290373/2020/HSM

The Report

Of

The High-Power Committee

On

The Styrene Vapour Release Accident at M/s LG Polymers India Pvt. Ltd.

Under the Chairmanship of
Sri Neerabh Kumar Prasad, IAS
Special Chief Secretary to Government
EFS&T Department GoAP

Proceedings of the Committee

The Government of Andhra Pradesh, fully committed to probe into the causes of the unfortunate incident of release of styrene vapour from M/s LG Polymers India Pvt. Ltd. (LG Polymers) on 7th May 2020, decided to constitute a High-Power Committee (The Committee) vide G.O RT No. 803, General Administration (SC.I) Department, dated 8th May 2020 and G.O.RT.No. 959, General Administration (SC.I) Department, dated 9th June 2020. The terms of reference of the Committee are:

- Enquire the reasons for the leakage, verifying if the Company had adhered to all the safety protocols
- Study long-term effects of the gas leakage on the surrounding villages, if any
- Recommend proposed action to be taken against the Unit by the Government, in case of any negligence on the vapour leak incident in Visakhapatnam
- Suggest measures to be taken by industrial units, including safety audits, to prevent such mishaps in future
- In case there are any observations and suggestions for all similar industrial plants, those too shall be communicated in the report

The Committee has worked assiduously on all the above-mentioned terms of reference, as per the scope in the G.O.RT.No. 803, General Administration (SC.I) Department, dated 8th May 2020 and also suggested measures to improve the protocol for safety and environmental compliances by the industries dealing with chemicals like styrene.

The Committee has finalized the report based on an in-depth and detailed analysis of existing evidences including exhaustive and wide consultations with the stakeholders. The Committee followed a thorough process oriented approach, involving all the concerned Government Departments viz. Petroleum and Explosives Safety Organization (PESO), Government of India; Department of Factories; Department of Boilers; Fire Services; Andhra Pradesh Pollution Control Board (APPCB); Greater Visakhapatnam Municipal Corporation (GVMC), Visakhapatnam Metropolitan Region Development Authority (VMRDA), Department of Agriculture, Horticulture, Animal Husbandry, Sericulture, Dairy Development, Fisheries & Agricultural Marketing Departments;

Proceedings of the Committee

Research & Development Organizations such as National Environmental Engineering Research Institute (NEERI); Central Institute of Petrochemicals Engineering & Technology (CIPET, formerly known as Central Institute of Plastics Engineering & Technology), Indian Institute of Petroleum (IIP), Dehradun; Indian Institute of Petroleum And Energy (IIPE), Visakhapatnam; Andhra University, Visakhapatnam; Experts from Petrochemicals and Safety; Local Public; Non-Governmental Organizations (NGO); Public Representatives and the management of LG Polymers, etc.

The Committee is pleased to submit its report to the Government of Andhra Pradesh. It is our considered view that, implementation of suggested recommendations will make perceptible qualitative changes in the implementation of the Safety Protocols and Environmental Regulations.

Sri Neerabh Kumar Prasad, IAS
Special Chief Secretary to Govt, EFS&T Department
CHAIRMAN
High Power Committee

Sri R. Karikal Valaven, IAS
Special Chief Secretary to Govt, Industries & Commerce Department
MEMBER

Sri Vivek Yadav, IAS
Member Secretary, APPCB
MEMBER CONVENER

Sri Vinay Chand, IAS
Collector and District Magistrate, Visakhapatnam District
MEMBER

Sri R.K. Meena, IPS
Commissioner of Police, Visakhapatnam
MEMBER

Prof. (Dr.) S.K. Nayak, Director General
Central Institute of Petrochemicals Engineering & Technology
MEMBER

Shri Bharat Kumar Sharma
Regional Director, CPCB, Regional Directorate, Pune
MoEF&CC, GoI
MEMBER

Dr. R.K. Elangovan, Director General
Factory Advice Service Labour Institutes,
Ministry of Labour & Employment,
GoI, Mumbai
MEMBER

Dr. Anjan Ray, Director
NDMA, Indian Institute of Petroleum, GoI,
Dehradun
MEMBER

Message from Chairman of the Committee

It is a great honour to be selected to chair the nine-member High Power Committee (the Committee) constituted by Government of Andhra Pradesh. I express my gratitude to Hon'ble Chief Minister, Sri Y S Jagan Mohan Reddy for entrusting this important responsibility. As Chairman of the Committee, I have worked strenuously with all the members to bring this report to a just conclusion and meet the core objectives for which the Committee was constituted.

The calamitous accident on 7th May 2020 led to loss of human lives and substantial repercussions on the environment. Considering the seriousness of the incident, the main objective of the Committee is to identify the root causes and errors committed and learn lessons so that such accidents do not recur. The Committee has followed a very structured approach to find the root causes for the 'Uncontrolled Styrene Vapour Release from M6 Tank' that occurred on 7th May 2020. The Committee has also evaluated the preparedness and emergency response of the Company. This report further includes the immediate impact and long-term effects of the vapour release on surrounding habitations. The role of the various Government Departments has been studied in detail. The Committee has also delved deeply into safety and environmental regulatory systems. The suggestions by the Committee cover technical issues of Styrene and hazardous chemicals industries as well as administrative & regulatory framework and processes.

"What can be asserted without evidence can also be dismissed without evidence"[1]. I strongly believe that it is necessary to determine the fundamental causes of an accident and present the flaws explicitly to reach a logical conclusion and derive actionable recommendations. I had the good fortune of working with committed, expert members, who have been objective, meticulous, and analytical. The Committee has verified and reviewed all available information, evidences and proofs to arrive at the conclusion regarding the root causes of the accident with utmost accuracy.

[1] Christopher Hitchens 1949–2011 English-born American journalist and writer: in *Slate Magazine* 20 October 2003

Message from Chairman of the Committee

As Chairman of the Committee, I congratulate each member for their diligent work, in-depth analysis of the accident and proposing solutions that can be implemented effectively.

I am confident that the observations and recommendations highlighted in the report will support in building institutional structures which usher in a culture of Factories' Safety, Environmental protection and sustainable industrial growth. I sincerely hope that the recommendations of the Committee, based on the detailed investigation will be well received.

Sri Neerabh Kumar Prasad, IAS,
Special Chief Secretary to Govt, EFS&T Department
CHAIRMAN
High Power Committee

Preface

In the wee hours of 7th May 2020, an accident of uncontrolled release of Styrene vapour occurred at LG Polymers India Pvt. Ltd. (LG Polymers), RR Venkatapuram Village, Pendurthi Mandal, Visakhapatnam District, Andhra Pradesh from one of the Styrene storage tanks. The hazardous Styrene vapours spread beyond the factory premises, affecting the populace of five villages / habitations. The officials from the District administration along with Police Department, GVMC, National Disaster Response Force (NDRF) rushed to the spot for rescue operations. However, the grave accident led to 12 citizens losing their lives and 585 citizens being hospitalized.

Soon after the accident was reported, the Hon'ble Chief Minister of Andhra Pradesh rushed to Vishakhapatnam immediately and directed the entire administration to take relief operations and also consoled the victims.

The Hon'ble Prime Minister Sri Narendra Modi chaired a High-level meeting on 7th May 2020 to take stock of the steps being taken in response of the accident. An expert from CBRN & NEERI were sent to assist the local administration.

In this regard, the Government of Andhra Pradesh decided to investigate into the causes behind the leakage of Styrene Vapour and constituted a Nine-Member High-Power Committee (The Committee) vide G.O RT No. 803, General Administration (SC.I) Department, dated 8th May 2020 and G.O.RT.No. 959, General Administration (SC.I) Department, dated 9th June 2020. The terms of reference of the Committee is mentioned in para. 5 of the G.O RT No. 803, General Administration (SC.I) Department, dated 8th May 2020.

The Government of Andhra Pradesh fully committed to ensure that such a major chemical accident does not take place again, set out the terms of reference of the Committee vide G.O RT No. 803, General Administration (SC.I) Department, dated 8th May 2020. The Committee focused

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on these terms of reference for undertaking the detailed investigation of the incident and achieve the objective for which the Committee was constituted.

The Committee first visited Vishakhapatnam on the 9th, 10th and 11th of May 2020 to discuss the plan of action and approach towards the terms of reference. The Committee constituted a Technical Committee comprising of three expert members from Visakhapatnam on 13th May 2020 comprising of Professor VSRK Prasad, Director, Indian Institute of Petroleum and Energy, Vishakhapatnam; Professor S. Bala Prasad, Department of Civil Environmental Engineering, Andhra University, Vishakhapatnam; and Professor KV Rao, Former Professor, Andhra University, Vishakhapatnam to assist the Committee. The Committee held intensive discussions on the progress of the report on the 22nd May 2020. The Committee invited stakeholder view and representations through emails, phone calls and messages. The Committee met on the 6th, 7th, and 8th of June 2020 for further deliberations and discussion. The Technical Committee submitted interim reports which was thoroughly discussed by the Members of this Committee.

The Committee has thoroughly examined all the points raised during public consultation, interaction with media and news items appeared in newspapers, evidences furnished by the industry, stakeholders and summated feedback from all the members of High-Power Committee, the Technical Committee, Regulatory Authorities and the replies of the company LG Polymers. The Committee report is based on detailed technical evaluation done in a scientific manner and are presented in accordance to the terms of reference of the Committee.

We express our sincere gratitude to Honourable Chief Minister, Government of Andhra Pradesh, Sri YS Jagan Mohan Reddy for constituting this High Power Committee.

Preface

The Committee has tried to do justice in meticulously evaluating the details of the incident by highlighting the major parameters behind the accident, non-adherence of the safety protocols, lack of timely emergency response measures, the adverse impacts, the negligence and also provided suggestions. The Committee is sure, that the final recommendations presented in this report will facilitate a constructive change in the existing safety measures in Factories, and Environment Protection but at the same time promote growth in the manufacturing sector.

Acknowledgment

All members of the High-Power Committee express their heartfelt gratitude to Hon'ble Chief Minister Sri Y S Jagan Mohan Reddy, Government of Andhra Pradesh, for constituting this committee to probe into the Styrene gas leak at LG Polymers plant. This report was made possible thanks to the support and advice of various stakeholders across government, academia, institutions and the public.

The Committee thanks the Chief Secretary and other officers of Government of Andhra Pradesh for providing valuable inputs on the inquiry and analysis. The Committee is grateful to Ministry of Chemical & Fertilizers, Ministry of Environment, Forest & Climate Change, Ministry of Labour & Employment, National Disaster Management Authority (NDMA), Council of Scientific & Industrial Research (CSIR), Indian Institute of Petroleum, for nominating members to the High-Power Committee.

The Committee places on record its sincere gratitude and appreciation to the following Technical Committee members, for their immense contribution through detailed technical analysis and modelling studies:

- Prof. VSRK Prasad, Director, Indian Institute of Petroleum and Energy Visakhapatnam
- Prof. S. Bala Prasad, Department of Civil Environmental Engineering, Andhra University, Visakhapatnam
- Prof. KV Rao, Former Professor, Andhra University Visakhapatnam

The Committee thanks the Chemical, Biological, Radiological and Nuclear (CBRN) wing of National Disaster Response Force (NDRF) and National Environmental Engineering Research Institute for providing inputs on the initial emergency period.

Acknowledgment

The Committee acknowledges the support of Non-Governmental Organizations (NGOs) and other Civil Society Organizations for their comments and valuable contributions including technical and modelling inputs.

The Committee would like to specially acknowledge the public, press and other stakeholders, for the time and energy spent to share their comments with the Committee, either in person or through written communication via Emails, Messages, WhatsApp etc. The Committee appreciates the views shared by public representatives. The Committee has made the effort to answer each point raised in these deliberations.

Sincere gratitude to all departments for submitting their detailed reports in time, that has played a key role in preparation of this Report. The Committee also thanks LG Polymers (India) Private Limited for submitting the required information and replies to the questionnaire, though belatedly.

The Committee highly commends the efforts of the District Administration, Police Department, NDRF, Greater Visakhapatnam Municipal Corporation (GVMC), the Fire Department and other officials involved in rescue and relief operations.

The Committee extends thanks to the staff of Andhra Pradesh Pollution Control Board (APPCB) for all the secretarial assistance provided.

Contents

List of Abbreviations

Abbreviations	Explication
ACP	Assistant Commissioner of Police
ADIS	Advanced Diploma in Industrial Safety
AEGLs	Acute Exposure Guideline Levels
AFIH	Associate Fellowship in Industrial Health
AP SEAC	Andhra Pradesh and State Level Expert Appraisal Committee
APSDMA	Andhra Pradesh State Disaster Management Authority
APSDRFSD	Andhra Pradesh State Disaster Response and Fire Services Department
APVVP	Andhra Pradesh Vaidya Vidhana Parishad Office of the District Coordinator of Hospital Services
BIS	Bureau of Indian Standards
BLEVE	Boiling Liquid Expanding Vapour Explosion
CBRN	Chemical, Biological, Radiological and Nuclear
CCME	Canadian Council of Ministers of Environment
CFE	Consent for Establishment
CFO	Consent for Operation
CII	Confederation of Indian Industry
CIMC	Central Inspection Monitoring Committee
CIS	Central Inspection System
CIS	Common Inspection System
CMRF	Chief Minister's Relief Fund
COD	Chemical Oxygen Demand
CP	Commissioner of Police
CSIR- NEERI	CSIR- National Environmental Engineering Research Institute
DCP	Deputy Commissioner of Police
DCS	Distributed Control System
DDMA	District Disaster Management Authorities
Dir (O)	Director (Operations)
EC	Environmental Clearance
ECC	Emergency Control Centre
EoDB	Ease of Doing Business
EPA	Environment Protection Agency
EPS	Expandable Polystyrene
ERPG	Emergency Response Planning Guidelines
FSB	Factory Safety Boards
GM	General Manager
GoI	Government of India

Abbreviations	Explication
GPPS	General Purpose polystyrene
GVMC	Greater Visakhapatnam Municipal Corporation
HAZOP	Hazard and Operability Study
HCI	Hydrochloric Acid
HH	Households
HIPS	High Impact Polystyrene
HMIS	Hazardous Material Information System
IARC	International Agency for Research on Cancer
ICMR	Indian Council for Medical Research
IDLH	Immediate Danger to Life & Health
IPC	Indian Penal Code
IST	Indian Standard Time
LCG	Local Crisis Group
LEL	Lower Explosive Limit
LEP	Life Extension Programme
LG Polymers	LG Polymers India Private Limited
MAH	Major Accident Hazard
MCP	Manual Call Points
MGR	Meghadri Gedda Reservoir
MOC	Management of Change
MoEF&CC	Ministry of Environment, Forest and Climate Change
MSDS	Material Safety Data Sheets
MSIHC	Manufacture, Storage and Import of Hazardous Chemicals
NCMC	National Crisis Management Committee
NDM	n-dodecyl mercaptan
NDMA	National Disaster Management Authority
NDO	Night Duty Officer
NDRF	National Disaster Response Force
NFPA	National Fire Protection Association
NGO	Non-Governmental Organization
NGT	National Green Tribunal
NIDM	National Institute of Disaster Management
NOC	No Objection Certificate
OSH	Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PESO	Petroleum and Explosives Safety Organization
PFD	Process Flow Diagram
PPs	Project Proponents
PSDGA	Public Service Delivery Guarantee Act

Abbreviations	Explication
PSM	Process Safety Management
PSM	Process Safety Management
PSSR	Pre-start-up Safety Review
R & A/C	Refrigeration and Air Conditioning System
RARS	Rural Agriculture Research Station
RO	Regional Offices
SCBA	Self-Contained Breathing Apparatus
SDRF	State Disaster Response Force
SEIAA	State Environmental Impact Assessment Authority
SFAC	Standing Fire Advisory Council
SIC	Shift In-Charge
SM	Styrene Monomer
SMH	Styrene Monomer Handling
SMV	Styrene Monomer Vapour
SOP	Standard Operating Procedures
SPCB	State Pollution Control Boards
STEL	Short-term Exposure Limit
TBC	p-tert-butyl catechol
TDM	Tertiary Dodecyl Mercaptan
TDS	Total Dissolved Solids
TLV	Threshold Limit Value
TOC	Total Organic Carbon
TWA	Time Weighted Average
UTPCC	Union Territory Pollution Control Committees
VHF	Very High Frequency
VMRDA	Visakhapatnam Metropolitan Region Development Authority
VOC	Volatile organic compound

1.0 Introduction

On 7th May 2020, an incident of uncontrolled Styrene vapour Release occurred at LG Polymers, RR Venkatapuram, Visakhapatnam from one of the Styrene storage-tanks (M6 Tank). The uncontrolled Styrene vapour release from a storage tank into the atmosphere occurred for the first time in India.

The accident took the life of 12 persons in the immediate subsequent period and 585 people had to undergo treatment in hospitals, besides causing loss of livestock and vegetation. This Styrene vapour release, widely referred to as "Vizag Gas Leak", is one of the major Styrene vapour release incidents from a bulk storage tank anywhere in the world. The Figure 1.1 shows the location of the factory along with the surrounding habitations.

Figure 1.1: Google map of Factory Locations and surrounding habitation

The Honourable Chief Minister, Government of Andhra Pradesh, rushed to Visakhapatnam on the same day and took stock of rescue operations and directed the Honourable Ministers and the District Administration for taking the immediate necessary steps for evacuation, relief & medical assistance. The Chief Secretary, Government of Andhra Pradesh, monitored the situation by camping at Visakhapatnam.

The Hon'ble Prime Minister Shri. Narendra Modi chaired a High-Level meeting on 7th May 2020 morning to take stock of the steps being taken in response to the incident, where the measures being taken for the safety of the affected people as well as for securing the site affected by the disaster were discussed at length. The meeting was attended by Union Defense Minister Shri. Rajnath Singh, Union Home Minister Shri. Amit Shah, and other Ministers, besides Senior Officers.

The National Crisis Management Committee (NCMC) met under the Chairmanship of Cabinet Secretary Shri Rajiv Gauba to review the situation It was decided that a team from CBRN (Chemical, Biological, Radiological and Nuclear) unit of NDRF from Pune, along with an expert team of National Environmental Engineering Research Institute (NEERI), Nagpur would be rushed to Vishakhapatnam immediately to support the State Government in the management of the crisis on the ground.

The National Disaster Management Authority arranged a special aircraft for airlifting joint team of four response experts from 5th Battalion, NDRF Pune along with PPE, other equipment and five environmental experts from Nagpur. The aircraft reached Visakhapatnam on 7th May and the team immediately supported the local administration in controlling the situation.
As per the Manufacture, Storage and Import of Hazardous Chemicals Rules, (MSIHC) 1989,- '
"major accident" means an occurrence including any particular major emission, fire or explosion involving one or more hazardous chemicals and resulting from uncontrolled developments in the course of an industrial activity or due to natural events leading to serious effects both immediate or delayed, inside or outside the installation likely to cause substantial loss of life and property including adverse effects on the environments."

As per the above definition, the uncontrolled Styrene vapour release from the M6 Tank at LG Polymers Visakhapatnam, commonly reported as "Vizag Gas Leak" qualifies as a major accident under MSIHC Rules, 1989.

1.1 About LG Polymers, Visakhapatnam

Industrial activity at the current premises of M/s LG Polymers at R.R. Venkatapuram, Visakhapatnam started in 1961, under the name and style of M/s Sri Rama Mills to manufacture alcohol from molasses. Later, in 1962 M/s Sri Rama Mills was taken over by M/s Hindustan Polymers Ltd2. In 1967 (as per Factories Department License), M/s Hindustan Polymers Ltd. replaced the manufacturing activity of alcohol with manufacturing activity of Polystyrene & Co-Polymer. Manufacturing of Styrene Monomer was reportedly initiated in 1973. In 1978, M/s Hindustan Polymers Ltd. merged with McDowell & Co. Ltd of United Breweries Group[3]. The Company terminated manufacturing of Styrene monomer and started importing it in the year 1993.

The management has informed that the LG Chemicals (South Korea) Ltd set up the LG Chemicals India Pvt. Ltd., as a 100% subsidiary of LG Chemical, South Korea. The LG Chemicals India Pvt. Ltd. acquired M/s Hindustan Polymers Ltd in 1997 and renamed the company as M/s LG Polymers India Private Limited, Visakhapatnam with Company Registration bearing No. 01-25917, dated. 10.12.1996. The management also informed that the LG Chemicals India Pvt. Ltd. functions only as a holding company and does not have a separate office of its own and all operations are carried by LG Polymers India Pvt. Ltd. (LG Polymers, in short). The LG Polymers is a 100% subsidiary of LG Chemicals India Pvt. Ltd. After acquisition, the LG Polymers continued manufacturing of Polystyrene & Expandable Polystyrene and expanded the manufacturing capacities from time to time.

[2] Company Registration bearing No. 012527, dt. 29th November 1962 from Ministry of Corporate Affairs, GoI.
[3] Merged Company continued the manufacturing of Polystyrene in the name of M/s Hindustan Polymers Ltd

The details of the LG Polymers India Pvt. Ltd. is as follows[4]:

Company Identification Number Issued by Ministry of Corporate Affairs, GoI	:	U25203AP1996PTC025917
Date of Incorporation	:	10th December 1996
100% subsidiary Company of	:	L G Chemicals India Private Limited CIN-U24290DL1996PTC081742
Registered office address	:	R R V Venkatapuram Visakhapatnam – 530029 Andhra Pradesh, India
Authorized Capital	:	₹ 130 crores
Paid-up capital	:	₹ 126,33,00,010/-

Table 1.1: Details of Directors[5]

S.No.	Name of the Director / Signatory	Director Identification Number (DIN)	Date of appointment
1.	Byungkeun Song	07544349	16.06.2016
2.	Poorna Chandra Mohan Rao Pitchuka	07761858	03.02.2017–24.06.2018 Again, appointed on 26.06.2018
3.	Ravinder Reddy Surukanti	DDCPS7763E	20.08.2016
4.	Chan Sik Chung	08111654	20.04.2018
5.	Sunkey Jeong	08348471	01.12.2018

[4] Source: Report of Shri. Subba Rao Tallapragada, Company Secretary on the request of HPC (Volume V: Annexure-5.15)

[5] Source: Ministry of Corporate Affairs

The Summary of the Balance sheet[6] of the Company as on 31st December 2018 is as given below:

Table 1.2

LG POLYMERS INDIA PRIVATE LIMITED
CIN: U25203AP1996PTC025917

(Rs/Million)

Particulars	01/01/2018 to 31/12/2018	01/01/2017 to 31/12/2017	01/01/2016 to 31/12/2016	01/01/2015 to 31/12/2015
Revenue from Operations	15,709.53	14,978.31	11,907.47	11,207.03
Other Income	143.80	341.31	202.00	221.22
Total Income	**15,853.33**	**15,319.62**	12,109.46	11,428.24
Expenditure	15,679.24	14,264.35	11,128.01	10,947.03
Profit Before Tax	174.09	1,055.27	981.45	481.22
Less: Current Tax				
Current Yeat	119.33	329.31	315.20	126.70
Previous Year	18.87	-		
Deferred Tax	(0.27)	42.70	27.08	39.06
Profit after Tax	36.16	683.26	639.17	315.46
Balance from PY	3,411.14	2,721.83	2,082.66	1,773.07
Remeasurement/Net Tax liability	7.85	6.05	-	5.87
Profit carried forward	**3,455.15**	**3,411.14**	**2,721.83**	**2,082.66**

Note: Revenue from operations relating to 2017 are disclosed as 14133.608 for statement filed in the year 2017. However, in the 2018 statement Revenue from operation of 2017was disclosed as 14978.31.

The Company obtained permission from the Company Law Board to prepare its accounts on a calendar year basis instead of a financial year basis. The Company filed its annual accounts and annual returns with the Registrar of Companies up to the calendar year 2018. Filing of the 2019 return is due. The details given above are from the annual return filed by the Company.

At present, LG Polymers is spread over a total area of 213 Acres and engaged in manufacturing of Polystyrene used for General Purpose Polystyrene(GPPS) & High Impact Polystyrene (HIPS) to

[6] The Annual reports of the years 2016, 2017 and 2018 (Volume V: Annexure-5.15) analysed by Venkata Ramana B. Nath, Chartered Accountant

the tune of 313 Tons per day, Expandable Polystyrene (EPS) to the tune of 102 Tons per day and Engineering Plastics 36.67 Tons per day. M/s LG Polymers is storing Styrene[7], Pentane and other raw materials within the plant premises.

The location of the Company in the Topo map (Fig 1.2) and Google Earth map (Fig 1.3) are shown as below:

Figure 1.2: Topo-map of LG Polymers

[7] Styrene is one of the most widely used monomers globally and has a variety of applications in the chemical industry to produce Polystyrene, Acrylonitrile-Butadiene-Styrene rubber, and many other polymers; it is also used as a starting material for some pharmaceutical intermediates, adhesives, coatings and textile auxiliaries.

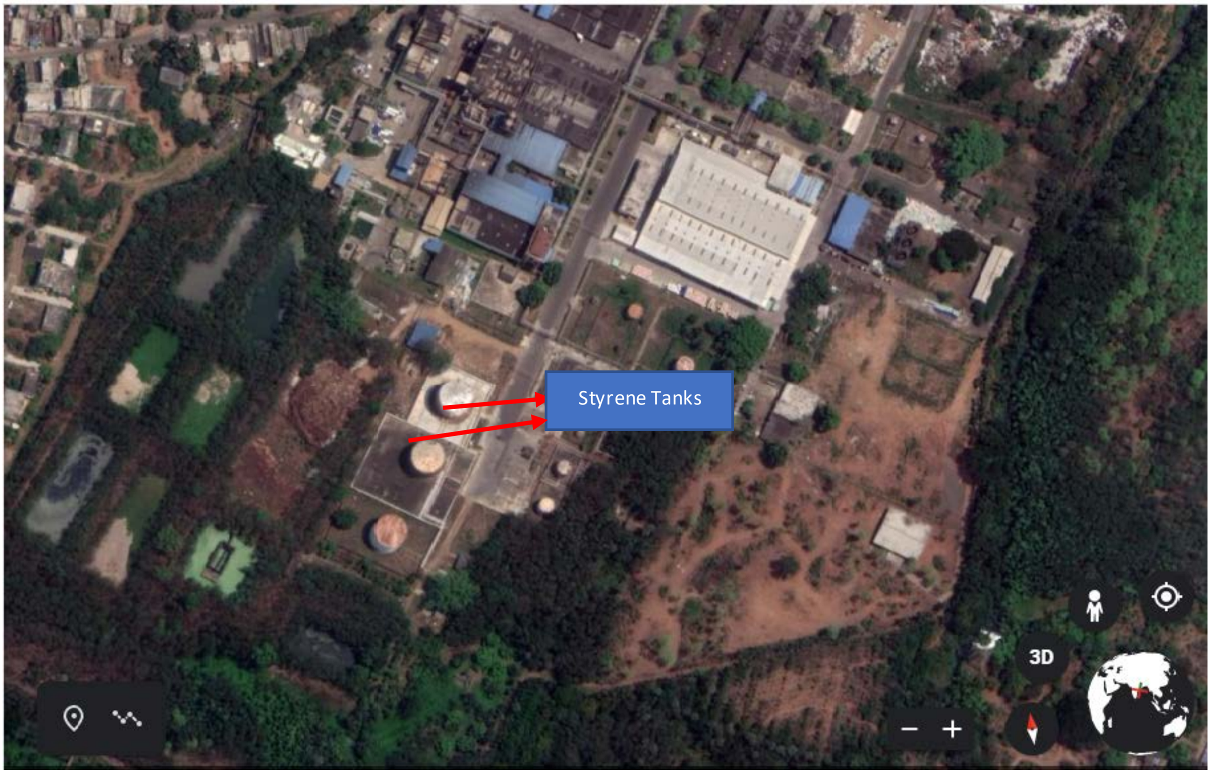


Figure 1.3: Google earth map of LG Polymers

Some of the major accidents that are related to Styrene production and handling are listed in Table 1.3:

Table 1.3: Accidents related to Styrene

Date	Location	Cause of the Accident	Consequences	
			Injury	Fatality
07/05/1994	Kaohsiung, Taiwan	Friction caused explosion in storage tank	0	1
01/26/1996	Chiayi, Taiwan	Electrical welding	1	0
01/21/1998	Kaohsiung, Taiwan	Truck collision	4	0
12/24/1998	Kanagawa, Japan	The temperature and pressure rise in a reactor caused the accident	0	0
06/27/1998	Channahon, IL, US	-	1	0
06/23/1999	Pasadena, TX, US	Explosion while performing hydrostatic test in Pipeline	21	2
10/06/1999	Chiayi, Taiwan	Sparking caused explosion	1	0
03/27/2000	Pasadena, TX, US	Cleaning of old tank	71	1
04/02/2003	Addyston, OH, US	Explosion of charged tank due to valve failure	0	1

Date	Location	Cause of the Accident	Consequences	
			Injury	Fatality
04/08/2004	Jiangsu, China	-	8	6
06/03/2005	Mesa, AZ, US	Cutting of empty barrel having traces of Styrene	0	1
25/8/2005	Styrene Rail Tanker, Cincinnati, Ohio, USA	Stationary railroad tank	0	1

1.2 The High Power Committee

On 8th May 2020, the Government of Andhra Pradesh constituted a 5-member High Power Committee (the Committee). Subsequently, 4 members from Government of India were also included as members. The Terms of reference of the Committee are:

a. The Committee shall enquire on reasons for the leakage, including verifying if the Company had adhered to all safety protocols;

b. The Committee shall study if there are long-term effects of the gas leakage on the surrounding villages, if any;

c. The Committee shall recommend proposed action to be taken against the Unit by the Government, in case of any negligence on the vapour leak incident in Visakhapatnam;

d. The Committee will suggest measures to be taken by industry units, including safety audits, to prevent such mishaps in future;

e. In case there are any observations and suggestions for all similar industrial plants, those too shall be communicated in the report.

