppm) Orange: 58 meters --- (1000 ppm) Yellow: 86 meters --- (500 ppm)	

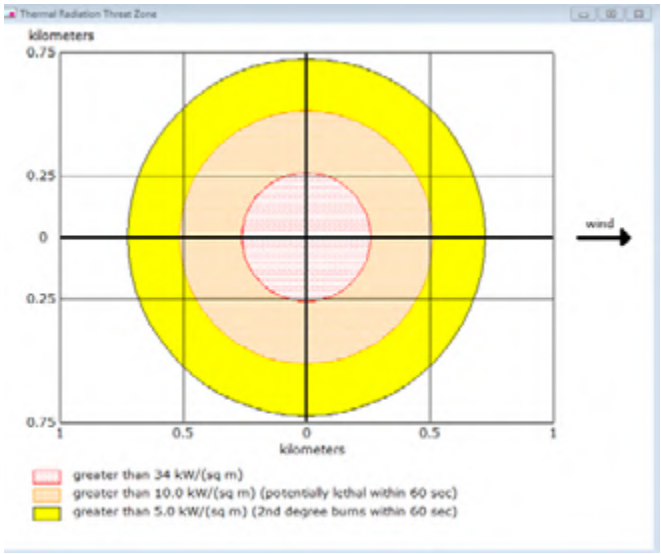
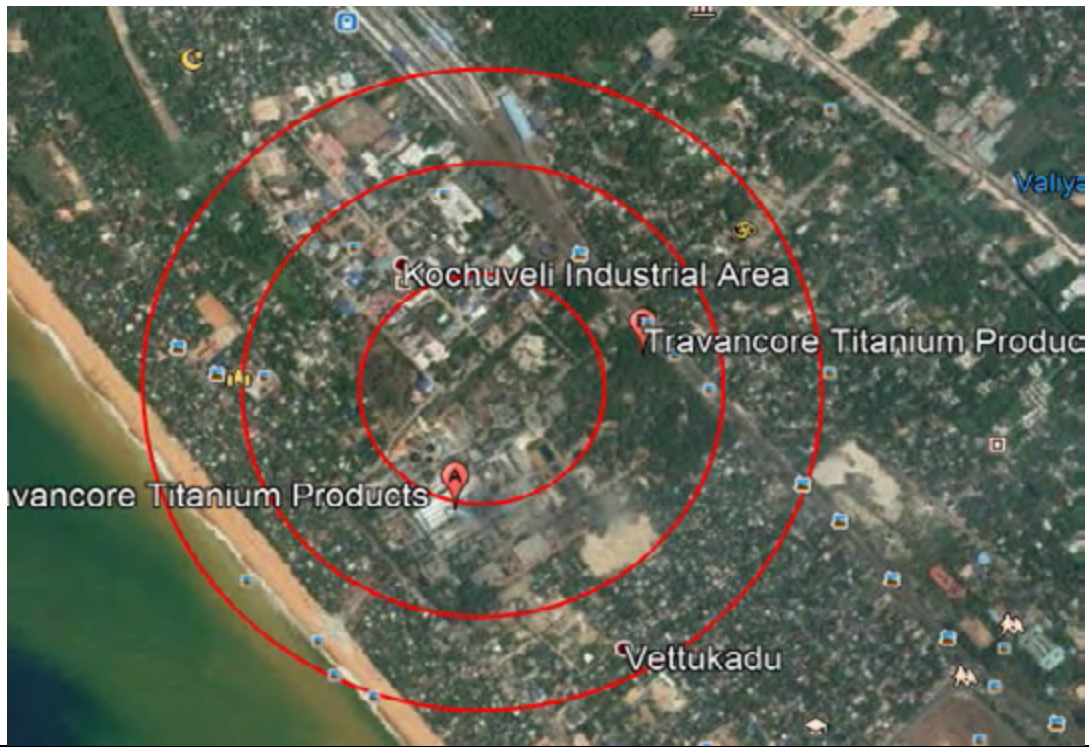
2.	Circular Opening Diameter: 4 inches Max Flame Length: 15 meters Burn Duration: 1 hour Max Burn Rate: 415 kilograms/ min Total Amount Burned: 24,401 kilograms Note: The chemical escaped as a liquid and formed a burning puddle. The puddle spread to a diameter of 10.0 meters.	Threat Modeled: Thermal radiation from pool fire Red : 21 meters --- (34 kW/(sq m))- fatal Orange: 29 meters --- (10.0 kW/ (sq m) = potentially lethal within 60 sec) Yellow: 36 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec	
All ignition sources within the diameter of the circle must be free from any ignition source. Switch off power supply to the area. Stop all vehicle movement so that source of ignition is eliminated. Outside battery limit will be within the danger zone. Inner envelop is 100% fatality.			
Remedial measures: In case of fire cool the tanks with water. Water sprinkler system is suggested for all the tanks. However, the company is not having any fire fighting facility			

like fire hydrant system, fire pump, cooling arrangement of the tank.

3)	Overpressure (blast force) from vapor cloud explosion from 2kg/sec leak	Type of Ignition: ignited by spark or flame. **Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)** **Orange: 14 meters --- (3.5 psi = serious injury likely)** **Yellow: 32 meters --- (1.0 psi = shatters glass)**	

<u>Remedial measures:</u> Isolate minimum 60 x 60 m area as shown in the fig. Stop movement of vehicles and isolate all source of ignition. Remove persons & vehicles from the circled area

4)	Burning Puddle / Pool Fire Puddle Area: 17 square meters Average Puddle Depth: 3 inches Initial Puddle Temperature: Air temperature Flame Length: 9 meters Burn Duration: 13 minutes Burn Rate: 89.3 kilograms/min Total Amount Burned: 1,186 kilograms	Red : 11 meters --- (34 kW/(sq m)) Orange: 15 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec) Yellow: 18 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)	
Effected area due to dyke fire. Drawn as per scale. Inner envelop=100% fatality.			
<u>Remedial Measures</u>: Dyke leak and accumulated oil is to be collected. Full fledged fire fighting facility is to be installed at the earliest by proper design of the system including sprinkler system for tank shell cooling.			

5	BLEVE of flammable liquid in vertical cylindrical tank	Chemical Mass in Tank: 86.8 tons Tank is 95% full Percentage of Tank Mass in Fireball: 100% Fireball Diameter: 249 meters Burn Duration: 15 seconds **Threat Modeled: Thermal radiation from fireball** **Red : 261 meters --- (34 kW/(sq m)) (100 % fatal)** **Orange: 514 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)** **Yellow: 725 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)**	
	Inner envelop = 100% fatality.		
Remedial measures : The effect will be catastrophic all around as can be seen. As mentioned earlier, full fledged fire fighting facility is to be installed at the earliest.			

Physical Properties

Flash Point: 150 ° F *(USCG, 1999)*

Lower Explosive Limit (LEL): 6 % *(USCG, 1999)*

Upper Explosive Limit (UEL): 13.5 % *(USCG, 1999)*

Autoignition Temperature: 640 ° F *(USCG, 1999)*

Specific Gravity: 0.848 at 60.8 ° F *(USCG, 1999)*

Boiling Point: 375 to 750 ° F at 760 mm Hg *(USCG, 1999)*

7.1.1 Risk Scenarios: wind velocity 10 m/sec at 3 m height. HSD

SKO:

KEROSENE

Chemical Identifiers | Hazards | Response Recommendations | Physical Properties | Regulatory Information | Alternate Chemical Names

Chemical Identifiers

CAS Number	UN/NA Number	DOT Hazard Label	USCG CHRIS Code
8008-20-6	1223	Flammable Liquid	KRS

NFPA 704

Diamond	Hazard	Value	Description
	Health	2	Can cause temporary incapacitation or residual injury.
	Flammability	2	Must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.
	Instability	0	Normally stable, even under fire conditions.
	Special		

General Description
A clear colorless to light amber liquid with a petroleum odor. Flash point 100°F. Less dense than water and insoluble in water. Vapors are heavier than air.

Hazards

Reactivity Alerts

- Highly Flammable

Air & Water Reactions
Highly flammable. Insoluble in water.

Fire Hazard
[Flammable Liquids (Water-Immiscible)]:

HIGHLY FLAMMABLE: Will be easily ignited by heat, sparks or flames. Vapors may form explosive mixtures with air. Vapors may travel to source of ignition and flash back. Most vapors are heavier than air. They will spread along ground and collect in low or confined areas (sewers, basements, tanks). Vapor explosion hazard indoors, outdoors or in sewers. Those substances designated with a (P) may polymerize explosively when heated or involved in a fire. Runoff to sewer may create fire or explosion hazard. Containers may explode when heated. Many liquids are lighter than water. Substance may be transported hot.

Health Hazard
Vapor causes slight irritation of eyes and nose. Liquid irritates stomach; if taken into lungs, causes coughing, distress, and rapidly developing pulmonary edema.

Reactivity Profile
Saturated aliphatic hydrocarbons, contained in KEROSENE, may be incompatible with strong oxidizing agents like nitric acid. Charring of the hydrocarbon may occur followed by ignition of unreacted hydrocarbon and other nearby combustibles. In other settings, aliphatic saturated hydrocarbons are mostly unreactive. They are not affected by aqueous solutions of acids, alkalis, most oxidizing agents, and most reducing agents.

Isolation and Evacuation
As an immediate precautionary measure, isolate spill or leak area for at least 50 meters (150 feet) in all directions.

LARGE SPILL: Consider initial downwind evacuation for at least 300 meters (1000 feet).

FIRE: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions. (ERG, 2016)

Firefighting

CAUTION: All these products have a very low flash point: Use of water spray when fighting fire may be inefficient. CAUTION: For mixtures containing alcohol or polar solvent, alcohol-resistant foam may be more effective.

SMALL FIRE: Dry chemical, CO_2, water spray or regular foam.

LARGE FIRE: Water spray, fog or regular foam. Do not use straight streams. Move containers from fire area if you can do it without risk.

FIRE INVOLVING TANKS OR CAR/TRAILER LOADS: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Non-Fire Response
ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). All equipment used when handling the product must be grounded. Do not touch or walk through spilled material. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. A vapor-suppressing foam may be used to reduce vapors. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. Use clean, non-sparking tools to collect absorbed material.

LARGE SPILL: Dike far ahead of liquid spill for later disposal. Water spray may reduce vapor, but may not prevent ignition in closed spaces. (ERG, 2016)

Protective Clothing
Skin: Wear appropriate personal protective clothing to prevent skin contact.

Eyes: Wear appropriate eye protection to prevent eye contact.

Wash skin: The worker should immediately wash the skin when it becomes contaminated.

Remove: Work clothing that becomes wet or significantly contaminated should be removed and replaced.

Change: No recommendation is made specifying the need for the worker to change clothing after the work shift.

Provide: Facilities for quickly drenching the body should be provided within the immediate work area for emergency use where there is a possibility of exposure. [Note: It is intended that these facilities provide a sufficient quantity or flow of water to quickly remove the substance from any body areas likely to be exposed. The actual determination of what constitutes an adequate quick drench facility depends on the specific circumstances. In certain instances, a deluge shower should be readily available, whereas in others, the availability of water from a sink or hose could be considered adequate.

Normalized Breakthrough Times (in Minutes)

Chemical	CAS Number	State	QC	SL	TF	TP	C3	BR	RC	TK	RF
Kerosene	8008-20-6	Liquid		58	>480	>480	>480	>480	>480	>480	>480

> indicates greater than.
A blank cell indicates the fabric has not been tested. The fabric may or may not offer barrier.

First Aid

EYES: First check the victim for contact lenses and remove if present. Flush victim's eyes with water or normal saline solution for 20 to 30 minutes while simultaneously calling a hospital or poison control center. Do not put any ointments, oils, or medication in the victim's eyes without specific instructions from a physician. IMMEDIATELY transport the victim after flushing eyes to a hospital even if no symptoms (such as redness or irritation) develop.

SKIN: IMMEDIATELY flood affected skin with water while removing and isolating all contaminated clothing. Gently wash all affected skin areas thoroughly with soap and water. IMMEDIATELY call a hospital or poison control center even if no symptoms (such as redness or irritation) develop. IMMEDIATELY transport the victim to a hospital for treatment after washing the affected areas.

INHALATION: IMMEDIATELY leave the contaminated area; take deep breaths of fresh air. IMMEDIATELY call a physician and be prepared to transport the victim to a hospital even if no symptoms (such as wheezing, coughing, shortness of breath, or burning in the mouth, throat, or chest) develop. Provide proper respiratory protection to rescuers entering an unknown atmosphere. Whenever possible, Self-Contained Breathing Apparatus (SCBA) should be used; if not available, use a level of protection greater than or equal to that advised under Protective Clothing.

INGESTION: DO NOT INDUCE VOMITING. If the victim is conscious and not convulsing, give 1 or 2 glasses of water to dilute the chemical and IMMEDIATELY call a hospital or poison control center. Be prepared to transport the victim to a hospital if advised by a physician. If the victim is convulsing or unconscious, do not give anything by mouth, ensure that the victim's airway is open and lay the victim on his/her side with the head lower than the body. DO NOT INDUCE VOMITING. IMMEDIATELY transport the victim to a hospital.

OTHER: Since this chemical is a known or suspected carcinogen you should contact a physician for advice regarding the possible long term health effects and potential recommendation for medical monitoring. Recommendations from the physician will depend upon the specific compound, its chemical, physical and toxicity properties, the exposure level, length of exposure, and the route of exposure. (NTP, 1992)

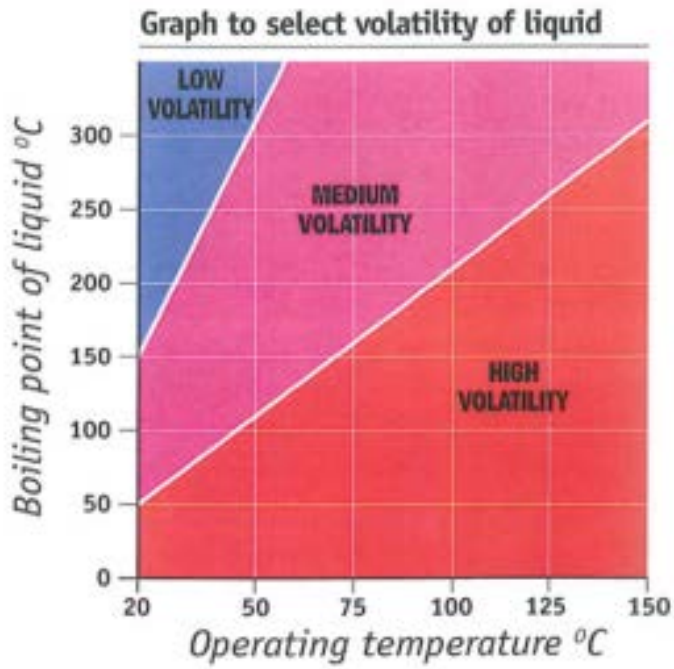
Physical Properties

Flash Point: 95 to 145 ° F (NTP, 1992)
Lower Explosive Limit (LEL): 0.6 % (NTP, 1992)
Upper Explosive Limit (UEL): 4.9 % (NTP, 1992)
Autoignition Temperature: 444 ° F (USCG, 1999)
Melting Point: less than -54.4 ° F (NTP, 1992)
Vapor Pressure: 0.1 psi at 100 ° F (NTP, 1992)
Vapor Density (Relative to Air): 4.5 (NTP, 1992)
Specific Gravity: 0.8 at 59 ° F (USCG, 1999)
Boiling Point: 338 to 617 ° F at 760 mm Hg (NTP, 1992)
Molecular Weight: 170 (approx) (NIOSH, 2016)
Water Solubility: Insoluble (NTP, 1992)

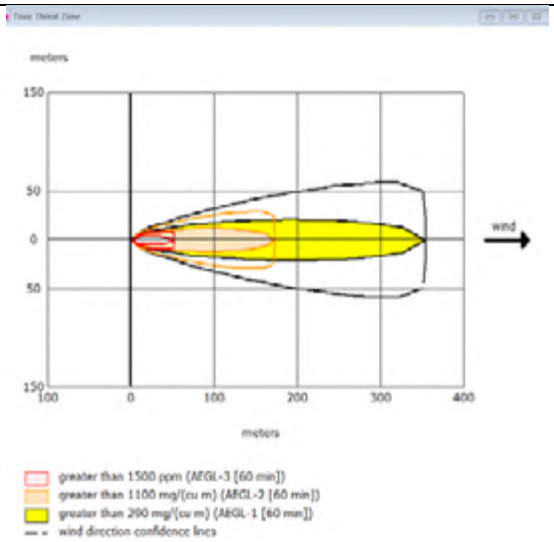
AEGLs (Acute Exposure Guideline Levels)

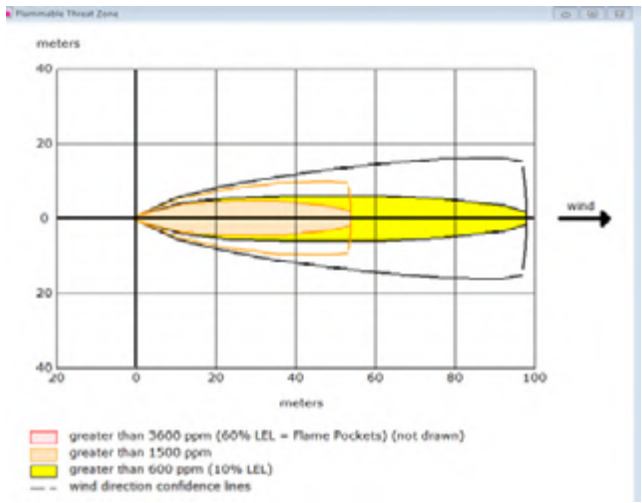
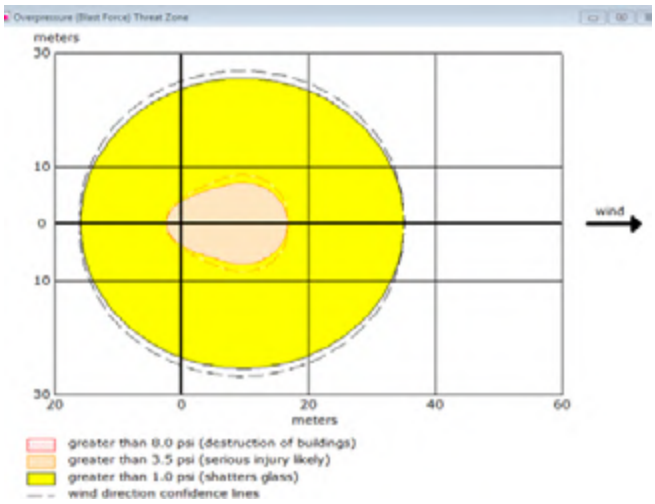
Exposure Period	AEGL-1	AEGL-2	AEGL-3
10 minutes	290 mg/m3	1100 mg/m3	NR
30 minutes	290 mg/m3	1100 mg/m3	NR
60 minutes	290 mg/m3	1100 mg/m3	NR
4 hours	290 mg/m3	1100 mg/m3	NR
8 hours	290 mg/m3	1100 mg/m3	NR

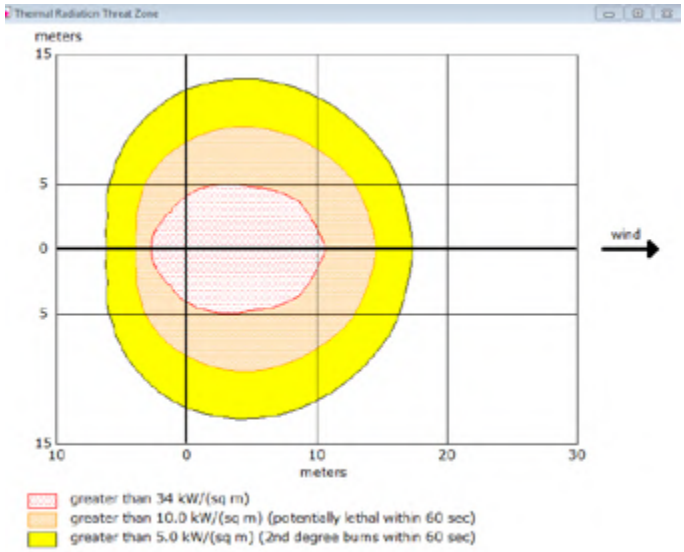
7.2.2 Risk Scenarios: wind velocity 10 m/sec at 3 m height.

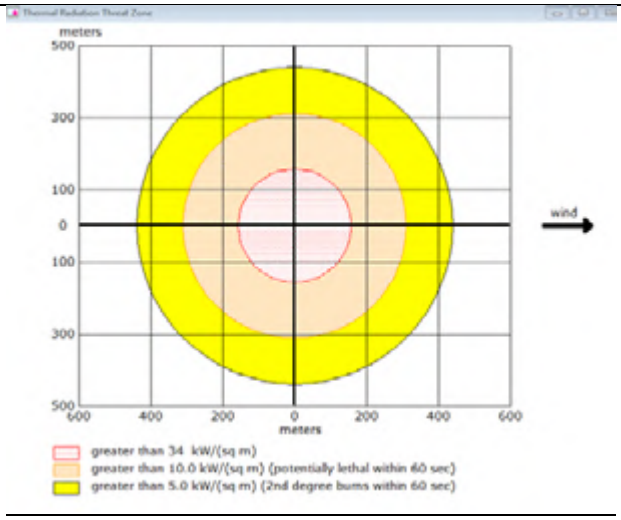


SKO Initial boiling point is 150 oC. Its volatility is medium at operating temperature of 35°C. Hence, this is to be handled carefully.

Sl. No	Risk Scenario	Effect	Figure
1.	Toxic threat zone- leak at 2 Kg/sec for 30 mins. Leak may occur during unloading, tank body leak, leak in transfer line from tank area.	THREAT ZONE: Model Run: Heavy Gas Red : 53 meters --- (1500 ppm = AEGL-3 [60 min]) Orange: 174 meters --- (1100 mg/(cu m) = AEGL-2 [60 min]) Yellow: 355 meters --- (290 mg/(cu m) = AEGL-1 [60 mi)	
The tank locations are in oil storage area (2 nos.), sulphuric acid plant -1 no (Tk. No. 6). which is in near the plant area. Any leak in this area will call for removing all ignition sources including vehicle movement which may not be possible and will result in massive fire. Since no effective fire protection measure is available, the result will be catastrophic.			
Area which will be covered by vapour leak based on wind direction south to north. This will vary depending on wind direction. In case of north to south, entire plant area will be affected. **In case of other horizontal tanks in Oil Storage area of the company, the inter tank distance is less . Vapour that will be generated by any leakage will spread all over. In case of any ignition source, the situation will be out of control.**			

2.	Flammable Area of Vapor Cloud	Threat Modeled: Flammable Area of Vapor Cloud Model Run: Heavy Gas Red : 31 meters --- (3600 ppm = 60% LEL = Flame Pockets) Note: Threat zone was not drawn Orange: 54 meters --- (1500 ppm) Yellow: 98 meters --- (600 ppm = 10% LEL)	
Remedial measures: Isolate at least 100 m down side and remove any ignition source			
3.	Overpressure (blast force) from vapor cloud explosion Type of Ignition: ignited by spark or flame	Red : LOC was never exceeded --- (8.0 psi = destruction of buildings) Orange: 39 meters --- (3.5 psi = serious injury likely) Yellow: 41 meters --- (1.0 psi = shatters glass)	
Remedial Measures: Isolate 50 m area. Evacuate man power from the area. Remove all source of ignition.			

4.	Burning Puddle / Pool Fire Puddle Area: 17 square meters Average Puddle Depth: 3 inches Initial Puddle Temperature: Air temperature Flame Length: 9 meters Burn Duration: 10 minutes Burn Rate: 88.6 kilograms/min Total Amount Burned: 877 kilograms	hreat Modeled: Thermal radiation from pool fire Red: 11 meters --- (34 kW/(sq m) Orange: 15 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec) Yellow: 17 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)	
Area covered in the event of puddle fire.			
Remedial measures: In unlikely case of fire, evacuate an area of 50m dia. Cool tanks with area within this area. Evacuate man power from the area. Isolate all source of ignition. However, proper fire fighting system is to be arranged at the earliest.			

Sl. No	Scenario	Effect	Figure
	BLEVE Tank Diameter: 1.7 meters Tank Length: 13 meters Tank Volume: 29.5 cubic meters Tank contains liquid Internal Storage Temperature: 35° C Chemical Mass in Tank: 19.8 tons Tank is 90% full Percentage of Tank Mass in Fireball: 100% Fireball Diameter: 152 meters Burn Duration: 10 seconds	Threat Modeled: Thermal radiation from fireball Red : 157 meters --- (34 kW/(sq m))- **FATAL** Orange: 311 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec) Yellow: 439 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)	

As can be seen, the effect will be catastrophic. In the absence of any fire fighting system, this type of situation cannot be avoided. In the inner envelop there will be 100% fatality.

SO2:

Chemical Datasheet

SULFUR DIOXIDE

Chemical Identifiers | Hazards | Response Recommendations | Physical Properties | Regulatory Information | Alternate Chemical Names

Chemical Identifiers

What is this information?

CAS Number	UN/NA Number	DOT Hazard Label	USCG CHRIS Code
7446-09-5	1079	Poison Gas Corrosive	SFD

NFPA 704

Diamond	Hazard	Value	Description
	Health	3	Can cause serious or permanent injury.
	Flammability	0	Will not burn under typical fire conditions.
	Instability	0	Normally stable, even under fire conditions.
	Special		

(NFPA, 2010)

NIOSH Pocket Guide	International Chem Safety Card
Sulfur dioxide	SULPHUR DIOXIDE

General Description

A colorless gas with a choking or suffocating odor. Boiling point -10°C. Heavier than air. Very toxic by inhalation and may irritate the eyes and mucous membranes. Under prolonged exposure to fire or heat the containers may rupture violently and rocket. Used to manufacture chemicals, in paper pulping, in metal and food processing.

Rate of onset: Immediate & Delayed

Persistence: Minutes to hours

Odor threshold: 1 ppm

Source/use/other hazard: Disinfectant and preserving in breweries and food/canning; textile industry; batteries.

Reactivity Alerts
Water-Reactive

Air & Water Reactions
Dissolves in water to form sulfurous acid, a corrosive liquid. Moist sulfur dioxide is very corrosive due to the slow formation of sulfuric acid

Fire Hazard
Containers may explode in heat of fire or they may rupture and release irritating toxic sulfur dioxide. Sulfur dioxide has explosive properties when it comes in contact with sodium hydride; potassium chlorate at elevated temperatures; ethanol; ether; zinc ethylsulfurinate at very cool temperatures (-15C); fluorine; chlorine trifluoride and chlorates. It will react with water or steam to produce toxic and corrosive fumes. When the liquid is heated it may release irritating, toxic sulfur dioxide gas. Avoid ammonia, monocesium or monopotassium acetylide; dicesium monoxide; iron (II) oxide; tin oxide; lead (IV) oxide; chromium; manganese; molten sodium, powder aluminum and rubidium. Sulfur dioxide has explosive properties when it comes in contact with sodium hydride; potassium chlorate at elevated temperatures; ethanol; ether; zinc ethylsulfurinate at very cool temperatures (-15C); fluorine; chlorine trifluoride and chlorates. It will react with water or steam to produce toxic and corrosive fumes. Hazardous polymerization may not occur.

Health Hazard
It may cause death or permanent injury after very short exposure to small quantities. 1,000 ppm causes death in from 10 minutes to several hours by respiratory depression. It is an eye and respiratory tract irritant. Persons with asthma, subnormal pulmonary functions or cardiovascular disease are at a greater risk.

Reactivity Profile
SULFUR DIOXIDE is acidic. Reacts exothermically with bases such as amines, amides, metal oxides, and hydroxides. Frequently used as a reducing agent although it is not a powerful one. Acts as a reducing bleach to decolorize many materials. Can act as an oxidizing agent. Supports combustion of powdered aluminum [Mellor 5:209-212 1946-47]. Reacts explosively with fluorine *[Mellor 2:1 1946-47]*. Supports burning of manganese [Mellor 12:187 1946-47]. Readily liquefied by compression. Contact between the liquid and water may result in vigorous or violent boiling and extremely rapid vaporization. If the water is hot an explosion may occur. Pressures may build to dangerous levels if the liquid contacts water in a closed container [Handling Chemicals Safely 1980]. Supports incandescent combustion of monocesium acetylide, monopotassium acetylide, cesium oxide, iron(II) oxide, tin oxide, and lead oxide [Mellor]. Ethylene oxide and SO2 can react violently in pyridine solution with pressurization if ethylene oxide is in excess *(Nolan, 1983, Case History 51).*
Belongs to the Following Reactive Group(s)
Acids, Strong Non-oxidizing
Reducing Agents, WeakRespo

General Description

A colorless gas with a choking or suffocating odor. Boiling point -10°C. Heavier than air. Very toxic by inhalation and may irritate the eyes and mucous membranes. Under prolonged exposure to fire or heat the containers may rupture violently and rocket. Used to manufacture chemicals, in paper pulping, in metal and food processing.

Rate of onset: Immediate & Delayed

Persistence: Minutes to hours

Odor threshold: 1 ppm

Source/use/other hazard: Disinfectant and preserving in breweries and food/canning; textile industry; batteries.

Reactivity Alerts
Water-Reactive

Air & Water Reactions
Dissolves in water to form sulfurous acid, a corrosive liquid. Moist sulfur dioxide is very corrosive due to the slow formation of sulfuric acid

Fire Hazard
Containers may explode in heat of fire or they may rupture and release irritating toxic sulfur dioxide. Sulfur dioxide has explosive properties when it comes in contact with sodium hydride; potassium chlorate at elevated temperatures; ethanol; ether; zinc ethylsulfurinate at very cool temperatures (-15C); fluorine; chlorine trifluoride and chlorates. It will react with water or steam to produce toxic and corrosive fumes. When the liquid is heated it may release irritating, toxic sulfur dioxide gas. Avoid ammonia, monocesium or monopotassium acetylide; dicesium monoxide; iron (II) oxide; tin oxide; lead (IV) oxide; chromium; manganese; molten sodium, powder aluminum and rubidium. Sulfur dioxide has explosive properties when it comes in contact with sodium hydride; potassium chlorate at elevated temperatures; ethanol; ether; zinc ethylsulfurinate at very cool temperatures (-15C); fluorine; chlorine trifluoride and chlorates. It will react with water or steam to produce toxic and corrosive fumes. Hazardous polymerization may not occur.

Health Hazard
It may cause death or permanent injury after very short exposure to small quantities. 1,000 ppm causes death in from 10 minutes to several hours by respiratory depression. It is an eye and respiratory tract irritant. Persons with asthma, subnormal pulmonary functions or cardiovascular disease are at a greater risk.

Reactivity Profile
SULFUR DIOXIDE is acidic. Reacts exothermically with bases such as amines, amides, metal oxides, and hydroxides. Frequently used as a reducing agent although it is not a powerful one. Acts as a reducing bleach to decolorize many materials. Can act as an oxidizing agent. Supports combustion of powdered aluminum [Mellor 5:209-212 1946-47]. Reacts explosively with fluorine *[Mellor 2:1 1946-47]*. Supports burning of manganese [Mellor 12:187 1946-47]. Readily liquefied by compression. Contact between the liquid and water may result in vigorous or violent boiling and extremely rapid vaporization. If the water is hot an explosion may occur. Pressures may build to dangerous levels if the liquid contacts water in a closed container [Handling Chemicals Safely 1980]. Supports incandescent combustion of monocesium acetylide, monopotassium acetylide, cesium oxide, iron(II) oxide, tin oxide, and lead oxide [Mellor]. Ethylene oxide and SO2 can react violently in pyridine solution with pressurization if ethylene oxide is in excess *(Nolan, 1983, Case History 51).*
Belongs to the Following Reactive Group(s)
Acids, Strong Non-oxidizing
Reducing Agents, WeakRespo

Isolation and Evacuation
[Gases - Corrosive]:

As an immediate precautionary measure, isolate spill or leak area for at least 100 meters (330 feet) in all directions.

FIRE: If tank, rail car or tank truck is involved in a fire, ISOLATE for 1600 meters (1 mile) in all directions; also, consider initial evacuation for 1600 meters (1 mile) in all directions.

Firefighting
Wear self-contained breathing apparatus and full protective clothing. Move container from fire area. Stay away from ends of tanks. Cool containers that are exposed to flames with water from the side until well after the fire is out. Isolate area until gas has dispersed. Keep unnecessary people away.
Not flammable. Extinguish fires with dry chemical, carbon dioxide, water spray, fog or foam. (EPA, 1998)

Non-Fire Response
[Gases - Corrosive]:
Fully encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire. Do not touch or walk through spilled material. Stop leak if you can do it without risk. If possible, turn leaking containers so that gas escapes rather than liquid. Prevent entry into waterways, sewers, basements or confined areas. Do not direct water at spill or source of leak. Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material. Isolate area until gas has dispersed.

Protective Clothing
Skin: Wear appropriate personal protective clothing to prevent skin from becoming frozen from contact with the liquid or from contact with vessels containing the liquid.
Eyes: Wear appropriate eye protection to prevent eye contact with the liquid that could result in burns or tissue damage from frostbite.

Wash skin: No recommendation is made specifying the need for washing the substance from the skin (either immediately or at the end of the work shift).

Remove: If chemical is in liquid form, work clothing that becomes wet or significantly contaminated should be removed and replaced.

Change: No recommendation is made specifying the need for the worker to change clothing after the work shift.

Provide: Quick drench facilities and/or eyewash fountains should be provided within the immediate work area for emergency use where there is any possibility of exposure to liquids that are extremely cold or rapidly evaporating. *(NIOSH, 2016)*

Normalized Breakthrough Times (in Minutes)

Chemical	CAS Number	State	QC	SL	TF	TP	C3	BR	RC	TK	RF
Sulfur dioxide	7446-09-5	Vapor	imm.	>480	38*	38*		>480	>480	>480	>480

> indicates greater than.

"imm." indicates immediate; having a normalized breakthrough time of 10 minutes or less.

* indicates actual breakthrough time; normalized breakthrough time is not available.
A blank cell indicates the fabric has not been tested. The fabric may or may not offer barrier.

Special Warnings from DuPont
Serged and bound seams are degraded by some hazardous liquid chemicals, such as strong acids, and should not be worn when these chemicals are present.

CAUTION: This information is based upon technical data that DuPont believes to be reliable. It is subject to revision as additional knowledge and experience are gained. DuPont makes no guarantee of results and assumes no obligation or liability...

First Aid

Note: Persons with asthma, subnormal pulmonary function, or cardiovascular disease are at greater risk. Signs and Symptoms of Acute Sulfur Dioxide Exposure: Sulfur dioxide may irritate the eyes and respiratory tract. Signs and symptoms of acute exposure to sulfur dioxide may be severe and include coughing, choking, dyspnea (shortness of breath), sneezing, wheezing, and chest discomfort. Upper airway edema (swelling) or obstruction, bronchoconstriction, pneumonia, pulmonary edema, and respiratory paralysis may occur. Fatigue may be noted. Gastrointestinal effects may include nausea, vomiting, and abdominal pain. Cyanosis (blue tint to skin and mucous membranes) may be noted following exposure to sulfur dioxide.

Emergency Life-Support Procedures: Acute exposure to sulfur dioxide may require decontamination and life support for the victims. Emergency personnel should wear protective clothing appropriate to the type and degree of contamination. Air-purifying or supplied-air respiratory equipment should also be worn, as necessary. Rescue vehicles should carry supplies such as plastic sheeting and disposable plastic bags to assist in preventing spread of contamination.

Inhalation Exposure:

1. Move victims to fresh air. Emergency personnel should avoid self-exposure to sulfur dioxide.
2. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support.
3. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures.
4. Transport to a health care facility.

Dermal/Eye Exposure:

1. Remove victims from exposure. Emergency personnel should avoid self- exposure to sulfur dioxide.
2. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support.
3. Remove contaminated clothing as soon as possible.
4. If eye exposure has occurred, eyes must be flushed with lukewarm water for at least 15 minutes.
5. Wash exposed skin areas with soap and water.
6. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures.
7. Transport to a health care facility.

Ingestion Exposure: No information is available.

Chemical Formula: SO_2

Autoignition Temperature	:	Not flammable
Melting Point	:	-98.9 ° F
Vapor Pressure	:	2432 mm Hg at 68 ° F
Vapor Density (Relative to Air)	:	2.26
Specific Gravity	:	1.434
Boiling Point	:	14 ° F at 760 mm Hg
Molecular Weight	:	64.07

Water Solubility : 10 %
Ionization Potentia **l:** 12.30 eV
IDLH : 100 ppm

AEGLs (Acute Exposure Guideline Levels)

Final AEGLs for Sulfur Dioxide (7446-09-5)

Exposure Period	**AEGL-1**	**AEGL-2**	**AEGL-3**
10 minutes	0.2 ppm	0.75 ppm	30 ppm
30 minutes	0.2 ppm	0.75 ppm	30 ppm
60 minutes	0.2 ppm	0.75 ppm	30 ppm
4 hours	0.2 ppm	0.75 ppm	19 ppm
8 hours	0.2 ppm	0.75 ppm	9.6 ppm

ERPGs (Emergency Response Planning Guidelines)

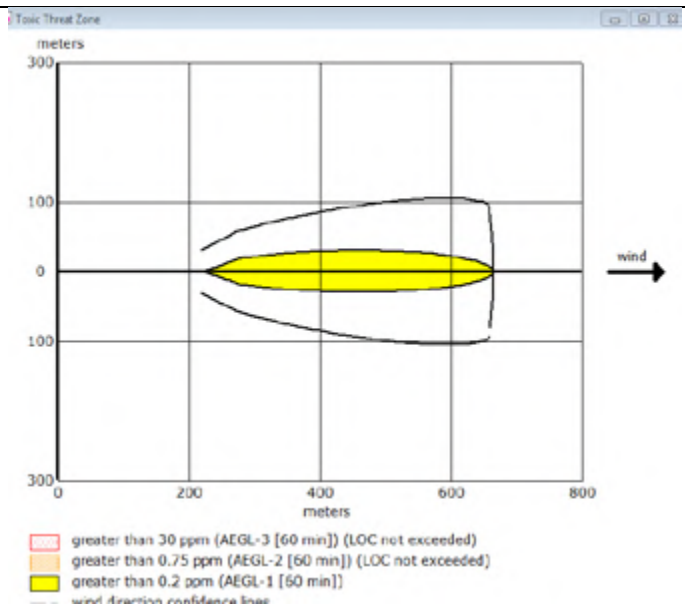
Chemical	**ERPG-1**	**ERPG-2**	**ERPG-3**
Sulfur Dioxide (7446-09-5)	0.3 ppm ✪	3 ppm	25 ppm

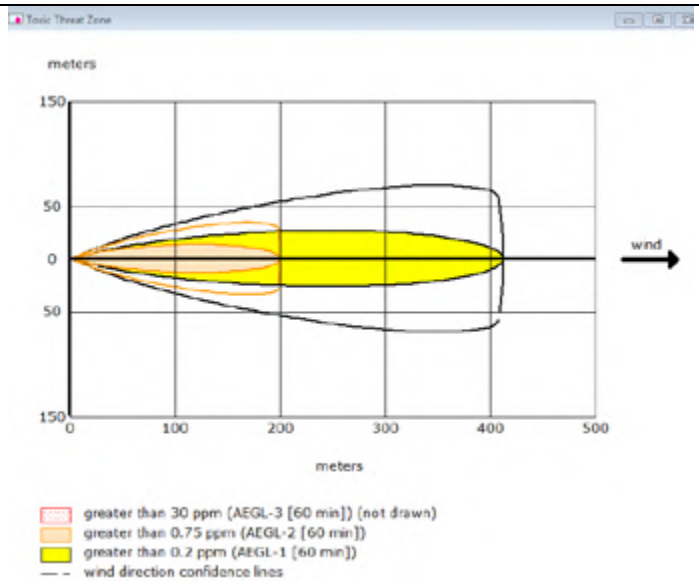
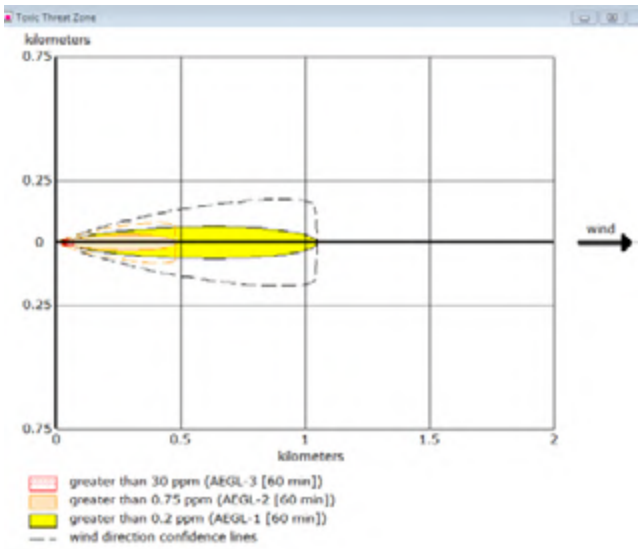
✪ indicates that odor should be detectable near ERPG-1.

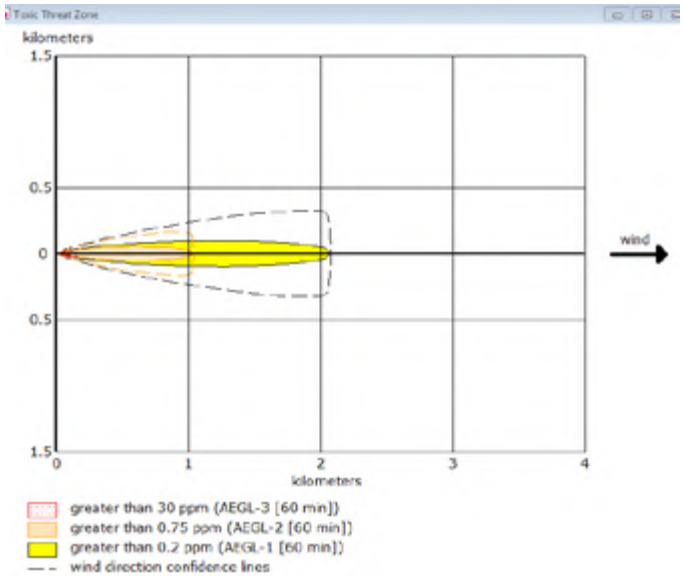
PACs (Protective Action Criteria)

Chemical	**PAC-1**	**PAC-2**	**PAC-3**
Sulfur dioxide (7446-09-5)	0.2 ppm	0.75 ppm	30 ppm

6.3.2 Risk Scenarios: wind velocity 10 m/sec at 25 m height & ground level .

Sl. No	Risk Scenario	Effect	Figure
1.	Direct Source: 50 grams/sec Source **Height: 25 meters** Release Duration: 30 minutes Release Rate: 3 kilograms/min Total Amount Released: 90.0 kilograms. Release from scrubber	Red : LOC is not exceeded --- (30 ppm = AEGL-3 [60 min]) Orange: LOC is not exceeded --- (0.75 ppm = AEGL-2 [60 min]) Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC. Yellow: 666 meters --- (0.2 ppm = AEGL-1 [60 min])	

2	Direct **Source: 10 grams/sec** **Source Ground level** Release Duration: 30 minutes Release Rate: 600 grams/min Total Amount Released: 18.0 kilograms	Red : 30 meters --- (30 ppm = AEGL-3 [60 min]) Note: Threat zone was not drawn Orange: 201 meters --- (0.75 ppm = AEGL-2 [60 min]) Yellow: 412 meters --- (0.2 ppm = AEGL-1 [60 min])	
3.	**Toxic threat zone-major leak** . Direct Source: 50 grams/sec **Source Height: 0** Release Duration: 30 minutes Release Rate: 3 kilograms/min Total Amount Released: 90.0 kilograms	Red : 68 meters --- (30 ppm = AEGL-3 [60 min]) Orange: 484 meters --- (0.75 ppm = AEGL-2 [60 min]) Yellow: 1.1 kilometers --- (0.2 ppm = AEGL-1 [60 min])	

4..	**Major leak :** Direct Source: 100 grams/sec **Source Height: 25 meters** Release Duration: 30 minutes Release Rate: 6 kilograms/min Total Amount Released: 180 kilograms	Red : 151 meters --- (30 ppm = AEGL-3 [60 min]) Orange: 1.0 kilometers --- (0.75 ppm = AEGL-2 [60 min]) Yellow: 2.1 kilometers --- (0.2 ppm = AEGL-1 [60 min]))	

SO3

Chemical Datasheet

SULFUR TRIOXIDE

Chemical Identifiers | Hazards | Response Recommendations | Physical Properties | Regulatory Information | Alternate Chemical Names

Chemical Identifiers

CAS Number	UN/NA Number	DOT Hazard Label	USCG CHRIS Code
7446-11-9	1829	Corrosive Poison Inhalation Hazard	none

NFPA 704

General Description

Sulfur trioxide, is a colorless to white crystalline solid which will fume in air. Often shipped with inhibitor to prevent polymerization. It reacts violently with water to form sulfuric acid with the release of heat. It is corrosive to metals and tissue. It causes eye and skin burns. Ingestion causes severe burns of mouth esophagus and stomach. The vapor is very toxic by inhalation. It is a fire risk when in contact with organic materials such as wood, cotton, fiberboard, etc.

Reactivity Alerts
Strong Oxidizing Agent

Known Catalytic Activity

Water-Reactive

Air & Water Reactions
Combines with water with explosive force, forming sulfuric acid. Sulfur trioxide chars most organic substances. On exposure to air it absorbs moisture rapidly, emitting dense white acidic fumes, mists *[Merck 11th ed. 1989].*

Fire Hazard
Fire risk in contact with organic materials. An explosive increase in vapor pressure occurs when the alpha form melts. Combines with water with explosive violence, forming sulfuric acid. May ignite other combustible materials (wood, paper, oil, etc.). Flammable poisonous gases may accumulate in tanks and hopper cars. Runoff to sewer may create fire or explosion hazard. Forms sulfuric acid on contact with water. Avoid water and organic materials. On exposure to air, it absorbs moisture and emits dense white fumes. (EPA, 1998)

Health Hazard
This material is highly toxic. It is an irritant and corrosive to mucous membranes. Poisonous if inhaled or swallowed. Contact causes severe burns to skin and eyes. (EPA, 1998)

Reactivity Profile
The reaction of SULFUR TRIOXIDE and oxygen difluoride is very vigorous and explosions occur if the reaction is carried out in the absence of a solvent [J. Chem. Eng. Data 13(4):529-531. 1968]. The reaction of sulfur trioxide in excess with tetrafluoroethylene causes explosive decomposition to carbonyl fluoride and sulfur dioxide [Chem. Eng. News 49(22):3. 1971]. The reaction of anhydrous perchloric acid with sulfur trioxide is violent and accompanied by the evolution of considerable heat (Pascal 16:300 1931-34). Liquid sulfur trioxide reacts violently with nitryl chloride, even at 75° C. The reaction of sulfur trioxide and lead oxide causes white luminescence [Mellor 7:654 1946-47]. The combination of iodine, pyridine, sulfur trioxide, and formamide developed a gas over pressurization after several months. This is due to the slow formation of sulfuric acid, from external water or dehydration of the formamide to hydrogen cyanide.

Belongs to the Following Reactive Group(s)

Acids, Strong Oxidizing

Potentially Incompatible Absorbents

Use caution: Liquids with this reactive group classification have been known to react with the absorbents listed below.

Cellulose-Based Absorbents

Expanded Polymeric Absorbents

Isolation and Evacuation
Excerpt from ERG Guide 137 [Substances - Water-Reactive - Corrosive]:

As an immediate precautionary measure, isolate spill or leak area in all directions for at least 50 meters (150 feet) for liquids and at least 25 meters (75 feet) for solids.

SPILL: See ERG Table 1 - Initial Isolation and Protective Action Distances on the UN/NA 1829 datasheet.

FIRE: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions. (ERG, 2016)

Firefighting

Keep unnecessary people away; isolate hazard area and deny entry. Stay upwind; keep out of low areas. Ventilate closed spaces before entering them. Wear positive pressure breathing apparatus and special protective clothing.

Do not get water inside container. Small fires: dry chemical or carbon dioxide. Large fires: flood fire area with water from a distance. Do not get solid stream of water on spilled material. Move container from fire area if you can do so without risk. Spray cooling water on containers that are exposed to flames until well after fire is out. (EPA, 1998)

Non-Fire Response

Fully encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Stop leak if you can do it without risk. Use water spray to reduce vapors; do not put water directly on leak, spill area or inside container. Keep combustibles (wood, paper, oil, etc.) away from spilled material.

SMALL SPILL: Cover with DRY earth, DRY sand or other non-combustible material followed with plastic sheet to minimize spreading or contact with rain. Use clean, non-sparking tools to collect material and place it into loosely covered plastic containers for later disposal. Prevent entry into waterways, sewers, basements or confined areas. (ERG, 2016)

Protective Clothing

For emergency situations, wear a positive pressure, pressure-demand, full facepiece self-contained breathing apparatus (SCBA) or pressure- demand supplied air respirator with escape SCBA and a fully-encapsulating, chemical resistant suit. (EPA, 1998)

First Aid

Warning: Sulfur trioxide is extremely corrosive. Caution is advised.

Signs and Symptoms of Sulfur Trioxide Exposure: Signs and symptoms of acute ingestion of sulfur trioxide may be severe and include salivation, intense thirst, difficulty in swallowing, chills, pain, and shock. Oral, esophageal, and stomach burns are common. Vomitus generally has a coffee-ground appearance. The potential for circulatory collapse is high following ingestion of sulfur trioxide. Acute inhalation exposure of sulfur trioxide may result in sneezing, hoarseness, coughing, choking, laryngitis, and respiratory tract irritation. Bleeding of nose and gums, ulceration of the nasal and oral mucosa, bronchitis, pneumonia, dyspnea (shortness of breath), chest pain, and pulmonary edema and respiratory failure may also occur. Eye exposure to sulfur trioxide may result in irritation, pain, swelling, corneal erosion, and blindness. Dermal exposure may result in dermatitis (red, inflamed skin), severe burns, and pain.

Emergency Life-Support Procedures: Acute exposure to sulfur trioxide may require decontamination and life support for the victims. Emergency personnel should wear protective clothing appropriate to the type and degree of contamination. Air-purifying or supplied-air respiratory equipment should also be worn, as necessary. Rescue vehicles should carry supplies such as plastic sheeting and disposable plastic bags to assist in preventing spread of contamination.

Inhalation Exposure:

1. Move victims to fresh air. Emergency personnel should avoid self-exposure to sulfur trioxide.
2. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support.
3. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures.
4. Transport to a health care facility.

Dermal/Eye Exposure:

1. Remove victims from exposure. Emergency personnel should avoid self-exposure to sulfur trioxide.
2. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support.
3. Remove and isolate contaminated clothing as soon as possible.
4. If eye exposure has occurred, eyes must be flushed with lukewarm water for at least 15 minutes.
5. Wash exposed skin areas thoroughly with soap and water.
6. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures.
7. Transport to a health care facility.