1.3 The Methodology adopted by the Committee

The Committee toured Visakhapatnam twice for visiting the accident site and to have extensive discussions with all the stakeholders. The committee interacted with a number of stakeholders on both the visits. The committee inspected the records available, analyzed the information gathered, verified all the correspondences and press reports. The committee also thoroughly examined the report of Technical Experts, CBRN of NDRF, CSIR-NEERI, APPCB and all others who have done detailed study in different domains.

The Committee visited the accident spot and carefully examined the Company premises along with the Director, IIP, Dehradun and Industry Expert. A detailed examination was done at the storage tank site, the control room and the factory premises. Discussions were also held with the top officials available in the factory covering all aspects of the accident and subsequent events.

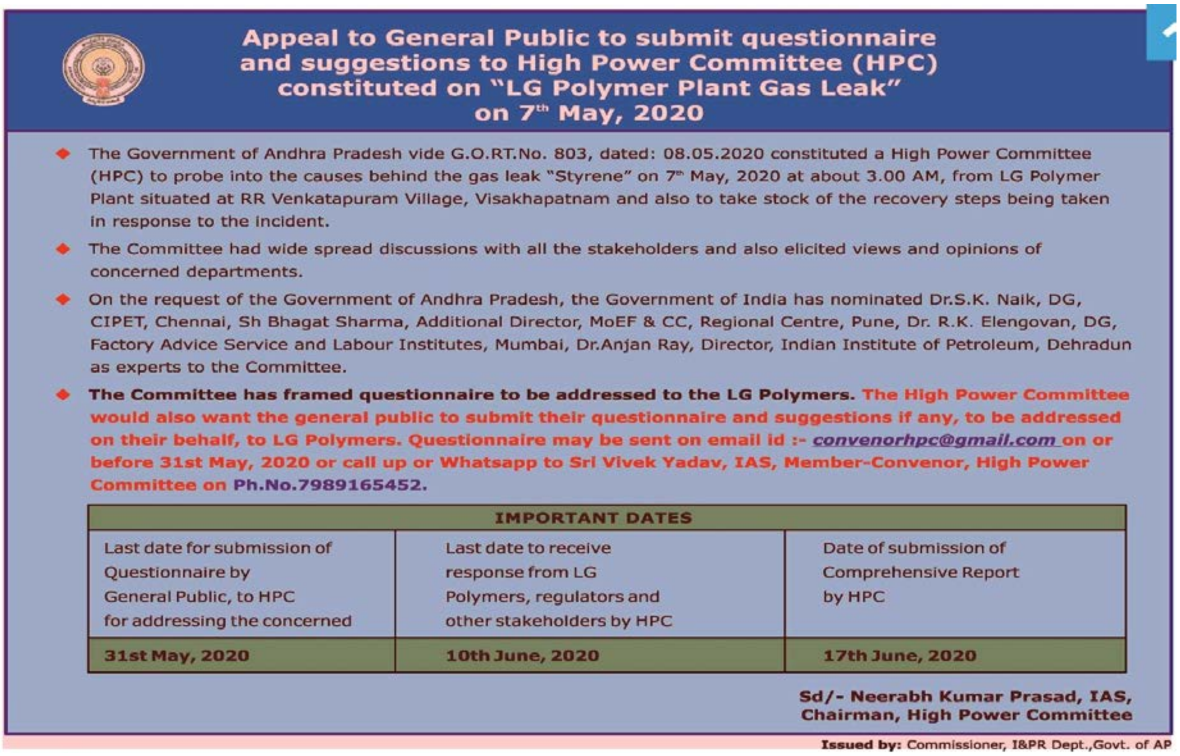
Figure 1.4: Members of The Committee visiting the plant (1)

Figure 1.5: Members of The Committee visiting the plant (2)

The Committee heard and held discussions with eyewitnesses, NGOs, environmentalists, public health activists, the industry associations like CII, AP Chapter, FAPCI, Federation of Andhra Pradesh Small and Medium Industries Association, AP Chambers of Commerce & Industry Federation. The views and opinions of all concerned regulatory departments like Greater Visakhapatnam Municipal Corporation (GVMC), Visakhapatnam Municipal Regional Development Authority (VMRDA), Factories Department, Petroleum and Explosives Safety Organisation (PESO), Boilers Department, Andhra Pradesh Pollution Control Board (APPCB), General Manager, District Industries Centre (GM, DIC), Joint Director Labour, District Fire Officer. The Committee also had detailed discussions with the relief and rescue teams and medical experts.

A 3-member Technical Committee was constituted comprising of experts from Visakhapatnam viz. Prof. VSRK Prasad, Director, Indian Institute of Petroleum and Energy, Vishakhapatnam, Prof. S. Bala Prasad, Department of Civil Environmental Engineering, Andhra University, Vishakhapatnam and Prof. KV Rao, Former Professor, Andhra University, Vishakhapatnam to aid and advice on technical matters.

The Committee examined all the records available, analysed the information gathered, verified all the correspondences, media coverage, expert opinions and also held detailed deliberations on 22nd May 2020. The Committee decided to widen the scope of stakeholder's involvement in the process of examination by issuing a press notification in the leading newspapers for taking inputs or questions from all interested persons/organizations by email, phone calls and messages by 31st May 2020.



Appeal to General Public to submit questionnaire and suggestions to High Power Committee (HPC) constituted on "LG Polymer Plant Gas Leak" on 7th May, 2020

- The Government of Andhra Pradesh vide G.O.RT.No. 803, dated: 08.05.2020 constituted a High Power Committee (HPC) to probe into the causes behind the gas leak "Styrene" on 7th May, 2020 at about 3.00 AM, from LG Polymer Plant situated at RR Venkatapuram Village, Visakhapatnam and also to take stock of the recovery steps being taken in response to the incident.
- The Committee had wide spread discussions with all the stakeholders and also elicited views and opinions of concerned departments.
- On the request of the Government of Andhra Pradesh, the Government of India has nominated Dr.S.K. Naik, DG, CIPET, Chennai, Sh Bhagat Sharma, Additional Director, MoEF & CC, Regional Centre, Pune, Dr. R.K. Elengovan, DG, Factory Advice Service and Labour Institutes, Mumbai, Dr.Anjan Ray, Director, Indian Institute of Petroleum, Dehradun as experts to the Committee.
- **The Committee has framed questionnaire to be addressed to the LG Polymers. The High Power Committee would also want the general public to submit their questionnaire and suggestions if any, to be addressed on their behalf, to LG Polymers. Questionnaire may be sent on email id :- convenorhpc@gmail.com on or before 31st May, 2020 or call up or Whatsapp to Sri Vivek Yadav, IAS, Member-Convenor, High Power Committee on Ph.No.7989165452.**

IMPORTANT DATES		
Last date for submission of Questionnaire by General Public, to HPC for addressing the concerned	Last date to receive response from LG Polymers, regulators and other stakeholders by HPC	Date of submission of Comprehensive Report by HPC
31st May, 2020	**10th June, 2020**	**17th June, 2020**

Sd/- Neerabh Kumar Prasad, IAS,
Chairman, High Power Committee

Issued by: Commissioner, I&PR Dept.,Govt. of AP

Figure 1.6: Press Release

The Committee on its second visit to Visakhapatnam had detailed discussions with the Technical Committee on their interim report and the Director of Factories[8] on issues related with Factories Act 1948, Manufacture, Storage, Import of Hazardous Chemical Rules, 1989 and Chemical Accidents (Emergency Planning, Preparedness and Response) Rules 1996. The Committee also interacted with Petroleum and Explosives Safety Organization (PESO)[9] on the Explosive licenses and implementation of Manufacture, Storage, Import of Hazardous Chemical Rules 1989. The Committee was privileged to interact with the expert members of the Committee constituted by Hon'ble NGT viz., Prof, Ch.V. Rama Chandra Murthy, Retired Professor, Andhra University, Vishakhapatnam and Prof. P. Jagannadha Rao, Department of Chemical Engineering, Andhra University.

[8] Details of the discussion with Direct of Factories is provided (Volume V: Annexure-5.5)
[9] Details of the meeting with PESO is provided (Volume III: Annexure-3.3)

The Committee met the affected people from Venkatadri Garden, Venkatapuram, Kamparapalem, Padmanabhanagar, Nandamuri Nagar, Srinagar and R. Venkatapuram[10]. The Committee also met representatives of recognized National / State level political parties[11] in Visakhapatnam District and media representatives[12]. The Committee also met the first responders from all the departments and ascertained their first-hand account.

The Committee, in the presence of the Technical Committee, held detailed enquiry about the Styrene vapour release with the management representatives of LG Polymers[13]. The following officials from LG Polymers attended:

1. Sri Sunkey Jeong, Managing Director
2. Sri P.P.C Mohan Rao, Director (Operations)
3. Sri Hyun Seok Jang, Chief Financial Officer
4. Sri G. Raju, GM (Production)
5. Sri P. Arun Kumar, Deputy Manager
6. Sri Hyun Cheol Cha, Translator

The Committee enquired with the management representatives of LG Polymers on all issues of concern regarding the accident

1.4 Report and the Annexures

The Technical Committee provided assistance to this Committee and submitted a detailed report on all the technical aspects. Further, the LG Polymers submitted detailed reply to the questionnaires on various dates, the last on 20th June 2020. All the reports received by this Committee from various departments, representations from stakeholders, NGO's and public, the press reports are voluminous and have been arranged volume-wise for easy reference.

[10] Details of the meeting with the residents of villages provided (Volume IV: Annexure-4.2)
[11] Details of the meeting with political representatives provided (Volume IV: Annexure-4.2)
[12] Details of the meeting with media representatives provided (Volume IV: Annexure 4.4)
[13] Details of the meeting with Company representatives provided (Volume III: Annexure 3.5)

All through this report, any reference to the papers in those documents have been referred by giving the Volume number and Annexure details. There are certain annexures, the Committee felt are important and have been included in this main report.

Details of the reports along with their annexures are given below.

- Volume I: Technical Committee Report
- Volume II: LG Polymers Replies and Reports

  Part A: Annexures 01- 60

  Part B: Annexures 61- 70

  Part C: Annexures 71- 95

  Part D: Annexures 96- 97
- Volume III: Departmental and Stakeholder Consultation
  a) Meeting with all regulatory Departments on 10.05.2020 at GVMC meeting Hall, Visakhapatnam
  b) Meeting with teams participated in relief operations and experts on 11.05.2020 at Collector Office, Visakhapatnam
  c) Record of Discussion with Petroleum and Explosives Safety Organization (PESO) on 06.06.2020 at Hotel Novotel, Visakhapatnam
  d) Record of discussions with NGT Committee experts & Discussion on APPCB report on 06.06.2020 at Hotel Novotel, Visakhapatnam
  e) Record of Discussions with representatives of M/s LG Polymers India (P) Ltd., on 07.06.2020 at Hotel Novatel, Visakhapatnam
  f) Record of discussion with VMRDA & GVMC officials on the location of Red category industries / GIS Maps in GVMC area on 08.06.2020 at GVMC Meeting Hall, Visakhapatnam
  g) Record of discussions with the first response team of the incident (Police, Health, Revenue) on 08.06.2020 at GVMC Meeting Hall, Visakhapatnam
- Volume IV: Interaction with Public, Media and NGOs

a) Meeting with representatives of NGOs, Industrial Associations, Experts on 10.05.2020 at GVMC meeting Hall, Visakhapatnam
b) Public consultation with people of affected villages on 07.06.2020 at GVMC Meeting Hall, Visakhapatnam
c) Record of discussions with the representatives of recognized National / State level Political Parties in Visakhapatnam District on 07.06.2020 at GVMC Meeting Hall, Visakhapatnam
d) Interaction held with representatives of Print and Electronic Media on 08.06.2020 at GVMC Meeting Hall, Visakhapatnam
e) Record of discussions with Environmentalists
f) List of Press reports related to the Styrene vapour release incident in LG Polymers India Pvt. Ltd. (LG Polymers), Visakhapatnam
g) Public Questions through emails and WhatsApp

- Volume V: Internal Discussions

a) Meeting chaired by Chief Secretary on 09.05.2020 at Collector Office, Visakhapatnam
b) Interaction with Experts on 09.05.2020 at Hotel Novotel, Visakhapatnam
c) Visit to M/s LG Polymers (I) Pvt. Ltd., on 10.05.2020
d) Meeting in the chambers of Sri Neerabh Kumar Prasad, Spl CS, EFS&T with Collector, Visakhapatnam and Commissioner of Police, Visakhapatnam participated through Tele Conference on 22.05.2020.
e) Record of discussions with Technical Committee on 06.06.2020 at Hotel Novotel, Visakhapatnam
f) Record of the discussions of the video conference held on 20.06.2020 at APPCB, Vijayawada to discuss the causes behind the incident and followed by presentation by VMRDA.
g) Report of the Joint Monitoring Committee constituted by the Hon'ble National Green Tribunal vide Order O.A.No. 73 of 2020, Dated 28.05.2020
h) Report dated 14.05.2020 furnished by Assistant Director of Horticulture, Horticulture Department, GoAP

i) Report dated 29.05.2020 furnished by the Animal Husbandry Department, GoAP

j) Report dated 01.06.2020 furnished by the Joint Director, Agriculture Department, GoAP

k) Report dated 03.06.2020 furnished by PCCF, Forest Department, GoAP

l) Report dated 03.06.2020 furnished by CCF, Forest Department, GoAP

m) Report dated 05.06.2020 furnished by Commissioner of Agriculture, Agriculture Department, GoAP

n) Report dated 09.06.2020 furnished by the Assistant Director of Horticulture, Horticulture Department, GoAP

- Volume VI: Reports submitted by regulatory bodies
- Part A – Reports of Collector, Commissioner of Police, AP State Disaster Response and Fire Services Department, AP State Disaster Management Authority, Factories Department, Petroleum and Explosives Safety Organization (PESO), Boilers Department, Labour Department, Department of Industries
- Part B - Andhra Pradesh Pollution Control Board (APPCB)
- Part C – State Environment Impact Assessment Authority (SEIAA), VMRDA, GVMC and DTCP

2.0 Reasons for the release of Styrene Vapour in LG Polymers India Pvt. Ltd.

The first term of reference of the Committee is to enquire into the reasons for leakage including verifying if the company had adhered to all the safety protocols.

The Committee observed from the various inputs received that there are number of contributory factors which led to the accident. During the deliberations, the Committee noted the following quote of Trevor A. Kletz "A case history shows that an accident generally does not have one cause, but many, and that, the deeper we go, the more causes we find."[14]

2.1 Background[15]

The factory is situated at R.R. Venkatapuram, Visakhapatnam in Andhra Pradesh and it was registered under Factories Act in the year 1967 in the name of "**Hindustan Polymers Ltd.**" for manufacturing Polystyrene and its Co-polymers at Visakhapatnam. It was merged with Mc Dowell & Co. Ltd. of UB Group in 1978. Later it was taken over by LG Chemicals India under the umbrella of LG Chem (South Korea) and it was renamed as **LG Polymers India Private Limited (LG Polymers)** in July 1997. Presently, LG Polymers is one of the leading manufacturers of Polystyrene and Expandable Polystyrene in India. The range of products being manufactured are:

1. General Purpose polystyrene (GPPS)
2. High Impact Polystyrene (HIPS)
3. Expandable Polystyrene (EPS)
4. Engineering Plastics Compounds

[14] Trevor A. Kletz, Accident Investigation: How Far Should We Go? Plant/Operations Progress (Vol. 3, No.1) January 1984

[15] The Director of Factories has given a detailed report on the Factory & the properties of the Styrene, which is available in Volume – 6

Major Raw Materials:

a) Styrene Monomer
b) Ethyl Benzene
c) Pentane

2.1.1 Understanding the manufacturing process

a) GPPS is produced by continuous bulk polymerisation of Styrene monomer with addition of other chemicals such as, optical whitener, zinc stearate and benzoyl peroxide. The final polymer product is extruded and palletized to cylindrical solid granules in USG system. The unused Styrene recycles back into the process.
b) In EPS production, the raw materials are proportioned, subjected to reaction at 90°C and continuously stirred until desired bead size is obtained. Pentane is added into beads and after cooling, the reactor mass is transferred to acidification tank to be treated with hydrochloric acid (HCl). Post treatment slurry is made and centrifuged to produce EPS beads, which are further screened for separation into different sizes. Finally, the beads are coated and packed.
c) HIPS is produced by continuous bulk polymerisation of Styrene monomer with Poly Butadiene Rubber in presence of Ethyl Benzene and pelletized to cylindrical solid granules in USG system.
d) Engineering plastic compounds process consists of mixing, blending of different plastic base resins, fillers and additives with high temperature extrusion. Base polymer resins are mixed with additives. After completion of mixing cycle of 15 to 20 mins, it will be fed to the extruder along with fillers, glass fibre and talc to produce pellets.

2.1.2 Some properties of Styrene

- Colourless liquid at normal temperature
- Highly Flammable with Explosive range: 1.1 to 7%
- Flash point: 31°C
- Boiling point: 145°C

- Density: 0.906 g/mL at 20 °C; Vapor Density :3.6 (air -1)
- Threshold Limit Value (TLV) for 8 hours a day: 50 ppm; Short-term Exposure Limit (STEL) of maximum 15 minutes: 100 ppm; Immediate Danger to Life & Health (IDLH): 700 ppm
- Causes severe eye, skin and respiratory irritation, CNS depression, nausea, vomiting etc. on short term exposure
- Highly reactive and can polymerise (which is an exothermic reaction)
- The rate of polymerisation increases with increase in temperature and results in runaway reaction at 65°C
- Polymerisation is controlled in normal circumstances by adding low temperature inhibitor substance like p-tert-butyl catechol (TBC). At higher temperatures, only high temperature inhibitors like Tertiary Dodecyl Mercaptan (TDM) and n-dodecyl mercaptan (NDM) etc. can inhibit the polymerisation of Styrene

2.1.3 Styrene Monomer storage M6 Tank involved in the accident

As informed, this tank was originally constructed by Hindustan Polymers Ltd. It is also informed that it was initially used for storing Molasses from 1967. Later it was converted as Styrene storage tank. The PESO authorities at Visakhapatnam confirmed that the plan of this tank was approved and the license for filling this tank were accorded by PESO under Petroleum Act & Rules in 1977 vide P/HQ/AP/15/40(3488) on 1st January 1977.

2.1.4 Activities During the Lockdown

a) It is reported that before the Covid-19 lockdown was imposed, the manufacturing activities were carried out normally. Owing to the lockdown, the factory was shut down on the intervening night of 24th / 25th March 2020.

b) For the maintenance of the plant during the lockdown period, LG Polymers had applied permission for 60 persons, of which they received permission to engage 45 persons (at the rate of 15 per shift) by the district administration.

c) All the factories except those in containment zones were relaxed from the Covid-19 lockdown w.e.f 4th May 2020 and allowed to resume operations. The management had proposed to undertake the restart of the factory from 7th May 2020. LG Polymers stated that as per the Covid-19 protocol, they carried out activities like cleaning, sanitization, disinfestation etc. between 4th to 6th May 2020. The Director of Boilers also reported that test run of one of the boilers was conducted by LG Polymers on 6th May 2020.

d) Regular day to day activities were undertaken on 6th May 2020 at LG Polymers. The refrigeration of Styrene storage tanks M5 & M6 was stopped around 03.45 p.m. All the other activities in Styrene Monomer Handling (SMH) area were also closed by 05:00 p.m., with chiller outlet temperature of Styrene reported as 11°C and M6 Tank temperature reported as 17.4°C.

2.1.4.1 Sequence of events of the accident

In the early hours of 7th May 2020, the Styrene storage M6 Tank with 1937 MT storage had started uncontrolled release of Styrene vapors from the top of the tank through the Flame arrestor / Vent (N6) and Dip hatch vent (N1), which spread beyond the factory boundary, affecting the neighboring areas & habitations.

The major sequence of events regarding the alarms of the accident is submitted below in chronological order.

- 02:31 a.m.: No Styrene vapour release captured in the CCTV Figure 2.1

Figure 2.1

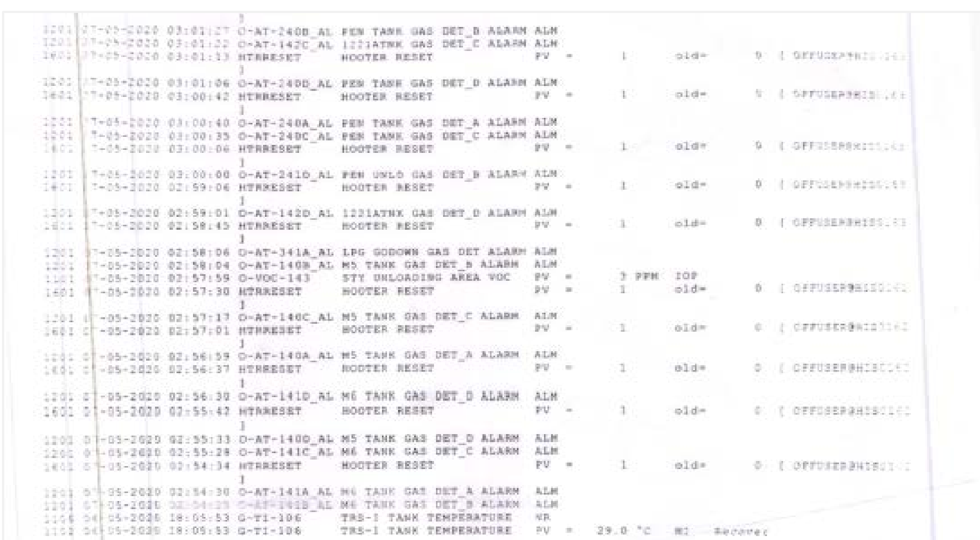
- 02:42 a.m.: Styrene vapour release captured in the CCTV Figure 2.2

Figure 2.2

- 02:53 a.m.: Styrene vapour cloud formation captured in the CCTV (Figure 2.3)

Figure 2.3

- 02:54 a.m.: Gas detector alarm noticed in Distributed Control System (DCS)



```
1201 07-05-2020 03:01:27 O-AT-240B_AL PEN TANK GAS DET_B ALARM ALM
1201 07-05-2020 03:01:22 O-AT-142C_AL 1221ATNK GAS DET_C ALARM ALM
1601 07-05-2020 03:01:13 HTRRESET     HOOTER RESET             PV  =   1   old=   0  [ OFFUSER@HI
1201 07-05-2020 03:01:06 O-AT-240D_AL PEN TANK GAS DET_D ALARM ALM
1601 07-05-2020 03:00:42 HTRRESET     HOOTER RESET             PV  =   1   old=   0  [ OFFUSER@HI
1201 07-05-2020 03:00:40 O-AT-240A_AL PEN TANK GAS DET_A ALARM ALM
1201 07-05-2020 03:00:35 O-AT-240C_AL PEN TANK GAS DET_C ALARM ALM
1601 07-05-2020 03:00:06 HTRRESET     HOOTER RESET             PV  =   1   old=   0  [ OFFUSER@HI
1201 07-05-2020 03:00:00 O-AT-241B_AL PEN UNLD GAS DET_B ALARM ALM
1601 07-05-2020 02:59:06 HTRRESET     HOOTER RESET             PV  =   1   old=   0  [ OFFUSER@HI
1201 07-05-2020 02:59:01 O-AT-142D_AL 1221ATNK GAS DET_D ALARM ALM
1601 07-05-2020 02:58:45 HTRRESET     HOOTER RESET             PV  =   1   old=   0  [ OFFUSER@HI
1201 07-05-2020 02:58:06 O-AT-341A_AL LPG GODOWN GAS DET ALARM ALM
1201 07-05-2020 02:58:04 O-AT-140B_AL M5 TANK GAS DET_B ALARM  ALM
1101 07-05-2020 02:57:59 O-VOC-143    STY UNLOADING AREA VOC   PV  =   3 PPM  IOP
1601 07-05-2020 02:57:30 HTRRESET     HOOTER RESET             PV  =   1   old=   0  [ OFFUSER@HI
1201 07-05-2020 02:57:17 O-AT-140C_AL M5 TANK GAS DET_C ALARM  ALM
1601 07-05-2020 02:57:01 HTRRESET     HOOTER RESET             PV  =   1   old=   0  [ OFFUSER@HI
1201 07-05-2020 02:56:59 O-AT-140A_AL M5 TANK GAS DET_A ALARM  ALM
1601 07-05-2020 02:56:37 HTRRESET     HOOTER RESET             PV  =   1   old=   0  [ OFFUSER@HI
1201 07-05-2020 02:56:30 O-AT-141D_AL M6 TANK GAS DET_D ALARM  ALM
1601 07-05-2020 02:55:42 HTRRESET     HOOTER RESET             PV  =   1   old=   0  [ OFFUSER@HI
1201 07-05-2020 02:55:33 O-AT-140D_AL M5 TANK GAS DET_D ALARM  ALM
1201 07-05-2020 02:55:28 O-AT-141C_AL M6 TANK GAS DET_C ALARM  ALM
1601 07-05-2020 02:54:34 HTRRESET     HOOTER RESET             PV  =   1   old=   0  [ OFFUSER@HI
1201 07-05-2020 02:54:30 O-AT-141A_AL M6 TANK GAS DET_A ALARM  ALM
1201 07-05-2020 [illegible] O-AT-141B_AL M6 TANK GAS DET_B ALARM  ALM
1106 04-05-2020 18:05:53 G-TI-106     TRS-I TANK TEMPERATURE   NR
1102 04-05-2020 18:05:53 G-TI-106     TRS-I TANK TEMPERATURE   PV  =  29.0 °C   HI   Recover
```

Figure 2.4: Abstract of DCS Record

It may be noted that the Gas Detector Alarm was set at 2200 ppm. This setting is discussed in detail in Chapter 3.

- 03:01 a.m.: Sudden spike in Styrene level in M6 Tank Figure 2.5

Figure 2.5: DCS log for level and temperature in M6 Tank

- 03:02 a.m.: M6 Tank temperature started rising rapidly, refer figure 2.5 above
- 03:04 a.m.: The premises covered with dense Styrene vapour cloud

Figure 2.6

- 03:15 a.m.: The premises covered with dense Styrene vapour cloud

Figure 2.7

From the above the Committee noted that from 02:42 a.m. (CCTV time) onwards, Uncontrolled Styrene Vapour Release occurred from the M6 Tank. The further actions are covered in chapter 3 dealing with Emergency Response.

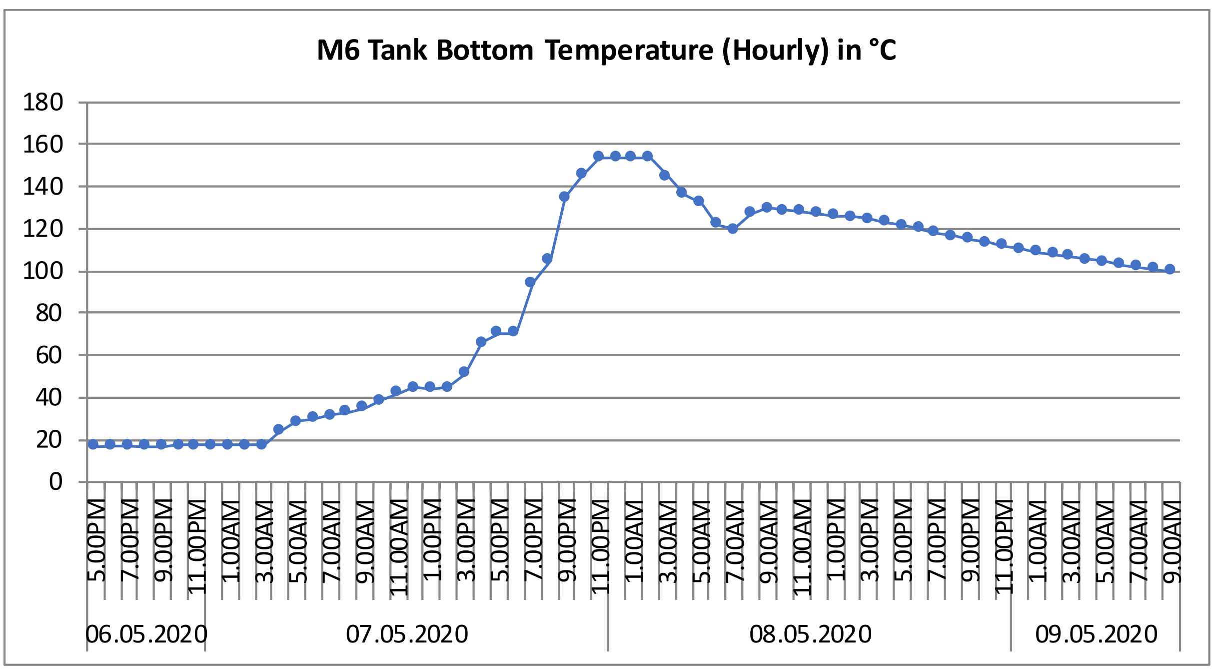
All the times recorded are as per the respective source equipment viz CCTV, DCS. It was reported by the factory management representatives before the High-Power Committee that there was an approximate 12 minutes lag in the time settings between CCTV camera and the DCS as well as about 4 minutes lag between DCS and Indian Standard Time (IST).