Ingestion Exposure:

1. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support.
2. DO NOT induce vomiting or attempt to neutralize!
3. Rinse mouth with large amounts of water. Inform victims not to swallow this water.
4. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures.
5. Activated charcoal is of no value.
6. Give the victims water or milk: children up to 1 year old, 125 mL (4 oz or 1/2 cup); children 1 to 12 years old, 200 mL (6 oz or 3/4 cup); adults, 250 mL (8 oz or 1 cup). Water or milk should be given only if victims are conscious and alert.
7. Transport to a health care facility. (EPA, 1998)

Chemical Formula: SO_3

Melting Point: 144° F Alpha form 90.5° F Beta form 62.2° F Gamma form *(EPA, 1998)*

Vapor Pressure: 73 mm Hg at 77° F Alpha form 344 mm Hg at 77° F Beta form 433 mm Hg at 77° F Gamma form *(EPA, 1998)*

Vapor Density (Relative to Air): 2.76 *(EPA, 1998)*

Specific Gravity: 1.92 at 68 ° F Gamma form (liquid) *(EPA, 1998)*

Boiling Point: 113 ° F at 760 mm Hg all forms *(EPA, 1998)*

Molecular Weight: 80.06 *(EPA, 1998)*

AEGLs (Acute Exposure Guideline Levels)

Interim AEGLs for Sulfur trioxide (7446-11-9)

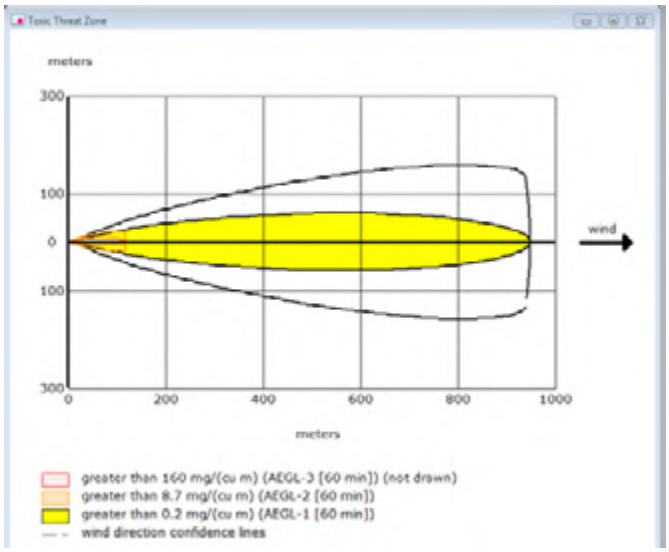
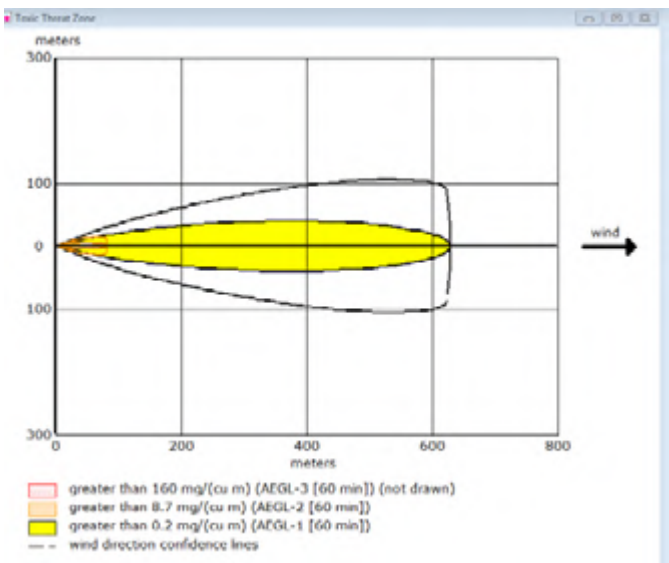
Exposure Period	AEGL-1	AEGL-2	AEGL-3
10 minutes	0.2 mg/m^3	8.7 mg//m^3	270 mg//m^3
30 minutes	0.2 mg/m^3	8.7 mg//m^3	200 mg//m^3
60 minutes	0.2 mg//m^3	8.7 mg//m^3	160 mg//m^3
4 hours	0.2 mg/m3	8.7 mg//m^3	110 mg//m^3
8 hours	0.2 mg//m^3	8.7 mg//m^3	93 mg//m^3

(NAC/NRC, 2016)

ERPGs (Emergency Response Planning Guidelines)

Chemical	ERPG-1	ERPG-2	ERPG-3
Sulfuric Acid (Oleum [8014-95-7], Sulfur Trioxide [7446-11-9], and Sulfuric Acid [7664-93-9])	2 mg//m^3 ✪	10 mg//m^3	120 mg//m^3

✪ indicates that odor should be detectable near ERPG-1.

Sl. No	Risk Scenario	Effect	Figure
1.	**Major leakage**: Direct Source: 1.0 kilograms/min Source Height: 0 Release Duration: 15 minutes Release Rate: 1,000 grams/min Total Amount Released: 15.0 kilograms	Red : 27 meters --- (160 mg/(cu m) = AEGL-3 [60 min]) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. Orange: 117 meters --- (8.7 mg/(cu m) = AEGL-2 [60 min]) Yellow: 949 meters --- (0.2 mg/(cu m) = AEGL-1 [60 min])	
2.	**Minor Leakage** Direct Source: 0.5 kilograms/min Source Height: 0 Release Duration: 15 minutes Release Rate: 500 grams/min Total Amount Released: 7.50 kilograms	Red : 19 meters --- (160 mg/(cu m) = AEGL-3 [60 min]) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. Orange: 82 meters --- (8.7 mg/(cu m) = AEGL-2 [60 min]) Yellow: 630 meters --- (0.2 mg/(cu m) = AEGL-1 [60 min])	

6.4 FO

FUEL OIL,

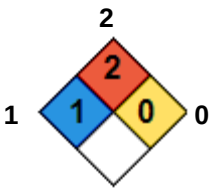
6.4.1 Chemical Data Sheet:

Chemical Identifiers | Hazards | Response Recommendations | Physical Properties | Regulatory Information | Alternate Chemical Names

Chemical Identifiers

CAS Number	UN/NA Number	DOT Hazard Label	USCG CHRIS Code
68553-00-4	1993 (domestic) 1202 (international)	Flammable Liquid	OSX

NFPA 704

Diamond	Hazard	Value	Description
	Health	1	Can cause significant irritation.
	Flammability	2	Must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.
	Instability	0	Normally stable, even under fire conditions.
	Special		

(NFPA, 2010)

General Description

Thick black liquid with the odor of tar. Liquid is shipped at elevated temperature. Insoluble in water and usually less dense than water . (USCG, 1999)

Hazards

Reactivity Alerts

none

Air & Water Reactions

Flammable. Insoluble in water.

Fire Hazard

HIGHLY FLAMMABLE: Will be easily ignited by heat, sparks or flames. Vapors may form explosive mixtures with air. Vapors may travel to source of ignition and flash back. Most

vapors are heavier than air. They will spread along ground and collect in low or confined areas (sewers, basements, tanks). Vapor explosion hazard indoors, outdoors or in sewers. Those substances designated with a (P) may polymerize explosively when heated or involved in a fire. Runoff to sewer may create fire or explosion hazard. Containers may explode when heated. Many liquids are lighter than water. Substance may be transported hot. For hybrid vehicles,

Health Hazard

INGESTION: gastrointestinal irritation. ASPIRATION: pulmonary irritation is normally minimal but may become more severe several hours after exposure.

Reactivity Profile

FUEL OIL, [NO. 6] may be incompatible with strong oxidizing agents such as nitric acid. Charring may occur followed by ignition of unreacted material and other nearby combustibles. In other settings, mostly unreactive. Not affected by aqueous solutions of acids, alkalis, most oxidizing agents, and most reducing agents. When heated sufficiently or when ignited in the presence of air, oxygen or strong oxidizing agents, burns exothermically to produce mostly carbon dioxide and water.

Belongs to the Following Reactive Group(s)

Hydrocarbons, Aliphatic Saturated

Response Recommendations

Isolation and Evacuation
As an immediate precautionary measure, isolate spill or leak area for at least 50 meters (150 feet) in all directions.

LARGE SPILL: Consider initial downwind evacuation for at least 300 meters (1000 feet).

FIRE: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions. (ERG, 2016)

Firefighting

Fire Extinguishing Agents Not to Be Used: Water may be ineffective

Fire Extinguishing Agents: Dry chemical, foam, or carbon dioxide

Non-Fire Response

ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). All equipment used when handling the product must be grounded. Do not touch or walk through spilled material. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. A vapor-suppressing foam may be used to reduce vapors. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. Use clean, non-sparking tools to collect absorbed material.

LARGE SPILL: Dike far ahead of liquid spill for later disposal. Water spray may reduce vapor, but may not prevent ignition in closed spaces.

Protective Clothing
Protective gloves; goggles or face shield.

First Aid
INGESTION: do NOT lavage or induce vomiting.

ASPIRATION: treatment probably not required; delayed development of pulmonary irritation can be detected by serial chest x-rays; consider prophylactic antibiotic regime if condition warrants.

EYES: wash with copious quantity of water.

SKIN: wipe off and wash with soap and water. (USCG, 1999)

Physical Properties

Flash Point: greater than 150 ° F

Lower Explosive Limit (LEL): 1 %)

Upper Explosive Limit (UEL): 5 %

Autoignition Temperature: 765 ° F

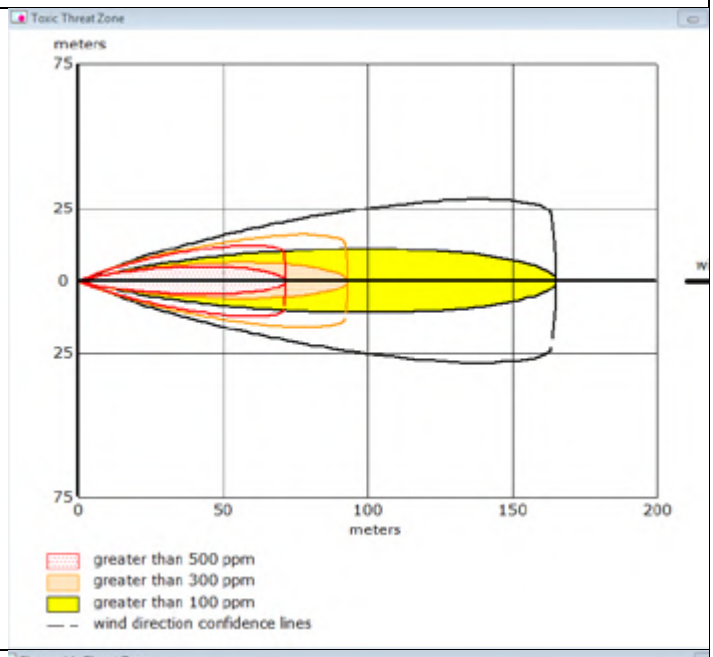
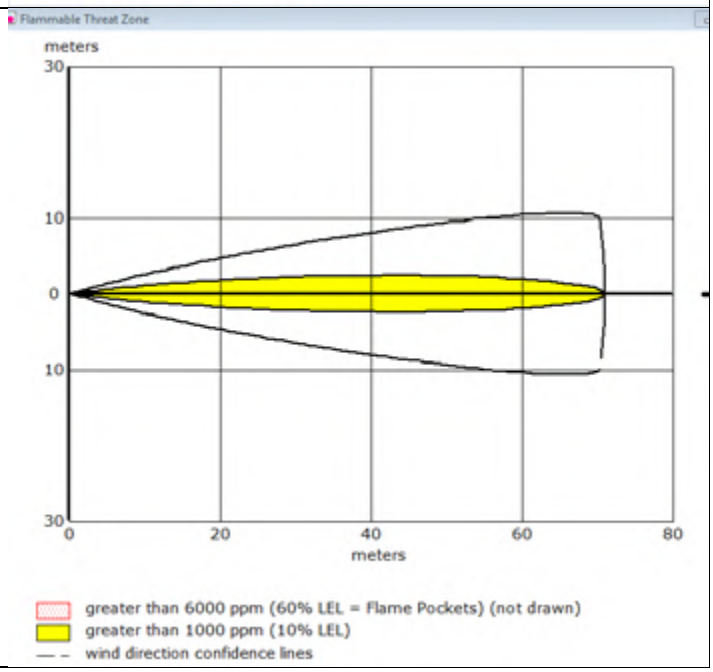
Melting Point: 55 ° F

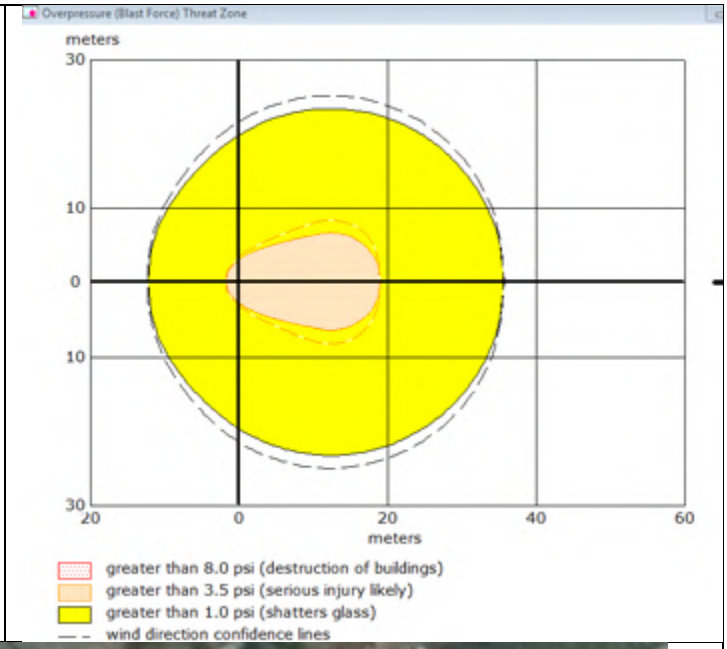
Specific Gravity: 0.95 at 68 ° F (approx.)

Boiling Point: 415 to 1093 ° F at 760 mm Hg

6.4.2 Risk Scenarios:

	Product	Scenario	Effect
4)	FO	i) Hose rupture during unloading.	Vapour cloud
		ii) Leakage from unloading pump	do
		iii) Tank drain valve not closed properly	do
		iv) Leakage from tank body	do

Sl. No	Risk Scenario	Effect	Figure
1.	Leakage due to hose rupture, leakage from unloading pump, tank body leak. Leak qty. 5 kg/sec for 30 mins.	Red : 72 meters --- (500 ppm) Orange: 93 meters --- (300 ppm) Yellow: 165 meters --- (100 ppm)	
	Flammable Area of Vapor Cloud	Red : 28 meters --- (6000 ppm = 60% LEL = Flame Pockets) Yellow: 71 meters --- (1000 ppm = 10% LEL)	

	Overpressure (blast force) from vapor cloud explosion	Model Run: Gaussian Red : LOC was never exceeded --- (8.0 psi = destruction of buildings) Orange: 19 meters --- (3.5 psi = serious injury likely) Yellow: 36 meters --- (1.0 psi = shatters glass)	
	Affected area is shown in the fig.		

Chemical Datasheet

SULFURIC ACID

Chemical Identifiers | Hazards | Response Recommendations | Physical Properties | Regulatory Information | Alternate Chemical Names

Chemical Identifiers

CAS Number	UN/NA Number	DOT Hazard Label	USCG CHRIS Code
7664-93-9	1830	Corrosive	SFA

NFPA 704

Diamond	Hazard	Value	Description
	Health	3	Can cause serious or permanent injury.
	Flammability	0	Will not burn under typical fire conditions.
	Instability	2	Readily undergoes violent chemical changes at elevated temperatures and pressures.
	Special	W	Reacts violently or explosively with water.

(NFPA, 2010)

NIOSH Pocket Guide

Sulfuric acid

International Chem Safety Card

SULFURIC ACID

General Description

Sulfuric acid is a colorless oily liquid. It is soluble in water with release of heat. It is corrosive to metals and tissue. It will char wood and most other organic matter on contact, but is unlikely to cause a fire. Density 15 lb / gal. Long term exposure to low concentrations or short term exposure to high concentrations can result in adverse health effects from inhalation. It is used to make fertilizers and other chemicals, in petroleum refining, in iron and steel production, and for many other uses.

Rate of onset: Immediate

Persistence: Hours, days

Odor threshold:

Source/use/other hazard: Battery/dyes/paper/glue/metals industries; volcanic gas; toxic fumes when heated.

Reactivity Alerts

Strong Oxidizing Agent

Known Catalytic Activity

Water-Reactive

Air & Water Reactions

Reaction with water is negligible unless acid strength is above 80-90% then heat from hydrolysis is extreme, may cause severe burns [Merck, 11th ed. 1989]. During sulfonation of mononitrobenzene by fuming sulfuric acid, a leak from an internal cooling coil permitted water to enter the reaction tank. A violent eruption occurred due to the heat of solution [MCA Case History 944 1963].

Fire Hazard

It is highly reactive and capable of igniting finely-divided combustible materials on contact. When heated, it emits highly toxic fumes. Avoid heat; water and organic materials. Sulfuric acid is explosive or incompatible with an enormous array of substances. Can undergo violent chemical change at elevated temperatures and pressure. May react violently with water. When heated, it emits highly toxic fumes. Hazardous polymerization may not occur. (EPA, 1998)

Health Hazard

Corrosive to all body tissues. Inhalation of vapor may cause serious lung damage. Contact with eyes may result in total loss of vision. Skin contact may produce severe necrosis. Fatal amount for adult: between 1 teaspoonful and one-half ounce of the concentrated chemical. Even a few drops may be fatal if the acid gains access to the trachea. Chronic exposure may cause tracheobronchitis, stomatitis, conjunctivitis, and gastritis. Gastric perforation and peritonitis may occur and may be followed by circulatory collapse. Circulatory shock is often the immediate cause of death. Those with chronic respiratory, gastrointestinal, or nervous diseases and any eye and skin diseases are at greater risk. *(EPA, 1998)*

Reactivity Profile

SULFURIC ACID is strongly acidic. Reacts violently with bromine pentafluoride *[Mellor 2 Supp. 1:172 1956]*. Exploded with para-nitrotoluene at 80°C *[Chem. Eng. News 27:2504]*. An explosion occurred when concentrated sulfuric acid was mixed with crystalline potassium permanganate in a vessel containing moisture. Manganese heptoxide was formed, which explodes at 70°C *[Delhez 1967]*. A mixture of acrylonitrile with concentrated sulfuric acid must be kept well chilled, otherwise a vigorous exothermic reaction occurs [Chem. Safety Data Sheet SD-31:8. 1949]. Mixing sulfuric acid (96%) in equal portions with any of the following substances in a closed container caused the temperature and pressure to increase: acetonitrile, acrolein, 2-aminoethanol, ammonium hydroxide (28%), aniline, n-butyraldehyde, chlorosulfonic acid, ethylene diamine,

ethyleneimine, epichlorohydrin, ethylene cyanohydrin, hydrochloric acid (36%), hydrofluoric acid (48.7%), propiolactone, propylene oxide, sodium hydroxide, styrene monomer *[NFPA 1991]*. Sulfuric acid (concentrated) is extremely hazardous in contact with carbides, bromates, chlorates, fulminates, picrates, and powdered metals [Haz. Chem. Data 1966]. Allyl chloride may polymerize violently under conditions involving an acid catalyst, such as sulfuric acid [Ventrone 1971]. React exothermically with sodium hypochlorite to produce chlorine gas. Mixing chlorosulfuric acid and 98% sulfuric acid may evolve HCl [Subref: Anon, Loss Prev. Bull. 1977, (013), 2-3]. Zinc iodide reacts violently with H2SO4. *(Pascal, 1962, Vol. 5, 168).*

Belongs to the Following Reactive Group(s)
Acids, Strong Oxidizing
Potentially Incompatible Absorbents

Use caution: Liquids with this reactive group classification have been known to react with the absorbents listed below. More info about absorbents, including situations to watch out for...

Cellulose-Based Absorbents

Expanded Polymeric Absorbents

Isolation and Evacuation
Excerpt from ERG Guide 137 [Substances - Water-Reactive - Corrosive]:

As an immediate precautionary measure, isolate spill or leak area in all directions for at least 50 meters (150 feet) for liquids and at least 25 meters (75 feet) for solids.

SPILL: Increase, in the downwind direction, as necessary, the isolation distance shown above.

FIRE: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions. (ERG, 2016)

Firefighting

Fight fire from safe distance or from protected location. Use care as water applied directly to this acid results in evolution of heat and causes spattering. Cool containers that are exposed to flames with streams of water until fire is out. Wear positive pressure breathing apparatus and special protective clothing.

Not flammable. For small fires use dry chemical or carbon dioxide. Use water on combustibles burning in vicinity of this material. For large fires flood fire area with water from a distance. Do not get solid streams of water on material. Move container from area if you can do so without risk. (EPA, 1998)

Non-Fire Response

[Substances - Water-Reactive - Corrosive]:

Fully encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Stop leak if you can do it without risk. Use water spray to reduce vapors; do not put water directly on leak, spill area or inside container. Keep combustibles (wood, paper, oil, etc.) away from spilled material.

SMALL SPILL: Cover with DRY earth, DRY sand or other non-combustible material followed with plastic sheet to minimize spreading or contact with rain. Use clean, non-sparking tools to collect material and place it into loosely covered plastic containers for later disposal. Prevent entry into waterways, sewers, basements or confined areas.

Protective Clothing

Skin: Wear appropriate personal protective clothing to prevent skin contact.

Eyes: Wear appropriate eye protection to prevent eye contact.

Wash skin: The worker should immediately wash the skin when it becomes contaminated.

Remove: Work clothing that becomes wet or significantly contaminated should be removed and replaced.

Change: No recommendation is made specifying the need for the worker to change clothing after the work shift.

Provide: Eyewash fountains should be provided (when concentration is >1%) in areas where there is any possibility that workers could be exposed to the substance; this is irrespective of the recommendation involving the wearing of eye protection. Facilities for quickly drenching the body should be provided (when concentration is >1%) within the immediate work area for emergency use where there is a possibility of exposure. [Note: It is intended that these facilities provide a sufficient quantity or flow of water to quickly remove the substance from any body areas likely to be exposed. The actual determination of what constitutes an adequate quick drench facility depends on the specific circumstances. In certain instances, a deluge shower should be readily available, whereas in others, the availability of water from a sink or hose could be considered adequate.] (NIOSH, 2016)

First Aid

Caution: Sulfuric acid is extremely corrosive. Caution is advised.

Signs and Symptoms of Acute Sulfuric Acid Exposure: Signs and symptoms of acute ingestion of sulfuric acid may be severe and include salivation, intense thirst, difficulty in swallowing, pain, and shock. Oral, esophageal, and stomach burns are common. Vomitus generally has a coffee-ground appearance. The potential for circulatory collapse is high following ingestion of sulfuric acid. Acute inhalation exposure may result in sneezing, hoarseness, choking, laryngitis, dyspnea (shortness of breath), respiratory tract irritation, and chest pain. Bleeding of nose and gums, ulceration of the nasal and oral mucosa, pulmonary edema, chronic bronchitis, and pneumonia may also occur. If the eyes have come in contact with sulfuric acid, irritation, pain, swelling, corneal erosion, and blindness may result. Dermal exposure may result in severe burns, pain, and dermatitis (red, inflamed skin).

Emergency Life-Support Procedures: Acute exposure to sulfuric acid may require decontamination and life support for the victims. Emergency personnel should wear protective clothing appropriate to the type and degree of contamination. Air-purifying or supplied-air respiratory equipment should also be worn, as necessary. Rescue vehicles should carry supplies such as plastic sheeting and disposable plastic bags to assist in preventing spread of contamination.

Inhalation Exposure:

1. Move victims to fresh air. Emergency personnel should avoid self-exposure to sulfuric acid.
2. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support.

3. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures.
4. RUSH to a health care facility.

Dermal/Eye Exposure:

1. Remove victims from exposure. Emergency personnel should avoid self- exposure to sulfuric acid.
2. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support.
3. Remove contaminated clothing as soon as possible.
4. If eye exposure has occurred, eyes must be flushed with lukewarm water for at least 15 minutes.
5. Wash exposed skin areas THOROUGHLY with soap and water.
6. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures.
7. RUSH to a health care facility.

Ingestion Exposure:

1. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support.
2. Rinse mouth with large amounts of water. Instruct victims not to swallow the water.
3. DO NOT induce vomiting or attempt to neutralize!
4. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures.
5. Activated charcoal is of no value.
6. Give the victims water or milk: children up to 1 year old, 125 mL (4 oz or 1/2 cup); children 1 to 12 years old, 200 mL (6 oz or 3/4 cup); adults, 250 mL (8 oz or 1 cup). Water or milk should be given only if victims are conscious and alert.
7. RUSH to a health care facility. (EPA, 1998)

Chemical Formula: H_2SO_4

Autoignition Temperature: Not flammable *(USCG, 1999)*

Melting Point: 50.65 ° F *(EPA, 1998)*

Vapor Pressure: 1 mm Hg at 294.8 ° F *(EPA, 1998)*

Vapor Density (Relative to Air): 3.4 *(EPA, 1998)*

Specific Gravity: 1.841 *(EPA, 1998)*

Boiling Point: 554 ° F at 760 mm Hg *(EPA, 1998)*

Molecular Weight: 98.08 *(EPA, 1998)*

Water Solubility: Miscible *(NIOSH, 2016)*

IDLH: 15 mg/m^3 *(NIOSH, 2016)*

AEGLs (Acute Exposure Guideline Levels)

Interim AEGLs for Sulfuric acid (7664-93-9)

Exposure Period	AEGL-1	AEGL-2	AEGL-3
10 minutes	0.2 mg/ m^3	8.7 mg/ m^3	270 mg/ m^3
30 minutes	0.2 mg/ m^3	8.7 mg/ m^3	200 mg/ m^3
60 minutes	0.2 mg/ m^3	8.7 mg/ m^3	160 mg/ m^3
4 hours	0.2 mg/ m^3	8.7 mg/ m^3	110 mg/ m^3
8 hours	0.2 mg/ m^3	8.7 mg/ m^3	93 mg/ m^3

(NAC/NRC, 2016)

ERPGs (Emergency Response Planning Guidelines)

Chemical	**ERPG-1**	**ERPG-2**	**ERPG-3**
Sulfuric Acid (Oleum [8014-95-7], Sulfur Trioxide [7446-11-9], and Sulfuric Acid [7664-93-9])	2 mg/ m^3 ✪	10 mg/ m^3	120 mg/ m^3

✪ indicates that odor should be detectable near ERPG-1.