The Committee observed that the difference of time between the CCTV camera time, the DCS time and the IST time can be checked by running the two equipment together and calibrating it with the IST. However, this is not possible at present as the factory has been closed. The Committee noted that this version of company may only be an excuse for explaining for the delay in the recording times. For e.g. the CCTV has recorded vapour release at 02:42 a.m. while the DCS data records the gas detector alarm at 02:54 a.m. Thus, the company is trying to explain the 12 min gap as difference in timings between the CCTV time and the DCS time. This may not be true as the Styrene vapour was released from the top of the tank while the gas detector is not at the top of the tank, but on the four sides of the tank nearly at ground level (300 mm from the ground).

There is certain to be a time gap between the release at the top of the tank and the detection at the bottom as the Styrene vapour would have taken some time to settle down. Further, the gas detector was not sensitive enough to detect the gas immediately as the gas detector alarm was tuned for 2200 ppm (20% of the LEL value). Hence, it appears that the company is trying to explain the shortcomings of the gas detector by explaining in terms of time gap, which may not be true. However, this issue is not dealt further, as it does not take away the fact that whether at 02:42 a.m. or at 02:54 a.m. or any time in between, there was an uncontrolled Styrene release from the M6 Tank.

2.2 Reasons for uncontrolled release of Styrene vapour in LG Polymers

The temperature recorded in the M6 Tank from 05:00 p.m. of 6th May 2020 to 09:00 a.m. of 9th May 2020, by the DCS is placed in Annexure 2.1 of this report. The data is shown graphically below:



Graph 2.1: Temperature Profile

It is evident from the temperature graph 2.1 above that the temperature probe was by and large stable below 20°C until about 03:00 a.m. of 7th May 2020 and started increasing thereafter. The rise in temperature was sudden and occurred at a fast rate. The rate of increase of temperature slightly reduced between 05:00 a.m. to 09:00 a.m. and thereafter again started increasing. From 03:00 p.m. there was a further increase in the rate and finally the temperature peak of 153.7°C was recorded at about 10:00 p.m. The Technical Committee has estimated that the boiling temperature of Styrene monomer is 153.7°C at 1.25 atm. This also indicates that the pressure of 1.25 atm developed in the M6 Tank due to limited sized vents, which led to uncontrolled Styrene vapour release. There is a flat line between the time 10:00 p.m. of 7th May 2020 to about 3:00 a.m. of 8th May 2020, implying that the temperature remained constant. This issue can be investigated later in the forensic audit whether the probe could measure any temperature beyond 153.7°C. The temperature in the tank started reducing from 03:00 a.m. of 8th May 2020 and as per data in Annexure 2.2, the temperature reduced to 58.8°C at 7:00 a.m. on 16th May 2020.

The Technical Committee also obtained the M6 Tank surface temperature profile of M6 Tank on 8th May 2020 from the LG Polymers and the data is shown in the table 2.1 below:

Table 2.1: M6 Surface Tank Temperature in °C (on 8th May 2020)

Hours	19:00	21:00	23:00	01:00	03:00	05:00	07:00	09:00
Bottom	49.0	44.1	40.0	43.2	33.0	31.6	36.9	43.7
↓	65.1	55.0	50.4	45.8	44.8	43.0	44.6	45.7
	81.1	75.1	56.0	63.2	53.0	51.8	56.1	62.2
	93.2	91.0	72.3	74.8	60.0	61.5	68.2	74.6
Top	95.0	91.4	73.0	75.4	58.0	58.1	65.4	71.7

It is evident from the above table that the outside surface temperature profile of M6 Tank also showed high temperatures even on the 8th of May. It is also to be noted that the top-level temperatures on the surface on M6 Tank was much higher than the bottom level temperatures. Therefore, the Committee observed that it is abundantly clear that the uncontrolled release of Styrene vapour from M6 Tank was due to the high increase in temperatures in the M6 Tank. The increase in temperatures led to polymerisation and the heat generated due to polymerisation finally led to runaway reactions. Increase in temperature to the boiling point of Styrene monomer viz 145°C led to the boiling of the liquid Styrene, leading to uncontrolled vapour formation. Further increase in temperature led to increase in the pressure of the vapour which led to the uncontrolled release of vapour from the vents into the atmosphere. Why did the temperature increase; Why did the polymerisation take place; are further mentioned in the following paragraphs.

It is also important to note that M6 Tank was insulated. This implies that the heat generated in the M6 Tank was by and large not transmitted outside. The insulation was reported to be partially stripped as a part of the emergency response measures to enable faster cooling of the M6 Tank after the accident. Accordingly, the outside surface temperatures were only recorded much later after the accident. The Technical Committee has also examined the outside surface temperature of the M6 Tank on 8th May 2020, as furnished by the company in Table 2.1 of the report.

Analysis of previous Styrene related accidents

The determination of the root cause of the Styrene vapour release needs knowledge and analysis of previous accidents. **From the records compiled on similar accidents and literature available, it is understood that accidents occurring due to runaway reactions are limited and in most of those accidents, runaway reaction had resulted in explosion of the tank.** The LG Polymers Styrene vapour release from a bulk storage tank is a unique and exclusive accident. The only accident, called as Cincinnati Styrene Release, on 28th August 2005, from a rail tanker containing about 80 MT of Styrene, has been reported before. It was stated in the report – “The safety valve had opened to release excessive pressure build up, slowly avoiding a catastrophic explosion”. The error was that the stationary rail car was allowed for nine months, during which time the inhibitor became depleted and possibly the temperature increased due to ambient heat. The increase in pressure was attributed to heat generated within the tank due to polymerisation of the Styrene monomer within the tank. The Styrene vapour release from a bulk storage tank is unique and therefore, it is very important to investigate the accident thoroughly and bring out the causes of the uncontrolled Styrene vapour release.

The Technical Committee has followed the Guidelines for Investigating Process Safety Incidents issued by the "Centre for Chemical Process Safety, American Institute of Chemical Engineers (AIChE)" for the root cause analysis. The Technical Committee Report (Volume - I) is a detailed report in the matter and may be read as a part and parcel of this report.

Parameters that contributed to the calamitous accident

All the factors/parameters have been analysed to arrive at the root cause of uncontrolled Styrene vapour release from the M6 Tank of LG Polymers. The parameters that influenced the increase of temperature of Styrene in the tank (M6) are categorized into the following sub-heads: 1) Tank Design, 2) Tank Temperature Measurement and Control, 3) Recirculation and Refrigeration System, 4) Inhibitor Addition Protocols, 5) Polymerisation & Runaway reaction. Later the Committee has also mentioned about the lockdown period and the human resource quality.

2.2.1 Tank Design

The M6 Tank is made of mild steel without any inside lining and insulated outside. The details of the tank, as per license issues by PESO is as follows in Table 2.2.

Table 2.2: Details of M6 Tank

Identification No	1267(M6)
Tank Size	Dia: 18.002 Mtrs. Height: 12.15 Mtrs.
Total Capacity – KL	3090.96
Operating Capacity – KL/MT	2450 / 2200
Product	Styrene Monomer
Class of Petroleum	"B"
License No & Date	P/HQ/AP/15/40 (P3488)
License Expiry Date	31.12.2021

The figure 2.8 below provides the plan and view from the east of the M6 Tank.

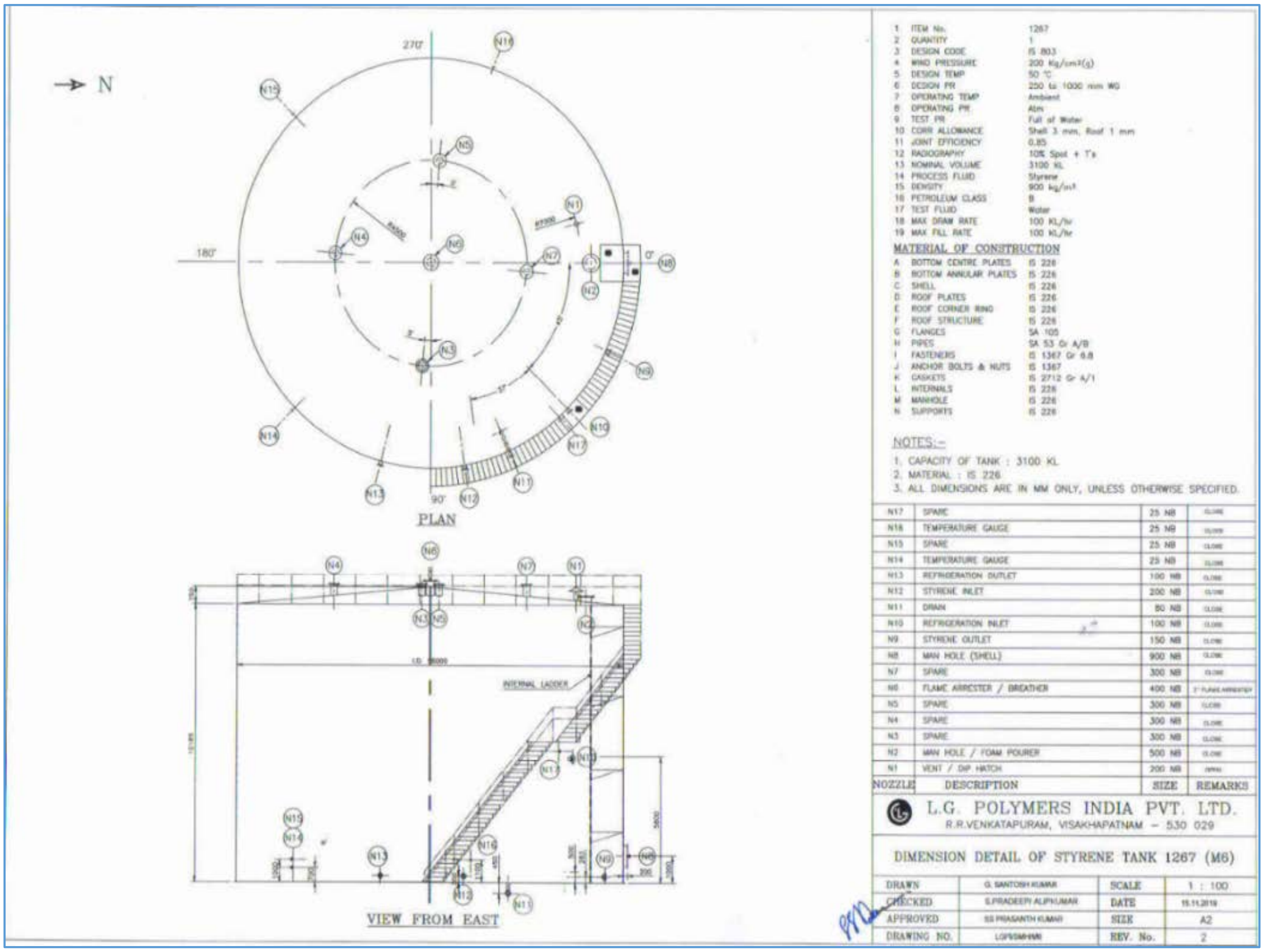


Figure 2.8: M6 Tank Drawing

The M6 Tank designs along with the legend is shown above in figure 2.8. As can be seen, it operates under atmospheric pressure and has a Flame Arrestor / Vent (N6) and a Vent / Dip hatch (N1). In addition, there is a manhole / foam pourer (N2). There are a total of 17 nozzles in the M6 Tank and the nozzle schedule and the roof top of M6 Tank is at Appendix – B of the Technical Committee Report (Volume – I).

The photograph of the top of the tank, showing N1: Vent / Dip Hatch (S.No. 1 below), N6: Flame Arrestor / Vent (S.No. 2 below) and N2: Manhole / Foam Pourer (S.No. 3 below) is as below in Figure 2.9.

Figure 2.9: Roof Top of M6 Tank Showing Vents

The Process Flow Diagram (PFD) of the M6 Tank and M5 tank is as below.

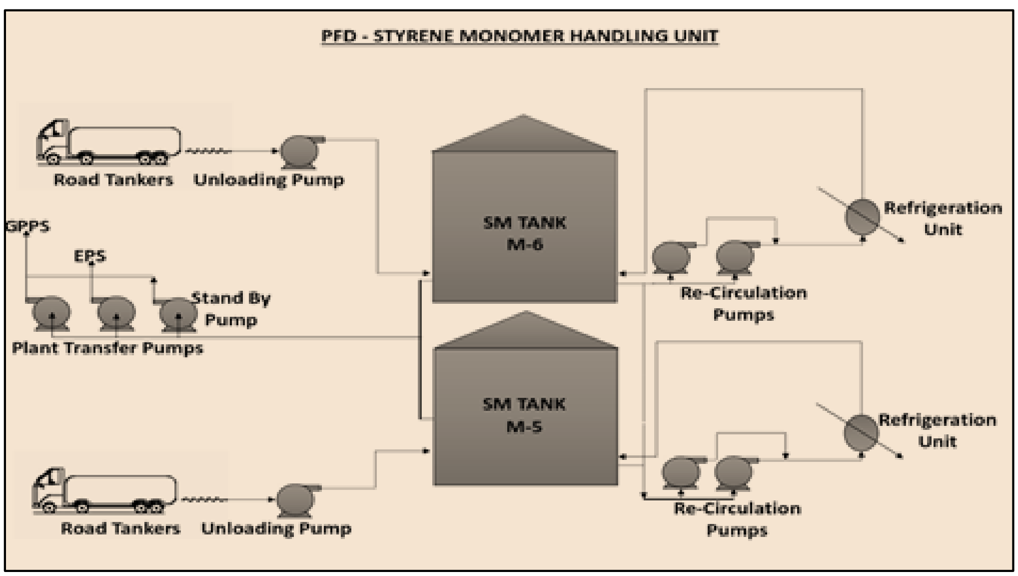


Figure 2.10: Styrene Handling Plant

A recirculating system with a pump, with a capacity of 30 m^3/hr is provided for in the tank. Further, a dedicated refrigeration unit of capacity 38 TR forms part of recirculation loop to cool the Styrene. **The design range of temperature** for cooling Styrene by the refrigeration unit was given between 40°C to 20°C. But it was being used to cool the Styrene from 25°C to 17°C.

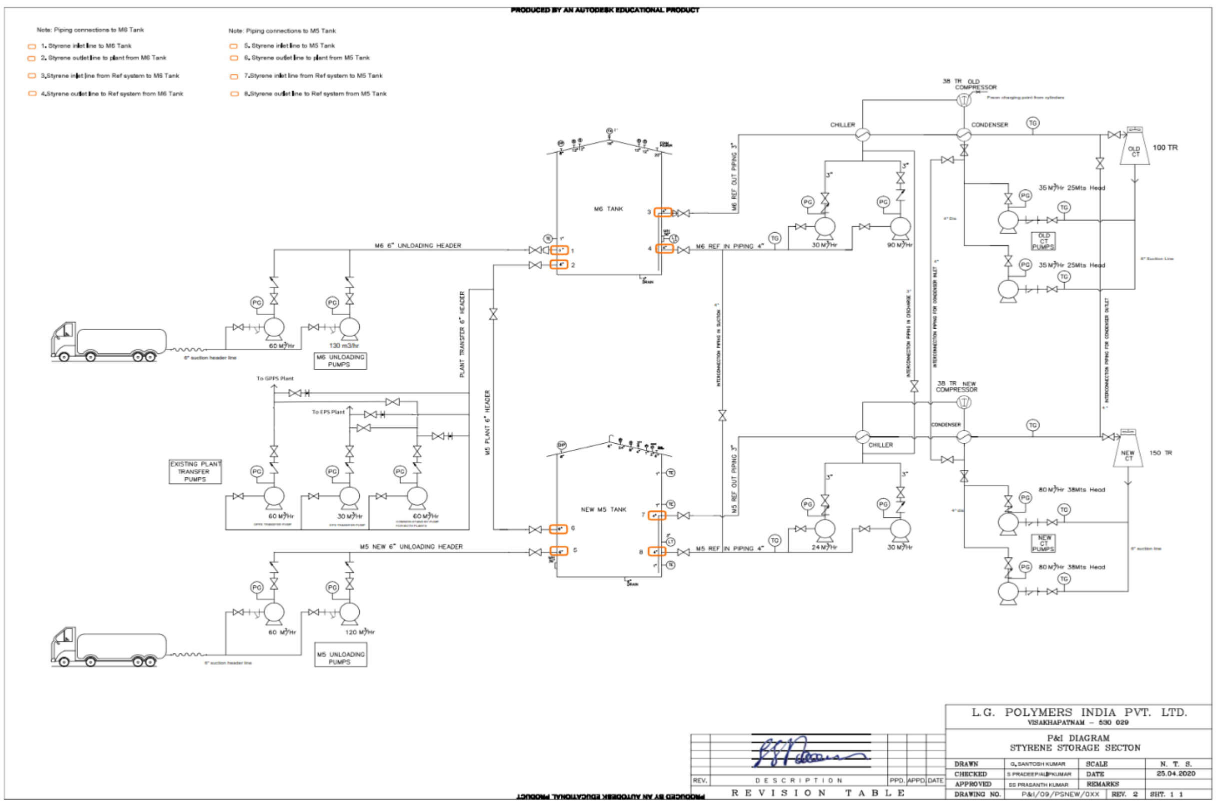


Figure 2.11. : P&I Diagram of M5 & M6 Tanks

2.2.1.1 Poor Maintenance of M6 Tank

The last time the tank was cleaned, as per the records, was in 2015. The company informed that their standard protocol is to clean tanks once in 5 years. However, the Committee noted that this protocol is not supported by any industry standard guidelines. The literature[16] on Styrene monomer bulk storage in tank suggests the periodical internal cleaning, visual inspection and application of appropriate coating in order to prevent the accumulation of polymer inside of the roof of the tank be undertaken once in every two years. In LG Polymers, the last periodic

16 Product guide of LyondellBasell

maintenance of the M6 Tank was performed only in the year 2015. This complacency certainly increased the potential for accumulation of polymerised Styrene monomer vapour at the roof top.

Further, the Technical Committee has observed that as the inner side of the tank is not lined, rust might have formed **at the inside wall due to the long period of absence of inside maintenance of the M6 Tank.** Also, as per the Technical Committee report, the presence of contaminants inside the tank like iron oxide (rust), oxidizing agents, metallic hydrides, iron chlorides and other solid compounds due to insufficient and incorrect cleaning of storage, is a potential source for initiation of polymerisation of Styrene which can overwhelm the inhibition effects of TBC. The Technical Committee also reported that the presence of rust (particles) inside the tank can promote and initiate polymerisation.

The Committee strongly felt that there is a need for an intensive technical forensic study of the inside of the tank to establish the inside conditions of the tank. However, due to the last maintenance carried out in 2015, the Committee is of the view that there must be significant stalactite formation and rust / contaminants accumulation within the tank.

2.2.1.2 Roof of M6 Tank

In the case of M6 Tank, the conical roof is supported within the tank interior. This is conducive for Styrene vapour to condense and collect upon the internal structure or surface irregularities available. This condensate does not contain polymerisation inhibitor and so it tends to polymerise to polystyrene. It collects on the parts of internal structures and forms stalactites. The company has reported that the float valve got stuck in the stalactites, as a result of which, in October – December 2019, they had to discard the piping connected to the float valve and bring in alternate piping. This clearly proves that the design of roof of this M6 Tank is poor as the structure supporting the roof of this tank is inside the tank, which is more prone for stalactite formation, unlike the modern tank (M5 in this factory) where this roof supporting structure is on the top of the roof outside the tank.

2.2.1.3 Nozzles of M6 Tank

The number of **idle nozzles should also be kept at minimum** so as to avoid dead pockets filled with Styrene. The figure 2.8 shows that there are a total of 17 nozzles of which many are spare nozzles.

2.2.1.4 Life of M6 Tank

The Committee also noted that this Styrene storage tank was not subjected to any mechanical integrity assessment study and the plant has never implemented any Life Extension Programme (LEP), since the Styrene tank has performed beyond its designed life period. Even the PESO license was accorded in 1977 (Life span till now 43 years) and if we consider that the tank was earlier used as a molasses tank from the date of factories license in 1967, the life of the tank is 53 years. It is a very risky proposition to store a hazardous chemical in about a 50-year-old tank, that too without implementing any life extension program.

2.2.1.5 Material of the tank

It is also observed that the Styrene tanks and pipelines of the LG Polymers plant are made of mild steel, which is a serious non-conformance to the laid down standards and guidelines. Lined carbon steel tanks are generally used for the bulk storage of Styrene monomer. The inlet and outlet lines for these tanks are located near the bottom. It is also seen that the bottom and lower 6 to 8 inches (15-20 cm) of vertical storage tanks have not been coated with inorganic zinc silicate linings to provide electrical grounding. Piping is normally of carbon steel, although stainless steel and aluminum may also be used. Therefore, the M6 Tank is inferior in design in all respects for storing Styrene.

2.2.1.6 Vents open to atmosphere

As the vents of the tank are open to atmosphere, emissions of Styrene are prevalent. Unlike the modern designs, **the tank neither has a flare system that burns the Styrene vapours forming carbon dioxide nor a cryogenic system to condense Styrene vapours** that can be collected separately. The Committee is of the view that bulk storage tanks should be vented to a **vapour**

collection and containment system that effectively eliminates discharges of Styrene monomer vapour to the atmosphere. **The M6 Tank is not provided with** any of the above safety systems.

2.2.1.6.1 Crack at the top manhole / foam pourer

The GM Production of the Factory also seems to have informed the Technical Committee that there is a wide crack at the top manhole / foam pourer. The GM Production has also claimed that the Styrene vapours also came out through this crack. The Committee felt that this statement of the GM Production of the existence of a wide-crack in the top manhole / foam pourer (N2) need to be examined through a forensic and intensive check of the M6 Tank. However, the Committee noted that the GM Production version is extremely worrisome that they used the M6 Tank for storage of hazardous chemical in spite of GM Production being aware of a crack in the top manhole / foam pourer.

2.2.1.7 Change of Design in the suction and discharge lines of recirculation circuit in M6 Tank

The LG Polymers management in its hearing on 7th June 2020, informed the High-Power Committee on a query that they modified the M6 Tank in December 2019 to the present design. The DCS temperature data of the M6 Tank furnished to the Director Factories also shows no recording of temperature from 5th October 2019 to 31st December 2019 (Annexure 2.3 Temperature Data from September 2019 to January 2020). Perhaps, the modification in design was carried out during this period. On specific query about the changes carried out, they have further informed that the modification had not been informed to PESO or any other concerned statutory organization to get it approved. The company management further informed that they have not informed the modification as they considered it only a change in the piping only. This was a critically wrong assessment on the part of the company. The Committee noted that **any modification of equipment or plant should be subjected to HAZOP and Risk Assessment Study**. **Originally, the tank was having a swing pipe arrangement to discharge the cooled Styrene from the recirculation and refrigeration unit,** just below the liquid surface. Thus, the cooled liquid was delivered at the top of the tank and by its chemical property, it would slowly circulate to the bottom of the tank from where it would be pumped through the refrigeration unit. Thus, the

contents of the tank were well mixed by the chemical properties, as the denser cold Styrene moves down towards the bottom by gravity and natural convection, such that **the temperature would be less thermally stratified in the tank.** The management of the company has reported that the float valve got stuck in the stalactites in the M6 Tank, as a result of which, they had to discard the piping connected to the float valve and bring in alternate piping of dip leg arrangement. The alternate piping provided for the cooled Styrene monomer liquid to be delivered at the bottom of the tank. The modified system of the tank, as carried out by December 2019 and confirmed by the company management in its statement, is depicted in the diagram below in Figure 2.12 and Figure 2.13.

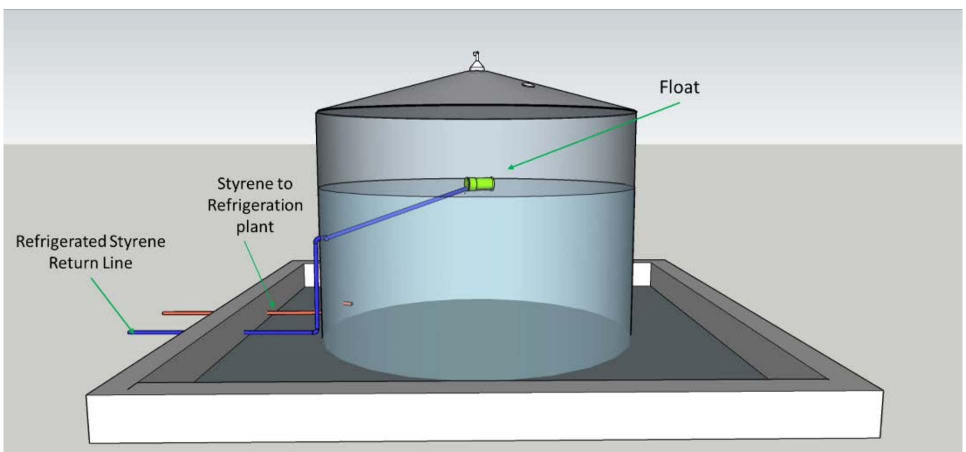


Figure 2.12: Before the Modification in Styrene M6 Tank

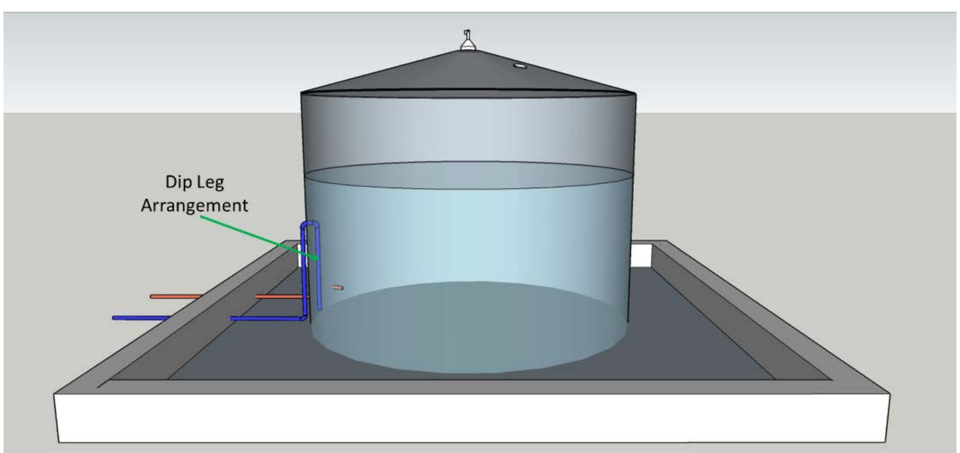


Figure 2.13: After the Modification in Styrene M6 Tank

As can be seen from the diagrams of the M6 Tank above, the modified piping design provided for the cooled Styrene return line from the refrigeration unit to the nozzle located about 300 mm above the bottom of the tank. Not only it totally disturbed the chemical circulation system, it led to significant thermal stratification in the M6 Tank with high temperature gradient. The top level of the Styrene monomers in M6 Tank experienced much higher temperatures than the bottom. On the whole the Committee felt that this change in design, in a way, sowed the seeds of disaster.

2.2.2 Tank Temperature Measurement & Control

Single Temperature Measuring Probe at the Bottom

The M6 Tank is provided with a temperature measuring probe (RTD sensor) at the bottom only. The probe is located 0.7 m from the bottom and about 4.09 m distance between the discharge port, N13 and the port of the temperature probe, N14 as is shown below in **Figure 2.14** and **Table 2.3.**

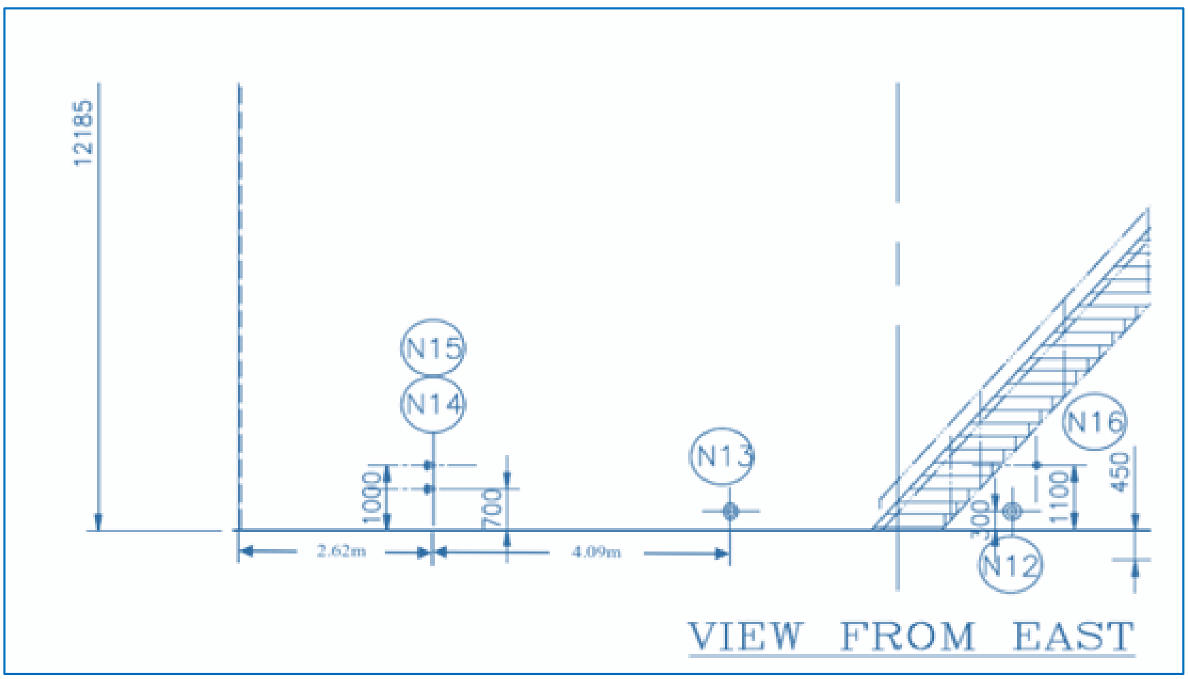


Figure 2.14: The Temperature Measuring Port of M6 Styrene Monomer Storage tank

Table 2.3: Details of Nozzles in Figure 2.14

N16	Spare	25 NB
N15	Spare	25 NB
N14	Temperature Gauge	25 NB
N13	Refrigeration Inlet	100 NB
N10	Refrigeration Outlet	100 NB
N12	Styrene Inlet	200 NB

From the location, the Committee is of the view that the location of the temperature probe is not adequate to give a representative value of temperature in the tank. The **temperature measurement is restricted to the bottom zone liquid**, whereas **top and middle zones may have different temperatures**, which is further explicated in section 2.2.2.1.