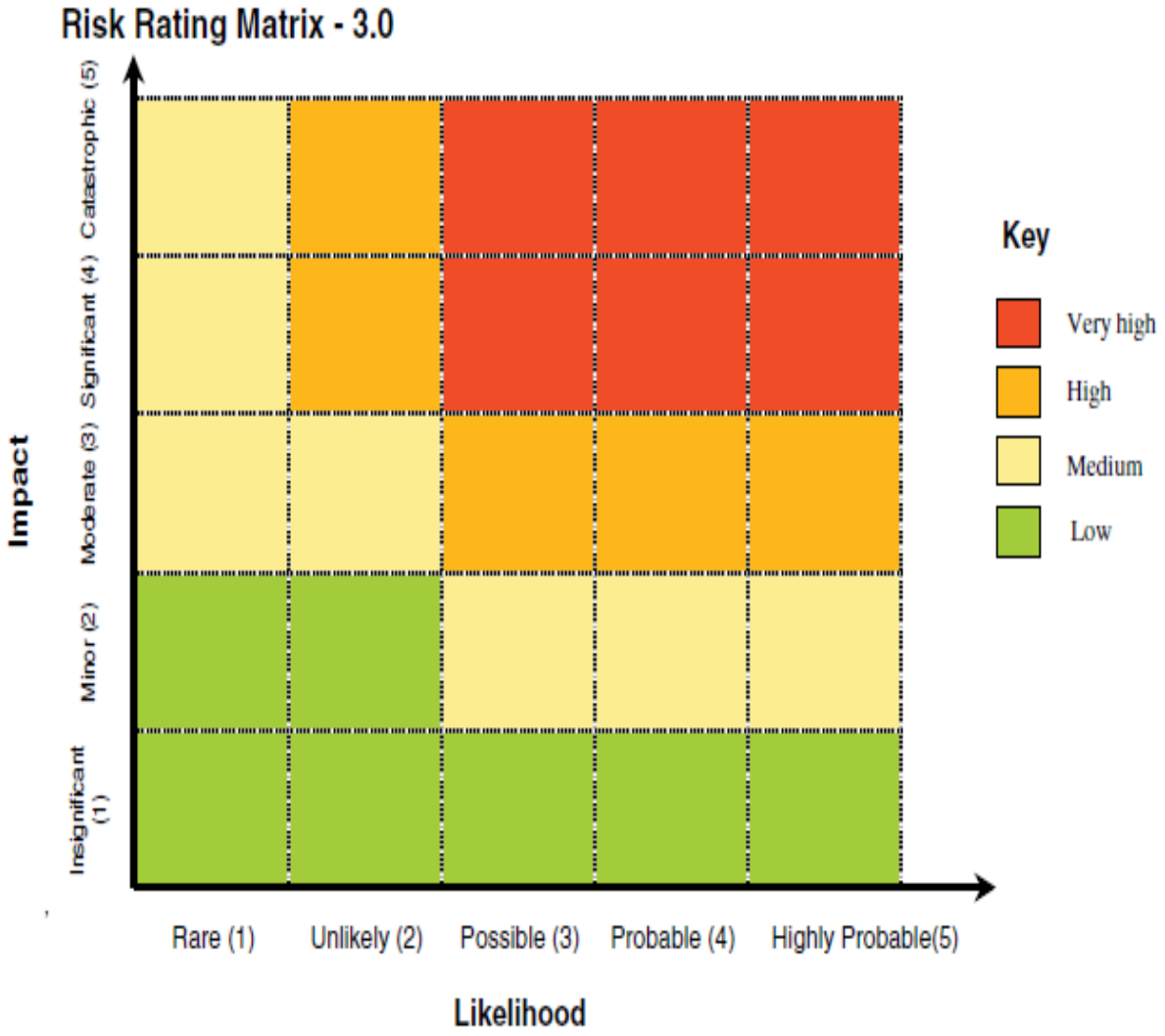
(AIHA, 2016)

PACs (Protective Action Criteria)

Chemical	PAC-1	PAC-2	PAC-3
Sulfuric acid (7664-93-9)	0.2 mg/ m^3	8.7 mg m^3	160 mg/ m^3

7.0 Risk Assessment

In the absence of any data on incident, Risk assessed is based on the following:



Likelihood Scoring Scale - Quantitative and Qualitative Measures - 3.2

Level	Descriptor	Indicative chance of occurrence in a given 5 year period	Description
1	Rare	1%or less	May occur only in exceptional circumstances; may occur once every five hundred or more years.
2	Unlikely	2%-25%	Is not expected to occur; and/or no recorded incidents or anecdotal evidence; and/or no recent incidents in associated organizations. facilities or communities; and/or little opportunity, reason or means to occur; may occur once every one hundred years.
3	Possible	26°/o-50%	Might occur at some time; and/or few. infrequent, random recorded incidents or little anecdotal evidence; and/or very few incidents in associated or comparable Organizations, facilities or communities; and/or some opportunity, reason or means to occur; may occur once every twenty years.
4	Probable	51°/o-75%	Likely to or may occur/recur every 5 - 7 years; regular recorded incidents and strong anecdotal evidence and will probably occur in many circumstances.
5	Highly Probable	76°/o-100%	Likely to or may occur/recur every 5 years or less; high level of recorded incidents and/or strong anecdotal evidence.

Impact Scoring Scale – Qualitative Measure – 3.3

Level	Descriptor	Categories of Impact	Description of Impact
1	Insignificant	Human Welfare	• No fatalities, injuries or impact on health. • No persons displaced and no personal support required. • No damage to properties. • No disruption to community services or infrastructure.
		Environment	– No impact on environment.
2.	Minor	Human Welfare	• Small number of people affected (<10), no fatalities, and small number of minor injuries with first aid treatment. • Minor displacement of people for <8 hours and minor personal support required. • Minor localized disruption to community services or infrastructure <6 hours.
		Environment	– Minor impact on environment with no lasting effects.
3.	Moderate	Human Welfare	• Limited number of people affected (11-50), no fatalities, but some hospitalization and medical treatment required. • Localized displacement of small number of people for 6-24 hours. Personal support satisfied through local arrangements. • Localized damage that is rectified by routine arrangements. • Normal community functioning with some inconvenience.
		Environment	– Some impact on environment with short-term effects or small impact on environment with long-term effects.
4.	Significant	Human Welfare	• Significant number of people (51-100) in affected area impacted with multiple fatalities, multiple serious or extensive injuries, significant hospitalization. • Large number of people displaced for 6-24 hours or possibly beyond. External resources required for personal support.

Level	Descriptor	Categories of Impact	Description of Impact
			• Significant damage that requires external resources. • Community only partially functioning, some services unavailable.
		Environment	– Significant impact on environment with medium to long-term effects.
5.	Catastrophic	Human Welfare	• Very large number of people (>100) in affected area(s) impacted with significant numbers of fatalities, large number of people requiring hospitalization with serious injuries with long term effects. • General and widespread displacement for prolonged duration and extensive personal support required. • Extensive damage to properties in affected area requiring major demolition. • Serious damage to infrastructure causing significant disruption to, or loss of, key services for prolonged period. Community unable to function without significant support.
		Environment	– Significant long-term impact on environment and / or permanent damage.

8.0 Risk rating matrix

Product	Activity	Likelihood	Impact	Key	Risk mitigation measure.	Key after risk mitigation measure.
HSD	Hose rupture during unloading	Possible	Minor	Medium	Periodic inspection of hoses to be carried out and replaced as specified by manufacturer.	Low
	Leakage from unloading pump	Possible	Minor	Medium	Preventive maintenance of the pump to be carried out as scheduled	Low
	Tank drain valve not closed properly/ passing.	Unlikely	Minor	Low	Operators must be careful.	
	Leakage from tank body with fire inside the dyke.	Possible	Significant	Very High	i) Leakage to be stopped if possible. ii)Tank Maint. & Inspection to be carried out as scheduled. iii) Install full fire fighting system with storage tank, pump, hydrant and sprinkler system.	Medium
	BLEVE of tank	Unlikely	Catastrophic	High	i) Leakage to be stopped if possible. ii) Tank Maint. & Inspection to be carried out as scheduled. iii) In case of fire, entire area will be affected. iv) Install full fire fighting system with storage tank, pump, hydrant and sprinkler system. v) Cooling of tank in fire should be proper and over all the area so that tank metal colour do not change. vi) Install automatic water sprinkler system in HSD if possible.	Medium

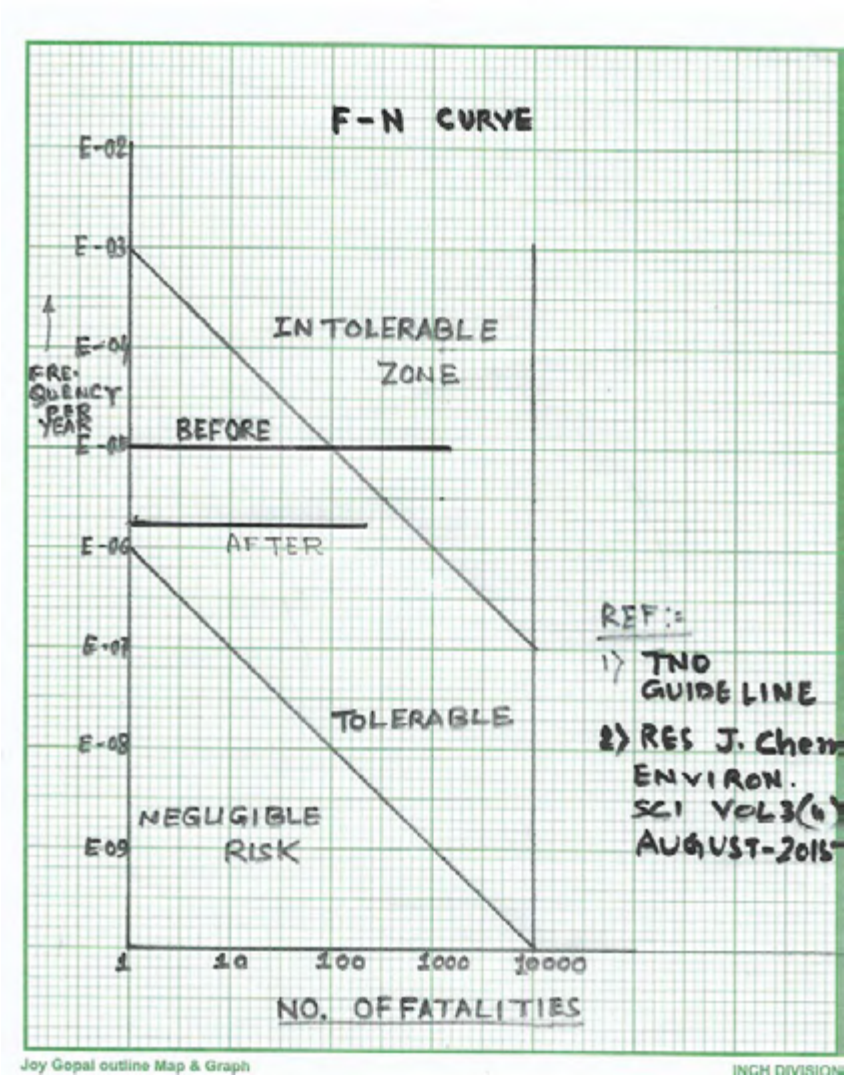
Product	Activity	Likelihood	Impact	Key	Risk mitigation measure.	Key after risk mitigation measure.
SKO	i) Leakage in supply line	Possible	Minor	Medium	i) Line inspection/line thickness must be carried out periodically	Low
	ii) Leakage from unloading pump	Possible	Moderate	High	i) Operator must check line up from tank to pump ii) Tank must have sufficient material to pump iii) In any case, pump should not run dry - priming of the pump must be ensured before starting the pump iv) Preventive maintenance of the pump must be carried out as per schedule	Possibility will be Unlikely; Hence, Medium risk
	iii) Tank drain valve not closed properly	Unlikely	Minor	Low	Operator must be careful	
	iv) Leakage from tank body/ overflow	Unlikely	Moderate	Medium	Tank maintenance and inspection must be carried out as per schedule	Low
	BLEVE of tank	Unlikely	Catastrophic	High	i) Leakage to be stopped if possible ii) Tank maintenance & inspection to be carried out as scheduled iii) In case of fire, entire area will be affected iv) Install full firefighting system with storage tank, pump, hydrant and sprinkler system v) Cooling of tank in fire should be proper and all over the area so that tank metal colour do not change vi) Install automatic water sprinkler system in SKO tank area particularly in oil storage area where to horizontal vessels are very close	Medium

Product	Activity	Likelihood	Impact	Key	Risk mitigation measure	Key after risk mitigation measure
SO_2 & SO_3	i. Leakage at ground level from acid plant	Possible	Significant	Very high	Preventive maintenance of the plant is to be carried out as specified by the designer and the manufacturer of the equipment; The corrosion level of the piping system must be monitored and replacement to be carried out	Medium
	ii Discharge from scrubber stacks	Possible	Significant	Very High	Stack emission gas quality must be monitored and caustic circulation rate should be maintained as per inlet gas quality; Automatic flow control of caustic will be helpful; Strength of caustic solution is to be checked and maintained	Medium

Product	Activity	Likelihood	Impact	Key	Risk mitigation measure	Key after risk mitigation measure
H_2SO_4	i) Leakage at ground level from acid plant, pumps, etc.	Possible	Moderate	High	Should not mix up with water; Control the spill within a small area so that it does not flow to sewerage, closed area, etc. Spread earth or sand on the spill amount in case of small spill and cover with a plastic sheet afterwards; In case of large spill, contain the material in a small area; Collect the material using non-sparking tools in a loosely covered dry plastic container and protect the same for any water ingress; Avoid contact with metals; Preventive maintenance of the plant should be carried out as per recommendation of the designer/equipment manufacturer	Low
	ii) leakage from tank, despatch pump, loading arm.	Possible	Moderate	High	Preventive maintenance of the tanks are to be carried out as per schedule. Monitor thickness of the tank regularly. The loading arm should be replaced as per the recommendation of the manufacturer. Operators must be careful during loading and must follow all safety precautions including PPE and operating procedure.	Low
Product	**Activity**	**Likelihood**	**Impact**	**Key**	**Risk mitigation measure.**	**Key after risk mitigation measure.**
FO	i) Hose rupture during unloading.	Possible	Minor	Medium	Check the storage area for any leakage. Provide secondary containment around the unloading area to avoid spillage to larger area.	Low
	ii) Leakage from unloading pump	Possible	Moderate	High	Carry out timely preventive maintenance of pumps. Keep a mobile pump with flame proof motor to transfer the spilled product in to the tank.	Medium
	Iii) Tank drain valve not closed properly	Unlikely	Minor	Low	Line thickness must be checked at regular interval with particular attention on the bends, LPD if any etc.	
	iv)Leakage / overflow from tank body	Possible	Moderate	High	Periodic inspection of tank is a must. FO is a high sulphur product. Care should be taken against Pyrophoric iron. Operator must be careful while unloading FO to tank.	Low

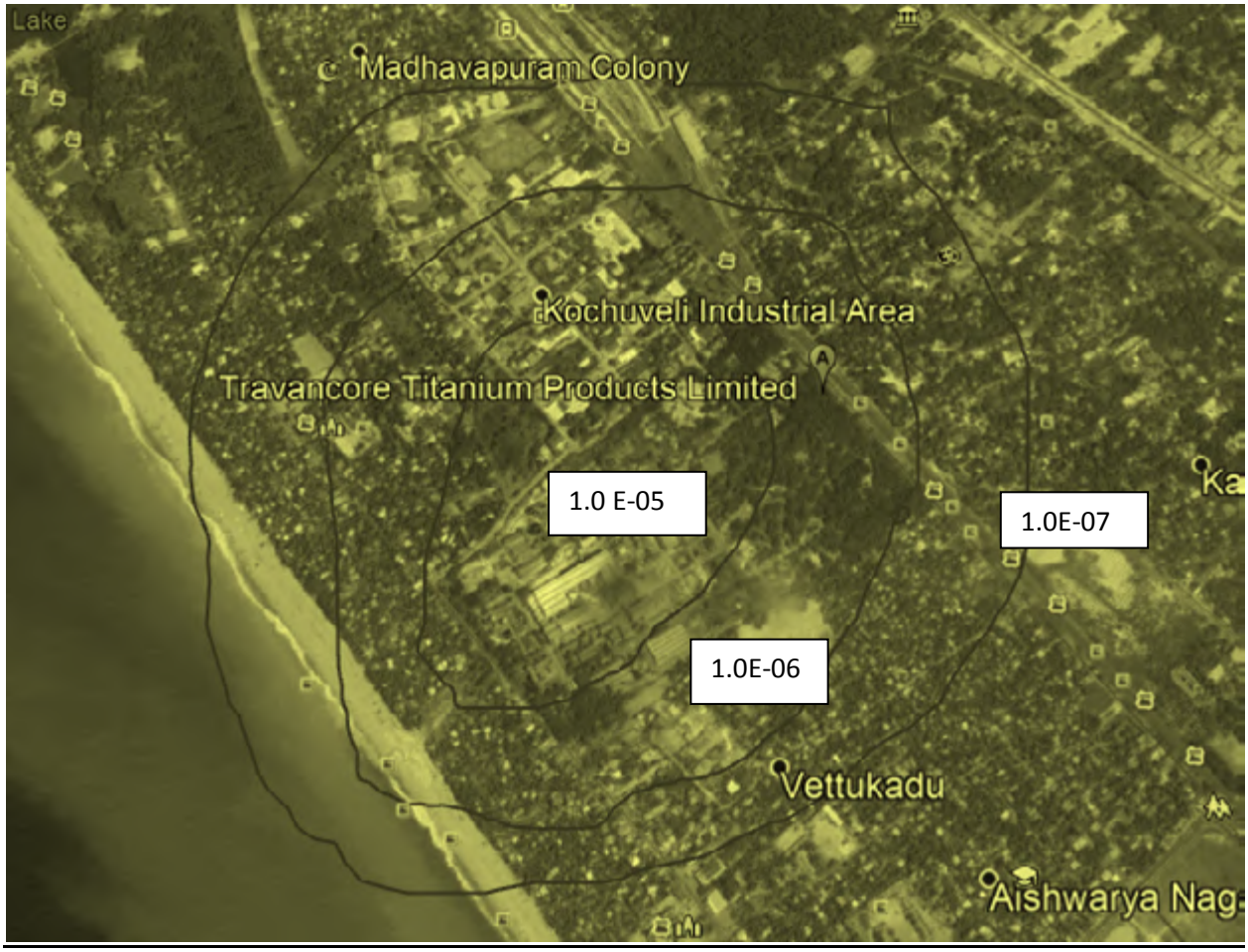
9.0 Societal Risk:

Societal risk has been calculated based on the guide line of TNO and reference from Res J. Chem. Environ. Sci. Vol 3 [4] August 2015: 36-43;. As can be seen risk is outside the tolerable limit in case of BLEVE of HSD tank. The risk can be brought down further by adopting the risk mitigation as explained earlier. Slope of the curve is considered as -1.



10.0 Individual Risk:

Individual risk curve is enclosed.



11.0 Recommendations:

Based on the discussions above, recommendations are

Sl. No	Material	Scenario	Recommendations.
1.	HSD	i) Hose rupture during unloading.	i) Hose must be replaced within the time span as mentioned by OEM.
		ii) Leakage from unloading pump	ii) Preventive maintenance of the pump to be carried out as per OEM recommendation. iii) Pump should be started after proper priming of the pump – operators to be trained accordingly.
		iii) Tank drain valve not closed properly	Proper operator training is required.
		iv) Leakage from tank body	Tank Maint. & Inspection to be taken based on the tank body thickness survey. In case of any leakage area must be isolated from all source of ignition.
		v) Leakage in supply line to consumers	Line thickness survey and corrective measures must be taken.
		vi) BLEVE	HSD leak / spillage should not be there. In case of leakage, all ignition source within the area must be isolated. **FIRE FIGHTING SYSTEM IS TO BE INSTALLED AT THE EARLIEST WITH COOLING FACILITY OF THE TANKS.** Oil spillage should be contained within a small area.
2.	SKO	Hose rupture during unloading.	Hose must be replaced within the time span as mentioned by OEM. In case of leakage, contain spillage within a small area.
		Leakage from unloading pump	- Preventive maintenance of the pump to be carried out as per OEM recommendation. - Pump should be started after proper priming of the pump – operators to be trained accordingly.
		Tank drain valve not closed properly	Proper operators training.
		Leakage from tank body	– Tank material must be transferred to other empty tank as available. – Drained material must be contained in the dyke and collected in container using vacuum pumps or any other suitable equipment with flame proof motor. – Preventive maintenance of the tank must be taken as per schedule / based on tank thickness measurement.
		Leakage in supply line to unit	- Same as above. - Line inspection with thickness measurement must be carried out regularly.
		BLEVE	i)Leakage to be stopped if possible. ii) Tank Maint. & Inspection to be carried out as scheduled. iii) In case of fire, entire area will be affected. iv**) Install full fire fighting system with storage tank, pump, hydrant and sprinkler system**. v) cooling of tank in fire should be proper and over all the area so that tank metal colour do not change. vi) Install automatic water sprinkler system in SKO tank area particularly in oil storage area where to horizontal vessels are very close.
3)	FO	v) Hose rupture during unloading.	Hose must be replaced within the time span as mentioned by OEM.
		vi) Leakage from unloading pump	Proper preventive maintenance of the pump is required. Pump should not run dry in any case.
		vii) Tank drain valve not closed properly	Proper operator training is to be ensured.
		viii) Leakage from tank body	Periodic thickness measurement and maintenance is to be ensured.

4.)	SO_2 & SO_3	i) Leakage at ground level from acid plant	Preventive maintenance of the plant is to be carried out as specified by designer and manufacturer of equipments. Corrosion level of piping system must be monitored and replacement carried out.
		ii) Discharge from scrubber stacks	Stack emission gas quality must be monitored and caustic circulation rate should be maintained as per inlet gas quality. Automatic flow control of caustic will be helpful. Strength of caustic solution is to be checked and maintained Caustic dosing pumps are to be maintained properly.
5.	H_2SO_4	i) Leakage at ground level from acid plant, pumps etc.	Should not mix up with water. Control the spill within a small area so that it does not flow to sewerage, closed area etc. Spread earth or sand on the spill amount in case of small spill and covered with a plastic sheet afterwards. In case of large spill, contain the material in a small area. Collect the material using non-sparking tools in a loosely covered dry plastic container and protect the same for any water ingress. Avoid contact with metals. Preventive maintenance of the plant should be carried out as per recommendation of the designer/ equipment manufacturer.
		ii) leakage from tank, despatch pump, loading arm.	Preventive maintenance of the tanks are to be carried out as per schedule. Monitor thickness of the tank regularly. The loading arm should be replaced as per the recommendation of the manufacturer. Operators must be careful during loading and must follow all safety precautions including PPE and operating procedure.

General :

i) Material from leaky tanks are to be transferred to other container / tank
ii) Use of non-sparking tools and pump with flame proof motor are to be used for collection of spill material..
iii) Spill sulphuric acid must be contained in a small area and should not come in contact with water.
iv) Caustic scrubber system – operating parameters, equipments, strength of caustic must be maintained properly. Suggest to consider auto control caustic injection flow based on outlet SO_2 / SO_3

Caution: The company should immediately set up proper facility of fire fighting with water tank, pumps, line, hydrants, tank cleaning system. Also suggest to store foam for fire fighting in hydrocarbon storage area. This will avoid catastrophic failure of hydrocarbon tanks in case of any fire in the dyke or around and minimize societal risk.

References:

i) IS 15656
ii) TNO Guidelines for QRA.
iii) Research Journal of Chemical and Environmental Sciences, ©Academy for Environment and Life Sciences, INDIA

Disclaimer

This report is prepared and submitted to the management in accordance with the agreed scope and criteria. Consultivo does not accept responsibility to any other person or organization. Any reliance that any third party may place on this report is entirely at their own risk.

All conclusions are based on data collected during the Assessment. Accordingly the findings of this report reflect the conditions prevailing on the day of the assessment and may therefore vary from the ground reality on a subsequent date.

Assessment team has been drawn from qualified personnel with wide industry experience. It is ensured that no member of the assessment team has a business relationship with the Assessee organizations beyond that required of this assignment.