In fact, there must be four or five temperature measurement locations along the 12m height of the tank, that would have measured the true temperature of the liquid Styrene in the different zones of the tank. **For the long-time storage of Styrene**, in large tanks, it is **necessary to measure the temperatures at different locations across the height of the tank** to identity the temperature differentials.

The neighbouring M5 tank has temperature measuring probes at three locations. The tanks T2 and T23 of the EIPL at Visakhapatnam port area has temperature measuring probes at four and five levels respectively. Like the **neighbouring M5 tank as well as tanks T2 and T23** at EIPL, the M6 should have been **provided temperature measuring probes in the tank at multi-locations along the height**.

2.2.2.1 Temperature differentials and Mixing in storage tanks

The density of Styrene is a function of its temperature.

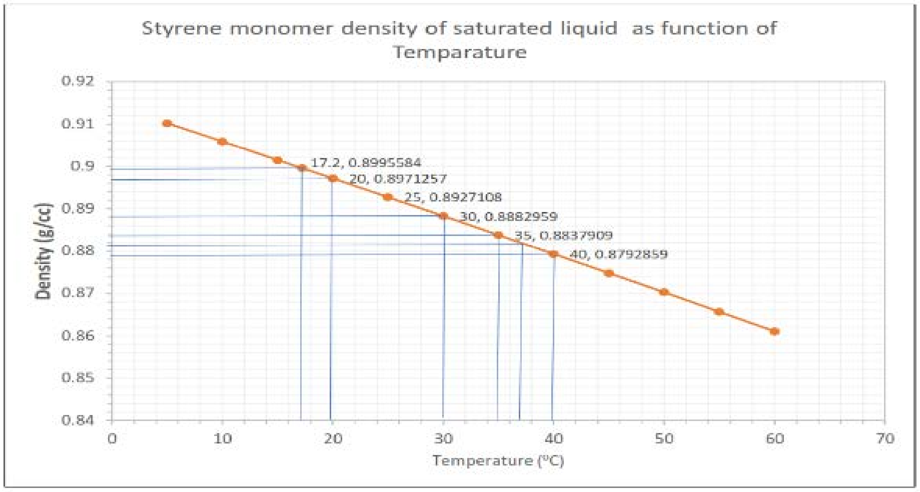


Figure 2.15: Density of Styrene as a function of Temperature

When Styrene is warmer, it gets less dense for each increment in degree celsius. This allows for thermal layering; where warmer Styrene moves on to the top of colder Styrene which is defined as "thermal stratification". Due to this, there will always be a level of "self-induced" thermal stratification in the Styrene storage. As a matter of fact, for any large storage of any liquid is subjected to thermal stratification in the tanks or vessels. Similarly, addition of chemical compounds (like TBC) can also be stratified due to the self-induced thermal stratification. Both these scenarios of thermal stratification and TBC stratification are shown below for example in Figure 2.16.

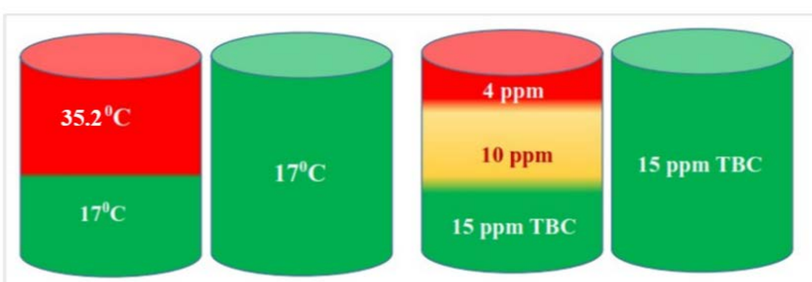


Figure 2.16: Stratification vs fully mixed

Thermal Stratification in M6 Tank

The temperature log of two tanks M5 and M6 in the tank farm are given in Table 2.4.

Table 2.4: Selected Temperature Log for M5 and M6

Time	O-TI-104.PV	O-TI-102.PV	O-TI-103.PV	O-TI-101.PV	O-LI-135.PV	O-LI-131.PV
	M5 Tank Radar Level	M5 Tank Middle Temperature	M5 Tank Top Temperature	M5 Tank Bottom Temperature	M6 Tank Level	M6 Tank Temp
	%	°C	°C	°C	%	°C
Date: 06.05.2020						
06:00	89.50	29.80	31.00	10.80	56.80	17.40
08:00	89.50	29.80	31.00	11.00	56.90	17.45
10:00	89.59	29.90	31.10	10.60	56.90	17.00
12:00	89.50	29.90	31.10	10.00	56.90	16.50
14:00	89.50	29.90	31.10	9.40	56.90	17.10
16:00	89.50	29.90	31.00	9.20	56.90	17.30
18:00	89.50	29.90	31.00	9.40	56.80	17.00
20:00	89.50	29.90	31.00	9.50	56.80	17.10
22:00	89.50	29.83	31.00	9.70	56.80	17.10
23:00	89.50	29.90	31.10	9.70	56.80	17.30
Date: 07.05.2020						
00:00	89.50	29.90	31.00	9.80	56.80	17.20
02:00	89.50	29.90	31.00	9.90	56.80	17.30
04:00	89.50	29.80	31.00	10.00	53.90	24.00
06:00	89.50	29.80	31.00	10.20	53.60	30.10
08:00	89.50	29.80	31.01	10.50	52.00	33.00
10:00	89.50	29.80	31.10	10.60	48.71	38.61
12:00	89.50	29.90	31.01	10.80	47.10	44.60
14:00	89.40	29.90	31.10	10.90	45.70	44.60
16:00	89.40	29.90	31.10	11.10	45.10	66.00
18:00	89.40	29.90	31.10	11.20	42.90	70.80
20:00	89.40	29.90	31.10	11.30	43.00	104.88
22:00	89.40	29.90	31.10	11.40	41.10	145.60
23:00	89.50	29.90	31.00	11.50	36.53	153.70

Time	O-TI-104.PV	O-TI-102.PV	O-TI-103.PV	O-TI-101.PV	O-LI-135.PV	O-LI-131.PV
	M5 Tank Radar Level	M5 Tank Middle Temperature	M5 Tank Top Temperature	M5 Tank Bottom Temperature	M6 Tank Level	M6 Tank Temp
	%	°C	°C	°C	%	°C
Date: 08.05.2020						
00:00	89.50	29.90	31.10	11.50	34.80	153.70

It shows M5 tank temperatures at three locations, middle, top and bottom. M5 tank temp transmitter elevation (from bottom of tank) are given as N3A - bottom - 0.40 m; N3B - Middle - 7.40 m; N3C - Top - 11.50 m and liquid height from bottom of tank was 11.99 meters as on 7th May 2020. A perusal of the Table 2.4 reveals that the difference in temperature in the top layer and the bottom layer of M5 tank is nearly 20°C. The recorded values of temperatures, as given in the Table 2.4, manifest thermal stratification in the tank irrespective of the bottom temperatures of the M5 tank, which is a comparatively modern tank commissioned only in 2019. On the analogy of M5 tank, the temperature at the top layer of the M6 Tank, considering the height and the level of the Styrene liquid, would be nearly 35.2°C. **The Technical Committee has estimated the M6 Tank temperature at 41.7°C, calculated on the basis of the DCS level percentage data (56.8%), recorded on 28-4-2020, which continued till the early hours of 7th May 2020.**

Temperature Profile of Liquid Styrene in M6 Tank

The management of the company informed that the Standard Operating Procedure provides for their temperature to be kept below 35°C. This cut off temperature of 35°C is not supported by any literature. In fact, the flash point of Styrene Monomer itself is 31°C. Harold Fisher[17] has simulated auto-polymerisation initiation at 33.9°C after depletion of TBC. In light of the above, the company's protocol temperature of 35°C maximum for all their Styrene Storage is highly

[17] An overview of emergency relief system design practice

questionable when the Guidelines given by Chevron Philips[18] and Plastic Europe[19] say that the temperature in the Styrene Storage Tank should not exceed 25°C.

Wrongful assumption of Bottom Temperature as Temperature of the Whole Liquid Styrene in M6 Tank

As the bottom temperature was showing constantly at about 17°C, the operators in the shifts recorded the same in the logs following the company's SOP. The operator log data in respect of M6 Tank temperature is conforming to the DCS log in the control room. There is no separate temperature data collection within the M6 Tank by the operator, except the inlet / outlet pipe data temperature recording during operations. However, as elucidated in the Thermal Stratification section above, 17°C at the bottom of the M6 Tank is not the representative value of M6 Tank temperature. As already estimated above, the temperature fell in the range of 35.2°C (by analogy of M5 tank) at the top layer. The Technical Committee has estimated the temperature at 41.7°C at the top layer. The ignorance and negligence towards this fact of temperature at the top level being much higher than 17°C has been one of the major factors in making the management complacent and taking no corrective action.

As the ambient temperatures are high in summer, the Styrene vapour in the vapour space of tank is heated due to heat leaks from the roof of the tank. The vapour in the tank is liable to be heated through several flanges and other parts which were not insulated. Invariably, the liquid surface gets heated up and reaches an equilibrium temperature with the heated vapour. However, there is no temperature probe for measuring the vapour temperature in the top of the tank. The tank had only one temperature measurement probe at the bottom of the tank.

2.2.3 Recirculation and Refrigeration System

Under no circumstances the temperature of Styrene in whole tank should exceed 25°C **according to the standard guidelines for Styrene storage**. Hence, it necessitates maintenance of

[18] Safe Handling and Storage of Styrene Monomer
[19] Styrene Monomer: Safe Handling Guide July 2018

lower storage temperature in the tank. Higher temperatures are bound to cause Styrene vaporization and subsequent build-up of polymer. Usually, the preferred storage temperature is in the range of 10 – 18°C. If the temperature approaches 20°C, the tank contents must be cooled. Thus, proper refrigeration–recirculation systems need to be provided. As the tank is insulated, the exothermic polymerisation heat cannot be dissipated. The M6 Tank does not have proper mixing arrangement to take care of any increase in temperature in middle and upper zones. Although the company have stated that there are temperature alarms at 35°C and 37.5°C, the temperature data recorded in the DCS on the 7th of May does not record any temperature alarm either at 35°C or 37.5°C. The Technical Committee, in its report has mentioned that there is no temperature alarm also for the M6 Tank. The temperature of liquid Styrene Monomer is a very crucial factor. The temperature maintenance throughout the large storage tanks at 15-20°C is essential in light of possibility of runaway polymerisation characteristic of Styrene.

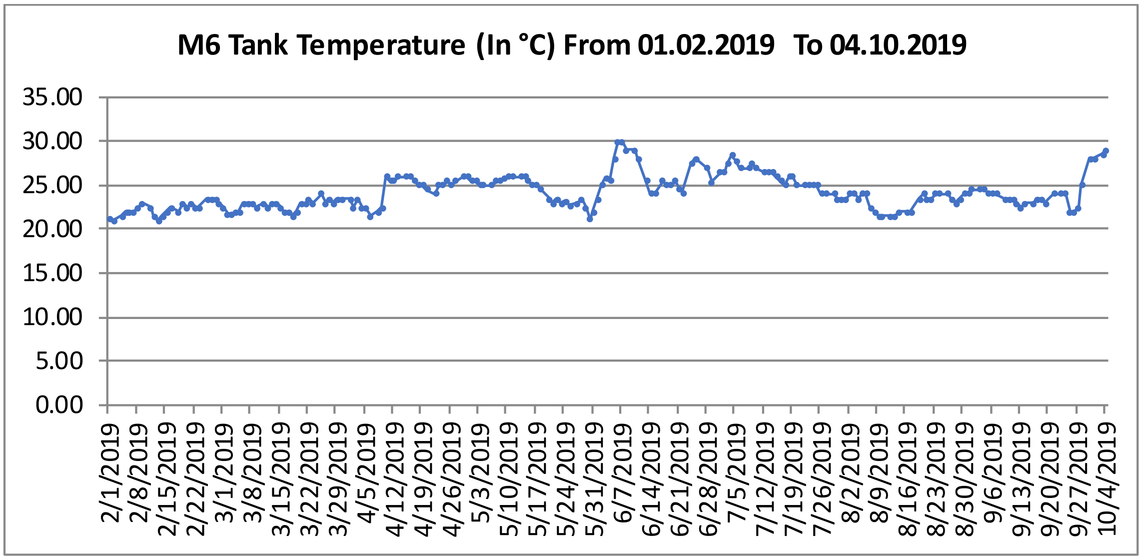
2.2.3.1 Inadequate Time for Refrigeration and Manual Operation

The refrigeration system of the M6 Tank (as well as of the M5 tank) are manually operated. The company management informed that it is their normal practice to switch on the refrigeration / cooling system at 08:00 a.m. and close at 05:00 p.m. every day, except when unloading of Styrene Monomer from tanker takes place, during which refrigeration system is kept on. The management also informed that all through the lockdown period, the refrigeration subsystem was operated from 08:00 a.m. to 05:00 p.m. However, on the 6th May 2020, as per the logbook, the Director of Factories has reported that the refrigeration system was switched off at 3:45 p.m. On a specific query as to whether the same practice is followed in LG Chemicals in South Korea, no reply was received. For a place like Visakhapatnam, with temperatures mostly ranging from 20°C to 36°C, it is but essential to operate the refrigeration system on a continuous basis to ensure temperature at all levels of tank below 20°C. This is one of the major shortcomings in the refrigeration system followed by the LG Polymers. It needs to be checked whether in much cooler climates of South Korea whether LG Chemicals in their South Korean Plants run the refrigeration continuously.

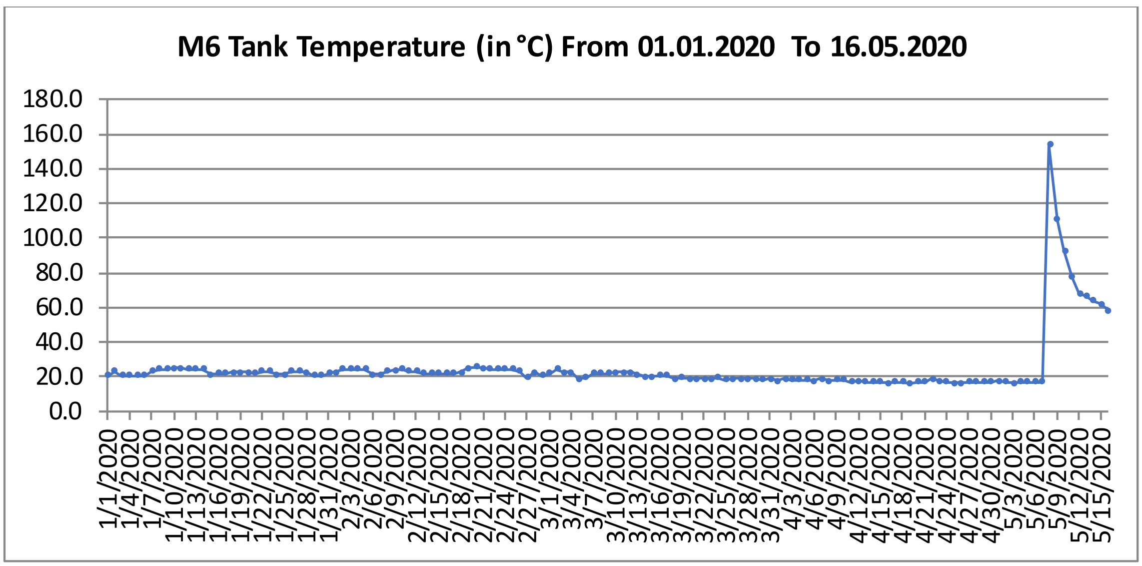
The Committee is of the view that Refrigeration system of the Styrene storage tank should have been provided with a fully automated instrumentation system of adequate safety integrity level, coupled with the temperature sensor for automatic switching-on and off the system based on the temperature reading of the gauges. The non-provision of this system has permitted the human error and onset of reactive hazard resulting in the release of toxic vapour cloud.

2.2.3.2 Improper Cooling of Styrene Monomer due to Design Change in the Refrigeration

The design range of the temperatures of the refrigeration units is given for cooling Styrene from 40°C to 20°C. But in practice, especially from January 2020, it was being used to cool the Styrene up to 17°C. This was also caused due to the change in the piping design in the M6 Tank as mentioned in section 2.2.1.7. It may be seen from the discussions in section 2.2.1.7 that the float swing pipe arrangement was replaced with dip leg arrangement with release of cooled Styrene Monomer liquid at virtually at the bottom of the tank viz., 300 mm from the bottom. Similarly, the liquid Styrene monomer is taken into the refrigeration cooling system from the N13 port, located at nearly the bottom of the tank at 100 mm. As explained in Section 2.2.1.7. it totally destroyed the natural chemical circulation (mixing) system. Moreover, it resulted in cooled liquid Styrene Monomer being pumped for further cooling in the refrigeration system. This is the cause why the temperatures at the bottom of the M6 Tank recorded low temperatures in the range of 17°C. This is also borne by the temperature reading in the M6 Tank in the year 2019 and the year 2020, which is shown in the Graph 2.2 and Graph 2.3 below:



Graph 2.2: M6 Tank temperature reading for year 2019



Graph 2.3: M6 Tank temperature reading for year 2020

As can be seen from the Graph 2.2 and Graph 2.3 above, the temperature recorded in the year 2019 prior to the piping design changes depicted the temperature range between 22°C to 30°C while the temperatures recorded from January to April 2020, after the piping design changes, depicted temperatures in the range of 17°C to 22°C. Thus, the refrigeration system was used for improperly cooling upto 17°C when the designed temperature for the refrigeration system is upto

20°C. In addition, it was improperly used for cooling the already cooled Styrene Monomer liquid, due to the piping design change.

2.2.3.3 Other possibilities

2.2.3.3.1 Possibility of R-22 contamination of Styrene Monomer in M6 Tank

The refrigerant, R – 22 is used to cool the Styrene. R – 22 is difluoro, mono-chloro methane, also known as HCFC-22 or Freon 22. The cooling takes place in a shell and tube heat exchanger. According to LG Polymers, Styrene flows in the shell and high-pressure R – 22 flows in the tubes. The liquid R-22 vaporizes at about minus 40.7°C and cools the liquid Styrene that is recirculated in the shell. If there is any pinhole in any tube in the tube bundle or tube sheet joint of the shell and tube exchanger, there is a danger of R–22 contaminations in Styrene. The R-22 contamination may have synergetic effect along with other contaminants already present in Styrene.

As per the report of the Technical Committee, on inspection of the refrigeration unit, it was observed that the insulation of the pipelines and equipment were damaged, and the rusted flanges can also be seen in figures 2.17 and figure 2.18 below. Under these circumstances, **the possible leak of R–22 into the recirculating Styrene cannot be ruled out.**


Figure 2.17 and Figure 2.18: Present status of the refrigeration system and the alarm

2.2.3.3.2 Insufficient Capacity of refrigeration unit

The recirculating pump capacity is 30 m^3/hr. and the capacity of refrigeration unit (ACCEL Make) is 38 TR. Further, the Technical Committee has reported, GM (production) had answered to queries at different times about the capacity of recirculation pump as 90 m^3/hr., 60 m^3/hr. and finally 30 m^3/hr. As such the 30 m^3/hr. pump is not adequate to recirculate the contents of tank contents of the order of 2250 m^3 in 8 /24 hours. It clearly proves that the capacity of the refrigeration unit, especially the recirculating pump was not sufficient for the full tank capacity of M6 especially considering the tropical conditions in Visakhapatnam.

2.2.3.3.3 Clogging of Valves and Lines of the Refrigeration Systems

The Technical Committee has also stated that the plant was shut down from 25th March 2020. During the shut-down, it was expected to drain liquid Styrene from the recirculation-refrigeration circuit. As per the instruction manual, operators normally drain the Styrene from suction side of the recirculating pump. It is not known whether any transfer lines got choked up because of pumping viscous Styrene with high polymer content causing deadhead conditions. The management stated that the refrigeration along with recirculation system was working without causing any problems. Moreover, the recirculation of Styrene through refrigeration system was suspended at 03:45 p.m. (not 5:00 p.m. on 6th May 2020 as LG Polymers claimed). It is suspected that the refrigeration system could have malfunctioned / stopped as the valves and lines might have got clogged from the polymer content in the Styrene. The pump motor might have got tripped also due to high viscous polymerised Styrene. In the oral statements, the company management informed that the refrigeration system was attempted to be switched on as an emergency response measure on 7th May 2020 to reduce the temperature of Styrene. However, it is understood that the system could not be operated. This version of the company that they started the refrigeration system needs further investigation. However, from the eyewitness accounts, it is highly improbable that the refrigeration system was attempted to be operated, at least in the emergency period. Therefore, the Committee felt the transfer pipes of the recirculation system also needs to be examined during the forensic audit of the M6 Tank to come to a definite conclusion in this regard.

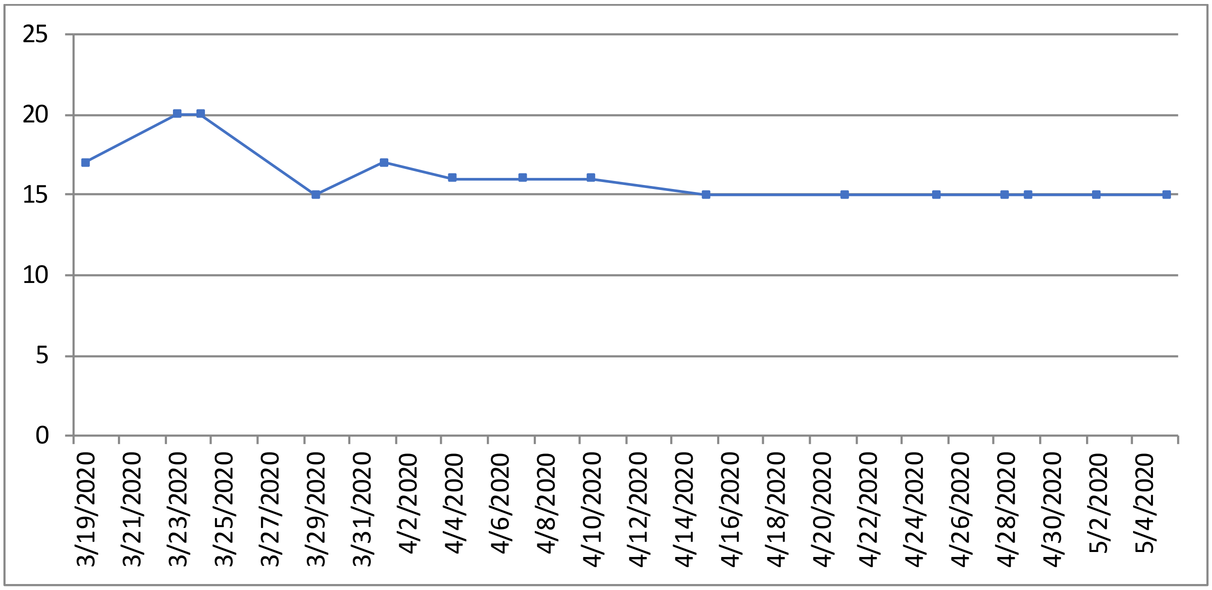
The Committee also noted that the pump motor might have got tripped also due to high viscous polymerised Styrene, in case the recirculation system was attempted to be operated. The proof can be established if the lines of refrigeration system, particularly evaporator part of heat exchanger is opened and inspected during the forensic audit and further investigation.

2.2.4 Inhibitor Addition Protocols

TBC (p-tert-butylcatechol) is commonly added to Styrene to prevent polymer formation and oxidative degradation during shipment and subsequent storage. Inhibitors prevent polymerisation in two ways: (i) They can react with and deactivate the free radical in a growing chain; (ii) They can act as an antioxidant and prevent polymerisation by reacting with oxidation products in the monomer. The inhibitor levels recorded in the M6 Tank is depicted in the table 2.5 below:

Table 2.5: Analytical Results of TBC Content (in ppm)

Date	TBC	Date	TBC	Date	TBC
03.01.2020	15	02.02.2020	15	19.03.2020	17
06.01.2020	15	08.02.2020	25	23.03.2020	20
07.01.2020	15	10.02.2020	15	24.03.2020	20
09.01.2020	15	11.02.2020	15	29.03.2020	15
10.01.2020	15	12.02.2020	15	01.04.2020	17
13.01.2020	15	15.02.2020	15	04.04.2020	16
20.01.2020	15	17.02.2020	15	07.04.2020	16
21.01.2020	18	18.02.2020	20	10.04.2020	16
22.01.2020	18	19.02.2020	20	15.04.2020	15
23.01.2020	18	20.02.2020	20	21.04.2020	15
24.01.2020	18	25.02.2020	20	25.04.2020	15
25.01.2020	18	27.02.2020	20	25.04.2020	15
26.01.2020	15	28.02.2020	20	28.04.2020	15
27.01.2020	15	29.02.2020	17	29.04.2020	15
28.01.2020	15	02.03.2020	17	02.05.2020	15
30.01.2020	15	03.03.2020	17	05.05.2020	15
31.01.2020	15	10.03.2020	15		



Graph 2.4: M6 Tank TBC (Inhibitor) Values in PPM

2.2.4.1 Improper SOP for Inhibitor Measurement

The TBC level should be checked daily for samples taken from bottom and top of the tank. Additional inhibitor should be added to maintain a safe level of 15 ppm provided the temperatures are within their effective range. In respect of M6 Tank, only samples of Styrene Monomer from the recirculation and refrigeration system viz., bottom of the tank was analysed once in 4 days approximately by LG Polymers. The samples were also taken from the top of the tank; however, the practice seems to be very irregular. Of the measurements available in the period from March 24th to May 7th, 2020, the sample was taken from the top of the Tank only one day viz., on 25th April 2020. In summer, it warrants daily sampling and testing should be carried out as per the guidelines as given in Table 2.6. But, in LG Polymers, daily sampling and testing was not practiced.

Table 2.6: Styrene Monomer Storage Testing

Temperature	Frequency of TBC & Polymer Monitoring
> 25°C (> 77°F)	Daily
15 - 25°C (59 - 77°F)	2 – 3 times a week
< 15°C (<59°F)	1 time weekly

No addition of TBC

The company management informed in the statement that there has been no need for adding of TBC in either M6 or the other tanks. Mostly the Styrene Monomer comes with added TBC. They have not added TBC in the M6 Tank even for the last 10 years. The Technical Committee has also confirmed that there was no addition of TBC in M6 Tank since February 2019.

The Committee felt that it was sheer providence due to the continuous operations that the lack of TBC inhibitors was not felt. In section 2.2.2.1 the TBC stratification has already been discussed. It is to be noted that the LG Polymers primarily measured TBC content only from the samples collected from the bottom of the Tank. Further, the collection from the top was very irregular. While the samples from the bottom layer show TBC content as 15 ppm within the permitted range, the management of the company totally failed to consider the TBC stratification. As shown in the Figure 2.16 above for the bottom level TBC of 15 ppm, the top-level TBC reduces to 4 ppm. Further there could have been further depletion of TBC or it becoming ineffective at higher temperatures experienced in the top layers.

The possibility of having lower than critical concentrations of TBC at the high temperature top zone of the M6 Tank cannot be discounted as no TBC was added in the M6 Tank in the near past. However, as the temperature in the upper zone of the M6 Tank was supposed to be as higher than as 35°C, the effectiveness of the TBC inhibitor would have been lost.

2.2.4.2 Unavailability of TBC Stock

48 kg of TBC stock was only available as on 01st January 2020 as per the information furnished by the management. The company informed that they were maintaining a limited stock as the Styrene Monomer was received with added TBCs. The Technical Committee has noted that as per the statement of Director Operations, no stock of TBC was available from 23rd March 2020 after sending 48 kg of TBC for the maintenance of T2 & T23 at the port area on 22nd March 2020. However, the SAP data furnished (Annexure 2.4) by the management of the company, shows issue of 48 kg in the month of April 2020.