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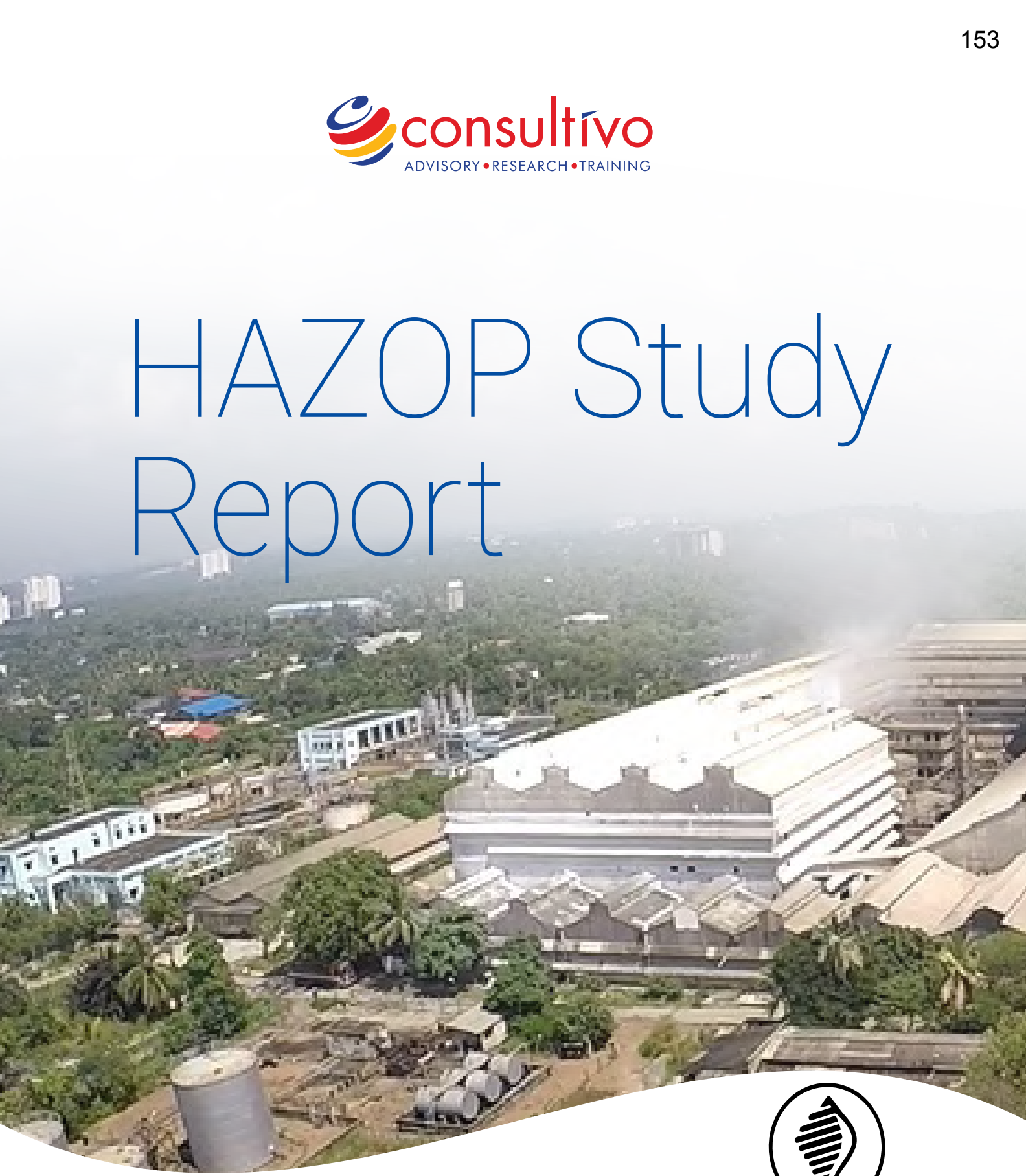
HAZOP Study Report



Titanium

Travancore Titanium Products Limited

Report title: **HAZOP study report**
Date: 15th March 2018

Customer: Travancore Titanium Products Limited (TTPL)
Customer Purchase Order No.: 394/17-18

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Report no: CBS/ASRN/17-18/013/HAZOP
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Contents

1.0 INTRODUCTION

Travancore Titanium Products Limited (TTPL) was incorporated on the 18th of December 1946, to produce pigment grade titanium dioxide from ilmenite which is abundantly available as placer deposits on beaches near Kollam, 65 Kms north of the capital city, Thiruvananthapuram in the coastal state of Kerala, India. The unit was promoted by the then princely state of Travancore in collaboration with the British Titan Products (BTP) Company Limited, U.K.(now known as Tioxide Group Limited).The administrative control of the company was with a managing agency, Indian Titan Products Company.

The company which started production at a modest rate of 5 tonnes per day, increased its capacity in stages to the present level of 40-45 tonnes per day. Till recently, Travancore Titanium Products Ltd., was the only unit producing Anatase grade titanium dioxide pigment in India. TTPL became a State Public sector unit in 1960, with the Government of Kerala owning 97.55% of the shares.

The production of titanium dioxide commenced in the year 1951and the capacity was raised to 10 tonnes per day in 1960, the year in which the management of the company was taken over by the Govt. of Kerala. The company also installed its own sulphuric acid plant to produce acid for captive consumption. In 1963, the capacity of titanium dioxide produced was further increased to 18 tonnes per day with a commensurate addition to the sulphuric acid production also.

Subsequently, a modern sulphuric acid plant was commissioned in 1996, which utilises the tail gas recycling DCDA (Double Catalysis Double Absorption) technology. The alkali scrubbing system incorporated therein, helps to keep the sulphur dioxide emissions well within the permissible limits and helps in maintaining a clean environment.

2.0 BACKGROUND

The Travancore Titanium Products Limited (TTPL) is engaged in manufacturing titanium dioxide pigment from the mineral, Ilmenite which is abundantly available in the beaches of Kerala. The processes use different chemicals , high temperature, different types of fuel, etc. The processes involve risks at various level of operation. Hence, the company was interested to carry out HAZOP study of some of their facilities. Travancore Titanium Products Limited (TTPL), Thiruvanathapuram, Kerala entrusted the job of carrying out HAZOP study of different units to Consultivo, Kolkata.

3.0 SCOPE OF WORK

The detailed scope of work is mentioned below:
Conduct a HAZOP and QRA of TiO2 plant and Acid plant at TTPL and submit a report with recommendations for reducing/eliminating the hazards and operationality problems.

The present report is regarding the HAZOP study of TTPL plant.

4.0 WHAT IS A HAZOP?

A Hazard and Operability study (or HAZOP) is a systematic, critical examination by a team of the engineering and operating intentions of a process to assess the hazard potential of maloperation or malfunction of individual items of equipment and the consequent effects on the facility as a whole.

5.0 WHY IS A HAZOP CARRIED OUT ?

The reasons for carrying out hazard and operability studies are:

i . Primarily, to identify hazards

ii. To a lesser extent, to resolve these hazards

6.0 HOW ARE HAZOPS DONE ?

Earlier, these studies were defined as examinations of engineering and operating intentions. An intention is the expected behaviour of a process and its associated hardware, under normal and abnormal conditions. It may be defined either diagrammatically or descriptively; diagrammatically in terms of flow sheets, P&ID's. etc., or descriptively with operating instructions or design specifications.

A very important assumption is that no hazard can arise from an intention that behaves as expected, i.e. no one deliberately builds in a hazard. Therefore, a hazard can arise only if there is a deviation from the expected behaviour. Hypothetical deviations are prompted by applying guide words, which will be explained shortly, to each intention. Consequently, the design basis is not explicitly challenged and process alternatives may not be recognised.

For example, it is proposed that excess pressure may exist in a line. Firstly, it must be established if there is a realistic cause of this deviation. If there is, the consequences must be considered. They may be trivial or significant. If significant, they must be evaluated to see if they constitute a hazard. In the example of line over-pressure, the excess may be within the line rating. This consequence is trivial. If the rating is exceeded, however, rupture may result. This is obviously a hazardous occurrence. Since the batch process is used here, guide words are different from continuous process plant.

The HAZOP study is carried out based on the following guide words:
A list of guide words are:

Guide Word	Meaning
NO OR NOT	Complete negation of the design intent
MORE	Quantitative increase
LESS	Quantitative decrease
AS WELL AS	Qualitative modification/increase
PART OF	Qualitative modification/decrease
REVERSE	Logical opposite of the design intent
OTHER THAN/INSTEAD	Complete substitution
EARLY	Relative to the clock time
LATE	Relative to the clock time
BEFORE	Relating to order or sequence
AFTER	Relating to order or sequence

7.0 PROCESS DESCRIPTION

Titanium (Ti) is the ninth most abundant element found in the earth's crust. Aerospace, sports and medicine are some of the common areas where the metal has applications, mainly due to its excellent strength to weight ratio and also due to high resistance to corrosion. However, the vast amount of titanium is not used in its elemental form, but rather as the oxide, Titanium Dioxide ($Ti0_2$). Nature does not yield titanium dioxide ($Ti0_2$) in a form suitable for commercial use.

There are two basic chemical processes exploited by manufacturers:

- The Sulphate Process (SP)
- The Chloride Process (CP)

The SP is usually a batch process and is the older of the two methods. The mineral Ilmenite or Synthetic titanium slag is available as the starting raw material for the SP. Travancore Titanium Limited is currently producing $Ti0_2$, Anatase and Rutile grade, through the Sulphate route from Ilemenite. Ilmenite is a complex compound of oxides of iron and titanium.

Titanium Dioxide is a versatile chemical with varied applications in different industrial products like paint, rubber, cosmetics, leather, ceramics, artificial fibres, pharmaceutical preparations, textile printing formulations, welding rods, etc. Titanium Dioxide is the most widely used white pigment in products such as paints, coatings because of its brightness and highest refractive index among all other white pigments and thus has an extraordinary capacity for dispersing light in the visible part of the light spectrum. When combined with other colours, soft pastel shades can be achieved.The properties like high refractive index, non-toxic nature, high stability, fine particle size, optimum gloss, high dispersion in medium etc. made Ti02 to achieve its technical effect.

Titanium Dioxide exists in nature in one of the three crystalline forms: Anatase, Rutile and Brookite, of which the two most important are Anatase and Rutile. Both Anatase and Rutile grades of Titanium Dioxide can be produced by the sulphaLe process, depending on particular processing conditions.
The brief description of the unit process of the sulphate route is given below:

Milling

The purpose of grinding is to increase the surface of the ore to achieve maximum reaction efficiency. Two ball mills, each with a capacity to deliver 4 tonnes/hour of ground Ilmenite of desired specification are available for grinding Ilmenite.

Specification of ground Ilmenite: Residue 2·8% (on 325 mesh sieve-ASTM)

Digestion

The digesters are cylindrical vessels, conical at the bottom (RCC), lined with lead and acid resistant) ricks. There are 6 digesters in the old plant with a capacity of 5.5 tonnes of Ilmenite to be reacted and 8 digesters in new plant with a capacity of 10.5 tonnes of Ilmenite. The processes in the digester at TTPL can be divided as follows:

1. Reaction
2. Baking
3. Dissolution
4. Reduction
5. Final adjustments

1. Reaction

Ground Ilmenite is reacted with concentrated Sulphuric Acid of strength 91-92.5%, depending upon the grades of the Ilmenite. The acid to ore ratio is 1.55. For reaction, calculated quantity of 98% and above, concentrated H_2SO_4 is routed to the empty digester. Agitation is provided by compressed air. Weighed quantity of ground Ilmenite is added at a uniform rate. Proper mixing time is allowed. Then, calculated quantity of cutting water is added to reduce the strength of the acid to 91-92.5% depending upon the quality of the Ilmenite. The heat of dilution initiates the exothermic reaction.

$$TiO_2 + H_2SO_4 \longrightarrow TiOSO_4 + H_2O$$

$$FeO + H_2SO_4 \longrightarrow FeOSO_4 + H_2O$$

$$Fe_2O_3 + 3H_2SO_4 \longrightarrow Fe_2(S0_4)_3 + 3H_2O$$

Oxides of other elements present in the Ilmenite are also convened to their respective sulphates.

For example:

$$MnO + H_2SO_4 \longrightarrow MnSO_4 + H_2O$$

$$V_2O_5 + 5\ H_2SO_4 \longrightarrow V_2(SO_4)5 + H_2O$$

2. Baking

After the reaction, the solid mass will be kept in the digester at lower air rate level for two hours. This process is called the baking. After the baking period, the reacted product is found to be a porous mass which is soluble In water.

3. Dissolution

Stipulated quantity of concentrated sulphuric acid and weak liquor (the occluded liquor in the sludge is called weak liquor) are added to the reacted mass after the baking time. The unreacted solid mass that settled down in the settling process is called sludge. Then the reacted mass is dissolved in water with specific gravity of 1.48 - 1.49(at 60°c) in stipulated time .

4. Reduction

Reduction is carried out to reduce Fe_3+ to Fe_2+, because Ferric ion (Fe_3+), Fe_2O_3 precipitates with titanium ion at the precipitation stage and that will affect the quality and colour of the final product. At the time of reduction, the temperature will be around 62°C. The reduction of crude liquor is carried out by making use of scrap iron. The mechanism of reduction is as follows:

The scrap iron reacts with the acid to produce nascent hydrogen.

$$Fe + H_2SO_4 \longrightarrow FeSO_4 + 2(H)$$

Nascent hydrogen so formed, being a strong reducing agent reduces titanyl sulphate to titanous sulphate.

$$2TiOSO_4 + H_2S0_4 + 2(H) \longrightarrow Ti2\ (SO_4)_3 + 2H_20$$

Titanous sulphate, being a powerful reducing agent reduces ferric sulphate to ferrous and itself get oxidised back to TiOSO4.

$$Ti_2(SO_4)_3 + Fe_2(S0_4) + 2H_2O \longrightarrow TiOSO_4 + 2\ H_2SO_4 + 2FeSO_4$$

The efficiency of this reaction strongly depends on the quality of scrap iron.

5. Final adjustments

After completing the dissolution process, the specific gravity, A/T are adjusted. Specifications of finished batch are given below:

Specific gravity	:	1.532 at 60°C
Ti_2O_3	:	2-3 grams per litre
A/T	:	1.9 ± 0.2

Settling

Reduced liquor contains unreacted Ilmenite, residue due to scrap iron and finely divided suspended colloidal particles. In order to remove these, the output of the digester is sent to a temperature regulating tank where the temperature is maintained at 60°C and then the liquor is let out into the settler. Organic flocculent like acryl amide is used for settling purpose. The clarified liquor overflowed from settlers is collected into the settled liquid storage (SLS) tanks from where it is pumped to the concentration feed tanks.

Concentration

The Concentration unit consists of two parts, preheater and concentrator. The purpose of concentration is to increase the TiO_2 content in the liquor up to 200 gpl by removing the water by evaporation. The concentrated liquor with specific gravity 1.65 -1.67 at 60°C is sent to the storage tank.

Precipitation

Hydrated titania (Metatitanic acid TIO $(OH)_2$ precipitated from the concentrated liquor by thermal hydrolysis at 110°C. In the sulphate process for the manufacture of Titanium Dioxide pigment, precipitation is usually carried out by adding the nucleating agent to control the particle size 'insitu' method (Nuclei formed in place) of hydrolysis is the latest modification in TTPL. The titanyl sulphate is converted to titanyl hydroxide or hydrated titanium dioxide as follows:

$$TiOSO_4 + 2H_2O \longrightarrow TiO(OH)_2 + H_2SO_4$$

During the process, titanyl sulphate undergoes hydrolysis while sulphate of iron and other metals remain in solution. Precipitation tanks are made of MS lined with rubber and acid resistant bricks. The capacity per batch is 4 tonnes of TiO_2.

Post-precipitating filtration

The purpose of filtration is to separate precipitated hydrated titania and excess of sulphuric acid. The diluted precipitation batch is cooled below 70°C and filtered using rotary vacuum filter and the filter cake is washed simultaneously using iron free water spray. The filtrate is sent to the Dorr tank. The pulp (Specific Gravity 1.15) is forwarded to the next stage fil ter.

Pre-leach filtration

The feed in this filtration is from the post-precipitation filters and Dorr tanks. The purpose of this filtration is to wash off ferrous sulphate and to increase the TiO_2 content in the pulp. The filtrate then goes to the Dorr tanks.

Leaching

Leaching is done to reduce the ferric sulphate formed due to aerial oxidation of ferrous sulphate. Reduction

is effected with the help of nascent hydrogen formed by the reaction of aluminum powder and concentrated sulphuric acid at 70-90°C.

$TIO(OH)_2 + H_2SO_4 \longrightarrow TiOSO_4 + 2H_2O$

$2Al + 3H_2S0_4 \longrightarrow Al_2(SO_4)_3 + 6(H)$

$Ti_2(SO_4)_3 + Fe(SO_4)_3 + 2H_20 \longrightarrow 2TiOSO_4 + 2H_2SO_4 + 2FeSO_4$

Specifications :

Specific Gravity	:	1.21- 1.25
Acid	:	50-70 gpl
Ti_2O_3	:	0. 2 gpl (Max.)
Fe	:	0.10 gpl (Max.)

Titanium dioxide with rutile structure is manufactured by adding specially prepared 'rutile nuclei' at this stage.

Post-leach filtration

The leached pulp is filtered again and washed using rotator vacuum filter. This stage is called the post-leach filtration. The specific gravity is 1.29 to 1.30. Fe maximum will be 0.0 07 gpl.

Treatment

In the treatment, specific a mount of mono-ammonium phosphate and potassium sulphate are usually added to the pulp to improve the pigmentary qualities of the products. Treatment can also be changed depending upon the quality of the pigment to be produced.

De-watering filter

From the storage tank of treatment batch, the pulp is fed to the dewatering filter. This is the final stage of filtration. In the dewatering filter, vacuum is adjusted in such a way to get 7-39% of solid content. The pulp is then fed to the Calciner for calcinations.

Calcination

Calciner is a long, inclined, cylindrical rotatory kiln rotating at a speed of 1/17 r.p.m. The slope of the kiln is 1/18 per metre. It is kept inclined towards the furnace end. The pulp enters the kiln at the feed end and at the back end kerosene oil or furnace oil is burnt. The pulp entering the feed end is slowly moved to the back end by the rotary motion of the kiln. So, the pulp gets heated up uniformly. The dehydration process taken place upto the 2/3 port ion of the kiln. The pulp spurts into fine powder due to the high temperature of the furnace end.

$TiO(OH)_2 \longrightarrow Ti0_2 + H_20$

The purpose of calcinations are:

- To decompose hydrated titanium to titanium dioxide
- To remove residual acid through decomposition
- To develop crystal units

Milling of pigment

The granular form of titanium dioxide from the calciner is cooled and pulverised using pendulum mill (Bradely Pulveriser). The Bradely Pulveriser (BP) powders TiO_2 to a fine size of about 0.35 microns.

Packing

The milled pigment collected in the bunkers is weighed and packed in HOPE (High density Polyethylene) bags. The net weight per bag is 25 Kg.

Typical Result of Manufactured Anatase

Specific gravity	:	3.80	**Titanium Dioxide**	:	97.5% min
Refractive index	:	2.55	Volatiles	:	0.5%max.
Oil absorption	:	22:1:2	WaterSolubles	:	0.5% max.
Chalk resistance Odour	:	**Low**	P_2O_5	:	0.5% max.
Odour		Odourless	Fe		0.0170% max.
Colour	:	White powder (Solid)	SiO	:	0.7% max
Tinting strength (Reynold scale)	:	1250(min)	AL, O_3	:	**0.1%. max.**
Residue on 325 mesh	:	**0.1% max**	pH	:	6 -8

8.0 HAZOP PROCESS

TiO_2 unit

The unit is divided into following section:

1. Grinding
2. Digestion
3. Clarification
4. Concentration
5. Precipitation
6. Post-precipitation filtration
7. Pre-leaching filtration
8. Leaching
9. Post-leaching filters
10. Treatment
11. Dewatering filters
12. Calcination
13. Pulverisation
14. Packing

The sections mentioned above are evaluated based on the HAZOP method as mentioned earlier. The nodes considered for the study are:

Sl. No	Node No.	Content of the Node	Sl. No	Node No.	Content of the Node
1.	Node 1	Cooling water system	2.	Node2	Mill fan
3.	Node 3	Steam circuit	4.	Node 4	Digestor acid
5.	Node 5	Digestor ckt. 1110	6.	Node 6	Digestor reactor
7.	Node 7	Digestor baking	8.	Node 8	Digestor dissolution
9.	Node 9	Digestor reduction	10	Node 10	Settler – Temp. regulator tank
11.	Node 11	Concentration	12.	Node 12	Precipitation
13.	Node 13	Post-precipitation filter	14.	Node 14	1st stage washing sec.
15.	Node 15	Leaching 2nd stage washing sec.	16.	Node 16	Dewatering filtration
17.	Node17	Calciner & gas scrubbing			

The major deviations observed in different nodes are as mentioned below:

A) NODE 1: Cooling water system

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Actions/Facility available	Action Required
	None	No flow	Failure/malfunctioning of cooling water pump	Breakdown of griding mill	No facility for flow measurement	Suggested to provide flow indication in water line
		No pressure	Failure/malfunctioning of cooling water pump	Breakdown of griding mill	No facility for pressure indication	Suggested to provide PI in water line

Cooling water flow is an important requirement for the operation of grinding mill. It is suggested to provide pressure indication in cooling water line.

B) NODE 2: Mill fan

Preventive maintenance of the equipment connected with the system must be carried out as recommended by the equipment manufacturer or in-house data generation of running hours.

C) NODE 6: Digestor reactor

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Actions/ Facility available	Action Required
1	No or Not	Acid transfer	Error in measuring tank/ wrong level indication	Violent reaction; the acid strength will be more than 92%, more than required for reaction. Hence, it will effect the reaction.	LI in the acid tank	Operator must be careful. Level indication system preventive maintenance/calibration must be carried out. Since this is a important part of the process, it is suggested to have another independent level measurement arrangement.
		Initial air flow	Wrong air flow indication	Violent reaction	Flow indication is available	Operator must be careful. Flow Indication system preventive maintenance/calibration must be carried out regularly.
		Water flow	Wrong level indication in water measuring tank	Acid strength will be less than attack acid strength of 98.5%	Water measuring tank is available	LG must be cleaned from time to time so that the water level is visible. Operator must be careful.
		Pressure	Violent reaction/ formation of solid layer on the surface	The pressure will be released at some point creating safety hazards	No facility available to check pressure	It is suggested to provide pressure indication with high pressure alarm
2		Temperature	Violent reaction due to before time cutting water ingress, excess air agitation etc.	Higher pressure in the digestor	No facility available to check pressure	It is suggested to provide pressure indication with high pressure alarm
3	Less	Steam flow	Wrong indication/lower steam pressure	Lower removal of previous batch residue resulting in violent reaction	PI on the steam line and flow indication	Operators must be careful. The timely preventive maintenance of the instrument system in the circuit is to be ensured.
		Feed flow	Error in weighing in ore conveyor	Higher A/O ratio resulting in violent reaction	Weighed ore conveyor	Calibration and functioning of the system must be checked from time to time.
		Acid flow	Error in measuring tank/ wrong level indication/leak in the supply line	Lower A/O ratio	LI in the acid tank	Operator must be careful. Level Indication system preventive maintenance/calibration must be carried out. Since this is a important part of the process, it is suggested to have another independent level measurement arrangement.
		Cutting Water flow	Wrong level indication in water measuring tank	Acid strength will be less than attack acid strength of 92%	Flow indication is available	Operator must be careful. Flow indication system preventive maintenance/calibration must be carried out regularly.
		Air flow	Malfunctioning of air flow instrument	Turbulence required for mixing will not be possible affecting primary reactions	Flow indication is available	Operator must be careful. Flow indication system preventive maintenance/calibration must be carried out regularly.

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Actions/ Facility available	Action Required
4	As well as	Higher A/O ratio	Higher acid in the system	Violent reaction and unsafe condition	LI indication available in acid tank	Operator must be careful. Level indication system preventive maintenance/calibration must be carried out. Since this is an important part of the process, it is suggested to have another independent level measurement arrangement.
5	Part of	Bulk density ore will be increased	Higher titanium in the feed	Violent reaction and unsafe condition		Operator must confirm the quality of ore before start of a fresh batch production - Operator's training.
6	Early	Feed transfer to reactor	No checking of the time of air agitation/visual assessment of optimum turbulence	Turbulence required for mixing will not be possible affecting primary reactions		Operator must be careful before entry of feed into acid
7	Late	Slower transfer rate of ore also due to obstruction	Partial feed availability from digestor feed screw	No reaction will take place and strength will gradually decreased resulting in deterioration of quality		Calibration and functioning of the ore grinding section must be checked from time to time
8	Before	Before mixing with cutting water	By mistake	Violent reaction and unsafe condition		Operator must be careful and follow the SOP
9	After	excess air circulation	By mistake	Violent reaction and unsafe condition spillage		Operator must be careful and follow the SOP

This part of operation is very critical. The following are suggested for implementation:

a. Another independent level indication system in acid measurement tank

b. To install pressure indication in the reactor vessel

D) NODE 7: Digestor baking

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
4	Other than	Water or steam injection	Error of operator	No baking of reacted slurry mass	Isolation valves available	Operator must ensure that only air is introduced

Air is injected through the trident. Operator must ensure that only the air valve is open.

E) NODE 8: Digestor dissolution

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
1	More of	Water	Wrong checking of specific gravity	Lower sp.gravity <1.48 resulting in hydrolysis	Water taken by pressure line	LG must be cleaned from time to time so that the water level is visible. Operator must be careful.
2	Less	Less acid	Wrong indication in acid tank or error of operator	Stability of the liquor can not be maintained	LI is available in the acid tank	Operator must be careful. Level indication system preventive maintenance/calibration must be carried out. Since, this is an important part of the process, it is suggested to have another independent level measurement arrangement.

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
2	Less	Less air flow	Wrong indication or error of operator	Improper mixing in the digestor	PI and flow indication available	Operator must check the pressure of the header and flow before lining up of air
		Less of water	Wrong checking of specific gravity	Higher sp.gravity >1.55 will not help in dissolving the solid	Water measuring tank is available	LG must be cleaned from time to time so that water level is visible. Operator must be careful.
3	Other than	Air instead of water	Air valve not closed	Upset of sp.gravity of the liquor		Operators must be careful during water injection procedure
4	Early	Injection of water	Error of operator	May result in lower sp.gravity (<1.48)	Water measuring tank is available	Operator must be careful while checking sp.gravity

Involvement and alertness of operators is of prime importance in the entire manufacturing process – refresher training course is required to be arranged from time to time.