The company placed two orders of 50 kg each (totalling to 100 kg) on 16th & 20th April 2020. However due to the lockdown the commodities could not be received. In the representations before the committee, the management representatives clearly stated that the 48 kg of TBC was sent to the tanks T2 & T23 as these tanks had no refrigeration system. The Committee observed that certainly on 6th night / 7th morning, there was no stocks of TBC available in the factory premises. The TBC stocks were later airlifted by the assistance of NDMA on 8th May.

The LG Polymers as a standard practice followed fast stock turnover in processing of Styrene monomer, as per the statement of LG Polymers team before the High-Power Committee on 7th June 2020 and did not follow the practice of adding TBC in the tanks. As such no stock of TBC available with LG Polymers since April 2020 did not cause any extra concerns. For long time, the periodical addition of TBC was not carried out by the company. Further, because of non-availability of TBC there was no question of addition of any TBC as it was not a part of practice. The TBC was not available even for emergency response after the accident on 7th early hours, until 8th May 2020 when it was airlifted with the help of NDMA.

2.2.4.3 Decrease of TBC Concentration in Styrene

In-spite of no addition of TBC to the tanks from 23rd March 2020, the same level of TBC concentration at about 15 ppm was recorded for the bottom samples. A two-ppm reduction at 17°C in a month approximately may be normal. But, at higher temperatures, on the top regions of tank, the depletion of TBC should have been much faster. As noted in thermal stratification section it is estimated that the TBC availability at the top layers was reduced to about 4 ppm, which was further ineffective due to the high temperatures at the top levels of liquid Styrene monomer.

The time required for TBC concentrations to fall to a dangerously low level varies greatly because of different storage and handling conditions. The depletion rates in actual storage may be appreciably faster or slower depending on the set of environmental conditions. Factors which affect depletion of TBC are heat, water and air, with heat being the most important. The depletion of TBC with time at the temperature of 19°C is presented in the Figure 2.19. At higher temperatures, it is obvious that the depletion rate of TBC would be faster.

As is observed from the Figure 2.19, the 4 ppm TBC concentration is critical. If the inhibitor has been depleted and polymerisation begins, inhibitor should be added immediately. Additional inhibitor should be added when inhibitor levels drop below 10 ppm to maintain adequate inhibition. After addition, the storage tank should be recirculated until inhibitor is uniformly mixed and testing show that target levels have been achieved. Although with adding TBC and reducing the storage time, one may be able to prevent a runaway reaction, it should be realised that one of the main barriers to prevent polymerisation will be lost if the temperature cannot be controlled under all conditions.

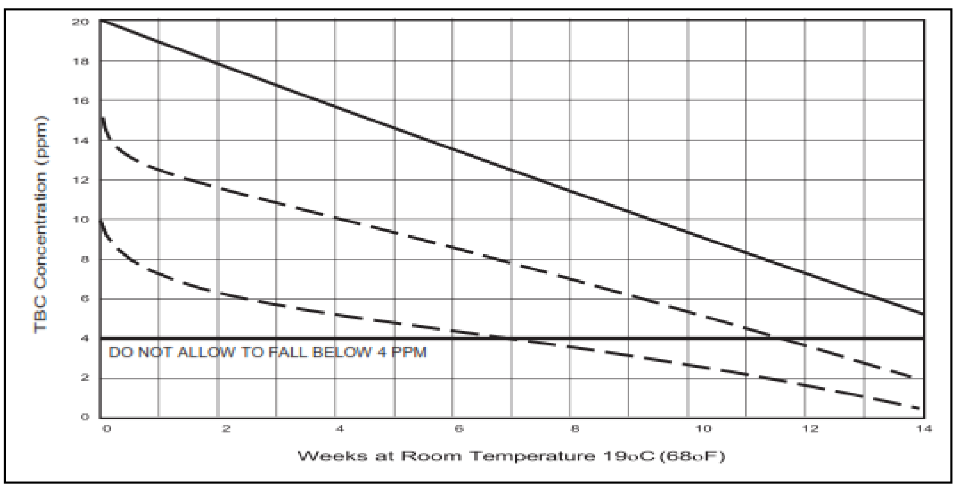


Figure 2.19: Decrease of TBC Concentration in Styrene

2.2.4.4 Absence of monitoring of Dissolved Oxygen

When Styrene monomer is exposed to light and/or heat, it forms radicals. These Styrene radicals react either with oxygen to form peroxide radicals or with Styrene to form polymer chains. In the presence of sufficient oxygen, the peroxide formation is significant because this reaction of peroxide radical formation is much faster compared to the polymer formation with Styrene. In the subsequent step, if inhibitor (TBC) is present, the peroxide radicals are scavenged via quinone formation whereas, if no inhibitor is present, the peroxide radicals react with Styrene to form peroxide chains. Oxygen works as the polymerisation inhibitor, while TBC controls its efficient use. The literature in this regard indicates at least 8 ppm of oxygen is a key parameter to inhibit the Styrene free radical polymerisation and make the TBC functional.

Unfortunately, there was no monitoring device or no monitoring system in place to measure the quantum of dissolved oxygen in the Styrene monomer in M6 Tank or any of the other tanks. This is not acceptable as dissolved oxygen is a critical input in the effectiveness of the inhibitor.

The vapour space of the atmospheric tanks contains air having Oxygen content of 21%. As the solubility of air is 0.15 at 25°C, the oxygen solubility should be monitored by automatic controller system to maintain soluble oxygen in the liquid Styrene > 8 ppm for the temperature of the tank. At higher temperatures, the vapour space in the tank is occupied by more Styrene vapour depriving of sufficient air that is required to be equilibrium with air soluble in the liquid. But there is no provision for monitoring of oxygen in the M6 Tank.

It is also to be noted that at higher temperatures, the solubility of oxygen in Styrene is less. The influence of oxygen on shelf life of Styrene is given in **Table 2.7**.

Table 2.7: Shelf Life of Styrene Monomer: General Effects of Inhibitor and Oxygen at Various Temperatures as reported in literature

Temperature °C	12 to 15 ppm TBC		50 to 75 ppm TBC
	O_2 Saturated	<3 ppm O_2	O_2 Saturated
15.6	5-6 mo.	10-15 days	more than 1 year
29.4	1-2 mo.	4-5 days	3-4 mo.
43.3	8-12 days	<24 hours	less than 30 days

In many of the modern designs of Styrene tank which are not atmospheric tanks, there is provision for circulation of oxygen/air so that the dissolved oxygen content is continuously monitored and maintained.

However, the M6 Tank was an atmospheric tank. Therefore, the management should have acted more scientifically to ensure saturation of dissolved oxygen. This could have been easily arranged by circulation of Styrene between the tanks. The empty spare tank which is available in the same area with 300 MT capacity would have served this purpose to a large extent.

2.2.5 Polymerisation & Runaway reaction

A critical question to be answered is why polymerisation took place, why temperature rose and why runaway reaction took place. LG Polymers in its reports has stated that "Polymerisation generally takes place by free radical reactions initiated thermally or catalytically. Polymer formation occurs slowly even at ambient temperatures and becomes rapid at elevated temperatures". The Committee has reflected on a lot on the issue and has concluded that there are mainly two possibilities or a combination of both the possibilities for initial polymerisation viz. (a) Thermal Radical Polymerisation or (b) Polymerisation due to presence of a catalyst or a combination of both (a) and (b) which are listed below.

2.2.5.1 Thermal radical polymerisation

The possibility of having lower than critical concentrations of TBC at the high temperature top zone of the M6 Tank cannot be discounted as no TBC was added in the M6 Tank in the near past. However, as the temperature in the upper zone of the M6 Tank was higher than 35°C, (estimated to be 41.7°C) the effectiveness of the TBC inhibitor had been lost and thermal radical polymerisation must have set in and being an adiabatic tank (insulated) the heat generated could not be dissipated. It must have resulted in further temperature increase leading to further polymerisation and finally leading to runaway reaction.

The Technical Committee adopted the model of Harold Fisher, who had simulated the runaway polymerisation, and using the data collected from M6 Tank, found that the runaway polymerisation was initiated at 33.9°C after depletion of TBC. The higher temperatures > 34°C of the upper regions of the tank are responsible for Styrene runaway polymerisation reaction.

This process was further aided by the fall of p-tert-butyl catechol (abbreviated as TBC) concentrations. Styrene monomer is inhibited with TBC to reduce and control runaway polymerisation reaction. Styrene monomer undergoes polymerisation slowly at ambient temperatures, but polymerisation will become rapid at elevated temperatures. Styrene monomer may experience rapid polymerisation if TBC inhibitor and dissolved oxygen are depleted at elevated temperatures or if product is contaminated with incompatible materials. Styrene monomer polymerisation is exothermic evolving (16700 kcal/kg mole or 160.36 kcal / kg). If excess heat is not adequately dissipated, the product temperature will rise with a subsequent rise in the rate of polymerisation. It is at temperatures above 65°C, when a runaway polymerisation reaction occurs.

When a runaway polymerisation occurs, temperatures can quickly reach the boiling point of Styrene monomer. Vapours may erupt violently from tank vents or if vents become plugged with polymer, excessive pressure can be generated that may rupture the containment vessel.

2.2.5.2 Presence of Catalyst

The polymerisation of Styrene vapour in the storage tank cannot be prevented with inhibitor as the same is ineffective for vapours, making accumulation on the inside of the roof top and formation of stalactite inevitable. These stalactites eventually **cause contamination and potentially creates bulk polymerisation hotspot where the exothermic polymerisation reaction can propagate.**

It is possible, when the accumulated polymer falls into the Styrene below, it can act as a catalyst, provide the initial polymer seed and further trigger the polymerisation. As the Styrene level in M6 Tank at the time of accident was about 7 mts., the polymer lumps if fallen, must have fallen through a depth of about 5 mts causing an impact / friction between lumps and Styrene liquid. This may have generated more free radicals of Styrene, initiating or aggravating the polymerisation at the top layers of Styrene in the tank and planted the seed for creation of hot spots at the top layers of Styrene in the tank towards runaway polymerisation which the management had failed in capturing it due to lack of temperature measurement system at the top level of the tank.

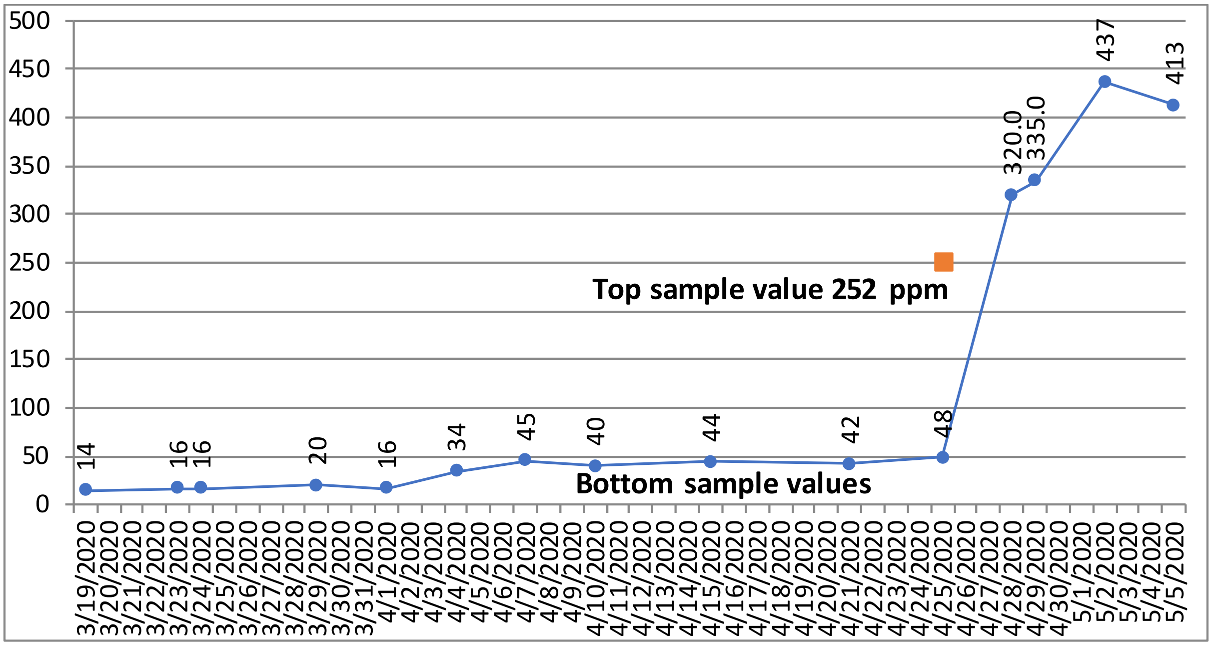
In addition, as already clarified previously, the M6 Tank is an old tank with high possibilities of rust and other contamination. These contaminations could have also acted as catalyst and led to further polymerisation and finally runaway reactions.

2.2.5.3 Overlooking Increase in Polymer Level on 24th April

The Table 2.8 below shows the polymer ppm levels in the M6 Tank.

Table 2.8: Analytical Results of Polymer Content (in ppm)

Date	Polymer	Date	Polymer	Date	Polymer
03.01.2020	18	02.02.2020	20	19.03.2020	14
06.01.2020	8	08.02.2020	15	23.03.2020	16
07.01.2020	10	10.02.2020	10	24.03.2020	16
09.01.2020	9	11.02.2020	17	29.03.2020	20
10.01.2020	8	12.02.2020	18	01.04.2020	16
13.01.2020	9	15.02.2020	10	04.04.2020	34
20.01.2020	16	17.02.2020	8	07.04.2020	45
21.01.2020	15	18.02.2020	15	10.04.2020	40
22.01.2020	18	19.02.2020	15	15.04.2020	44
23.01.2020	26	20.02.2020	17	21.04.2020	42
24.01.2020	20	25.02.2020	16	25.04.2020	252 (top)
25.01.2020	19	27.02.2020	16	25.04.2020	48 (bottom)
26.01.2020	18	28.02.2020	14	28.04.2020	320
27.01.2020	16	29.02.2020	14	29.04.2020	335
28.01.2020	15	02.03.2020	14	02.05.2020	437
30.01.2020	12	03.03.2020	15	05.05.2020	413
31.01.2020	18	10.03.2020	11		



Graph 2.5: M6 Tank Polymer (bottom sample) values in PPM

It may be noted that the polymer ppm level till 1st April 2020 by and large was in the range of 15 – 20 ppm. It may also be noted that all the measurements are from the sample collected from the bottom of the tank except an additional reading on 25th April 2020 with a sample from the top of the tank. A moderate increase of polymer content is noted from 4th April 2020 and a very sudden jump to 320 ppm on 28th April 2020 from the samples taken at the bottom level of the tank. However, in the sample taken from the top of the tank on 25th April 2020, the polymer content was already recorded as 252 ppm. It was a clear indication of onset of polymerisation in the tank towards unsafe levels.

Unfortunately, the company management had ignored the increase of polymer content from 4th April 2020 and then the sharp rise on 25th April 2020 / 28th April 2020. When questioned on this aspect by the High-Power Committee on 7th June 2020, the management replied that the rise in polymer content was seen as a quality measure for Styrene rather than a safety measure. The company management also informed that they have worked at these levels previously and it was only the quality in terms of colour of the Styrene polymer which was affected. They also mentioned that their internal maximum limit of specification 1000 ppm. However, the

Committee found that this value is not supported by any standard guidelines of Styrene storage and handling. Further, the company management in their written replies have changed this standard figure to 500 ppm. The Committee is of the opinion that neither 1000 ppm or 500 ppm is supported by any standard guideline. The Committee feels that if the Styrene industry has not defined the polymer ppm content limit for safety considerations, it cannot be ignored any further and should be clearly specified. From the experience the Committee felt that a limit about 50 ppm is in order.

The ignorance and negligence of the management in dealing with the sudden rise of polymer content of Styrene tank samples on 25th April 2020 / 28th April 2020 had led to a calamity of Styrene release from the M6 Tank. The management stand that this was a normal situation cannot be accepted under any circumstances as there was a sudden spike (pointing strongly towards the possibility of initiation of polymerisation in polymer hotspot) and no precautionary or corrective steps were taken.

2.2.5.4 Increase in temperature, runaway reaction & vaporization

Styrene monomer undergoes polymerisation slowly at ambient temperatures, but polymerisation becomes rapid at elevated temperatures. The Committee is of the view that combination of both the possibilities of Thermal Radical Polymerisation and Polymerisation due to presence of catalyst, caused the polymerisation in the M6 Tank. Styrene monomer polymerisation reaction is exothermic evolving (16700 kcal/kg mole or 160.36 kcal / kg). The M6 Tank is insulated and thus, there is no provision for heat dissipation. Thus, the initial polymerisation led to further increase in temperature, which led to further increase in polymerisation. Without any effective inhibitor being available in the M6 Tank, the temperatures in the hotspot areas in the top layers of the tank increased to above 65°C. At temperatures above 65°C runaway polymerisation reaction occurs. If excess heat is not adequately dissipated, the product temperature will rise with a subsequent rise in the rate of polymerisation.

With runaway polymerisation the temperatures increased further and reached 145°C and the liquid Styrene monomer vaporised. The vapours must have filled the volume of the tank above the liquid surface. As per the chemical properties the temperature must have been steady at 145°C till the liquid vaporised. The temperature probe in M6 Tank records 145°C only at about 10:00 p.m. of 7th May 2020 (refer Graph 2.1: Temperature Profile), although the first vapour release was recorded in the CCTV camera at 02:42 a.m. The resultant effect was pressure build up in the tank due to vaporization of Styrene. Thereafter, the temperature increased further increasing the vapour pressure further. The M6 Tank is an atmospheric tank and Styrene vapour is heavier than air. When the vapour pressure of Styrene vapour in the M6 Tank increased, the Styrene vapour was released uncontrollably through vents on the tank. As the rate of vaporization was overwhelmed, the Technical Committee estimated the pressure in the tank reached a value of 1.25 atm (as calculated based on 154°C). The hot Styrene vapour came out with a plume through the flame arrestor / vent (N6) and a Vent / Dip hatch (N1) {Please refer Figure 2:2}.

The management in its statement has also stated that the vapour was also released through an additional third opening - the wide-crack in the manhole / foam pourer (N2). This contention of the management is based on the CCTV footages showing near angular movement of the Styrene vapour from one of the vents. However, the Figure 2.2 shows the release only from two vents, at least initially at 02:42 a.m. It is to be noted that the vapour released from tank N6 - flame arrestor / vent vertically. The Dip Hatch Vent (8 inches) has a manual cap and canopy. The Styrene vapour which was released from the Dip Hatch Vent, must have hit the upper canopy and the Styrene vapour must have come out at an angle. The same is also reflected in the Figure 2.2. However, the Committee is of the view that this contention of the wide-crack in the manhole / foam pourer (N2) should be thoroughly examined during the technical forensic examination of the M6 Tank.

2.2.6 Lockdown Period

The analysis of the lockdown period is very important as the company management in their statement have stated that the accident occurred due to the long storage arising during the lockdown period, without the regular operations. The factors are examined in the paragraphs below.

Styrene stocks: Like many other factories, LG Polymers was closed during the Covid-19 lockdown period. Accordingly, in case of tanks M5, M6, T2, T23, the storage time has been prolonged as the production activities of LG Polymers have come to a standstill. As such, there was no consumption of Styrene in the process plants. The tanks M5, T2, T23 have better design features with adequate safety layers than M6 to cope up with long duration storage whereas the M6 Tank, about 53 years old with poor design for maintaining uniform temperatures as well as TBC concentrations appeared to be burdened for long duration storage of Styrene and its continuous use without periodical cleaning. **The following are the inventory of Styrene in different tanks prior to the accident.**

Table 2.9: Styrene tank Capacities

SM Storage Tank	Capacities	Styrene (MT) present in tanks as on 06.05.2020
M5	3300 MT	2970
M6	2800 MT	1937*
T2 (in EIPL, Port area)	5419 KL	3200
T23 (in EIPL, Port area)	7325 KL	6800

***** The GM (production) answered to a questionnaire that the tank was having 1937 MT as on 06-05-2020. As per the statement of Director of Operations, 95 MT of Styrene was transferred from M6 on the morning of 7th May 2020, as a part of the Emergency Response. Hence, 1842 MT of Styrene must be present in the M6 Tank after 07.30 a.m. on 07-05-2020.

Further, the Director of Factories has reported that as per his information, 95 MT of Styrene liquid was transferred from M6 Tank i.e. 70 Tons to one Spare Tank -1221A, 10 Tons into Feed preparation tank and 15 Tons in Feed Solution Tank on the 7th of May 2020 as per the statement of Shri M. Rajesh the SMH operator.

The Committee observed that only an intensive investigation by recording statements of all concerned can conclusively prove whether liquid Styrene monomer was transferred during the accident in early hours of 7th May 2020.

Further, the Technical Committee, based on statement of Mr. M. Rajesh, Operator at SMH, had examined the operator log sheets, on 6th May 2020, where very scanty information was noted. In a shift of 8 hours, no information about pump was mentioned. There was no flowmeter to observe the flow of Styrene being pumped in the circuit. LG Polymers is at fault of not deigning proper log-sheet to note the timings for each activity.

Not an essential industry, only minimum staff given permission: According to the statement of the Director (Operations), the LG Polymers approached the District Collector through an email and a letter dated 23rd March 2020 to grant permission for partial operation of the plant with skeletal staff during the lockdown period in view of the nature of Styrene and its storage in large quantities at the plant complex. However, permission was not accorded by the district administration as it was not classified as an essential industry. In line with the guidelines of lockdown by Government of AP through G.O.Rt.No.209 of the Health, Medical & Family Welfare (b2) Department dated 22.03.2020 imposing certain restrictions, Special Chief Secretary Industries and Commerce Department has issued operational guidelines vide Lr. No. I&CDept./SPL.CS/171. Dt 24.03.2020 exempting 25 types of essential industries from lockdown. In the list of 25 essential industries "Manufacturing Polystyrene and Expandable Polystyrene and Engineering Plastics Compounds", are not included. Subsequently, the company applied for minimum staff for maintaining the factory. Permission was granted on 28th March 2020 and passes were issued for 45 personnel @ 15 per shift.

Further, the management did not take up the matter with the higher authorities like the Commissioner of Industries, the Principal Secretary of Industries Department, Government of Andhra Pradesh, if they had felt the absolute necessity for continuing the operations during the Covid-19 lockdown period, keeping the safety of the factory into account, in view of hazardous

Styrene in bulk storage. The Technical Committee has reported that it is learnt that all the Styrene-based plants around the world are being operated smoothly in spite of the Covid-19 lockdowns in several countries. The Committee observed that the management of the company did not take up this issue in full earnestness.

No special measures in the lockdown: Since 29th March 2020, 45 operating personnel have been working in two shifts, 06:00 a.m. to 06:00 p.m.; 06:00 p.m. to 06:00 a.m. and in general shift from 08:00 a.m. to 05:00 p.m. Thus, the Styrene storage tanks were being monitored from 29th March 2020 by an operator in each shift, and the shift in charge in general shift. As per the SOPs for handling and storage of Styrene given by the company, the operators have been maintaining parameters and noting the values in the logs. From the analysis of Styrene samples collected from the storage M6 Tank along with other tanks, it can be seen that the measurements were carried out in the same manner as before the lockdown. While, the minimum sampling was conducted, no special measures were taken for the lockdown period. In summer, it warrants daily sampling and testing should be carried out as per the guidelines But, in LG Polymers, daily sampling and testing was not practiced even in normal times and as stated above no special measures were taken during the lockdown period.

No stocks of TBC: As per the statement of the Director (Operations), no stock of TBC was available from 23rd March 2020. After sending 48 kg of TBC for the maintenance of T2 and T23 at the port area on 22nd March 2020, there was no TBC in the factory although an order was placed on 16th April 2020. Anyway, it was not the practice in the LG Polymers to add TBC to the Styrene storage tanks. Even in the lockdown period, the management or the senior technical executives did not consider adding TBC as a preventive measure. When TBC arrived immediately after the disaster, it was not useful to the M6 Tank which reached about 154°C. The TBC is ineffective at high temperatures even in the presence of soluble oxygen in Styrene.

Total number of days sensitivity analysis: H. Fisher provides an inhibitor effectiveness rate equation as given as $L = A * \exp\left(\frac{E}{RT}\right) * C^N$,where the induction days (L), is a function of (T)

Temperature expressed in degrees Kelvin and Concentration of Inhibitor (C); where, A – Pre-exponential Factor (days/ppm-inhibitor)= 3.176 E-18; R – Gas Constant(1.9872 cal / gm-mole K); E – Activation Energy (cal / gm-mole) = 25070; N – Concentration Exponent-1.308. Table 2.10 gives Incubation days sensitivity analysis with temperature and TBC Concentration.

Incubation Days [Temperature in Rows (°C), and Inhibitor concentration in column (ppm)].

Table 2.10: Incubation Days Sensitivity Analysis

	20	25	30	35	40	45
4	97.4656	47.32621	23.53461	11.97189	6.222955	3.301922
8	241.3229	117.1788	58.27123	29.64216	15.40792	8.175494
10	323.1148	156.8943	78.02117	39.68881	20.63014	10.94642
12	410.1342	199.1482	99.03337	50.37757	26.18613	13.89445
14	501.7558	243.6367	121.1568	61.63162	32.03595	16.99839
15	549.1415	266.6458	132.5989	67.4521	35.06142	18.60371
16	597.5109	290.1324	144.2784	73.39341	38.1497	20.24236
18	697.033	338.4572	168.3096	85.6179	44.50396	23.61395
25	1071.18	520.1311	258.6533	131.5751	68.39238	36.28924
50	2652.221	1287.835	640.4205	325.7773	169.3382	89.85144

As seen from the table 2.10 above, at temperatures of 17°C and inhibitor ppm of 15 ppm as recorded for M6 Tank from the samples taken at the bottom level of the tank, the Styrene can be safely stored for 549 days or more. Alas! this was not the case and the accident took place in 44 days of storage. As seen from the table 2.10, the 44 days safe period corresponds to 4 ppm at about 26°C and corresponds to 11 ppm at about 35°C. Thus, it is more likely that the top levels of the liquid Styrene monomers were having TBC content in the range of 4 ppm to 11 ppm and the temperature in the range of 26°C to 35°C. This also confirms the finding earlier that the temperature at the top levels of the M6 Tank was much higher and the TBC content was highly depleted. The conclusion of having lower than critical concentrations of TBC at the high temperature top zone of the M6 Tank is confirmed. This would have set in process the thermal radical polymerisation and being an adiabatic tank (insulated) the heat generated could not be dissipated. It must have resulted in further temperature increase beyond 65°C, leading to runaway reactions.

A simple step which could have been taken in lockdown period: The EIPL carries out reverse circulation of the contents in the tanks T2 and T23 daily, to ensure thorough mixing of the liquid in the tanks. The same operational technique could have also been carried out by LG Polymers for M5 and M6 Tanks as they are inter-connected, as a part of its Standard Operating Procedures. While in normal running conditions this was not felt essential, this was an absolutely essential requirement during the lockdown period. **The General Manager at EIPL informed the Committee on 17th May 2020** that the reverse circulation of contents in tanks T2 and T23 (uninsulated) daily to ensure thorough mixing of the liquid in the tanks. **Recirculation minimizes localised heating** maintaining **uniform temperatures** in the tank.

White Cloud Formation of Styrene vapor

There is a question of explaining the white cloud formation. As light passes through a cloud of vapour, it passes through the liquid droplets in the vapor making its appearance white. This concept is known as Mie scattering. The moisture in the original liquid Styrene is also vaporised when the temperature in the tank reaches 100°C. The white vapor is an admixture of Styrene vapour, water vapour and the water present in the air as humidity.

2.2.7 Knowledge / Talent Deficit

The technical investigating team determined root and contributing causes for the accident and revealed the deficiencies in the following management systems.

a) Incident Investigation
b) Human Resources
c) Hazard Recognition
d) Emergency Response and Communications
e) Knowledge / Talent Deficit

There was a dearth of knowledge talent among the top, middle and shift management in LG Polymers. The information of employees has been provided by the company. After going through the list, the Technical Committee has checked the composition of the employees. Many chemical engineers with 20 – 30 years of experience in the Styrene and its polymers plants have either retired or left the company for better opportunities. **Most of the present shift in-charges / engineers are not qualified engineers**. The operators once upon a time with science degree / intermediate qualifications have been promoted based on their experience as engineers. These candidates may run the process plants meticulously according to the process operating manuals and SOPs. But their knowledge and skills would not be adequate when faced with a challenge or an emergency. Such decision-making experience and capability are important in dealing with major upsets during processing hazardous chemicals like Styrene. The list shows 26 chemical engineers. Among the 4 Korean engineers, the technical advisor looks after the day to day technical operations in the LG Polymers. He was asked to submit a statement regarding the prima facie of the accident. He has sent a letter saying that their investigating team did not find the reasons yet. He informed that he was unable to submit any statement until then. The seventeen diploma chemical engineers are trainees and hardly have the requisite experience. That leaves 5 chemical engineers whose experience is limited in Styrene and its polymer plants. LG Polymers at Visakhapatnam needed well-qualified engineers with minimum of 20 years of experience in Styrene plants. Is it a cost reduction that held the LG Polymers to employ right candidates? At the helm of operations, to lead the team, the director (operations) should be a chemical engineer to provide the necessary leadership for hazardous chemical processing. In the present case, the director is an instrumentation man with an MSc degree. During the investigation, the Technical Committee was surprised to find that most of the process units were being manned by the senior engineers and managers who had qualifications of intermediate and bachelor's degree in science. At some of the locations even the 10th class candidates were employed. Thus, the knowledge / talent deficit among top, middle and lower cadres also contributed to the disaster.

Table 2.11: List of Employees / Contractor Workers as on 7th May 2020

(6th May 2020 C Shift)

S. No	Name of Employee	Dept.	S. No	Name of Employee	Dept.
Employees			**Contract Workers**		
1.	Mr. Chakrapani	GPPS	1	T Uma Maheshwara Rao	Security
2.	Mr. Achyut	GPPS	2	G Srinivasa Rao	-do-
3.	Mr. Gowri Nath Babu	HIPS	3	Y Rama Krishna	-do-
4.	Mr. R Mohan	HIPS	4.	G. Yeruku Naidu	-do-
5.	Mr. T Shyam	HIPS	5	P Venkata Raju	-do-
6.	Mr. S Pavan	Elect	6	E. Eswara Rao	-do-
7.	Mr. Balavenkata Rao	Elect	7	D S Raju	Canteen
8.	Mr. E Venkata Rao	Elect	8	G Jagadish	First Aid
9.	Mr. Ravi Krishna	EPS	9	G Nooka Raju	Driver
10.	Mr. UV Ramana	GPPS	10	DJ Ganesh	Safety
11.	Mr. Jaya Ram	GPPS	11	M Venkata Ramana	Flt Driver
12.	Mr. P Balajee	EPS (NDO)	12	M Narasinga Rao	Flt Driver

The management of LG Polymers has provided a selective information regarding the employees present during the emergency response and their educational qualification & experience. As seen from the report of Director of Factories, the LG Polymers have reported the following staff to the Director of Factories as listed below in Table 2.12.

Table 2.12: Experience of the Staff

Employee Details	Educational Qualifications	Experience		
		Within LG Polymers	Outside LG Polymers	Total
P. Balajee, Manager (Production) & Night Duty Officer	M.Tech, in Chemical Engineering	6 Years 7 Months	2 Years 7 Months	9 Years 2 Months
S. Atchyut, Shift In charge, GPPS plant	Diploma in Chemical Engineering	1 Year 10 Months	5 Years 1 month	6 Years 11 Months
K. Chakrapani, Engineer	B.Sc. Chemistry	7 Years 8 Months	--	7 Years 8 Months
U. Venkata Ramana, Asst Engineer	B.Sc. Chemistry	4 Years 11 Months	_	4 Years 11 Months

Employee Details	Educational Qualifications	Experience		
		Within LG Polymers	Outside LG Polymers	Total
N. Jayaram Kumar, Jr Engineer	B.Sc. Chemistry	3 Years 10 Months	--	3 Years 10 Months

2.3 Root cause

The Technical Committee has used the details of level records to estimate the loss of Styrene from the M6 Tank as vapour into atmosphere (Refer Volume - I). The total release of Styrene vapour up to 07:40 a.m. on 8th May 2020 is approximately 562.43 MT. The total loss of Styrene till 11:52 a.m. is approximately 818.16 MT. This is based on the assumption that 95 MT of Styrene monomer was withdrawn during the emergency response measures; otherwise the quantities will be 95 MT more. The modelling is explained in detail in Chapter 4.

The Technical Committee has made an intensive investigation in a scientific manner and the report in Volume – I may be read as a part and parcel of this analysis. The Technical Committee has also prepared a fishbone diagram explaining the root causes (refer Volume – I) and is produced below in Figure 2.20.

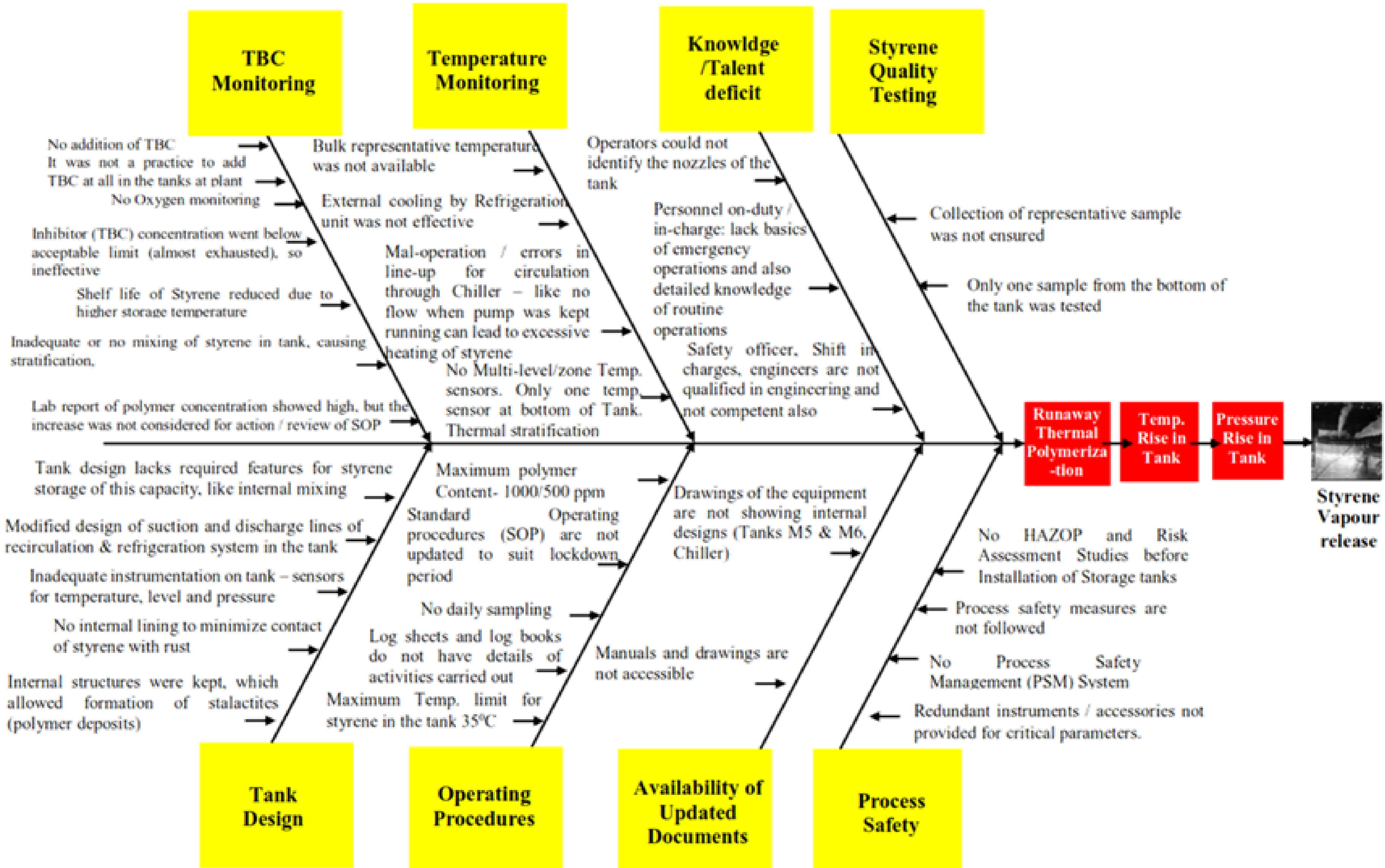


Figure 2.20: Ishikawa Fishbone diagram

The Committee deliberated on the main causes of the accident and identified the following as the root causes behind runaway polymerisation reaction leading to uncontrolled Styrene vapour release from M6 Tank in LG Polymers Visakhapatnam.

- The modified piping design carried out by December 2019, within the M6 Tank not only totally disturbed the Styrene recirculation system but also led to significant thermal stratification in the M6 Tank with high temperature gradient. Hence, the top level of the Styrene monomers in M6 Tank experienced much higher temperatures than the bottom layer.
- The refrigeration system was operated as a standard practice in LG Polymers from 8:00 a.m. to 05:00 p.m. only on all days manually. There was inadequate time duration for Refrigeration and cooling system to maintain the temperature of Styrene monomer below 20°C in the M6 Tank at all levels in the tank.
- The temperature measurement in M6 Tank is restricted to the bottom zone, while the top and central zones had higher temperatures. Thereby, the temperatures at the top level and the middle level were not available at all to detect the temperature rise in the upper levels. Further, the SOP followed by LG Polymers for the temperature limit of 35°C was improper. The prescribed frequency standards of polymer and TBC measurement were also not followed and the samples of Styrene monomer from the recirculation and refrigeration system viz., bottom of the M6 Tank was analysed once in 4 days approximately by LG Polymers.
- The high temperatures at the top levels of the tank led to Thermal Radical Polymerisation. The high temperatures made the limited TBC available (due to Thermal Stratification) at the top layers ineffective.
- The M6 Tank was an old tank with old design structures. The inner side of the tank was not lined. Further, LG Polymers was complacent in cleaning the tank once in 5 years (last cleaned in 2015) resulting in the accumulation of contaminants, which acted as catalyst inside the tank, initiating polymerisation of Styrene which overwhelmed the inhibition effects of TBC.

- The company management had ignored the increase of polymer content from 4th April 2020 and then the sharp rise on 25th April 2020 / 28th April 2020. The management considered polymer content as a quality measure for Styrene rather than a safety measure. The early indications of a runaway reaction shown in the rise in polymer content in the M6 Tank was totally ignored.
- Onset of runaway polymerisation reaction is the critical parameter in the root causes of the accident. There was only one sensor for temperature which measured only the local temperatures and did not indicate the temperatures at the higher level of the tank as the contents were not well mixed. The measured temperature reported by LG Polymers did not reflect any potential catastrophic high temperature hot spots in the tank. Polymerisation was ongoing and unnoticed in zones that are not near the lone temperature sensor for the quantity (1937 MT) of Styrene monomer in (in 18 m dia x 12.185 m tall vertical cylindrical fixed roof tank). The uncontrolled Styrene vapour release from the M6 Tank was due to high temperatures, well beyond the company's protocol temperature of 35°C.
- The company failed to consider the TBC stratification and measured TBC only from the samples from the bottom layer. Further, there was no stocks of TBC available in the LG Polymers at the time of accident. The quantity of high temperature inhibitors like TDM & NDM was also limited, which got exhausted after few hours and failed in preventing the runaway reactions.
- There was no monitoring device or no monitoring system in place to measure the quantum of dissolved oxygen in the Styrene monomer in M6 Tank.
- As clarified later in this chapter, no process safety management system was followed in LG Polymers.
- There was a dearth of knowledge and talent among the top, middle and shift management in LG Polymers. Most of the present shift in-charges / engineers were not qualified engineers. Hence, their knowledge and skills were not adequate when faced with a challenge or an emergency.

- LG Polymers was closed during the Covid-19 lockdown period as it is a non-essential industry and the minimum staff were given permission to maintain the factory during the lockdown period. However, the LG Polymers management was irresponsible, as they followed the same SOP as applicable for regular steady state operational circumstances, during the lockdown period as well and did not consider the idling conditions in the M6 Tank. Further, they ignored the early indications in rise in polymer content.
- No separate SOP was created for the lockdown and restart operations (PSSR: Pre-Start up Safety Review). Thus, the LG Polymers did not at all consider the idling conditions in all the tanks including M6.

In the light of the root causes mentioned above, the Committee is of the view that the accident in the Styrene storage M6 Tank can be attributed to poor design of tank, inadequate refrigeration and cooling system, absence of circulation & mixing systems, inadequate measurement parameters, poor safety protocol, poor safety awareness, inadequate risk assessment and response, poor process safety management systems, slackness of management, insufficient knowledge amongst staff, insufficient knowledge of the chemical properties of Styrene, especially during storage under idle conditions.

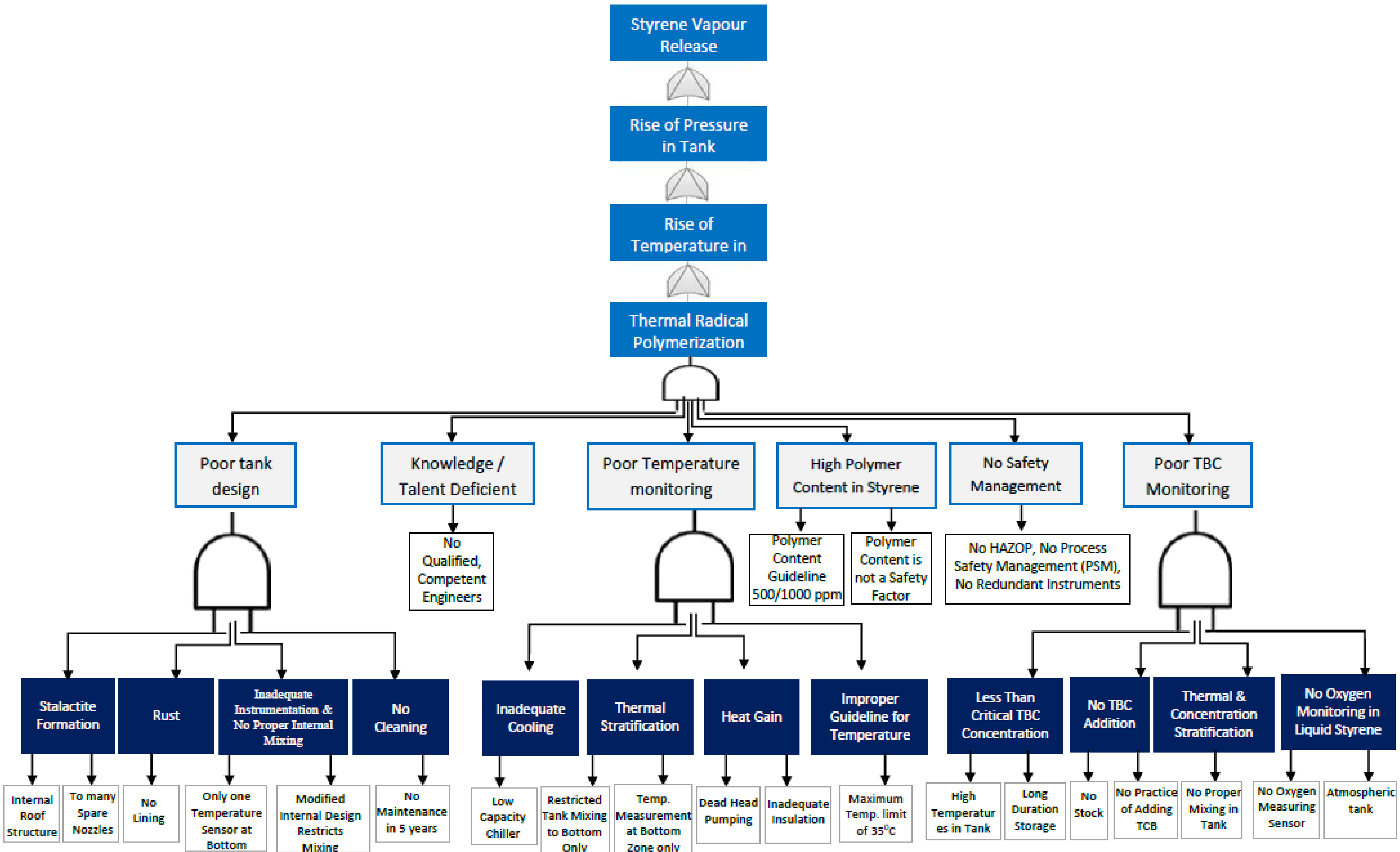


Figure 21: Fault Tree Diagram

2.4 Safety Protocols

i. The Occupier of the factory has failed to provide and ensure the information, instruction, training and supervision to ensure health and safety of all workers during start-up operations. The restarting process has not been carried out as per the standard procedures, protocols and guidelines in the presence of entire technical team, including safety officer and factory medical officer of the factory.

ii. The Occupier has failed to provide and maintain the plant and systems to be safe and without risks to the health of the workers. The arrangements for ensuring safety and health of the workers by ensuring absence of risks in connection with the use, handling, storage and transport of chemicals in the factory premises have also been not provided.

iii. The Pre-Startup Safety Review (PSSR), which is a safety review conducted prior to startup of a processing/manufacturing plant to ensure that installations meet the original design or operating intent, to catch, re-assess any potential hazard due to changes during the lockdown period, has not been done. The identified hazards through the Pre-Startup Safety Review (PSSR) study have not been eliminated, prevented and controlled before starting the operations in plant. A record on this was also not maintained for the review by the regulatory authorities.

iv. The Styrene storage tank has been originally designed to store some other chemical substance (molasses) and after the acquisition of this factory by the present management, this tank has been used to store Styrene since 1977, without any perceptible changes. A self-supporting type dome roof is recommended for vertical storage tanks. Insulation and refrigeration of storage tanks is recommended for environments where temperatures exceed 75˚F (23.9˚C) for long periods of time. Lined carbon steel tanks are generally used for the bulk storage of Styrene monomer. The inlet and outlet lines for these tanks normally located near the bottom. It is also seen that the bottom and lower 6 to 8 inches (15-20 cm) of vertical storage tanks have not been coated with inorganic zinc silicate linings to provide electrical grounding. Piping is normally of carbon steel, although stainless steel and aluminum may also be used. Further, this Styrene storage tank was also not subjected to any mechanical integrity assessment study and the plant has never implemented any Life Extension Programme (LEP), since the

Styrene tank has performed beyond its designed life period. It is also observed that the Styrene tanks and pipelines of the plant are made of mild steel, which is a serious non-conformance to the laid down standards and guidelines.

v. The roof opening of the Styrene storage tanks above the normal liquid level should be large in diameter and kept to a minimum number. By sloping the tanks toward the drains, horizontal tanks can be drained more completely. However, the above safeguards are found to be missing in the plant.

vi. The prevention of polymer build-up is the primary concern in the stage of Styrene monomer. Prevention of color formation is also important, but this is normally caused by contamination such as rust. Low temperatures, maintaining proper inhibitor and dissolved oxygen levels, correct construction materials, and good housekeeping are all important factors in maintaining a long shelf life. However, it is seen that the above requirements were not met during operation and maintenance of the Styrene tanks of the plant.

vii. The management has informed during the meeting that they have resorted to the process of switching-on in the morning and switching-off in the evening of the Refrigeration and Air Conditioning System (R & A/C) of the Styrene storage tank on daily basis , despite the fact that as per the standards, the R & A/C of the Styrene storage tank should not be switched on or off under any circumstances, since the temperature of Styrene in the tank is a critical safety parameter and the increase in temperature will lead the system to polymerisation and on reaching the critical temperature, resulting in runaway reaction which produces increase of temperature, pressure and volume and formation of toxic gas, and further, due to mechanical failure, the formed toxic gas cloud will be released to the atmosphere and dispersed along with the wind movement. The released dense gas has further moved downwards towards the ground due to its high density, being a dense gas thus reaching the breathing space of the human beings and cattle. The manual switching - on and switching - off of the R & A/C of the Styrene storage tank is an unscientific, human error oriented and unacceptable in terms of process safety, which has allowed the temperature to spike to attain the critical temperature of Styrene, thereby resulting in polymerisation and consequential run away reaction, which in turn resulted in the release of Styrene gas to the environment thereby killing and injuring human and animal population.

viii. R & A/C system of the Styrene storage tank should have been provided with a fully automated instrumentation system of adequate safety integrity level, coupled with the temperature sensor for automatic switching-on and off the R & A/C system based on the temperature reading of the gauges. The non-provision of this system has permitted the human error and onset of reactive hazard resulting in the release of toxic gas cloud.

ix. Styrene polymerises slowly at normal ambient temperatures but very rapidly at elevated temperatures. Styrene polymerisation is initiated by heat, lack of inhibitor and dissolved oxygen, and contact with peroxides and other free-radical initiators, ionic initiators, and redox initiators. The polymerisation process is exothermic, evolving 288 BTU/Ib (17.8 kcal/g-mole). If this evolved heat cannot be dissipated rapidly enough, the temperature may rise to a point, where the reaction becomes very rapid and self-sustaining (a runaway polymerisation). Normally, temperatures above 149 ˚F (65˚C) are needed to initiate runaway polymerisation. During a runaway polymerisation, the temperature will reach and exceed the boiling point of Styrene. The vapor may erupt violently from the tank vents or, if the vents are plugged or too small, it can create enough pressure to rupture the tank. Although some particulate matter in Styrene originates from outside contamination via the receiving-transfer system, it is also formed by the reaction of concentrated TBC solutions with iron. This may occur in lines which have contained Styrene but have been blown dry. Styrene should be free of particulate matter when it is polymerised. It was observed by some of the members during the meeting that there has been high level of corrosion and the tank has not been cleaned for a very long time and they were corroded particles, flakes and substances of mild steel, even though mild steel tanks are not recommended for the storage of Styrene, and in the presence of such corroded particles inside the storage tank, which had acted as a catalyst during the polymerisation thus aiding and propelling the reaction to attain criticality much faster and released the toxic gas cloud. The plant has failed to maintain corrosion free piping and safe Styrene storage systems thus compromising the process safety of the plant.

x. Polymerisation during storage may be prevented by close attention to monomer temperature and inhibitor level polymer content. Care should be taken that vents, valves, pressure-relief devices, gauges, and controls do not become plugged with polymer. However, it is seen that the above procedures were not followed in the plant.

xi. Blanketing of tanks for fire protection should be considered if ambient temperatures warrant this (t >30˚C). However, exothermic polymer formation is prevented by oxygen, so a minimum level of 3-8 volume percent of oxygen in the vapour phase is recommended. But the plant has not maintained nitrogen blanketing system for the Styrene storage tanks even though the ambient temperature in Visakhapatnam is very much higher during the summer season.

xii. There has been only one temperature gauges in the Styrene storage tank, but to ensure reliability, there should have been two independent temperature gauges such that even if one sensor fails the other one would be giving the data.

xiii. Preferably, the vents should be connected to a vapour collection and recovery or treatment system and thus minimizing emission. Proper venting, scrubbing and treatment systems have not been provided to the Styrene storage tank as per the standards. The venting system of the molasses tank has not been redesigned and modified for storing Styrene which is a non-conformance to the applicable standards.

xiv. The plant has not been implemented the Process Safety Management (PSM) system and the system of Management of Change (MOC) has not been implemented in the plant, since the changes such as of using the tank designed for storing some other chemical substance (molasses) for Styrene storage, switching on and off of the R & A/C system of the Styrene storage tank and non-provision of automated instrumentation system of adequate safety integrity level for R & A/C system of the Styrene storage tank have not been assessed and validated as a MOC change before adopting and implementing such changes in the plant. The MOC concept provides for validation and approval of the changes by the expert multidisciplinary team comprising of senior most officers of the plant representing design, operation, maintenance, safety and health departments. If this system had been implemented in the plant, all these changes, which had been carried out in isolation, might have got validated by the MOC team and the hazards that had arisen due to such changes might have been anticipated well in advance and prevented by providing necessary safeguards.

xv. The SOPs on charging of inhibitors to the Styrene storage tanks have not been prepared, issued and followed, since it is understood that the inhibitors have not been charged in the tanks since February 2019 onwards. If the process of charging the inhibitors had been carried out periodically, as per the laid down standards, the reactive safety of Styrene storage might have been ensured, which is a violation on safety.

xvi. The two Styrene storage tanks have not been provided with a buffer tank inter- connected to these tanks and in case of emergency in a tank, the Styrene in the damaged or affected tank might have been transferred to the buffer tank thus preventing, controlling and reducing the emergency.

xvii. The Styrene storage tanks have not been marked, labelled and/or placarded with Hazardous Material Information System (HMIS).

xviii. The plant has not implemented any training programme covering entire management representatives, staff and workers, at least once in every year, consisting of the following training modules:

- Properties and health hazards of Styrene.
- Styrene physical hazards including the potential for fire and explosion.
- Styrene's primary routes for entry into body.
- Safe work and good housekeeping practices.
- The importance of protection from Styrene contact; the proper clothing and cleaning requirements.
- Signs and symptoms of Styrene exposure and action to be taken and medical conditions aggravated by exposure to Styrene.
- The care that must be taken whenever and wherever Styrene is used, handled, stored and transported.
- The availability of written Styrene usage, health hazard and training program procedures.
- Emergency procedures for leaks, spills, and fires, including protective clothing to be worn in such instances.

xix. The Occupier and Manager of the factory have individually failed to provide, maintain and monitor safe and risk free work environment by ensuring that the permissible limits of exposure of Styrene monomer (TWA : 50 ppm and 215 mg/m^3; STEL: 100 ppm and 425 mg/m^3) as laid down under Section 41-F of the Factories Act, 1948, are never exceeded.

xx. Static electricity can cause hazards such as fire and explosion unless certain precautions are observed. To minimize the hazard of static electricity during the operations, bonding and grounding need to be provided. The plant has not conducted electrical safety audit in the plant on annual basis thus violating electrical safety measures, to have a check on the electrical hazards including the electrical fire hazards. Bonding and grounding of Styrene storage tanks and pipelines, and inspection of these system on a periodical basis are also missing in the plant.

xxi. The Safety Officer of the plant has not undergone the one year full-time Advanced Diploma in Industrial Safety (ADIS) course conducted by the Central Labour Institute and Regional Labour Institutes of DGFASLI. His name is also not reflected in the personnel reported to work during the toxic gas cloud release.

xxii. A qualified medical practitioner having undergone 3 months Associate Fellowship in Industrial Health (AFIH) course conducted by DGFASLI has not been appointed as the factory medical officer of the plant and the same has also not been approved by the Directorate of Industrial Safety and Health, Andhra Pradesh.

xxiii. The supervisors handling and storage of chemicals in the plant have not undergone and completed the one-month course for factory supervisors conducted by DGFASLI to make them competent and eligible to handle Styrene in the plant, thus violating Section 41-C (b) of the Factories Act, 1948.

xxiv. The safety report of the plant has not been prepared and made available as under Rule 10 of the MSIHC Rules, 1989.

xxv. The on-site emergency plan has not been approved by the Directorate of Industrial Safety and Health, Andhra Pradesh and this plan does not capture the release of toxic gas cloud from storage tanks as an emergency scenario and no procedures or protocol have been prepared and laid down on the existing onsite emergency plan of the plant. It is understood that the plant has 36 Manual Call Points (MCP) and none of these points were operated during the emergency situation of the toxic gas release to communicate the emergency, which clearly proves on lack of training. Further, it is clear that the team members and team leader as per the onsite emergency plan of the plant and the other workers of the plant were not trained and re-trained on the onsite emergency plan of the plant, which has defeated the entire on-site emergency planning process. Emergency Control Centre has also not been provided and made functional as per the standards. Off-site mock drills for the plant were not conducted once in a year. It is clear from the above that a robust emergency planning has not been made available in the factory.

It may be noted that as per Section 92 and 94 of the Factories Act, 1948, the Occupier and Manager of the factory, shall each be liable for any contravention of the provisions of the Act and the Andhra Pradesh Factories Rules, 1950. Further, whoever contravenes Section 41-B, 41-C and 41-H of the Factories Act, 1948 and the Rules made there under, is liable for punishment as under Section 96-A of the Act. In view of the above, it is clear that the occupier and manager of the plant have violated, individually and jointly, the safety and health requirements laid down under the Factories Act, 1948 and the Andhra Pradesh Factories Rules, 1950.

2.4.1 Failure to submit HAZOP & Risk Assessment Reports and absence of PSM

i. In spite of the several requests, M/s LG Polymers did not submit the HAZOP and risk assessment report carried out for M6 Tank before it was installed, commissioned, modified and converted from molasses storage tank to Styrene storage tank. This comes under the purview of the Department of Factories.

ii. M/s LG Polymers modified the M6 Tank internal design for recirculation and refrigeration circuit in December 2019 without taking permission from PESO and the Department of Factories. Any modification of equipment entails submission of HAZOP and risk assessment report also.

iii. Also, M/s LG Polymers did not submit the HAZOP and risk assessment report on recently constructed M5 tank. Any design of new equipment is subjected to HAZOP and risk assessment study before it is installed and commissioned. This also comes under the purview of the Department of Factories.

iv. LG Polymers does not have any process safety management system

On the whole, it can be concluded that LG Polymers did not have proper safety protocols and violated a number of safety protocols.