F) NODE 10: Settler – Temperature regulator tank

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
1	None	Flow of steam	Malfunctioning of TRT/non-availability from header/wrong line up.	More time required to prepare the operation	PI available on main header and by-pass of TRT	Operator must be careful. Preventive maintenance of the temperature control system is to be carried out as per schedule.
2		No temperature	Malfunctioning of TRTs/non-availability from header/wrong line up	More time required to prepare the operation	PI available on main header and by-pass of TRT	Operator must be careful. Preventive maintenance of the temperature control system is to be carried out as per schedule.
3	More of	Temperature	Malfunctioning of TRCs on the steam line	Temperature more than 60°C	Temperature control system is available	Preventive maintenance of instrument system is to be carried out
4	Other	More steam than required	Leakage in the steam coil	Off-spec product generation partial break		Steam coil must be checked from time to time for any leakage
		No movement of agitator	Mechanical or electrical problem	Improper temperarture distribution		Preventive maintenance of agitator system is to be carried out

Preventive maintenance of agitator, temperature control system and steam coil must be carried out at regular interval.

G) Node 11: Concentration

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
3	Less	Steam flow	Wrong indication/lower steam pressure	Quality of liquor will be affected as specific gravity goes down	Manual adjustment	Operator must be careful

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
		Feed flow	Wrong adjustment	Higher temperature than desired; May cause additional pressure & upset system unit choke, poor quality liquor	Flow recorder in steam line Manual adjustment	Calibration and functioning of the system must be checked from time to time
5	Part of	Ingress of water along with feed.	Passing water valve or wrong line up	Poor quality of liquor	Isolation valve available	Operator must be careful and follow the SOP; May consider positive isolation of water valve before introducing feed
8	Before	Steam before feed charging	By mistake	Concentration units choking		Operator must be careful and follow the SOP

The production system is a batch process depending mostly on manual control. Hence training of operators and preventive maintenance of equipments, instrument system is required.

H) NODE 12: Precipitation

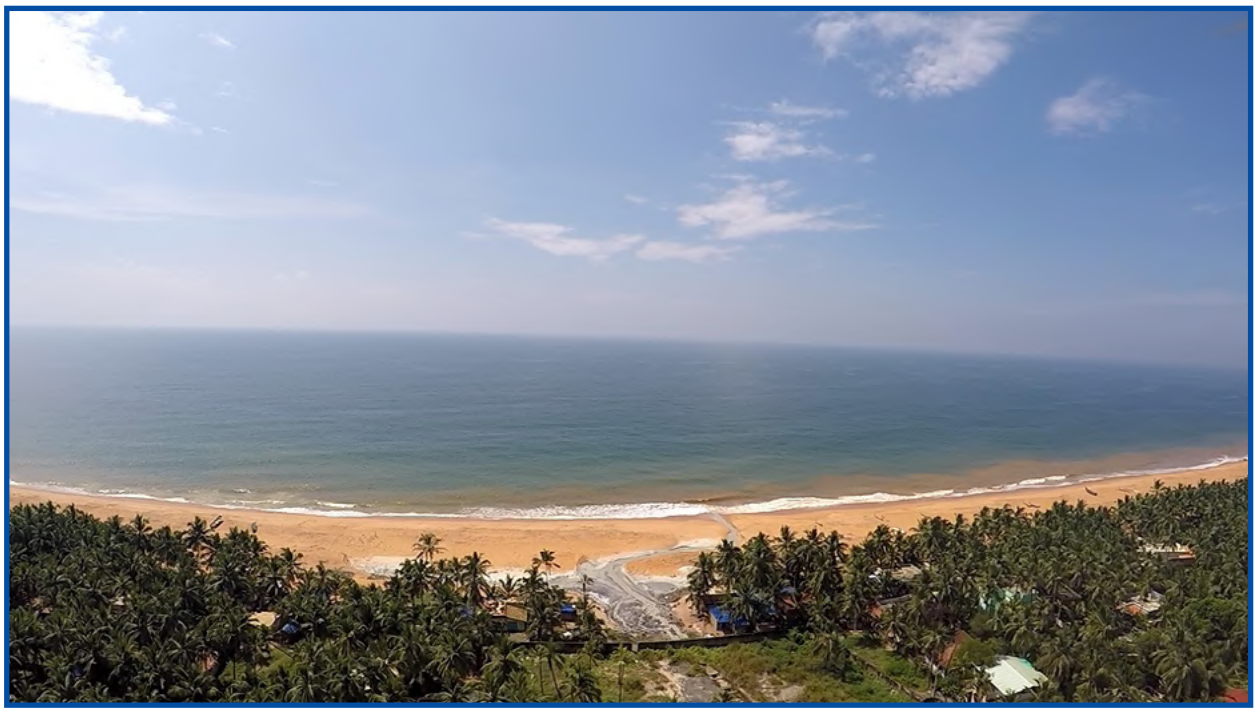
No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
1	None	No water flow HOT water tank	No level in the tank 1282 A or wrong line up	More time for the process	LG is available	Operator must check the levels in the tank
		No feed flow	No level in tank 1150	More time for the process	Pumping by 2842	Operator should ensure that the pump is on. It is suggested to provide LG/LI in tank 1150
2	More of	Water transfer	Wrong level indication or human error	Will disturb hydrolysis process	LG is available	LG must be cleaned from time to time. Operator must be careful during transfer
		Steam flow	Wrong flow indication or human error	Higher temperature than desired; May cause additional pressure & upset system	Flow recorder in steam line; Precipitation tank TR is also available	Operator must be careful and watch for normal steam flow; Must monitor temperature of 1151
		Temperature	Wrong flow indication or human error	Higher temperature than desired; May cause additional pressure & upset system	Flow recorder in steam line; Precipitation tank TR is also available	Operator must be careful and watch for normal steam flow. Must monitor Pressure & temperature of 1151.Suggest to convert PRC to TRC as temperature control is a main operating criteria here. PRC may be PR.
3	Less	Steam flow	Wrong indication/ lower steam pressure	Lower temperature in 1150.	Manual adjustment	Operator must be careful

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
4	Before	Feed entry before temperature of 100°C	Human error or wrong temperature indication	Process delay	TR is available	Operator must be careful and follow the SOP
5	Early	Closing of steam valve and addition of cutting water	Human error	Will effect Hydrolysis process		Operator must be careful and follow the SOP
6	Other	Stoppage of agitator	Mechanical or electrical or no power	Entire process will stop in that precipitator		Preventive maintenance of agitator must be carried as per the guideline of equipment supplier

I) Node 14: 1st stage washing sec.

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
2	Other	Leakage in filter cloth	Wear and tear	Passing of precipitate with filtrate		Preventive maintenance of filter must be carried out as per guideline of equipment supplier. Leaks in filter cloth is to be identified before by keeping blowing system on.
		Agitator break down in 1160	Mechanical or electrical failure	No uniform mixing of filter feed resulting in unsteady filtration		Preventive maintenance of agitator must be carried out as per guideline of equipment supplier

Leakage in filter cloth will result in off-spec product. Please ensure that there is no leak in filter cloth.



9.0 RECOMMENDATIONS

The node-wise recommendations are mentioned against each node and enclosed as Annexure A.
The major recommendations are as under:

1. The mixing of ore, acid and water in proper portion is important for production of titanium di oxide. Preventive maintenance of the same in required time is a must.
2. The process is dependant on proper ratio of ore & acid, correct amount of water and air for agitation etc. Also, the sequence of addition is of prime importance. Operators must be trained accordingly. It is suggested to arrange refresher course for the production group from time to time.
3. Acid addition is one of the most important part of operation. This is being added based on a calibrated acid tank. The tank is having LI. It is suggested to provide one more LI from an independent tapping to ensure correct level in the tank.
4. As in PID, TI point is available. However, pressure will be an important parameter in the digestion process as the reaction is highly exothermic. It is also suggested to collect the vapour coming out during reaction. The vapour can be condensed, collected and used in the process again. The condensed liquid will be acidic water.
5. In the precipitation tanks 1151, it is suggested to convert PRC on steam line to TRC as temperature is a major criteria. Pressure recording system will continue. TR can be made TRC on steam line.
6. It is suggested to provide Level indication in tank 1159 (concentration measuring tank).

10.0 CONCLUSION

1. The entire production process is on manual control. The process is also in batch and concentrated forms. Sulphuric acid is the major component in the production process. Hence, operators' training/ refresher course is very important.
2. Some additional facilities are suggested in recommendation for consideration.

Note: The HAZOP study has been carried out based on the PIDs and other documents made available.

H_2SO_4

Here, the operation is on continuous process.

The HAZOP study is carried out based on the following guide words.

A list of Guide words are:

GUIDE WORDS	
NONE	No forward flow when there should be, i.e. no flow or reverse flow.
MORE OF	More of any relevant physical property than there should be, e.g. higher flow (rate or total quantity), higher temperature, higher pressure, higher viscosity, etc.
LESS OF	Less of any relevant physical property than there should be, e.g. lower flow (rate or total quantity), lower temperature, lower pressure, etc.
PART OF	Composition of system different from what it should be, e.g. change in ratio of components, component missing, etc.
AS WELL AS MORE THAN	More components present in the system than there should be, e.g. extra phase present (vapour, solid), impurities (air, water, acids, corrosion products), etc.
REVERSE	A parameter occurs in the opposite direction to that for which it was intended e.g. reverse flow.
OTHER THAN	Complete substitution e.g. sulphuric acid was added instead of water.
EQUIPMENT WORDS "OTHER"	What else can happen apart from normal operation, e.g. start-up, shutdown, uprating, low rate running, alternative operation mode, failure of plant services, maintenance, catalyst change, etc.

1. Process description

Furnace is a horizontal cylinder in which molten sulphur from clean pit is injected with the help of Sulphur gun. Air is sucked from atmosphere through air filters with the help of other steam driven or electrically driven blower and fed to Air Drying tower. Dry air from ADT (Air Drying Tower) is blown in and the quantity of air Is adjusted so that maxi 10.5% SO_2 is present. The reaction being highly exothermic, huge quantity of heat is produced which has to be removed before the gas is sent to the converter. This is achieved with the help of Waste Heat Boiler (WHB), which is provided as part of a furnace itself. This waste heat is used to convert the de-mineralized water to steam at 250°C. This SO_2 gas passes through

the tubes of WHB straight away to the first bed of the converter. Equipment used is the steam drum provided just above the WHB in which 50% water and 50% steam are present. The water is converted to steam with the help of heat in the tube side. The steam goes back to the steam drum through the vertical path provided. Thus, the whole gases are cooled down to the required optimum temperature without any loss of energy.

Air & gas circuit

All drying tower (ADT) is used to dry the air that is to remove the moisture present in the air. It is a packed tower with intallox saddles as packing material. Air is supplied to the bottom of ADT with the help of either steam-driven or electrically-driven blower. In order to remove the dust, air from the atmosphere is sucked through a filter. Turbine-driven blower works with the help of super-heated steam produced in the super heater. Concentrated sulphuric acid (98.5%) from the cooler is sprayed at the top of the tower. The moisture present in the air absorbed in concentrated acid. A demister pad is located at the top of the tower to prevent the carryover of acid mist. Diluted acid from the bottom of the tower is collected in APT. The air then flows to Sulfur burner where molten Sulfur is burnt to produce gases containing about 10% to 10. 5% SO_2. This, being a highly exothermic reaction, the released heat raises the gas temperature to about 1020°C.

The conversion of SO_2 to SO_3 is optimised by carrying it out in four stages In the converter. Gases from the waste heat boiler passes through the first bed of the converter where approximately 60% conversion is achieved. This increases the temperature of the outlet gases due to the heat of reaction. The hot gases are cooled in super heater and fed to the second bed of the converter 1. A cumulative conversion of around 88% is achieved in the second bed and 94% in the 3rd bed. The hot gases coming from second bed are taken through tube side of hot heat exchanger and fed to the 3rd bed of the converter. Gases leaving the 3rd bed are cooled in the tube side of cold heat exchanger and fed to interpass Absorption tower where SO_3 is absorbed in circulating stream of sulfuric acid. Removal of SO_3 from gas streams create more favourable conditions for conversion of SO_2 . Cold gases from absorption tower are heated to reaction temperature of 425°C and fed to 4th bed of converter. The SO_3 generated in 4th bed is absorbed by circulating sulphuric acid before venting the gases to the atmosphere via the scrubber. The rate of conversion is 60%, 28%, 6% & 5.75% in 1st, 2nd, 3rd and 4th bed of the converter respectively.

The reaction occurring is as follows,

$H_2SO_4 + SO_3 \longrightarrow H_2S_2O_7$ (oleum)

Oleum so formed is diluted with water to give 2 molecules of Sulphuric acid

$H_2S_2O_7 + H_2O_2 \longrightarrow H_2SO_4$

This dilution process increases the temperature of acid, which is to be cooled with the help of plate coolers. A candle filter is placed at the top of IPAT to avoid escape of acid mist. The product is taken from the bottom and the gas, which is now at 70°C pass through the top of the tower. Gas at 70°C is heated to 312°C in cold heat exchanger and 425°C in Hot Heat Exchanger which then passes to the 4th bed of the converter.

In the 4th bed, 5.75% conversion occurs and temperature increases to 435°C. It is cooled to 180°C in

economiser 2 and fed to Final Absorption Tower (FAT) where acid is sprayed. The product from the interpass absorption tower and final absorption tower comes to acid pumping tank, where required amount or water is added resulting in the production of 98.5% H_2SO_4.

1) HAZOP process

For HAZOP study, the entire facility was divided into various nodes. They are:

Sl. No.	Node No	Content of the Node
1.	1	Molten sulphur & to leaf filter
2.	2	Molten sulphur to furnace
3.	3	Boiler feed water
4.	4	Air & acid gas
5	5	Air & acid gas 2nd bed
6.	6	Air & acid gas 3rd bed
7.	7.	Acid circuit
8.	8.	Acid circuit
9.	9.	Air circuit
10.	10.	Alkali scrubber

Major abnormalities as observed node-wise are:

A) NODE 1: Molten sulphur & to leaf filter

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
1	None	No Flow of dirty sulphur	i) No level in pit – Low steam pressure – Sulphur is hard to melt – low level in melting pit	i) No feed flow to the filter & and no /low level in clean pit.	TI point is available	i) Monitoring by operator is required. Suggest to provide level indication in dirty and clean pit.
			ii) No flow from melting pit due to low temperature	i) No feed flow to the filter & and no/low level in clean pit	TI point is available	i) Monitoring by operator is required

It is suggested to provide LI in dirty and clean pit.

B) NODE 2 : Molten sulphur to furnace

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
1	None	No flow of molten sulphur	ii) No level in pit	No sulphur burning in furnace	PI is available in pump discharge	i) Monitoring by operator is required. May consider LI in the pit.
			Chokage of sulphur line due to no steam of jacket steam.	No sulphur burning in furnace		Operator must ensure the steam and condensate flow to maintain temperature at 140°C
		No air flow	Air blower stop/ trip	The system will trip		
2	Other than	No steam flow to melting pit coil	Leakage in steam coil in the melting pit	Sulphur will not melt & unit will be shut down		Steam coils must be pressure-tested at regular intervals.

1. Heating of sulphur line is of importance to keep sulphur in molten state.
2. At present, SO_2 % is maintained by controlling temperature in the furnace. In case of malfunctioning of TI point, there is no control. It is suggested to provide flowmeter in sulphur and air line so that air requirement can be calculated theoretically. Further, the air flow can be linked to analyser to have smooth and steady operation with maximum capacity. Online SO_2 % monitoring is necessary.

C) NODE 4: Air & acid gas

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
1	None	No flow of SO_2 to converter inlet	No burning of sulphur in furnace due to no supply of sulphur	No production	TI point is provided	Ensure steady operation of upstream facility.
2	More	Inlet temperature to converter	Fouling of waste heat boiler	Higher temperature in converter inlet and higher temperature in 1st bed outlet	TI point is provided	Preventive maintenance of waste heat boiler must be carried out as per schedule. Quality of BFW is to be maintained by proper Hydrazine & TSP dosing and proper blow down from steam drum.
		Inlet temperature to 2nd bed	Higher outlet temperature from bed 1	Higher temperature in converter restricting production		Preventive maintenance of waste heat boiler must be carried out as per schedule. Quality of BFW is to be maintained by proper Hydrazine & TSP dosing and proper blow down from steam drum.
			Higher SO_2 % in gas from furnace to converter 1st bed	– Loss of conversion efficiency – Venting of unconverted SO_2	Analyser is available	air/sulphur ratio must be maintained so that more than 10.5% SO2 in the entrance of converter is avoided.
			Lower heat transfer in E-402 super heater	Will restrict production		Preventive maintenance of E-402 is to be carried out as per guideline of manufacturer.
3	Other	Ingress of moisture in 1st reactor	Waste heat boiler tube leak	Acid mist formation effecting absorption as the SO_3 contacts with humid air, white fumes are formed ,hence introduction of view glass after IPAT, FAT duct to detect the same. If possible at ECONOMIZER too	PI point in steam drum	Preventive maintenance of waste heat boiler must be carried out as per schedule. Quality of BFW is to be maintained by proper Hydrazine & TSP dosing and proper blow down from steam drum.

1. Preventive maintenance of waste heat boiler must be carried out as per rule/recommendation by equipment manufacturer as any ingress of moisture into the system is not desireable.
2. SO_2 % in the outlet of furnace is very important which is manually controlled. It is suggested to make the system more reliable by automation like combining air flow with analyser.

D) NODE 7: Acid circuit C-503

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
1	None	No flow of acid to C-503	i) Tripping or malfunctioning of acid pump.	Main air blower and sulphur feed pump will trip. But residual gases in the process will flow till the system is depressurised. This is only in case of tripping.	Production will stop because of tripping of sulphur and air blower.	Residual gases will escape to scrubber. Scrubber must be in circulation to take care of such eventuality. Otherwise, lot of SO3 may escape to atmosphere. It is suggested to provide a Remote Operated Motorised valve on the line routed to scrubber stack directly which will close in case of tripping of acid pump.. Also, it is suggested to start the caustic circulation pump immediately in case of acid pump trip as an interlock system motor operated valve to be provided at air inlet furnace and /or at scrubber end
		Cooling water to acid cooler	Tripping or malfunctioning of water pump	Main air blower and sulphur feed pump will trip. But residual gases in the process will flow till the system is depressurised.	Production will stop because of tripping of sulphur and air blower.	As suggested above, management may consider. All trips are electrical. In case of low flow of cooling water, the acid temperature will increase. But the system will not trip. Since, high temperature is an area of concern, may consider tripping facility of pumps from higher acid temperature also.
2	More	Temperature of water	Tripping or malfunctioning of water pump or lower heat transfer in plate exchanger.	Main air blower and sulphur feed pump will trip. But residual gases in the process will flow till the system is depressurised.	Production will stop because of tripping of sulphur and air blower.	Plate heat exchanger is to be cleaned as per guidance of manufacturer or own data generated during operation of the plant.
3	Less of	acid flow	Malfunctioning of acid pump	Lower absorption and escape of gases to scrubber.		In case of low flow of cooling water, the acid temperature will increase. But the system will not trip. Since, high temperature is an area of concern, it is suggested to provide tripping facility of pumps from higher acid temperature also.
		water flow	Higher acid temperature	Effiecency of absorption depend on conc. Of H_2SO_4 (98.3%-98.7%) and acid temp(7^0c -12^0c). But we contraol the cid temperature because In APT we are adding water to bring down acid conc. Which causes sudden increase in temp and acid being in bulk, tends to spurt out. (adding water into acid without string causes explosion.This situation is highly dangerous)		In case of low flow of cooling water, the acid temperature will increase. But the system will not trip. Since, high temperature is an area of concern, suggest to provide tripping facility of pumps from higher acid temperature also.
4	Other	Mixing of acid with cooling water	In the Plate exchanger	pH of cooling water will be low and corrosion of cooling water line.	pH indicator PHT 308 is available.	Preventive maintenance of exchangers is to be carried out as recommended by equipment manufacturer.

1. Residual gases will escape to scrubber.Scrubber must be in circulation to take care of such eventuality. Otherwise, a lot of SO_3 may escape to atmosphere. It is suggested to provide a Remote Operated Motorised valve on the line routed to scrubber stack directly which will close in case of tripping of acid pump. Also, it is suggested to start the caustic circulation pump immediately in case of acid pump trip as an interlock system.

2. In case of low flow of cooling water, the acid temperature will increase. But the system will not trip. Since, high temperature is an area of concern, it is suggested to provide tripping facility of pumps from higher acid temperature also.

E) Node 8: Acid circuit

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
1	None	No flow of acid to C-502	i) Tripping or malfunctioning of acid pump.	Main air blower and sulphur feed pump will trip.	Production will stop because of tripping of sulphur and air blower.	Residual gases will escape to scrubber.Scrubber must be in circulation to take care of such eventuality. Otherwise, a lot of SO3 may escape to atmosphere. It is suggested to provide a Remote Operated Motorised valve on the line routed to scrubber stack directly which will close in case of tripping of acid pump. Also, it is suggested to start the caustic circulation pump immediately in case of acid pump trip as an interlock system.

As mentioned in previous node, modifications as suggested may be considered.

F) Node 9: Air circuit

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
1	None	No flow of air to C-501	i) Tripping or malfunctioning of air blower	sulphur feed pump will trip		Residual gases will escape to scrubber.Scrubber must be in circulation to take care of such eventuality. Otherwise, a lot of SO3 may escape to atmosphere. It is suggested to provide a Remote Operated Motorised valve on the line routed to scrubber stack directly which will close in case of tripping of acid pump. Also, suggested to start the caustic circulation pump immediately in case of acid pump trip as an interlock system.
2	Less of	acid flow	Malfunctioning of acid pump	Lower absorption and escape of gases to 4th bed of converter		In case of low flow of acid, load on bed 4 of converter will increase. But the system will not trip. Also, suggested to provide low flow alarm .
		water flow to T-503	Malfunctioning of ACV in water line	Conversion of oleum to sulphuric acid will not be complete absorption of $S0_3$ will be affected	By-pass of ACV & strength analyser ANT 301 is available	Preventive maintenance of instrumentation system is to be carried out regularly.

It is suggested to provide low flow alarm on acid line to C-501.

G) Node 10: Alkali scrubber

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
1	None	No flow of caustic flow to C-504	i) Tripping or malfunctioning of pump	Acid gas will escape from scrubber vent	Spare pump is available	One pump must be always available for caustic circulation. May consider auto start of spare pump in case of tripping or low flow.

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
1	None	No flow of oxidising solution	No level in tank	Oxidation of sodium bi sulphate to sodium sulphate will not be possible		Suggested to provide level indication in the tank
2	Less of	caustic flow	Malfunctioning of caustic pump	Acid gas will escape from scrubber vent		One pump must be always available for caustic circulation. May consider auto start of spare pump in case of tripping or low flow.

1. It is suggested to provide auto-start of alkali pump along with tripping of acid pump. Also, facility to auto start stand by pump is to be considered.

2. Recommendations

The node-wise major recommendations are mentioned below each node. The list is:

1. Heating of sulphur line is of importance to keep sulphur in molten state.
2. At present, SO_2 % is maintained by controlling temperature in the furnace. In case of malfunctioning of TI point, there is no control. It is suggested to provide flowmeter in sulphur and air line so that air requirement can be calculated theoretically. Further, the air flow can be linked to analyser to have smooth and steady operation with maximum capacity.
3. It is suggested to provide LI in dirty and clean pit.
4. Preventive maintenance of waste heat boiler must be carried out as per rule/recommendation by equipment manufacturer as any ingress of moisture into the system is not desireable.
5. SO_2 % in the outlet of furnace is very important which is manual control. Suggested to make the system more reliable by automation like combining air flow with analyser.
6. Residual gases will escape to scrubber. Scrubber must be in circulation to take care of such eventuality. Otherwise, a lot of SO_3 may escape to atmosphere. It is suggested to provide a Remote Operated Motorised valve on the line routed to scrubber stack directly which will close in case of tripping of acid pump. Also, suggested to start the caustic circulation pump immediately in case of acid pump trip as an interlock system
7. In case of low flow of cooling water, the acid temperature will increase. But the system will not trip. Since, high temperature is an area of concern, it is suggested to provide tripping facility of pumps from higher acid temperature also.
8. It is suggested to provide low flow alarm on acid line to C-501.
9. It is suggested to provide auto-start of alkali pump along with tripping of acid pump. Also, facility to auto start stand by pump is to be considered.
10. Apart from all the technical part, the most important is the operation by the operators. It is suggested to impart refresher course for them and cover all the operators annually.

11. Mock drill in different leak scenarios of SO_2, SO_3 and sulphuric acid is to be conducted so as to fix the responsibility of each during any emergency situation.

Note: The HAZOP study has been carried out based on the PIDs and other documents made available.

3. Conclusion

The process involves handling of hazardous solids, liquid and gases. Process safety is important in this plant. The safety requirement as observed during HAZOP study are listed. The training of operator on safety and operation is a major part for smooth and safe operation.

Neutralisation area

Introduction

Acidic water from titanium di 0xide plant is routed here. The water is highly acidic. Two stage neutralisation process is carried out here. In the 1st stage, acidic water is treated with $CaCO_3$ to pH level 2.0. White Gypsum is precipitated and is removed as a product using filter press.Balance portion is further neutralised with $Ca(OH)_2$, softened by Na_2CO_3. Red gypsum and heavy metals deposited and removed by filter press.

HAZOP Process

The same methodology as followed in the acid plant is also followed here.

Nodes

Sl. No.	Node No.	Content of the Node
1.	1	Effluent equilisation tank
2.	2	Flash mixer & clarifier
3.	3	Sludge holding tank, thickener & sludge holding tank
4.	4	Flash mixer & clarifier
5.	5	Reactor clarifier
6.	6	Sludge holding tank, thickener & sludge holding tank

The salient issues arising out of HAZOP study are as under. The detail study report is attached as Annexure III

NODE 2

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
2	More of	Dosing of CaCO3	Malfunctioning of return line (instrument or wrong pH indication of effluent going to clarifier A)	White gypsum will not be produced.	flow measurement of $CaCO_3$ is available.	i) Monitoring by operator is required. Preventive maintenance of the instrument system is to be carried out at regular interval.
3	Less of	Dosing of CaCO3	Malfunctioning of return line instrument or wrong pH indication of effluent going to clarifier A	White gypsum will be reduced	flow measurement of $CaCO_3$ is available.	i) Monitoring by operator is required. Preventive maintenance of the instrument system is to be carried out at regular interval.

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
4	Other	Breakdown rakes of agitator in flash mixer	Mixing with $CaCO_3$ will not be proper	White gypsum will be reduced		Preventive maintenance of agitator must be carried out as per the recommendation of the manufacturer. Proper cleaning of reaction chamber.
		Breakdown of agitator in Clarifier A	Higher sludge resulting in higher torque.	Upset in operation	Check, proper sludge withdrawal from Clarifier A	Quality of incoming influent is to be analysed. Also, $CaCO_3$ dosing is to be monitored.

The plant is controlled by instrument system with interlocks which must be properly maintained as per the guideline of equipment manufacturer.

NODE 3

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
1	None	No level in T-003	Malfunctioning of UV 10116	High level in upstream clarifier and chances of sludge carryover to clarified water tank.	Manual operation of UV 10116 is available.	i) Monitoring by operator is required. Preventive maintenance of the instrument system is to be carried out at regular interval.
2	More of	Level in T-004	Malfunctioning of filter press feed pump	Over flow of sludge holding tank	Manual operation of UV 10129 is available.	i) Monitoring by operator is required.
3	Other	Breakdown of agitator in sludge holding tank	Uniform sludge mixture will not be produced.	White gypsum will be reduced.		Preventive maintenance of agitator must be carried out as per the recommendation of the manufacturer.
		Breakdown of agitator in Thickener A	Higher sludge resulting in higher torque.	Upset in operation	Check, proper sludge withdrawal from Thickener A	Preventive maintenance of agitator must be carried out as per the recommendation of the manufacturer.

Monitoring by operator is of importance here.

NODE 4

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
1	None	No air blowing in degasser	Air blower BL-001A/B malfunctioning or tripping or wrong line up	No removal of CO_2	PG is available	i) Monitoring by operator is required. Preventive maintenance of the blower system is to be carried out at regular interval.
2	More of	Dosing of $Ca(OH)_2$	Malfunctioning of return line instrument or wrong pH indication of effluent going to clarifier A	pH will be high and more HCL dosing will be required	Flow measurement of $Ca(OH)_2$ is available	i) Monitoring by operator is required. Preventive maintenance of the instrument system is to be carried out at regular interval.

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility Available	Action Required
3	Less of	Dosing of $Ca(OH)_2$	Malfunctioning of return line instrument or wrong pH indication of effluent going to clarifier A	Total precipitation of red gypsum will not be complete	flow measurement of $Ca(OH)_2$ is available Provide sufficient poly-electrolyte	i) Monitoring by operator is required. Preventive maintenance of the instrument system is to be carried out at regular interval.
4	Other	Breakdown of agitator in flash mixer	Mixing with $Ca(OH)_2$ will not be proper	Total precipitation will not be possible		Preventive maintenance of agitator must be carried out as per the recommendation of the manufacturer.
		Breakdown of agitator in Clarifier B	Higher sludge resulting in higher torque.	Upset in operation		Quality of incoming influent is to be analysed. Also, $CaCO_3$ dosing is to be monitored.

Proper air blowing in degasser is required to vent out CO_2 from the system. Operatos training and preventive maintenance of equipments, analysers is important.

Recommendations

1. The plant is totally controlled by instrumentation system & interlocks. Proper maintenance of calibration of the instruments is a major area.
2. Training of operators and technician, particularly, that of instrumentation is to be conducted regularly.

Attachments: 1

HAZOP MINUTES						
System No.: 1			System Name: Cooling water circuit Node 1		Page of 1	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 23.02.2018			Present:		Report by:	
System Number			System TTP/EP/B-895/1		BATCH PROCESS	
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
	None	No flow	Failure /malfunctioning of cooling water pump.	Breakdown of griding mill	No facility for flow measurement.	Suggested to provide flow indication in water line.
		No pressure	Failure /malfunctioning of cooling water pump.	Breakdown of griding mill	No facility for pressure indication.	Suggested to provide PI in water line.
	More of	Temperature	Malfunctioning of cooling water system.	Breakdown of griding mill	No facility to measure temperature	Operator must be careful.

HAZOP MINUTES						
System No.: 2			System Name: Mill fan circuit Node 2		Page of 2	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 23.02.2018			Present:		Report by:	
System Number			System TTP/EP/B-895/1		BATCH PROCESS	
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
	None	No flow	Malfunctioning/ stoppage of Mill fan	No lifting of ore to cyclone separator	One fan is available for grinding mills.	Operator must be careful. Preventive maintenance of the fans 3100 must be carried out in schedule interval.
		No pressure	Stoppage of Mill fan	No lifting of ore to cyclone separator	One fan is available for grinding mills.	Operator must be careful about the operation of the fans.
	More of	Flow	Malfunctioning of blower discharge	Coarser product carried along with the fines	One fan is available for grinding mills.	Preventive maintenance of the system is to be carried out.
		Pressure	Malfunction/stoppage of exhaust fan for dust collector	No product carry over to cyclone separator	One fan is available for dust collectors.	Preventive maintenance of the system is to be carried out.

HAZOP MINUTES						
System No.: 3			System Name: Steam ckt.		Page of 3	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 23.02.2018			Present:		Report by:	
System Number			System TTP/EP/B-896/1		BATCH PROCESS	
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	No flow	Improper line up/ malfunctioning of H110B /no availability from boiler.	Less recovery	PI and flow measuring arrangement is available. Bye-pass of H110B is also available.	Steam pressure and temperature is to be ensured. Ensure proper condensate draining system from the line. Preventive maintenance of H 110B is to be ensured.
		No temperature	Improper line up/no availability from boiler.	Less recovery	PI and flow measuring arrangement is available.	Steam pressure and temperature is to be ensured. Ensure proper condensate draining system from the line.
2	Less of	Flow	Lower availability in the system due to line leakage/boiler problem.	More time required for flushing.	PI and flow measuring arrangement is available.	Ensure that steam pressure remains constant and at desire level.

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility available	Action Required
2	Less of	temperature	Lower steam availability, improper insulation of steamline. This will most be effected during heavy rain.	More time required for flushing.	PI and flow measuring arrangement is available.	Ensure proper insulation of steam lines and constant supply of steam.
		pressure	Lower steam availability from boiler.	More time required for flushing.	PI and flow measuring arrangement is available.	Ensure proper steam supply - operator to monitor steam presure before and during start of operation.
3	As well as	presence of more water.	Improper draining of condensate	No proper flushing.	PI and flow measuring arrangement is available.	Steam pressure and temperature is to be ensured. Ensure proper condensate draining system from the line.

HAZOP MINUTES						
System No.: 4			System Name: Digestor ckt. Acid. NODE 4		Page of 4	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 23.02.2018			Present:		Report by:	
System Number			System TTP/EP/B-896/1		**BATCH PROCESS**	
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	No Acid flow to reactor	Wrong line up or offsite pump malfunctioning or stoppage.	Increased batch time.	Acid supply is from outside battery limit to acid tank 1271. LI is available in acid tank.	Ensure that off-site acid pump is in operation at normal discharge pressure, proper line up done - responsibility of operator.
		No level in acid tank	Wrong line up or offsite pump malfunctioning or stoppage.	Increased batch time.	Supply is from off-site.	Operator to ensure that one pump is online
2	More of	Acid flow	Wrong level indication in acid tank.	Vigourous reaction	LI is available.	Operator must be careful. Level Indication system preventive maintenance/ calibration must be carried out. Since, this is a important part of the process, suggest to have another independent level measurement arrangement.
		Level	Wrong level indication	Overflow system to tank is available.	Level indication is available. Also heating arrangement of control valve is available.	Operator to monitor level carefully.

HAZOP MINUTES						
System No.: 5			System Name: Digestor ckt. 1110. NODE 5		Page of 5	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 23.02.2018			Present:		Report by:	
System Number			System TTP/EP/B-896/1		**BATCH PROCESS**	
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	No flow .	No air supply from source.	No mixing inside the digestor -Delay in producing the batch.Choking,if it is hot at the time of reaction	PI and flow indication available.	Operator must check the pressure of the header before lining up of air.
		No pressure.	No air supply from source.	No mixing inside the digester- Delay in producing the batch Violent reaction, if reation already started	PI and flow indication available. Emergency compressor is available.	Operator must check the pressure of the header before lining up of air.
2	More of	Flow - air	Higher upstream pressure/ maloperation of air flow valve.	Unnecessary mixing turbulence in digestor. May lead to forting and spillage	PI and flow indication available. Emergency compressor is available. Can be turned on even if main power supply is off	Flow measurement system to be checked regularly. Operator is to ensure correct amount of air flow.
3	Less of	Flow	Lower supply from upstream	More time in mixing and delaying batch. Chance of violent reaction	PI and flow indication available.	Flow measurement system to be checked regularly. Operator is to ensure correct amount of air flow.

HAZOP MINUTES						
System No.: 6			System Name: Digestor reactor NODE 6		Page of 6	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 23.02.2018			Present:		Report by:	
System Number			System TTP/EP/B-896/1		**BATCH PROCESS**	
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	No feed flow.	No ore in feed conveyor/chokage in conveyor system.	More time for batch preparation	Pneumatic conveying system	Mill fan arrangement operating conditions must be maintained as per SOP - operator training.
2	More of	feed transfer to reactor.	Error in weighing in ore conveyor	Incomplete reaction	Weighed ore bunker-discharge conveyor	Calibration and functioning of the system must be checked from time to time.
		Acid transfer	Error in measurement in measuring tank/wrong level indication	Violent reaction. Acid strength will be more than 92%, more than required for reaction. Hence, it will effect reaction.	LI in the acid tank.	Operator must be careful. Level Indication system preventive maintenance/calibration must be carried out. Since this is a important part of the process, it is suggested to have another independent level measurement arrangement.

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility available	Action Required
2	More of	Initial Air flow	Wrong air flow indication	Violent reaction	Flow indication is available.	Operator must be careful. Flow Indication system preventive maintenance/calibration must be carried out regularly.
		Water flow	Wrong level indication in water measuring tank	Acid strength will be less than attack acid strength of 92%	Water measuring tank is available.	LG must be cleaned from time to time so that water level is visible. Operator must be careful.
		Pressure	Violent reaction/ formation of solid layer on the surface.	The pressure will be released at some point creating safety hazards.	No facility available to check pressure.	Suggested to provide pressure indication with high pressure alarm.
		Temperature	Violent reaction due to before time cutting water ingress, excess air agitation etc.	Higher pressure in the digestor and violent reaction.	No facility available to check pressure.	Suggested to provide pressure indication with high pressure alarm.
3	Less	steam flow	Wrong indication/ lower steam pressure.	Lower removal of previous batch residue resulting in violent reaction.	PI on the steam line and flow indication .	Operators must be careful. The timely preventive maintenance of the instrument system in the circuit is to be ensured.
		feed flow	Error in weighing in ore conveyor	Higher A/O ratio resulting in violent reaction.	Weighed ore conveyor.	Calibration and functioning of the system must be checked from time to time.
		acid flow	Error in measurement in measuring tank/wrong level indication/leak in the supply line.	Lower A/O ratio	LI in the acid tank.	Operator must be careful. Level Indication system preventive maintenance/calibration must be carried out. Since this is a important part of the process, it is suggested to have another independent level measurement arrangement.
		Water flow	Wrong level indication in water measuring tank	Acid strength will be less than attack acid strength of 92%	Flow indication is available.	Operator must be careful. Flow Indication system preventive maintenance/calibration must be carried out regularly.
		Air flow	Mal-functioning of air flow instrument.	Turbulence required for mixing will not be possible affecting primary reactions.	Flow indication is available.	Operator must be careful. Flow Indication system preventive maintenance/calibration must be carried out regularly.
4	As well as	Higher A/O ratio.	Higher acid in the system.	Violent reaction and unsafe condition.	LI indication available in acid tank.	Operator must be careful. Level Indication system preventive maintenance/calibration must be carried out. Since this is a important part of the process, suggest to have another independent level measurement arrangement.
5	Part of	Lower residue in the feed	Higher titanium in the feed. Bulk density of ore will be increased	Violent reaction and unsafe condition.	Weighed ore conveyor.	Operator must confirm the quality of ore before start of a fresh batch production - Operator's training.

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility available	Action Required
6	Early	Feed transfer to reactor.	Not checking of the time of air agitation / visual assessment of optimum turbulence.	Turbulence required for mixing will not be possible affecting primary reactions.		Operator must be careful before entry of feed into acid.
7	Late	Slower transfer rate of ore.	Partial feed availability from digestor feed screw.	Primary reaction will take more time increasing batch preparation time.		Calibration and functioning of the ore grinding section must be checked from time to time.
8	Before	before mixing with cutting water.	By mistake.	Violent reaction and unsafe condition.		Operator must be careful and follow SOP.
9	After	excess air circulation	By mistake.	Violent reaction and unsafe condition.		Operator must be careful and follow SOP.

HAZOP MINUTES						
System No.: 7			System Name: Digestor baking NODE 7		Page of 7	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 23.02.2018			Present:		Report by:	
System Number			System TTP/EP/B-896/1		**BATCH PROCESS**	
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	No flow of air	No flow from off-site.	No baking of reacted slurry mass.	Flowmeter at on main supply line available.	Operator must be careful and check the system before hand.
3	Less of	Flow	Lower supply pressure or mal-functioning of instrument system.	Improper baking.	Flowmeter and PI at on main supply line available.	Operator must be careful and check the system before hand.
		Pressure	Lower supply pressure or mal-functioning of instrument system.	Improper baking.	Flowmeter and PI at on main supply line available.	Operator must be careful and check the system before hand.
4	Other than	Water or steam injection	Error of operator	No baking of reacted slurry mass.	Isolation valves available.	Operator must ensure that only air is introduced.

HAZOP MINUTES						
System No.: 8			System Name: Digestor dissolution NODE 8		Page of 8	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 24.02.2018			Present:		Report by:	
System Number			System TTP/EP/B-896/1		**BATCH PROCESS**	
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	No acid flow	No level in tank	Dissolution process can not start	LI is available in the acid tank	Operator must be careful. Level Indication system preventive maintenance/calibration must be carried out. Since this is a important part of the process, suggest to have another independent level measurement arrangement.
		No air flow .	No air supply from source.	No mixing inside the digestor -Delay in producing the batch.	PI and flow indication available.	Operator must check the pressure of the header and flow before lining up of air.
		No pressure.	No air supply from source.	No mixing inside the digestor -Delay in producing the batch.	PI and flow indication available.	Operator must check the pressure of the header before lining up of air.
2	More of	Water	Wrong sp. Gravity checking.	Lower sp.gravity <1.48 resulting in hydrolysis.	Water measuring tank is available.	LG must be cleaned from time to time so that water level is visible. Operator must be careful.
3	Less	Less acid	Wrong indication in acid tank or error of operator.	Stability of the liquor can not be maintained.	LI is available in the acid tank	Operator must be careful. Level Indication system preventive maintenance/calibration must be carried out. Since this is a important part of the process, suggest to have another independent level measurement arrangement.
		less air flow	Wrong indication or error of operator.	Improper mixing in the digestor.	PI and flow indication available.	Operator must check the pressure of the header and flow before lining up of air.
		less of water	Wrong sp. Gravity checking.	Higher sp.gravity >1.55 will not help in dissolving the solid..	Water measuring tank is available.	LG must be cleaned from time to time so that water level is visible. Operator must be careful.
4	Other than	Air instead of water	Air valve not closed.	Upset of sp.gravity of the liquor		Operators must be careful during water injection procedure.
5	Early	Injection of water	Error of operator	May result in lower sp.gravity (<1.48)	Water measuring tank is available.	Operator must be careful while checking sp.gravity.

HAZOP MINUTES						
System No.: 9			System Name: Digestor reduction NODE 9		Page of 9	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 24.02.2018			Present:		Report by:	
System Number			System TTP/EP/B-896/1		**BATCH PROCESS**	
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	More of	More Temperature	Addition of more iron scrap.	Temperature may exceed desired temperature.	Temperature measuring facility is available.	Operator should monitor temperature during the process.
2	Early	Addition of iron scrap.	Not proper monitoring of temperature	Temperature may exceed desired temperature.	Temperature measuring facility is available.	Operator should monitor temperature during the process.

HAZOP MINUTES						
System No.: 10			System Name: Settler - Temp. Regulator tank		Page of 10	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 24.02.2018			Present:		Report by:	
System Number			System TTP/EP/B-896/1		**BATCH PROCESS**	
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	Flow of steam	Malfunctioning of TRTs/non-availability from header/wrong line up.	More time required to prepare the operation.	PI available on main header and bye-pass of TRT	Operator must be careful. Preventive maintenance of the temperature control system is to be carried out as per schedule.
2		No temperature.	Malfunctioning of TRTs/ non-availability from header/wrong line up.	More time required to prepare the operation.	PI available on main header and by-pass of TRT	Operator must be careful. Preventive maintenance of the temperature control system is to be carried out as per schedule.
3	More of	Temperature	Malfunctioning of TRTs on the steam line.	Temperature more than 60°C, than 60°C, resulting in partial break	Temperature control system is available.	Preventive maintenance of instrument system is to be carried out.
4	Other	More steam than required.	Leakage in the steam coil.	Off-spec product generation.		Steam coil must be checked from time to time for any leakage.
		No movement of agitator.	Mechanical or electrical problem.	Longer batch time.		Preventive maintenance of agitator system is to be carried out.

HAZOP MINUTES						
System No.: 11			System Name: Concentration NODE 11		Page of 11	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 23.02.2018			Present:		Report by:	
System Number			System TTP/EP/B-901/1		**BATCH PROCESS**	
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	No feed flow.	no level in the tank1140A	More time for batch preparation	Overhead tank is available	Operator must check the levels in the tank.
			Chokage in pre-heater tubes.	More time for batch preparation	Water washing facility is available.	Flushing with water is to be carried out properly-Operators training.
2	More of	feed transfer.	Manual adjustment	Temperature less than desired 110°C- incomplete concentration.	Manual adjustment	Feed flow is to be adjusted based on desired temperature of 110°C - operator's training.
		steam flow	Wrong flow indication or leak in evaporator tube.	Higher temperature than desired. May cause additional pressure & upset system. Sp.gr. After the process may be more than desired.	Flow recorder in steam line.	Operator must be careful and watch for normal steam flow. Preventive maintenance of evaporator is to be taken as per recommendation of manufacturer.
3	Less	steam flow	Wrong indication/ lower steam pressure.	Lower temperature in evaporators.	Manual adjustment	Operator must be careful.
		feed flow	Wrong adjustment	Higher temperature than desired. May cause additional pressure & upset system.	Flow recorder in steam line.	Calibration and functioning of the system must be checked from time to time.
5	Part of	Ingress of water along with feed.	Passing water valve or wrong line up	Lower temperature in evaporators and poor quality product liquor.	Isolation valve available.	Operator must be careful and follow SOP. May consider positive isolation of water valve before introducing feed.
8	Before	Steam before feed charging	By mistake.	Lower temperature in evaporators. May result in choking the evaporator tube		Operator must be careful and follow SOP.

HAZOP MINUTES						
System No.: 12			System Name: Precipitation NODE 12		Page of 12	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 24.02.2018			Present:		Report by:	
System Number			System TTP/EP/B-902/1		**BATCH PROCESS**	
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	No water flow.	no level in the tank 1282 A or wrong line up	More time for the process	LG is available.	Operator must check the levels in the tank.
		No feed flow.	No level in tank 1150	More time for the process	Pumping by 2842	Operator to ensure that the pump is on. Suggest to provide LG/ LI in tank 1150
2	More of	Water transfer	Wrong level indication or human error	Will disturb hydrolysis process	Measuring tank is available	LG must be cleaned from time to time. Operator must be careful during transfer.
		steam flow	Wrong flow indication or human error.	Higher temperature than desired. May cause additional pressure & upset system.	Flow recorder in steam line. Precipitation tank TR is also available.	Operator must be careful and watch for normal steam flow. Must monitor temperature of 1151
		Temperature.	Wrong flow indication or human error.	Higher temperature than desired. May cause additional pressure & upset system.	Flow recorder in steam line. Precipitation tank TR is also available.	Operator must be careful and watch for normal steam flow. Must monitor Pressure & temperature of 1151.Suggest to convert PRC to TRC as temperature control is a main operating criteria here. PRC may be PR.
3	Less	steam flow	Wrong indication/ lower steam pressure.	Lower temperature in 1150.	Manual adjustment	Operator must be careful.
4	Before	Feed entry before the batch attaining required quantity	Human error or wrong temperature indication	Process delay	TR is available.	Operator must be careful and follow SOP.
5	Early	Closing of steam valve and addition of cutting water	Human error.	will effect Hydrolysis process.		Operator must be careful and follow SOP.
6	Other	Stoppage of agitator.	Mechanical or electrical or no power	Entire process will stop in that precipitator & affect the quality of the batch.		Preventive maintenance of agitator must be carried as per guideline of equipment supplier.

HAZOP MINUTES						
System No.: 13			System Name: Post precipitation filter NODE 13		Page of 13	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 24.02.2018			Present:		Report by:	
System Number			System TTP/EP/B-903/1		**BATCH PROCESS**	
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	No feed flow.	no level in cooling tank or wrong line up or pump problem.	More time for the process	Pump 3750 available.	Operator must check the levels in the tank and ensure steady flow from pump 3750.
		No vacuum in filter	Mal-functioning of vacuum pumps or problem in cooling water supply. Nonavailbility of cooling water may cause no level in seal pot of 3450 A&B	No vacuum inside filter drum resulting in poor filtration.	Vacuum pumps 3150 and individual PI points available.	Operator to ensure that the vacuum pumps are on and proper vacuum is available before start of filtration process.
2	Other	Leakage in filter cloth.	Wear and tear.	Passing of precipitate with filtrate		Preventive maintenance of filter must be carried out as per guideline of equipment supplier. Leaks in filter cloth is to be identified before by keeping blowing system on

HAZOP MINUTES						
System No.: 14			System Name: 1st stage washing sec. NODE 14		Page of 14	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 25.02.2018			Present:		Report by:	
System Number			System TTP/EP/B-904/1		**BATCH PROCESS**	
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	No feed flow.	no level in cooling tank or wrong line up or pump problem.	More time for the process	Pump 3760 available.	Operator must ensure steady flow from pump 3760.
		No vacuum in filter	Malfunctioning of vacuum pumps or problem in cooling water supply. No liquid level in 1162A may cause a situation of no vacuum.	No vacuum inside filter drum resulting in poor filtration.	Vacuum pumps 3160 and individual PI points available.	Operator to ensure that the vacuum pumps are on and proper vacuum is available before start of filtration process.
2	Other	Leakage in filter cloth.	Wear and tear.	Passing of precipitate with filtrate		Preventive maintenance of filter must be carried out as per guideline of equipment supplier. Leaks in filter cloth is to be identified before by keeping blowing system on.

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility available	Action Required
2	Other	Agitator break down in 1160	Mechanical or electrical failure.	No uniform mixing of filter feed resulting in unsteady filtration		Preventive maintenance of agitator must be carried out as per guideline of equipment supplier.

HAZOP MINUTES						
System No.: 15			System Name: Leaching 2nd stage washing sec. NODE15		Page of 15	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 25.02.2018			Present:		Report by:	
System Number			System TTP/EP/B-905 & 906/1		**BATCH PROCESS**	
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	No acid flow.	No level in acid tank or wrong line up or pump problem.	More time for the process	Supply from sulphuric acid tank and LG in the tank	Operator must ensure required level in 1274A.
		Non addition of aluminium dust.	Human error .	No leaching reaction.		Operator must ensure mixing of Aluminium dust in sulphuric acid.
2	More of	temperature.	More steam injection or wrong temperature indication.	Effect the leaching process.	TI available.	Calibration of TI must be checked at regular frequency.
		More acid flow	Human error or wrong level indication.	Effect the leaching process.	Supply from sulphuric acid tank and LG in the tank	Operator must ensure required level in 1274A.
4	Other	Agitator break down in 1170 & 1171	Mechanical or electrical failure.	Leaching process can not be carried out.		Preventive maintenance of agitator must be carried out as per guideline of equipment supplier.

HAZOP MINUTES						
System No.: 16			System Name: Dewatering filtration NODE16		Page of 16	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 25.02.2018			Present:		Report by:	
System Number			System TTP/EP/B-907/1		**BATCH PROCESS**	
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	No feed flow.	Wrong line up or pump problem.	More time for the process	Pump 3780 available.	Operator must ensure steady flow from pump 3780.

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility available	Action Required
1	None		Potassium sulphate is provided with treatment storage before the dewatering filtration	Treatment process will not start.	Two pumps from preparation tank 1182 available for transfer to 1183 for gravity distribution to 1184	Operator must ensure that required quantity of chemical is available in 1184
		No vacuum in filter	Malfunctioning of vacuum pumps or problem in cooling water supply. No liquid level in 1162A may cause a situation of no vacuum.	No vacuum inside filter drum resulting in poor filtration.	Vacuum pumps 3180 and individual PI points available.	Operator to ensure that the vacuum pumps are on and proper vacuum is available before start of filtration process.
2	Other	Leakage in filter cloth.	Wear and tear.	Passing of precipitate with filtrate		Preventive maintenance of filter must be carried out as per guideline of equipment supplier. Leaks in filter cloth is to be identified before by keeping the blowing system on.
		Agitator break down	Mechanical or electrical failure.	No uniform mixing of filter feed resulting in unsteady filtration		Preventive maintenance of agitator must be carried out as per guideline of equipment supplier.

HAZOP MINUTES						
System No.: 17			System Name: Calciner & Gas scrubbing		Page of 17	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 25.02.2018			Present:		Report by:	
System Number			System TTP/EP/B-908/1		**BATCH PROCESS**	
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	No water flow	Wrong line up or pump problem in off-site.	Hot gases escape to Electrostatic Precipitators	Supply from off-site	Operator must ensure steady flow of water from off-site.
		No flow of weak acid.	Wrong line up or pump problem .	Improper gas treatment.	Two pumps are available	Operator must ensure that required quantity of acid is available in 1190B and pump operating satisfactorily to supply weak acid.