2.5 Annexures

2.5.1 Annexure 2.1: Temperature Profile from 6th May – 9th May 2020

The M6 Tank Temperature Data in Hourly Basis

Date	TIME	M6 TANK TEMPERATURE in deg C
	5.00PM	17.05
	6.00PM	17
	7.00PM	17
	8.00PM	17.1
	9.00PM	17.1
	10.00PM	17.15
06.05.2020	11.00PM	17.3
	12.00AM	17.2
	1.00AM	17.15
	2.00AM	17.3
	3.00AM	17.21
	4.00AM	24
	5.00AM	28.7
	6.00AM	30.1
	7.00AM	31.4
	8.00AM	33
	9.00AM	35.1
	10.00AM	38.61
	11.00AM	42.3
	12.00PM	44.6
	1.00PM	44.3
	2.00PM	44.6
	3.00PM	51.2
	4.00PM	66
	5.00PM	70.7
	6.00PM	70.8
	7.00PM	94.6
	8.00PM	104.9
	9.00PM	134.7
	10.00PM	145.6
07.05.2020	11.00PM	153.7
	12.00AM	153.7
	1.00AM	153.7
	2.00AM	153.7
	3.00AM	145
	4.00AM	136.2
	5.00AM	132.6
	6.00AM	122.2
	7.00AM	119.9
	8.00AM	127.5
	9.00AM	129.6
	10.00AM	128.9
	11.00AM	128.3
	12.00PM	127.4
	1.00PM	126.5
08.05.2020	2.00PM	125.6

Date	TIME	M6 TANK TEMPERATURE in deg C
	3.00PM	124.7
	4.00PM	123.4
	5.00PM	121.7
	6.00PM	120
	7.00PM	118.4
	8.00PM	116.9
	9.00PM	115.3
	10.00PM	113.8
08.05.2020	11.00PM	112
	12.00AM	110.6
	1.00AM	109
	2.00AM	107.9
	3.00AM	106.8
	4.00AM	105.3
	5.00AM	104.3
	6.00AM	103.1
	7.00AM	102.1
	8.00AM	100.8
09.05.2020	9.00AM	100

This Temperature data was received from DCS of LG Polymers India Pvt. Ltd. Visakhapatnam on time to time as per the instructions of District Collector, Visakhapatnam and compiled in tabular form.

26/6/2020

(K. SUDHAKAR)
INSPECTOR OF FACTORIES,
VISAKHAPATNAM – 1 CIRCLE.

2.5.2 Annexure 2.2: Temperature reduction to 58.8°C

Temperature of M6 Tank recorded by Factories Dept. From DCS Of LG Polymers (i) Pvt. Ltd. Visakhapatnam

Date	Time	Temperature in deg C	Date	Time	Temperature in deg C	Date	Time	Temperature in deg C
12.05.2020	9.00am	68.2	14.05.2020	8.00am	63.4	16.05.2020	12.00am	61.2
	10.00am	68.4		9.00am	63.4		2.00am	60.6
	11.00am	68.7		10.00am	63.6		4.00am	59.8
	12.00pm	68.9		11.00am	63.9		6.00am	59.4
	1.00pm	69.4		12.00pm	64		7.00am	58.8
	2.00pm	69.8		1.00pm	64.8			
	3.00pm	70.4		2.00pm	65.1			
	4.00pm	70.7		3.00pm	66.1			
	5.00pm	70.3		4.00pm	67			
	6.00pm	70		5.00pm	67.5			
	7.00pm	69.7		6.00pm	67.2			
				7.00pm	66.7			
			15.05.2020	8.00am	61			
13.05.2020	9.00am	65.7		9.00am	60.9			
	10.00am	65.9		10.00am	61.2			
	11.00am	66		11.00am	61.3			
	12.00pm	66.3		12.00pm	62			
	1.00pm	66.8		1.00pm	62.5			
	2.00pm	67		2.00pm	63.3			
	3.00pm	67.6		3.00pm	64.1			
	4.00pm	68.2		4.00pm	64.6			
	5.00pm	68.8		5.00pm	64.8			
	6.00pm	68.5		6.00pm	64.7			
	7.00pm	67.9		7.00pm	63.9			

20/6/2020

(K. SUDHAKAR)
Inspector of factories, Visakhapatnam-I Circle

2.5.3 Annexure 2.3: Temperature Data from 1st January 2019 to 11th May 2020

2

STYRENE MONOMER TANKS DATA AT LG POLYMERS

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
1/1/2019								8	19.5			19.5		
1/2/2019								6	21.5			20.5		
1/3/2019								5	22.0			22.0		
1/4/2019								10	18.5			18.5		
1/5/2019								6	19.0			18.5		
1/6/2019									18.5			19.5		
1/7/2019								8	18.5			20.0		
1/8/2019								8	19.0			21.0		
1/9/2019								9	21.0			22.5		
1/10/2019								9	20.0			18.5		
1/11/2019								8	22.0			19.0		
1/12/2019								15	18.0			20.5		
1/13/2019									18.0			20.5		
1/14/2019								12	18.5			22.0		
1/15/2019									18.0			20.5		
1/16/2019								10	21.5			18.5		
1/17/2019								14	23.0			20.0		
1/18/2019								13	23.5			20.0		
1/19/2019								15	18.5			19.5		
1/20/2019									20.0			20.0		
1/21/2019								13	20.5			20.0		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
1/22/2019								9	20.0			18.5		
1/23/2019								15	21.5			19.0		
1/24/2019								15	19.0			19.0		
1/25/2019								14	19.0			20.0		
1/26/2019									20.5			20.0		
1/27/2019									20.5			20.5		
1/28/2019								23	21.0			21.5		
1/29/2019								18	19.5			21.5		
1/30/2019								10	19.0			20.5		
1/31/2019								9	18.5			18.8		
2/1/2019						21.20		9	19.5			22.0		
2/2/2019						21.00		10	20.0			20.0		
2/3/2019									21.0			20.0		
2/4/2019						21.50		9	21.5			20.5		
2/5/2019						22.00		12	19.0			20.5		
2/6/2019						22.00		10	19.5			18.5		
2/7/2019						22.00		9	20.0			22.5		
2/8/2019						22.50		12	21.0			23.5		
2/9/2019						23.00		13	20.0			23.5		
2/10/2019									18.5			21.0		
2/11/2019						22.50		12	19.0			21.5		
2/12/2019						21.50		15	18.5			21.0		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
2/13/2019						21.00		12	19.5			19.0		
2/14/2019						21.50		9	19.5			20.0		
2/15/2019						22.00		8	21.5			19.0		
2/16/2019						22.50		8	20.0			23.5		
2/17/2019									18.5			22.0		
2/18/2019						22.00		10	19.5			20.0		
2/19/2019						23.00		10	20.5			19.0		
2/20/2019						22.50		7	21.0			22.5		
2/21/2019						23.00		4	19.5			20.5		
2/22/2019						22.50		14	20.0			21.5		
2/23/2019						22.50		9	20.0			19.5		
2/24/2019									20.5			20.0		
2/25/2019						23.50		8	24.5			19.0		
2/26/2019						23.50		12	21.5			19.5		
2/27/2019						23.50		14	19.5			20.0		
2/28/2019						23.00		6	22.5			20.0		
3/1/2019						22.50		8	22.0			19.5		
3/2/2019						21.80		6	19.0			20.5		
3/3/2019						21.80			22.0			24.0		
3/4/2019						22.00			22.5			21.5		
3/5/2019						22.00		11	21.0			23.0		
3/6/2019						23.00			20.5			21.5		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
3/7/2019						23.00		13	19.0			26.0		
3/8/2019						23.00		9	21.0			19.5		
3/9/2019						22.50		15	20.0			20.0		
3/10/2019									20.5			21.0		
3/11/2019						23.00		18	24.5			20.5		
3/12/2019						22.50		16	24.0			19.5		
3/13/2019						23.00		18	20.0			20.5		
3/14/2019						23.00		18	23.5			19.5		
3/15/2019						22.50		13	22.5			20.5		
3/16/2019						22.00		11	25.0			19.5		
3/17/2019						22.00			22.0			20.0		
3/18/2019						21.50		20	23.0			19.0		
3/19/2019						22.00		28	24.5			19.5		
3/20/2019						23.00		22	20.5			22.0		
3/21/2019						22.80		16	23.5			19.0		
3/22/2019						23.50		19	20.0			21.5		
3/23/2019						23.00		20	23.5			19.0		
3/24/2019									19.5			20.0		
3/25/2019						24.00		18	22.5			19.0		
3/26/2019						23.00		16	26.0			21.5		
3/27/2019						23.50		12	20.5			21.0		
3/28/2019						23.00		16	24.5			20.0		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
3/29/2019						23.50		16	20.0			21.5		
3/30/2019						23.50		11	22.5			20.5		
3/31/2019									19.5			21.5		
4/1/2019						23.50		9	20.5			20.0		
4/2/2019						22.50		8	26.5			21.5		
4/3/2019						23.50		9	23.5			25.5		
4/4/2019						22.50		8	20.0			24.0		
4/5/2019						22.30		8	19.5			22.0		
4/6/2019						21.50		7	25.0			22.0		
4/7/2019									19.5			20.5		
4/8/2019						22.00		8	20.0			24.0		
4/9/2019						22.50		8	20.0			21.5		
4/10/2019						26.00		7	25.0			22.0		
4/11/2019						25.50		4	21.5			20.5		
4/12/2019						25.50			23.0			20.5		
4/13/2019						26.00			23.0			19.0		
4/14/2019									21.5			20.0		
4/15/2019						26.00		4	21.0			20.0		
4/16/2019						26.00		5	24.5			19.5		
4/17/2019						25.50		5	20.0			22.0		
4/18/2019						25.00		5	26.0			20.0		
4/19/2019						25.00		15	24.5			19.0		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
4/20/2019						24.50		20	22.0			21.0		
4/21/2019									20.5			23.5		
4/22/2019						24.00		10	21.5			22.0		
4/23/2019						25.00		6	26.0			19.0		
4/24/2019						25.00		8	20.5			21.5		
4/25/2019						25.50		12	23.5			22.5		
4/26/2019						25.00		18	22.5			22.5		
4/27/2019						25.50		16	26.0			24.0		
4/28/2019									22.0			29.0		
4/29/2019						26.00		10	20.5			28.0		
4/30/2019						26.00		12	22.0			20.0		
5/1/2019						25.50		14	19.5			25.5		
5/2/2019						25.50		17	21.5			21.0		
5/3/2019						25.00		22	25.0			19.5		
5/4/2019						25.00		21	20.5			21.0		
5/5/2019									25.5			19.5		
5/6/2019						25.00		18	21.5			25.5		
5/7/2019						25.50		19	21.0			20.5		
5/8/2019						25.50		18	22.5			21.5		
5/9/2019						25.80		18	19.0			23.0		
5/10/2019						26.00		19	24.0			20.0		
5/11/2019						26.00		20	20.0			22.5		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
5/12/2019									22.5			20.0		
5/13/2019						26.00		18	20.0			25.0		
5/14/2019						26.00		12	18.5			26.5		
5/15/2019						25.50		12	20.5			21.5		
5/16/2019						25.00		12	22.0			19.5		
5/17/2019						25.00		10	22.5			20.0		
5/18/2019						24.50		8	18.0			21.5		
5/19/2019									22.0			19.0		
5/20/2019						23.50		6	20.0			20.5		
5/21/2019						23.00		6	18.5			22.5		
5/22/2019						23.40		8	21.5			20.5		
5/23/2019						23.00		10	19.5			23.0		
5/24/2019						23.20		8	21.5			20.0		
5/25/2019						22.70		8	21.5			23.5		
5/26/2019									22.5			20.0		
5/27/2019						23.00		11	19.5			24.0		
5/28/2019						23.50		18	20.5			E		
5/29/2019						22.50		26	19.5			E		
5/30/2019						21.20		30	19.0			E		
5/31/2019						22.00		17	19.0			E		
6/1/2019						23.50		15	19.0			E		
6/2/2019						25.00			20.5			E		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
6/3/2019						25.90		25	21.0			E		
6/4/2019						25.50		29	23.0			E		
6/5/2019						28.00		27	24.0			E		
6/6/2019						30.00		22	25.0			E		
6/7/2019						30.00		5	28.0			E		
6/8/2019						29.00		5	30.0			E		
6/9/2019									24.0			E		
6/10/2019						29.00		6	20.0			E		
6/11/2019						28.00		7	22.5			E		
6/12/2019								7	18.5			E		
6/13/2019						25.50		7	21.5			E		
6/14/2019						24.00		7	22.5			E		
6/15/2019						24.00		8	24.0			24.0		
6/16/2019									19.0			24.5		
6/17/2019						25.50		7	23.5			19.5		
6/18/2019						25.00		8	27.0			25.2		
6/19/2019						25.00		8	22.0			23.0		
6/20/2019						25.50		8	21.0			23.0		
6/21/2019						24.50		7	20.5			22.5		
6/22/2019						24.20		6	23.5			20.5		
6/23/2019									18.0			20.5		
6/24/2019						27.50		5	24.5			21.0		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
6/25/2019						28.00		5	24.0			21.0		
6/26/2019								5	18.0			24.0		
6/27/2019								7	25.4			22.0		
6/28/2019						27.00		6	24.0			23.5		
6/29/2019						25.40		6	26.0			19.5		
6/30/2019									18.5			20.0		
7/1/2019						26.50		6	17.5			19.5		
7/2/2019						26.50		8	26.0			25.0		
7/3/2019						27.50		15	20.5			23.5		
7/4/2019						28.40		12	24.0			20.5		
7/5/2019						27.80		12	18.5			22.5		
7/6/2019						27.00			22.5			19.5		
7/7/2019								13	18.5			21.5		
7/8/2019						27.00		15	18.0			20.0		
7/9/2019						27.50		9	24.5			20.0		
7/10/2019						27.00		10	21.0			21.0		
7/11/2019									23.0			19.5		
7/12/2019						26.50		10	19.5			21.5		
7/13/2019						26.50		11	17.0			24.5		
7/14/2019						26.50			22.5			22.0		
7/15/2019						26.00		9	18.5			22.0		
7/16/2019						25.50		10	18.0			24.0		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
7/17/2019						25.00		12	20.0			22.0		
7/18/2019						26.00		14	25.5			19.5		
7/19/2019						26.00		18	23.0			21.5		
7/20/2019						25.00		14	22.0			19.5		
7/21/2019									18.0			23.0		
7/22/2019						25.00		14	18.0			21.5		
7/23/2019						25.00		10	23.5			21.2		
7/24/2019						25.00		10	19.0			21.5		
7/25/2019						25.00		12	21.0			20.5		
7/26/2019						24.00		14	18.0			21.5		
7/27/2019						24.00		12	21.0			19.5		
7/28/2019									16.5			20.5		
7/29/2019						24.00		15	21.0			21.0		
7/30/2019						23.50		14	25.5			21.5		
7/31/2019						23.50		16	22.5			21.0		
8/1/2019						23.50		18	22.5			19.5		
8/2/2019						24.00		130	20.5			20.5		
8/3/2019						24.00		180	23.0			21.5		
8/4/2019						23.50		172	22.5			22.0		
8/5/2019						24.00		271	21.0			21.0		
8/6/2019						24.00		286	20.5			20.5		
8/7/2019						22.50		250	18.5			21.0		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
8/8/2019						22.00		135	19.0			21.5		
8/9/2019						21.50		250	21.5			21.5		
8/10/2019						21.50		350	19.0			20.5		
8/11/2019									20.5			21.5		
8/12/2019						21.50		280	20.5			20.5		
8/13/2019						21.50		300	26.0			22.0		
8/14/2019						22.00		272	19.5			25.5		
8/15/2019									25.8			21.0		
8/16/2019						22.00		190	21.5			21.0		
8/17/2019						22.00		300	16.5			25.0		
8/18/2019								313	25.5			22.5		
8/19/2019						23.50		282	22.5			21.5		
8/20/2019						24.00		290	18.0			26.0		
8/21/2019						23.50		276	22.0			22.0		
8/22/2019						23.50		280	19.0			22.5		
8/23/2019						24.00		288	22.0			20.5		
8/24/2019						24.00		280	24.0			22.0		
8/25/2019									23.0			21.0		
8/26/2019						24.00		290	20.0			21.0		
8/27/2019						23.50		364	21.0			21.5		
8/28/2019						23.00		300	27.0			21.0		
8/29/2019						23.50		261	20.5			24.0		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
8/30/2019						24.00		293	24.0			20.0		
8/31/2019						24.00		280	19.5			23.5		
9/1/2019						24.50			23.0			21.0		
9/2/2019									21.0			21.0		
9/3/2019						24.50		336	21.5			24.0		
9/4/2019						24.50		241	20.0			29.0		
9/5/2019						24.00		236	21.0			20.5		
9/6/2019						24.00		210	18.0			21.0		
9/7/2019						24.00		210	19.0			20.5		
9/8/2019									21.0			22.5		
9/9/2019						23.50		210	20.5			22.0		
9/10/2019						23.50		203	25.0			21.0		
9/11/2019						23.50		190	22.0			20.5		
9/12/2019						23.00		182	20.0			22.0		
9/13/2019					191	22.50		174	21.0			19.5		
9/14/2019					101	23.00			17.5			22.5		
9/15/2019									19.0			21.0		
9/16/2019					96	23.00		165	19.0			21.5		
9/17/2019					106	23.50		180	23.5			20.5		
9/18/2019					100	23.50		176	20.0			23.5		
9/19/2019					108	23.00		184	19.5			19.5		
9/20/2019					57			175	19.5			20.0		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
9/21/2019					50	24.00		166	16.5			23.5		
9/22/2019									25.0			22.0		
9/23/2019					25	24.00		162	20.5			23.0		
9/24/2019					21	24.00		164	18.0			24.0		
9/25/2019					13	22.00		180	22.0			20.5		
9/26/2019						22.00		179	20.0			21.0		
9/27/2019					18	22.50		181	14.0			19.0		
9/28/2019					18	25.00		190	21.5			20.0		
9/29/2019									21.0			24.0		
9/30/2019					6	28.00			22.0			24.0		
10/1/2019					8	28.00		188	25.0			23.0		
10/2/2019									22.0			23.5		
10/3/2019					9	28.50			21.0			21.0		
10/4/2019					8	29.00		187	25.5			19.5		
10/5/2019					5				24.5			24.5		
10/6/2019									23.5			19.5		
10/7/2019					5				20.5			21.5		
10/8/2019									18.2			21.0		
10/9/2019					5				20.0			23.0		
10/10/2019					6				25.5			28.5		
10/11/2019									27.0			24.5		
10/12/2019									26.5			23.0		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
10/13/2019									24.5			19.5		
10/14/2019					6				20.0			24.5		
10/15/2019									21.5			24.5		
10/16/2019					5				26.5			25.5		
10/17/2019									19.0			24.0		
10/18/2019					5				26.5			20.0		
10/19/2019					5				24.5			24.0		
10/20/2019									23.0			19.0		
10/21/2019					4				20.5			20.5		
10/22/2019					6				20.9			22.9		
10/23/2019					6				23.0			19.5		
10/24/2019									19.5			20.0		
10/25/2019					6				21.5			20.5		
10/26/2019					6				18.5			20.5		
10/27/2019									19.0			21.0		
10/28/2019									20.0			21.5		
10/29/2019									22.0			23.5		
10/30/2019					6				23.5			19.5		
10/31/2019					5				21.0			22.0		
11/1/2019					5				25.0			21.0		
11/2/2019					5				22.0			26.5		
11/3/2019									23.5			26.5		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
11/4/2019					6				20.5			27.0		
11/5/2019					5				21.5			27.0		
11/6/2019					6				19.5			28.5		
11/7/2019					5				19.5			26.0		
11/8/2019					5				19.0			26.5		
11/9/2019					5				19.5			22.5		
11/10/2019									21.0			26.0		
11/11/2019					9				18.0			24.5		
11/12/2019					8				20.0			24.0		
11/13/2019									20.0			23.5		
11/14/2019									20.5			26.5		
11/15/2019									19.0			23.5		
11/16/2019									20.5			27.0		
11/17/2019									21.0			26.0		
11/18/2019									18.0			24.0		
11/19/2019									22.5			26.0		
11/20/2019									22.5			27.5		
11/21/2019									19.0			21.0		
11/22/2019									19.5			19.5		
11/23/2019									20.0			20.5		
11/24/2019									20.5			21.5		
11/25/2019									22.0			23.0		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
11/26/2019									18.0			20.0		
11/27/2019									21.0			23.0		
11/28/2019									18.0			19.5		
11/29/2019									19.0			20.0		
11/30/2019									19.2			21.2		
12/1/2019									19.5			21.5		
12/2/2019									20.0			22.0		
12/3/2019									23.0			24.0		
12/4/2019									21.0			22.0		
12/5/2019									21.0			19.0		
12/6/2019									17.5			19.0		
12/7/2019									18.5			20.0		
12/8/2019									19.0			22.0		
12/9/2019									19.5			22.5		
12/10/2019									20.0			22.5		
12/11/2019									19.0			21.5		
12/12/2019									19.0			19.5		
12/13/2019									22.5			22.0		
12/14/2019									19.0			19.0		
12/15/2019									18.0			20.5		
12/16/2019									19.0			21.0		
12/17/2019									21.0			19.0		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
12/18/2019									18.0			22.0		
12/19/2019									21.0			18.5		
12/20/2019									18.0			23.0		
12/21/2019									20.5			19.0		
12/22/2019									21.0			19.0		
12/23/2019									21.0			19.0		
12/24/2019									20.5			19.5		
12/25/2019									19.0			20.5		
12/26/2019									21.5			19.5		
12/27/2019									18.5			19.5		
12/28/2019									18.5			19.0		
12/29/2019									20.0			19.0		
12/30/2019									20.5			19.5		
12/31/2019									20.0			21.0		
1/1/2020	27.1	25.2	24.3			20.5			20.5			18.5		
1/2/2020	27.0	25.3	18.8			23.0			19.5			20.5		
1/3/2020	26.9	25.3	19.5			20.8	15	18	18.0			19.0		
1/4/2020	26.8	25.2	21.8			21.0			18.5			19.0		
1/5/2020	26.8	25.2	23.0			21.0			23.0			19.0		
1/6/2020	27.2	25.3	23.3			21.0	15	8	23.0			20.0		
1/7/2020	26.8	25.3	19.9			23.0	15	10	18.0			20.0		
1/8/2020	26.8	25.3	20.6			24.4			20.0			19.5		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
1/9/2020	26.7	25.3	21.0			24.5	15	9	19.5			20.0		
1/10/2020	27.6	25.4	21.7			25.1	15	8	20.0			21.5		
1/11/2020	26.8	24.6	24.3			25.1			23.0			22.0		
1/12/2020	27.2	24.9	23.9			24.6			21.0			18.5		
1/13/2020	26.2	25.8	24.0			24.7	15	9	20.0			19.0		
1/14/2020	26.4	25.5	22.5			24.6			19.0			20.0		
1/15/2020	26.5	25.7	23.9			21.6			19.4			18.2		
1/16/2020	26.4	26.3	23.9			21.8			20.0			18.5		
1/17/2020	27.3	26.2	24.0			22.1			21.0			19.5		
1/18/2020	27.3	26.3	24.7			22.4			21.5			18.5		
1/19/2020	27.5	26.3	24.3			22.5			19.5			21.0		
1/20/2020	27.4	27.2	24.4			22.8	15	16	19.5			21.0		
1/21/2020	27.7	27.3	25.0			21.7	18	15	22.0			19.0		
1/22/2020	27.4	25.2	23.6			23.3	18	18	19.0			20.0		
1/23/2020	27.0	25.2	23.9			23.3	18	26	19.0			19.0		
1/24/2020	27.4	25.3	24.1			21.2	18	20	19.5			19.0		
1/25/2020	27.8	25.3	24.2			21.1	18	19	20.5			18.5		
1/26/2020	27.9	25.4	24.4			22.9	15	18	19.0			20.5		
1/27/2020	28.5	25.5	24.5			23.2	15	16	20.0			19.5		
1/28/2020	28.1	25.5	24.6			22.3	15	15	19.5			19.5		
1/29/2020	27.1	25.5	24.9			21.0			18.5			19.5		
1/30/2020	27.1	25.4	24.2			21.0	15	12	19.0			19.5		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
1/31/2020	27.7	25.5	21.8			22.1	15	18	19.5			20.0		
2/1/2020	27.9	25.5	18.5			22.5			22.5			19.0		
2/2/2020	26.3	25.5	24.2			24.5	15	20	19.0			21.0		
2/3/2020	26.6	25.6	25.0			24.5			18.5			19.0		
2/4/2020	26.9	25.8	24.5			24.5			22.0			19.5		
2/5/2020	25.0	25.6	23.4			24.4			18.5			21.5		
2/6/2020	26.8	25.2	25.2			21.4			21.0			19.0		
2/7/2020	26.8	25.2	22.7			21.5			20.0			20.5		
2/8/2020	27.4	25.0	22.5			22.9	25	15	19.5			20.5		
2/9/2020	26.5	25.1	22.9			24.0			19.5			23.0		
2/10/2020	26.3	25.2	24.8			24.6	15	10	20.0			23.5		
2/11/2020	27.4	25.3	25.1			22.9	15	17	22.5			21.0		
2/12/2020	27.2	25.2	21.6			23.0	15	18	20.5			20.5		
2/13/2020	27.8	25.3	22.1			22.2			19.5			20.5		
2/14/2020	28.3	25.3	24.4			21.7			21.0			20.5		
2/15/2020	28.6	25.0	24.7			21.7	15	10	19.0			19.5		
2/16/2020	28.9	25.0	24.7			21.8			22.0			19.5		
2/17/2020	29.1	25.5	24.6			22.1	15	8	19.0			22.0		
2/18/2020	29.4	26.2	19.9			22.3	20	15	18.0			25.0		
2/19/2020	29.4	26.4	17.4			24.9	20	15	20.5			19.5		
2/20/2020	29.1	26.5	13.8			25.8	20	17	19.0			19.5		
2/21/2020	29.2	26.7	15.7			25.1			19.5			19.5		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
2/22/2020	29.1	28.9	17.9			24.5			21.0			23.0		
2/23/2020	29.0	25.5	24.3			24.5			24.0			19.0		
2/24/2020	29.2	29.0	24.7			24.5			21.5			23.0		
2/25/2020	29.4	28.9	24.5			24.6	20	16	20.5			25.0		
2/26/2020	29.1	28.8	24.1			23.1			23.0			20.5		
2/27/2020	27.9	26.4	24.6			19.4	20	16	19.5			19.5		
2/28/2020	28.0	27.7	16.9			22.3	20	14	21.5			19.0		
2/29/2020	27.8	25.2	22.1			20.6	17	14	18.0			20.0		
3/1/2020	28.2	25.2	18.6			22.0			20.5			19.0		
3/2/2020	28.8	25.2	16.1			24.2	17	14	20.0			20.0		
3/3/2020	29.4	25.3	17.5			22.6	17	15	19.5			22.0		
3/4/2020	29.6	25.4	18.5	15	7	22.5			20.5			19.0		
3/5/2020	29.2	25.0	23.4	15	9	18.8			18.0			19.5		
3/6/2020	29.4	24.6	22.6	15	6	19.3			19.0			21.5		
3/7/2020	28.8	25.2	19.4	15	5	21.9			20.5			19.5		
3/8/2020	27.9	25.3	22.5	15	7	21.9			19.0			21.0		
3/9/2020	29.4	25.5	21.5	15	6	22.1			20.0			19.0		
3/10/2020	29.0	25.5	21.9	15	7	22.3	15	11	25.5			20.5		
3/11/2020	30.1	25.6	20.9	15	6	22.7			21.0			21.0		
3/12/2020	30.2	25.7	21.4	15	6	22.5			20.5			20.0		
3/13/2020	31.0	26.2	19.8	15	6	21.2			21.0			22.0		
3/14/2020	31.5	28.3	21.0	15	5	19.9			22.3			19.3		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
3/15/2020	31.2	30.6	20.7	15	6	20.1			19.5			21.5		
3/16/2020	30.9	30.5	23.1			20.6			19.5			19.0		
3/17/2020	31.5	31.1	24.5	15	6	20.9			25.5			19.0		
3/18/2020	30.9	30.6	25.3	15	5	19.1			21.5			20.5		
3/19/2020	28.5	28.9	23.6	15	6	19.5	17	14	22.5			19.5		
3/20/2020	26.6	26.6	24.4	15	6	18.7			18.5			20.7		
3/21/2020	27.6	27.3	25.7	15	6	19.1			19.1			22.2		
3/22/2020	29.6	29.2	26.9			18.7			19.5			21.0		
3/23/2020	30.1	29.8	27.2			19.1	20	16	20.5			19.0		
3/24/2020	27.5	27.9	27.5			19.8	20	16	24.0			20.0		
3/25/2020	29.5	29.1	22.2			18.2			20.0			15.0		
3/26/2020	30.0	29.6	22.7			18.7			17.5			17.6		
3/27/2020	31.4	30.9	23.4			18.7			17.7			16.8		
3/28/2020	32.0	31.4	22.1			18.9			15.5			16.4		
3/29/2020	32.6	32.0	22.7	15	8	19.0	15	20	15.8			16.3		
3/30/2020	32.0	31.3	26.2			18.3			18.0			26.9		
3/31/2020	31.8	31.2	28.3			18.7			16.9			25.9		
4/1/2020	32.2	31.5	24.7	15	14	17.8	17	16	17.0		50	21.5		52
4/2/2020	32.4	28.7	28.4			19.1			18.1			18.6		
4/3/2020	30.9	29.0	29.1			18.2			19.1			19.3		
4/4/2020	29.5	29.4	29.5	15	20	18.0	16	34	19.0		38	19.1		54
4/5/2020	29.6	29.4	25.7			18.0			19.1			18.3		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERA TURE	M5 TANK MIDDLE TEMPER ATURE	M5 TANK BOTTOM TEMPERA TURE	M5 TAN K TBC	M5 TAN K POLY MER	M6 TANK TEMPE RATUR E	M6 TANK TBC	M6 TANK POLYM ER	TA-111A TEMPE RATUR E	TA-111A TBC	TA-111A POLYM ER	TA-111B	TA-111B TBC	TA-111B POLYM ER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
4/6/2020	29.6	29.4	20.9			17.8			19.5			17.2		
4/7/2020	29.7	29.5	18.2	15	28	18.6	16	45	19.7		15	17.3		28
4/8/2020	29.8	29.5	17.0			17.6			19.5			17.8		
4/9/2020	29.9	29.5	18.1			18.4			19.6			17.8		
4/10/2020	29.9	29.5	14.9	15	20	18.4	16	40	19.7		51	16.9		45
4/11/2020	30.0	29.6	15.4			17.1			16.5			17.0		
4/12/2020	30.1	29.6	13.0			17.4			19.5			16.3		
4/13/2020	30.2	29.7	13.5			17.2			19.7			16.5		
4/14/2020	30.3	29.7	13.2			17.3			20.0			16.8		
4/15/2020	30.4	29.7	15.7	15	11	17.2	15	44	19.8		32	17.2		18
4/16/2020	30.5	29.7	13.0			16.4			20.1			16.8		
4/17/2020	30.6	29.8	16.0			17.1			20.3			18.2		
4/18/2020	30.7	29.8	19.0			17.3			20.5			17.5		
4/19/2020	30.7	29.8	15.4			16.2			20.7			17.6		
4/20/2020	30.8	29.8	17.4			17.1			20.6			17.1		
4/21/2020	30.9	29.8	18.6	15	13	17.1	15	42	20.3		25	17.1		30
4/22/2020	30.9	29.9	15.3			18.6			20.5			16.7		
4/23/2020	31.0	29.9	18.1			17.4			20.5			16.9		
4/24/2020	31.1	29.9	18.8			17.3			20.8			17.2		
4/25/2020	31.2	29.9	15.2	15	24	16.4	15	252	20.7		30	15.7		50
4/26/2020	31.2	29.9	19.4			16.5			20.7			17.1		
4/27/2020	31.3	29.9	19.7			17.0			20.7			17.7		