H_2SO_4

Annexure II

HAZOP MINUTES						
System No.: 1			System Name: Molten sulphur & to leaf filter - Node 1		Page of 1	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 22.02.2018			Present: U. K. Kundu		Report by: Consultivo	
System Number DMCC/ TTP/109			System 80/50-S-4/12/13/19-CS-H-25			
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Actions / Facility available**	**Action Required.**
1	None	No Flow of dirty sulphur	i) No level in pit	i) No feed flow to the filter & and no/low level in clean pit.	TI point is available	i) Monitoring by operator is required. Suggested to provide level indication in dirty and clean pit.
			ii) No flow from melting pit due to low temperature.	i) No feed flow to the filter & and no/low level in clean pit.	TI point is available	i) Monitoring by operator is required..
2	Less of	Less temperature	i)Insufficient steam flow	i) Low feed flow upsetting unit operation	TI point is available to measure temperature.	SOP to be followed - operators training.
		Less flow	i) Pump malfunctioning or sulphur filter conjealing.	i) Low feed flow upsetting unit operation	TI point is available to measure temperature.	SOP to be followed - operators training.
3	Other than	No steam flow to melting pit coil	Leakage in steam coil in the melting pit	Sulphur will not melt & unit will be shut down		Steam coils must be pressure tested at regular intervals.

HAZOP MINUTES						
System No.: 2			System Molten sulphur to furnace - Node 2		Page of 2	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 02.03.2018			Present: U. K. Kundu		Report by: Consultivo	
System Number DMCC/ TTP/110			System 880/50-S-8-CS-H-25			
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Actions / Facility available**	**Action Required.**
1	None	No Flow of molten sulphur	Pump malfunctioning or tripping .	No sulphur burning in furnace.	PI is available in pump discharge.	i) Monitoring by operator is required. Preventive maintenance of the pump is to be carried out at regular interval.
			ii) No level in pit	No sulphur burning in furnace.	PI is available in pump discharge.	i) Monitoring by operator is required. May consider LI in the pit.
			Chokage of sulphur line due to no steam of jacket steam.	No sulphur burning in furnace.		Operator must ensure the steam and condensate flow to maintain temperature at 140°C
2		No air flow.	Air blower stop/trip.			

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Actions / Facility available	Action Required.
3	Other than	No steam flow to melting pit coil	Leakage in steam coil in the melting pit	Sulphur will not melt & unit will be shut down		Steam coils must be pressure-tested at regular intervals.

HAZOP MINUTES						
System No.: 3			System Name: Boiler feed water- Node 3		Page of 3	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 02.03.2018			Present: U. K. Kundu		Report by: Consultivo	
System Number DMCC/ TTP/110			System 80-BW-4-BS-4-H-40			
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Actions / Facility available**	**Action Required**
1	None	No Flow of BFW	Pump malfunctioning or tripping .	i) No BFW flow to steam drum . Sulphur pump will trip.	Sulphur tripping facility in case of BFW pump tripping.	i) Monitoring by operator is required. Preventive maintenance of the pump is to be carried out at regular interval.
			ii) No level in V 301	i) No BFW flow to steam drum .	Level gauge is available in V-301	i) Monitoring by operator is required. .
			Malfunctioning of LCV 403	Heater will trip.	By-pass of control valve is available.	Preventive maintenance of the instrument system must be carried out and to ensure that the system is healthy.
3	Other than	Leakage in Economiser tube- E 405 /406	Corrosion in tube.	i) No BFW flow to steam drum .	Level indication with low level cut off of furnace is available.	Preventive maintenance of economisers are to be followed strictly.
		No dosing of TSP	No level in T-102 or tripping/ malfunctioning of pumps P-904 A/B	pH of BFW may not be maintained.	Two pumps are available.	i) Monitoring by operator is required. Preventive maintenance of the pump is to be carried out at regular interval.
		No dosing of Hydrazine.	No level in T-103 or tripping/ malfunctioning of pumps P-905 A/B	Dissolved oxygen removal will not be possible resulting in corrosion of boiler tubes.	Two pumps are available.	i) Monitoring by operator is required. Preventive maintenance of the pump is to be carried out at regular interval.

HAZOP MINUTES						
System No.: 4			System Name: Air & acid gas Node4		Page of 4	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 02.03.2018			Present: U. K. Kundu		Report by: Consultivo	
System Number DMCC/ TTP/			System 1000-GS-2/3-CS-1-H-75, 1000-GS-16-AS-1-H-75			
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Actions / Facility available**	**Action Required**
1	None	No flow of SO2 to converter inlet	No burning of sulphur in furnace due to no supply of sulphur.	No production.	TI point is provided .	Ensure steady operation of upstream facility. .
2	More	Inlet temperature to converter	Fouling of waste heat boiler	Higher temperature in converter inlet and higher temperature in 1st bed outlet.	TI point is provided .	Preventive maintenance of waste heat boiler must be carried out as per schedule. Quality of BFW is to be maintained by proper Hydrazine & TSP dosing and proper blow down from steam drum.
		Inlet temperature to 2nd bed.	Higher outlet temperature from bed 1	Higher temperature in converter inlet and higher temperature in 1st bed outlet restricting production		Preventive maintenance of waste heat boiler must be carried out as per schedule. Quality of BFW is to be maintained by proper Hydrazine & TSP dosing and proper blow down from steam drum.
			Higher SO2 % in gas from furnace to converter 1st bed.	Higher temperature in 1st bed outlet.	Analyser is available.	air /sulphur ratio must be maintained so that more than 10.5% SO2 in the entrance of converter is avoided.
			Lower heat transfer in E-402	Will restrict production.		Preventive maintenance of E-402 is to be carried out as per guideline of manufacturer.
3	Other	Ingress of moisture in 1st reactor.	Waste heat boiler tube leak.	Acid mist formation effecting absorption.	PI point in steam drum.	Preventive maintenance of waste heat boiler must be carried out as per schedule. Quality of BFW is to be maintained by proper Hydrazine & TSP dosing and proper blow down from steam drum.

HAZOP MINUTES						
System No.: 5			System Name: Air & acid gas 2nd bed Node 5		Page of 5	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 02.03.2018			Present: U. K. Kundu		Report by: Consultivo	
System Number DMCC/ TTP/			System 1000-GS-6/7-CS-1-H-75			
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
2	More	Inlet temperature to converter bed 3	Lower heat transfer in super heater	Higher temperature in 3rd bed inlet and higher temperature in 3rd bed outlet.	TI point is provided .	Preventive maintenance of super heater must be carried out as per schedule.
		Inlet temperature to 3rd bed.	Higher outlet temperature from bed 2	Higher temperaturein 2nd bed outlet restricting production		Preventive maintenance of hot heat exchanger must be carried out as per schedule.
			Higher SO_2 % in gas from 2nd bed to converter 3rd bed.	Higher temperature in 2nd bed outlet.	Analyser is available.	Air/sulphur ratio must be maintained so that proper SO2 % is maintained..
	Less of	Temperature to Bed 3 inlet.	Improper heat exchange in hot heat exchanger or low inlet temperature of cold gas.	Lower conversion of SO_2		Preventive maintenance of hot heat exchanger must be carried out as recommended by equipment supplier.
3	Other	Tube leakage in hot heat exchanger		Higher SO_2 % in 4th bed inlet.	Analyser is available.	Preventive maintenance of hot heat exchanger must be carried out as recommended by equipment supplier.

HAZOP MINUTES						
System No.: 6			System Name: Air & acid gas 3rd bed Node 6		Page of 6	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 07.03.2018			Present: U. K. Kundu		Report by: Consultivo	
System Number DMCC/ TTP/			System 1000-GS-8-CS-1-H-75			
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
2	More	Outlet temperature to econo-miser E-406	Lower heat transfer in E-404	More unconverted gas can escape via overhead	TI point is provided .	Preventive maintenance of E-404 must be carried out as per schedule.
		Inlet temperature to 3rd bed.	Higher outlet temperature from bed 2	Higher temperature in 3rd bed outlet restricting production		Preventive maintenance of heat exchangers must be carried out as per schedule.
			Higher SO_2 % in gas from 2nd bed to converter 3rd bed.	Higher temperature in 2nd bed outlet.	Analyser is available.	air/sulphur ratio must be maintained so that proper SO_2 % is maintained..

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility available	Action Required
2	Less of	Temperature to Bed 4 inlet.	Improper heat exchange in E-403 /404 or low inlet temperature of cold gas.	Lower conversion of SO_2		Preventive maintenance of E-403/404 must be carried out as recommended by equipment supplier.
3	Other	Tube leakage in E-403 or 404		Higher SO_2 % in 4th bed inlet.	Analyser is available.	Preventive maintenance of exchangers must be carried out as recommended by equipment supplier.

HAZOP MINUTES						
System No.: 7			System Name: Acid circuit Node 7		Page of 7	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 07.03.2018			Present: U. K. Kundu		Report by: Consultivo	
System Number DMCC/TTP/			System C-503			
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	No flow of acid to C-503	i) Tripping or malfunctioning of acid pump.	Main air blower and sulphur feed pump will trip. But residual gases in the process will flow till the system is depressurised. This is only in case of tripping.	Production will stop because of tripping of sulphur and air blower.	Residual gases will escape to scrubber. Scrubber must be in circulation to take care of such eventuality. Otherwise, a lot of SO3 may escape to atmosphere. Suggest to provide a Remote Operated Motorised valve on the line routed to scrubber stack directly which will close in case of tripping of acid pump. Also, it is suggested to start the caustic circulation pump immediately in case of acid pump trip as an interlock system
		Cooling water to acid cooler	Tripping or malfunctioning of water pump.	Main air blower and sulphur feed pump will trip. But residual gases in the process will flow till the system is depressurised.	Production will stop because of tripping of sulphur and air blower.	As suggested above, management may consider. All trips are electrical. In case of low flow of cooling water, the acid temperature will increase. But the system will not trip. Since, high temperature is an area of concern, may consider tripping facility of pumps from higher acid temperature also.
2	More	Temperature of water	Tripping or malfunctioning of water pump or lower heat transfer in plate exchanger.	Main air blower and sulphur feed pump will trip. But residual gases in the process will flow till the system is depressurised.	Production will stop because of tripping of sulphur and air blower.	Plate heat exchanger is to be cleaned as per guidance of manufacturer or own data generated during operation of the plant.
3	Less of	acid flow	Malfunctioning of acid pump.	Lower absorption and escape of gases to scrubber.		In case of low flow of cooling water, the acid temperature will increase. But the system will not trip. Since, high temperature is an area of concern, suggest to provide tripping facility of pumps from higher acid temperature also.

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility available	Action Required
3	Less of	water flow	Higher acid temperature	Lower absorption and escape of gases to scrubber.		In case of low flow of cooling water, the acid temperature will increase. But the system will not trip. Since, high temperature is an area of concern, it is suggested to provide tripping facility of pumps from higher acid temperature also.
4	Other	Mixing of acid with cooling water	In the Plate exchanger	pH of cooling water will be low and corro-sion of cooling water line.	pH indicator PHT 308 is available.	Ppreventive maintenance of exchangers is to be carried out as recommended by equipment manufacturer.

HAZOP MINUTES						
System No.: 8			System Name: Acid circuit Node 8		Page of 8	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 07.03.2018			Present: U. K. Kundu		Report by: Consultivo	
System Number DMCC/ TTP/			System C-502			
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	No flow of acid to C-502	i) Tripping or malfunctioning of acid pump.	Main air blower and sulphur feed pump will trip.	Production will stop because of tripping of sulphur and air blower.	Residual gases will escape to scrubber. Scrubber must be in circulation to take care of such eventuality. Otherwise lot of SO_3 may escape to atmosphere. Suggested to provide a Remote Operated Motorised valve on the line routed to scrubber stack directly which will close in case of tripping of acid pump. Also, it is suggest to start the caustic circulation pump immediately in case of acid pump trip as an interlock system
3	Less of	acid flow	Mal-functioning of acid pump.	Lower absorption and escape of gases to 4th bed of converter.		In case of low flow of acid, load on bed 4 of converter will increase. But the system will not trip. It is suggested to provide low alarm .

HAZOP MINUTES						
System No.: 9			System Name: Acid circuit Node 9		Page of 9	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 07.03.2018			Present: U. K. Kundu		Report by: Consultivo	
System Number DMCC/ TTP/			System C-501			
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	No flow of air to C-501	i) Tripping or malfunctioning of air blower.	sulphur feed pump will trip.		Residual gases will escape to scrubber. Scrubber must be in circulation to take care of such eventuality. Otherwise, a lot of SO3 may escape to atmosphere. Suggest to provide a Remote Operated Motorised valve on the line routed to scrubber stack directly which will close in case of tripping of acid pump. Also, suggested to start the caustic circulation pump immediately in case of acid pump trip as an interlock system

No.	Guide Word	Deviation	Possible Causes	Possible consequences	Facility available	Action Required
3	Less of	acid flow	Malfunctioning of acid pump.	Lower absorption and escape of gases to 4th bed of converter.		In case of low flow of acid, load on bed 4 of converter will increase. But the system will not trip. Suggested to provide low flow alarm .
		water flow to T-503	Malfunctioning of ACV in water line.	Conversion of oleum to sulphuric acid will not be complete.	Bye pass of ACV & strength analyser ANT 301 is available.	Preventive maintenance of instrumentation system is to be carried out regularly.
4	More of	water flow to T-503	Malfunctioning of ACV in water line.	Acid will ve diluted and rise in temperature.	Bye pass of ACV & strength analyser ANT 301 is available.	Preventive maintenance of instrumentation system is to be carried out regularly.

HAZOP MINUTES						
System No.: 10			System Name: Alkali scrubber Node10		Page of 10	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 07.03.2018			Present: U. K. Kundu		Report by: Consultivo	
System Number DMCC/ TTP/			System C-504			
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	No flow of caustic flow to C-504	i) Tripping or malfunctioning of pump.	Acid gas will escape from scrubber vent.	Spare pump available.	One pump must be always available for caustic circulation. May consider auto start of spare pump in case of tripping or low flow.
		No flow of oxidising solution.	No level in tank	Oxidation of sodium bisulphate to sodium sulphate will not be possible.		Suggested to provide level indication in the tank
3	Less of	caustic flow	Malfunctioning of caustic pump.	Acid gas will escape from scrubber vent.		One pump must be always available for caustic circulation. May consider auto start of spare pump in case of tripping or low flow.

Annexure III

HAZOP MINUTES						
System No.: 1			System Name: EFFLUENT EQUILISATION TANK- Node 1		Page of 1	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 22.02.2018			Present: U. K. Kundu		Report by: Consultivo	
System Number P092-D0015_001			System Stream A-I			
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Actions/Facility available**	**Action Required.**
1	None	No Flow from equilisation tank	i) Pump malfunctioning or tripping of pump P-001 A/B/C	No activity in the downstream with chances of high level/ overflowing of Equilisation tank.	Effluent cut off valve at inlet of equilisation tank is available.	i) Monitoring by operator is required. Operator must ensure that 2 pumps are in operation with full capacity.
2	Less of	Level	Lower effluent load or malfunctioning of UV 10113	Equilisation process will not start.	Security interlocks provided to stop the pump in case of low level.	Instrument system must be checked periodically for smooth functioning of security system.

HAZOP MINUTES						
System No.: 2			System Name: Flash mixer & clarifier NODE 2		Page of 2	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 13.03.2018			Present: U. K. Kundu		Report by: Consultivo	
System Number P092-D0015_001			System Stream A-I			
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Actions/Facility available**	**Action Required.**
1	None	level in flash mixer	Pump (P--001 A/B/C) malfunctioning or tripping or wrong line up	No processing of effluent.		i) Monitoring by operator is required. Preventive maintenance of the pump is to be carried out at regular interval.
		no dosing of $CaCO_3$	Malfunctioning of return line instrument or no starting of pump or wrong line up	White gypsum will not be produced.	FR is available	i) Monitoring by operator is required. Preventive maintenance of the instrument system is to be carried out at regular interval.
2	More of	Dosing of $CaCO_3$	Malfunctioning of return line instrument or wrong pH indication of effluent going to clarifier A	White gypsum will not be produced.	flow measurement of CaCO3 is available.	i) Monitoring by operator is required. Preventive maintenance of the instrument system is to be carried out at regular interval.
3	Less of	Dosing of $CaCO_3$	Malfunctioning of return line instrument or wrong pH indication of effluent going to clarifier A	White gypsum will be reduced.	flow measurement of CaCO3 is available.	i) Monitoring by operator is required. Preventive maintenance of the instrument system is to be carried out at regular interval.
4	Other	Break down of agitator in flash mixer	Mixing with $CaCO_3$ will not be proper	White gypsum will be reduced.		Preventive maintenance of agitator must be carried out as per the recommendation of the manufacturer.
		Break down of agitator in Clarifier A	Higher sludge resulting in higher torque.	Upset in operation		Quality of incoming influent is to be analysed. Also, $CaCO_3$ dosing is to be monitored.

HAZOP MINUTES						
System No.: 3			System Name: Sludge holding tank, thickener & sludge holding tank NODE3		Page of 3	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 13.03.2018			Present: U. K. Kundu		Report by: Consultivo	
System Number P092-D0015_001			System Stream A-I			
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Actions/Facility available**	**Action Required.**
1	None	No level in T-003	Malfunctioning of UV 10116	High level in upstream clarifier and chances of sludge carry over to clarified water tank.	Manual operation of UV 10116 is available.	i) Monitoring by operator is required. Preventive maintenance of the instrument system is to be carried out at regular interval.
2	More of	Level in T-004	Malfunctioning of filter press feed pump.	Over flow of sludge holding tank	Manual operation of UV 10129 is available.	i) Monitoring by operator is required.
3	Other	Breakdown of agitator in sludge holding tank	Uniform sludge mixture will not be produced.	White gypsum will be reduced.		Preventive maintenance of agitator must be carried out as per the recommendation of the manufacturer.
		Breakdown of agitator in Thickener A	Higher sludge resulting in higher torque.	Upset in operation		Preventive maintenance of agitator must be carried out as per the recommendation of the manufacturer.

HAZOP MINUTES						
System No.: 4			System Name: Flash mixer & clarifier NODE 4		Page of 4	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 13.03.2018			Present: U. K. Kundu		Report by: Consultivo	
System Number P092-D0015_002			System Stream A-II			
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Actions/Facility available**	**Action Required.**
1	None	No flow to Degasser	Pump (P-004 A/B/C) malfunctioning or tripping or wrong line up	No processing of effluent.		i) Monitoring by operator is required. Preventive maintenance of the pump is to be carried out at regular interval.
		No air blowing in degasser	Air blower BL-001A/B malfunctioning or tripping or wrong line up	No removal of CO_2	PG is available.	i) Monitoring by operator is required. Preventive maintenance of the blower system is to be carried out at regular interval.
2	More of	Dosing of $Ca(OH)_2$	Malfunctioning of return line instrument or wrong pH indication of effluent going to clarifier A	pH will be high and more HCL dosing will be required.	flow measurement of $Ca(OH)_2$ is available.	i) Monitoring by operator is required. Preventive maintenance of the instrument system is to be carried out at regular interval.
3	Less of	Dosing of $Ca(OH)_2$	Malfunctioning of return line instrument or wrong pH indication of effluent going to clarifier A	Total precipitation of red gypsum will not be complete	flow measurement of $Ca(OH)_2$ is available.	i) Monitoring by operator is required. Preventive maintenance of the instrument system is to be carried out at regular interval.
4	Other	Break down of agitator in flash mixer	Mixing with $Ca(OH)_2$ will not be proper	Total precipitation will not be possible.		Preventive maintenance of agitator must be carried out as per the recommendation of the manufacturer.
		Break down of agitator in Clarifier B	Higher sludge resulting in higher torque.	Upset in operation		Quality of incoming influent is to be analysed. Also, $CaCO_3$ dosing is to be monitored.

HAZOP MINUTES						
System No.: 5			System Name: Reactor clarifier.NODE 5		Page of 5	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 13.03.2018			Present: U. K. Kundu		Report by: Consultivo	
System Number P092-D0015_002			System Stream A-II			
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Actions/Facility available**	**Action Required.**
1	None	No level in T-003	Malfunctioning of UV 10116	High level in upstream clarifier and chances of sludge carryover to clarified water tank.	Manual operation of UV 10116 is available.	i) Monitoring by operator is required. Preventive maintenance of the instrument system is to be carried out at regular interval.
		Na2CO3 dosing	Malfunctioning of upstream dosing pump.	No water sftening resulting in no precipitation of heavy metals.	PV 10247 is available.	i) Monitoring by operator is required.
5	Other	Break down of agitator in Thickener A	Higher sludge resulting in higher torque.	Upset in operation		Preventive maintenance of agitator must be carried out as per the recommendation of the manufacturer.

HAZOP MINUTES						
System No.: 6			System Name: Sludge holding tank, thickener & sludge holding tank NODE6		Page of 6	
Report of HAZOP study			Client: TTPL, Thiruvananthapuram		Content no.	
Date: 13.03.2018			Present: U. K. Kundu		Report by: Consultivo	
System Number P092-D0015_003			System Stream A-II			
No.	**Guide Word**	**Deviation**	**Possible Causes**	**Possible consequences**	**Facility available**	**Action Required**
1	None	No level in T-007	Malfunctioning of pumps P-042A/B	High level in upstream clarifier and chances of sludge carryover to clarified water tank.	Two pumps are available.	i) Monitoring by operator is required. Preventive maintenance of the pumps is to be carried out at regular interval.
2	More of	Level in T-007	Malfunctioning of thickener feed pump.	Over flow of sludge holding tank	Two pumps are available.	i) Monitoring by operator is required. Preventive maintenance of the pumps is to be carried out at regular interval.
3	Less of	Level in T-008	Malfunctoning or UV 10312	Sludge accumulation in thickener B	Manual operation of UV 10228 is available.	i) Monitoring by operator is required. Preventive maintenance of the instrument system is to be carried out at regular interval.
4	Other	Breakdown of agitator in sludge holding tank T-007	Uniform sludge mixture will not be produced.	Thickener operation will be effected.		Preventive maintenance of agitator must be carried out as per the recommendation of the manufacturer.
5		Breakdown of agitator in Thickener B	Higher sludge resulting in higher torque.	Upset in operation		Preventive maintenance of agitator must be carried out as per the recommendation of the manufacturer.

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Annexure 7

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For Approval, GM Tech (ic)/CFO

15.02.2022

10/02/2021 ൽ ട്രാവൻകൂർ ടൈറ്റാനിയത്തിൽ ഫർണസ് ഓയിൽ ലൈൻ പൊട്ടി കടലിലേക്കുള്ള ഡ്രെയിനേജ് ഓട വഴി ഫർണസ് ഓയിൽ കടലിലേക്ക് ഒഴുകി ഓട മുതൽ തുമ്പ ഐ എസ് ആർ ഒ അതിർത്തി വരെയുള്ള കടൽ തീരമാകെ മണലിൽ ഫർണസ് ഓയിൽ കലരുകയും ചെയ്തു. ജില്ലാ കളക്ടറിന്റെ നിർദ്ദേശപ്രകാരം ടൈറ്റാനിയം മാനേജ്മെന്റിന്റെ അനുമതിയോടെ വളരെ പെട്ടെന്ന് തന്നെ ഓയിൽ കലർന്ന മണൽ നീക്കം ചെയ്യുവാൻ ഓരോ പ്രദേശത്തെയും മത്സ്യത്തൊഴിലാളി കുടുംബങ്ങളിലെ തൊഴിലാളികളെ ചുമതലപ്പെടുത്തുകയുണ്ടായി. ഓരോ പ്രദേശത്ത് ജോലിചെയ്ത തൊഴിലാളികളുടേയും നൽകിയ വേതനത്തിന്റെയും അതിനോടനുബന്ധിച്ചുണ്ടായ ചെലവുകളുടെയും വിവരങ്ങൾ ചുവടെ ചേർക്കുന്നു.

1)10/02/2021ൽ	പൊഴിക്കര ഭാഗം (1500 രൂപ വീതം 51 പേർ)	- Rs 76,500/-
2) കൊച്ചുവേളി	മോസ്കോ നഗർ ഭാഗം (1500 രൂപ വീതം 107 പേർ)	- Rs1,60,500/-
3)11/02/2021ൽ	കൊച്ചുവേളി കുരിശുംമൂട് ഭാഗം (1500 രൂപ വീതം 187 പേർ)	- Rs 2,80,500/-
4)12/02/2021ൽ	പൊഴിക്കര ഭാഗം (500 രൂപ വീതം 12 പേർ)	- Rs 6,000/-
5)13/02/2021ൽ	പൊഴിക്കര ഭാഗം (700 രൂപ വീതം 17 പേർ)	- Rs 11,900/-
6)14/02/2021ൽ	പൊഴിക്കര ഭാഗം (700 രൂപ വീതം 20 പേർ)	- Rs 14,000/-
7)01/03/2021ൽ	വെട്ടുകാട് മുതൽ പുത്തൻതുറ ഓട ഭാഗം വരെ (1500 രൂപ വീതം 264 പേർ)	- Rs 3,96,000/-
8)01/03/2021ൽ	KL-01CK 8516 പിക്കപ്പ് വണ്ടി വാടക (750/- രൂപ വീതം നാല് ട്രിപ്പ് കമ്പനിക്കകത്ത് ഓയിൽ കലർന്ന മണ്ണും വേസ്റ്റും കൊണ്ടു വരുന്നതിനായി)	- Rs 3,000/-
9)01/03/2021ൽ	KL-01CQ ആപ്പേ വണ്ടി വാടക (500 രൂപ വീതം 10 ട്രിപ്പ്)	- Rs 5,000/-

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ആകെത്തുക - Rs 9,53,400/-

വിശ്വസ്തതയോടെ

ജോയ്
എ എം പബ്ലിക് റിലേഷൻസ്