Date	M5 TANK					M6 TANK			111A TANK			111B TANK		
	M5 TANK TOP TEMPERATURE	M5 TANK MIDDLE TEMPERATURE	M5 TANK BOTTOM TEMPERATURE	M5 TANK TBC	M5 TANK POLYMER	M6 TANK TEMPERATURE	M6 TANK TBC	M6 TANK POLYMER	TA-111A TEMPERATURE	TA-111A TBC	TA-111A POLYMER	TA-111B	TA-111B TBC	TA-111B POLYMER
UNITS	in deg C	in deg C	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM	in deg C	PPM	PPM
4/28/2020	30.9	29.7	16.0	15	84	17.1	15.0	320.0	20.7		81	18.2		80
4/29/2020	30.9	29.7	15.4	15	98	17.1	15.0	335.0	21.1			17.4		44
4/30/2020	30.9	29.8	13.5			17.1			20.9			17.5		
5/1/2020	30.9	29.8	13.7			17.4			20.7			17.8		
5/2/2020	30.9	29.8	12.3	15	89	17.2	15	437	20.8		55	17.1		63
5/3/2020	31.0	29.8	11.3			16.7			21.0			17.2		
5/4/2020	31.0	29.8	11.9			17.0			20.9			17.1		
5/5/2020	31.0	29.8	10.5	15	90	17.0	15	413	20.8		46	16.2		54
5/6/2020	31.0	29.8	10.5			17.3			20.3			15.6		
5/7/2020	31.0	29.9	9.8			17.2			18.6			13.7		
5/8/2020	31.1	29.9	11.5	15.0	95.0	153.7			17.5		42	12.1		48
5/9/2020	30.3	28.6	11.0	20	80	110.6			16.6	20		11.2	23	
5/10/2020	27.1	26.2	16.4			92.4			16.6			12.0		
5/11/2020	25.5	25.3	25.3			77.3			15.6			11.3		

The Blank data not available

(A. RAVI)

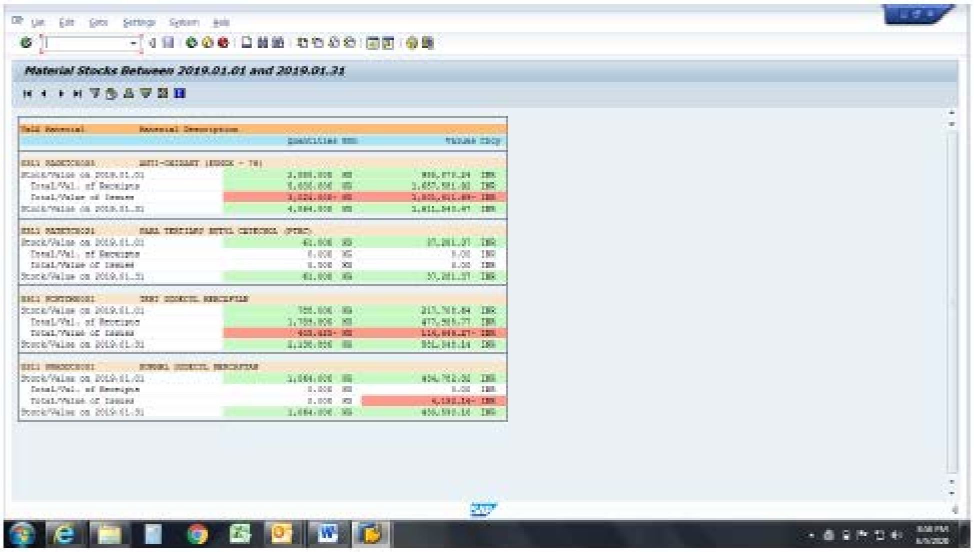
(KVN. RAMESH PATNAIK)
(SAFETY OFFICER)

for LGPI

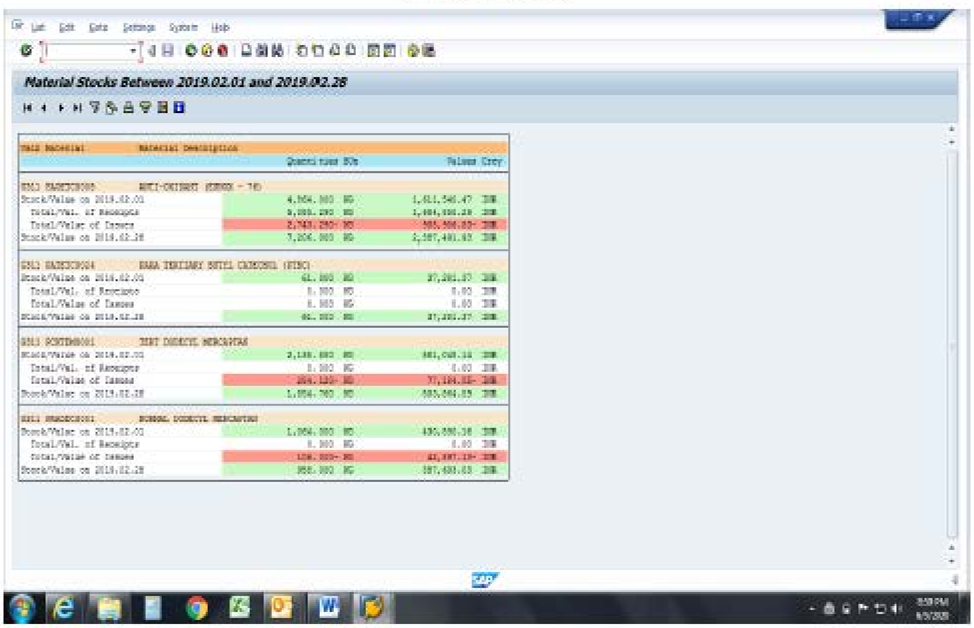
(B. Suresh Babu)
FM.

2.5.4 Annexure 2.4: SAP data

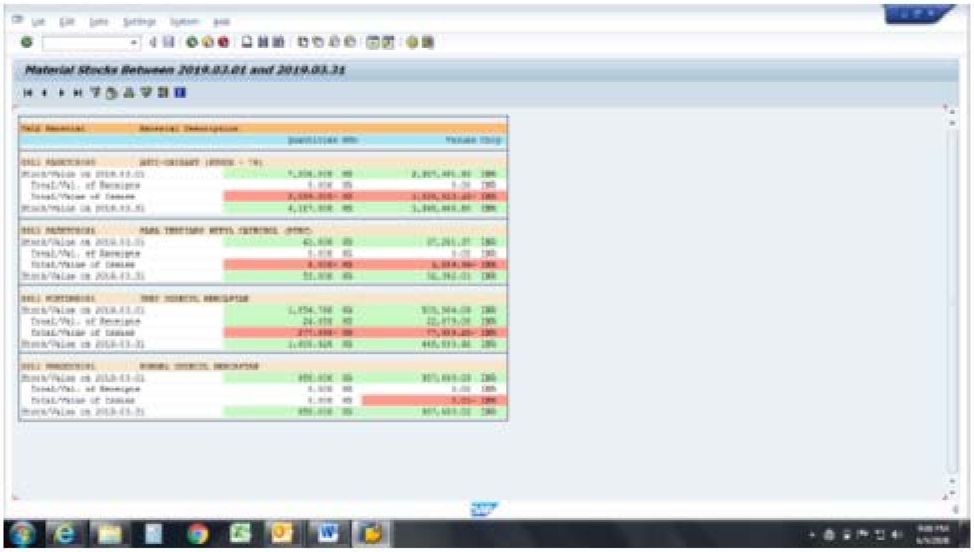
Jan 2019



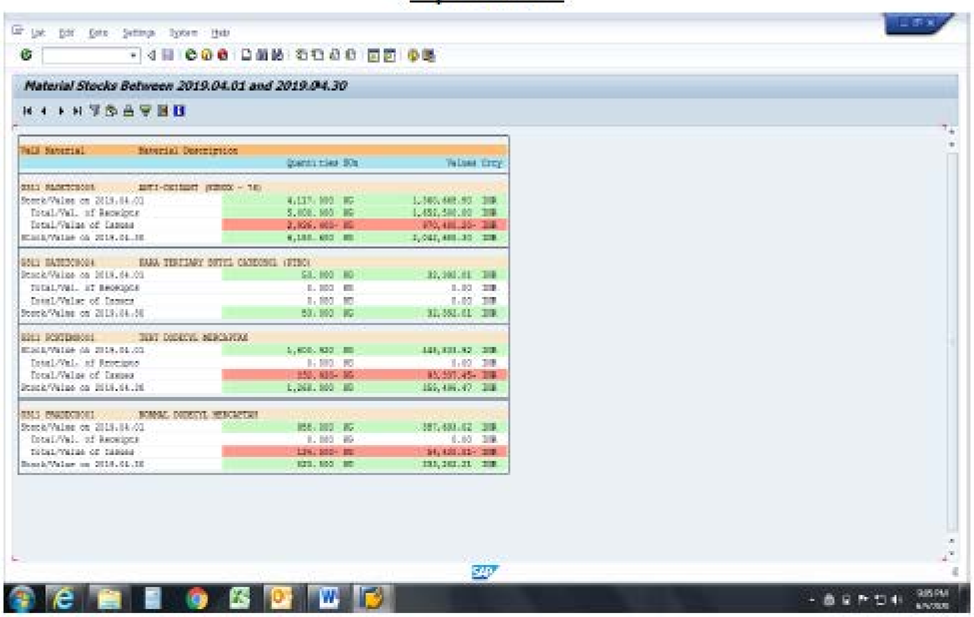
Feb 2019



Mar 2019



Apr 2019



May 2019

2.5.5 Annexure 2.5 : DCS Data

Q 11 - SM Tank DCS Data(From Jan'2020-May'2020)

	INCIDENT TANK		TANK ADJACENT TO INCIDENT TANK				TANKS OF OPPOSITE PLANT SITE	
DATE	M6 TANK TEMP. (Deg C)	M6 TANK LEVEL (%)	M5 TANK TOP TEMPERATURE (Deg C)	M5 TANK MIDDLE TEMPERATURE (Deg C)	M5 TANK BOTTOM TEMPERATURE (Deg C)	M5 TANK RADAR LEVEL (%)	TA-111A TEMPERATURE (Deg C)	TA-111B TEMPERATURE (Deg C)
01-01-2020	20.5	48.6	27.1	25.2	24.3	87.3	20.5	18.5
02-01-2020	23.0	50.7	27.0	25.3	18.8	83.8	19.5	20.5
03-01-2020	20.8	50.0	26.9	25.3	19.5	83.8	18.0	19.0
04-01-2020	21.0	47.1	26.8	25.2	21.8	90.4	18.5	19.0
05-01-2020	21.0	47.1	26.8	25.2	23.0	88.0	23.0	19.0
06-01-2020	21.0	47.1	27.2	25.3	23.3	79.8	23.0	20.0
07-01-2020	23.0	46.4	26.8	25.3	19.9	84.6	18.0	20.0
08-01-2020	24.4	47.3	26.8	25.3	20.6	84.6	20.0	19.5
09-01-2020	24.5	38.6	26.7	25.3	21.0	84.6	19.5	20.0
10-01-2020	25.1	42.6	27.6	25.4	21.7	81.0	20.0	21.5
11-01-2020	25.1	42.6	26.8	24.6	24.3	85.1	23.0	22.0
12-01-2020	24.6	49.6	27.2	24.9	23.9	81.8	21.0	18.5
13-01-2020	24.7	49.6	26.2	25.8	24.0	73.7	20.0	19.0
14-01-2020	24.6	49.6	26.4	25.5	22.5	76.8	19.0	20.0
15-01-2020	21.6	49.6	26.5	25.7	23.9	73.8	19.4	18.2
16-01-2020	21.8	49.6	26.4	26.3	23.9	65.1	20.0	18.5
17-01-2020	22.1	49.6	27.3	26.2	24.0	56.8	21.0	19.5
18-01-2020	22.4	49.6	27.3	26.3	24.7	54.9	21.5	18.5
19-01-2020	22.5	49.6	27.5	26.3	24.3	57.7	19.5	21.0
20-01-2020	22.8	49.6	27.4	27.2	24.4	49.2	19.5	21.0
21-01-2020	21.7	49.6	27.7	27.3	25.0	51.9	22.0	19.0
22-01-2020	23.3	44.6	27.4	25.2	23.6	62.3	19.0	20.0
23-01-2020	23.3	48.0	27.0	25.2	23.9	62.3	19.0	19.0
24-01-2020	21.2	50.5	27.4	25.3	24.1	62.3	19.5	19.0
25-01-2020	21.1	48.5	27.8	25.3	24.2	62.4	20.5	18.5
26-01-2020	22.9	53.5	27.9	25.4	24.4	62.4	19.0	20.5
27-01-2020	23.2	47.5	28.5	25.5	24.5	62.4	20.0	19.5
28-01-2020	22.3	52.3	28.1	25.5	24.6	62.4	19.5	19.5
29-01-2020	21.0	49.0	27.1	25.5	24.9	68.6	18.5	19.5
30-01-2020	21.0	49.1	27.1	25.4	24.2	72.9	19.0	19.5
31-01-2020	22.1	48.4	27.7	25.5	21.8	74.4	19.5	20.0
01-02-2020	22.5	44.1	27.9	25.5	18.5	74.4	22.5	19.0
02-02-2020	24.5	53.6	26.3	25.5	24.2	68.0	19.0	21.0
03-02-2020	24.5	53.6	26.6	25.6	25.0	59.2	18.5	19.0
04-02-2020	24.5	53.6	26.9	25.8	24.5	54.9	22.0	19.5
05-02-2020	24.4	53.6	25.0	25.6	23.4	59.0	18.5	21.5
06-02-2020	21.4	53.6	26.8	25.2	25.2	62.3	21.0	19.0
07-02-2020	21.5	53.6	26.8	25.2	22.7	67.5	20.0	20.5
08-02-2020	22.9	49.0	27.4	25.0	22.5	76.3	19.5	20.5
09-02-2020	24.0	40.5	26.5	25.1	22.9	76.3	19.5	23.0
10-02-2020	24.6	36.8	26.3	25.2	24.8	71.5	20.0	23.5
11-02-2020	22.9	47.8	27.4	25.3	25.1	63.0	22.5	21.0
12-02-2020	23.0	41.8	27.2	25.2	21.6	66.7	20.5	20.5
13-02-2020	22.2	45.0	27.8	25.3	22.1	66.7	19.5	20.5
14-02-2020	21.7	46.9	28.3	25.3	24.4	67.4	21.0	20.5
15-02-2020	21.7	46.9	28.6	25.0	24.7	69.9	19.0	19.5
16-02-2020	21.8	47.0	28.9	25.0	24.7	67.1	22.0	19.5
17-02-2020	22.1	47.0	29.1	25.5	24.6	58.4	19.0	22.0
18-02-2020	22.3	44.4	29.4	26.2	19.9	54.7	18.0	25.0
19-02-2020	24.9	47.0	29.4	26.4	17.4	54.6	20.5	19.5
20-02-2020	25.8	50.4	29.1	26.5	13.8	54.6	19.0	19.5
21-02-2020	25.1	55.1	29.2	26.7	15.7	54.6	19.5	19.5
22-02-2020	24.5	49.7	29.1	28.9	17.9	51.8	21.0	23.0
23-02-2020	24.5	49.7	29.0	25.5	24.3	57.0	24.0	19.0
24-02-2020	24.5	49.7	29.2	29.0	24.7	48.5	21.5	23.0
25-02-2020	24.6	49.7	29.4	28.9	24.5	51.5	20.5	25.0
26-02-2020	23.1	55.1	29.1	28.8	24.1	48.0	23.0	20.5
27-02-2020	19.4	55.1	27.9	26.4	24.6	0.0	19.5	19.5
28-02-2020	22.3	54.8	28.0	27.7	16.9	0.0	21.5	19.0
29-02-2020	20.6	46.3	27.8	25.2	22.1	0.0	18.0	20.0
01-03-2020	22.0	43.1	28.2	25.2	18.6	0.0	20.5	19.0
02-03-2020	24.2	34.8	28.8	25.2	16.1	0.0	20.0	20.0
03-03-2020	22.6	35.9	29.4	25.3	17.5	63.0	19.5	22.0
04-03-2020	22.5	40.2	29.6	25.4	18.5	63.0	20.5	19.0
05-03-2020	18.8	38.0	29.2	25.0	23.4	67.1	18.0	19.5

06-03-2020	19.3	38.0	29.4	24.6	22.6	70.8	19.0	21.5
07-03-2020	21.9	48.3	28.8	25.2	19.4	62.8	20.5	19.5
08-03-2020	21.9	48.3	27.9	25.3	22.5	65.4	19.0	21.0
09-03-2020	22.1	48.3	29.4	25.5	21.5	57.0	20.0	19.0
10-03-2020	22.3	43.8	29.0	25.5	21.9	60.4	25.5	20.5
11-03-2020	22.7	46.7	30.1	25.6	20.9	60.4	21.0	21.0
12-03-2020	22.5	49.1	30.2	25.7	21.4	60.4	20.5	20.0
13-03-2020	21.2	52.5	31.0	26.2	19.8	55.3	21.0	22.0
14-03-2020	19.9	52.5	31.5	28.3	21.0	52.8	22.3	19.3
15-03-2020	20.1	52.5	31.2	30.6	20.7	49.6	19.5	21.5
16-03-2020	20.6	52.5	30.9	30.5	23.1	41.0	19.5	19.0
17-03-2020	20.9	52.5	31.5	31.1	24.5	32.7	25.5	19.0
18-03-2020	19.1	52.5	30.9	30.6	25.3	30.4	21.5	20.5
19-03-2020	19.5	52.5	28.5	28.9	23.6	26.5	22.5	19.5
20-03-2020	18.7	52.5	26.6	26.6	24.4	23.0	18.5	20.7
21-03-2020	19.1	52.5	27.6	27.3	25.7	15.6	19.1	22.2
22-03-2020	18.7	52.5	29.6	29.2	26.9	13.0	19.5	21.0
23-03-2020	19.1	52.5	30.1	29.8	27.2	4.8	20.5	19.0
24-03-2020	19.8	48.6	27.5	27.9	27.5	4.9	24.0	20.0
25-03-2020	18.2	48.7	29.5	29.1	22.2	4.9	20.0	15.0
26-03-2020	18.7	48.7	30.0	29.6	22.7	4.9	17.5	17.6
27-03-2020	18.7	48.7	31.4	30.9	23.4	4.9	17.7	16.8
28-03-2020	18.9	48.7	32.0	31.4	22.1	4.9	15.5	16.4
29-03-2020	19.0	48.7	32.6	32.0	22.7	4.9	15.8	16.3
30-03-2020	18.3	48.7	32.0	31.3	26.2	16.9	18.0	26.9
31-03-2020	18.7	48.7	31.8	31.2	28.3	30.7	16.9	25.9
01-04-2020	17.8	48.7	32.2	31.5	24.7	46.0	17.0	21.5
02-04-2020	19.1	53.4	32.4	28.7	28.4	58.0	18.1	18.6
03-04-2020	18.2	53.4	30.9	29.0	29.1	74.9	19.1	19.3
04-04-2020	18.0	53.4	29.5	29.4	29.5	91.0	19.0	19.1
05-04-2020	18.0	53.3	29.6	29.4	25.7	91.0	19.1	18.3
06-04-2020	17.8	53.4	29.6	29.4	20.9	90.9	19.5	17.2
07-04-2020	18.6	53.4	29.7	29.5	18.2	90.9	19.7	17.3
08-04-2020	17.6	56.5	29.8	29.5	17.0	87.7	19.5	17.8
09-04-2020	18.4	56.5	29.9	29.5	18.1	87.7	19.6	17.8
10-04-2020	18.4	56.5	29.9	29.5	14.9	87.7	19.7	16.9
11-04-2020	17.1	56.5	30.0	29.6	15.4	87.7	16.5	17.0
12-04-2020	17.4	56.5	30.1	29.6	13.0	87.6	19.5	16.3
13-04-2020	17.2	56.5	30.2	29.7	13.5	87.6	19.7	16.5
14-04-2020	17.3	56.5	30.3	29.7	13.2	87.6	20.0	16.8
15-04-2020	17.2	56.5	30.4	29.7	15.7	87.6	19.8	17.2
16-04-2020	16.4	56.5	30.5	29.7	13.0	87.6	20.1	16.8
17-04-2020	17.1	56.5	30.6	29.8	16.0	87.6	20.3	18.2
18-04-2020	17.3	56.5	30.7	29.8	19.0	87.6	20.5	17.5
19-04-2020	16.2	56.5	30.7	29.8	15.4	87.6	20.7	17.6
20-04-2020	17.1	56.5	30.8	29.8	17.4	87.6	20.6	17.1
21-04-2020	17.1	56.5	30.9	29.8	18.6	87.6	20.3	17.1
22-04-2020	18.6	58.9	30.9	29.9	15.3	87.6	20.5	16.7
23-04-2020	17.4	58.8	31.0	29.9	18.1	87.6	20.5	16.9
24-04-2020	17.3	58.9	31.1	29.9	18.8	87.6	20.8	17.2
25-04-2020	16.4	58.9	31.2	29.9	15.2	87.5	20.7	15.7
26-04-2020	16.5	58.8	31.2	29.9	19.4	87.5	20.7	17.1
27-04-2020	17.0	58.9	31.3	29.9	19.7	87.6	20.7	17.7
28-04-2020	17.1	56.8	30.9	29.7	16.0	89.6	20.7	18.2
29-04-2020	17.1	56.8	30.9	29.7	15.4	89.6	21.1	17.4
30-04-2020	17.1	56.8	30.9	29.8	13.5	89.6	20.9	17.5
01-05-2020	17.4	56.8	30.9	29.8	13.7	89.6	20.7	17.8
02-05-2020	17.2	56.8	30.9	29.8	12.3	89.5	20.8	17.1
03-05-2020	16.7	56.8	31.0	29.8	11.3	89.5	21.0	17.2
04-05-2020	17.0	56.8	31.0	29.8	11.9	89.5	20.9	17.1
05-05-2020	17.0	56.8	31.0	29.8	10.5	89.5	20.8	16.2
06-05-2020	17.3	56.8	31.0	29.8	10.5	89.5	20.3	15.6
07-05-2020	17.2	56.8	31.0	29.9	9.8	89.5	18.6	13.7
08-05-2020	153.7	56.8	31.1	29.9	11.5	89.5	17.5	12.1

3.0 Emergency Response

3.1 Initial Response

3.1.1 Emergency Response by LG Polymers

As per the information given by LG Polymers, the sequence of events of the accident is given in Volume II: Part B Annexure- 2.63 of the Company's Report. The Company stated that the gas detector alarm was raised at 02:54 a.m. as per the Distributed Control System (DCS) time. However, they contend that the DCS time has 12 minutes time lag with the CCTV camera and accordingly noted the time of the gas detector alarm at 02:42 a.m., which is the time when the CCTV captured release of the Styrene gas vapour from the M6 Tank. This issue about the time lag is substantially discussed in Chapter 2, Section 2.1.4 and the Committee does not agree with the Company's contention. The explanations in Chapter 2 clearly provide reasons why the time lag between the CCTV camera and the gas detector detection in DCS alarm system would have occurred.

The Director of Factories noted the statement of Sri. P. P. C Mohan Rao, Director (Operations) on 15th May 2020 and recorded the sequence of events. The same is submitted in the Director of Factories Report, available at Volume VI: Part A Annexure-6.5.5. The sequence of events, as stated by Director (Operations), is summarized as follows:

As per DCS time:

- 02:54 a.m.: Gas detector alarm noticed in DCS (DCS Alarm Record- Annexure: VI)
- 03:02 a.m.: High VOC alarm noticed in DCS
- 03:02 a.m.: Immediately DCS operator informed to operator/ safety person/Night Duty Officer
- 03:02 a.m.: M6 Tank Temperature Started raising
- 03:03 a.m.: Night Duty Officer informed everyone about the high vapours at tank farm area
- 03:03 a.m.: Immediately night duty officer tried to go reach the fire hydrant sprinkler valve to open. But due to high vapour cloud it was impossible for him to go
- 03:04 a.m.: Alerted all other members to bring SCBA Sets to assemble point

- 03:07 a.m.: Informed to plant safety head/Dir (O) & others about the emergency
- 03:07 a.m.: Alerted security in charge to get the help from outside agencies (Fire service & ambulance etc.)

As per Indian Standard Time:

- 03:30 a.m.: Dir(O) & Safety heads & plant officials arrived at site. Residents were found running away
- 03.35 a.m.: Police have arrived and taken action for rescuing and shifting of people by ambulances and other available vehicles
- 04:15 a.m.: AP fire Service department team arrived. Fire Sprinklers were made functional manually by opening the deluge valve which was designed to open automatically in case of fire by heat detection
- 04:32 a.m.: Emergency chemicals such as n-dodecyl mercaptan (NDM), Tertiary Dodecyl Mercaptan (TDM), Antioxidant (Eunox-76) etc. were made ready for usage
- 05:15 a.m.: Chemical inhibitors dosing started one after the one till 3.00 p.m.
- 05.20 a.m.: The Officials of Factory Inspectorate arrived
- 06:30 a.m.: 10 Tons and 15 tons of Styrene was pumped to Feed Preparation & Feed solution tanks respectively
- 06.40 a.m.: NDRF team arrived and went for door search of houses in affected Areas along with the other departmental teams
- 07:30 a.m.: 70 Tons of Styrene pumped to one spare storage tank. Thereafter, considering risk associated with this operation, it was stopped. All these efforts have reduced the intensity of reaction thereby emission of vapour has come down and came into control
- 3.00 p.m.: Addition of Inhibitors was continued till this time and the conditions in the Tank started not favouring the further addition of inhibitors. In order to remove the heat of reaction, the combat team started pouring water into the tank through foam pourer & the hydrant water sprinklers kept open. However, the temperature kept on increasing
- 09.15 p.m.: The request for additional evacuation of residents on the upstream side of the factory was made in view of the suspected risk of bursting of Tank due to prevailing conditions of the Tank at that time
- 09.45 p.m.: The evacuation has been activated

- 10:45 p.m.: Tank temperature reached to 154°C and remained stable at that Level. Management of reaction heat with water was continued.

The Director of Factories also recorded the statement of P Balajee (Nigh Duty Officer and S Atchuyt (Shift in Charge). Broadly, it can be noted that during the early hours of 7th May 2020, at 02:54 a.m., M6 Tank's gas detector alarm had been triggered in the DCS room which was identified by board man and Shift In-Charge (SIC). The SIC alerted the Director (Operations) and other senior officers of the Company. He alerted the security to inform all concerned and came out of the factory through the main gate due to overwhelming exposure to toxic vapour.

Thereafter, the senior officers of LG Polymers and few technical staff, who were on shift duty, and others arrived at the factory. The team tried to arrest the leakage of vapour along with the support of the Fire and Safety Department. As the vapour persisted in the air, the staff could not reach near the Tank to control the leakage.

As per the report of the Director of Factories, LG Polymers stated that the management executives and Shri P. P. C Mohan Rao[20] arrived at the factory at 3:30 a.m. The team carried out emergency response operations initially by operating the sprinkler systems, followed by adding high-temperature inhibitors like TDM & NDM into storage M6 Tank. Thereby the intensity of the reaction was drastically brought down. Air pollution was being monitored in parallel. Despite progress, the conditions in the Tank were not favouring the addition of inhibitors by evening the same day. The temperature in the Tank gained momentum, reaching as high as at 154°C by 11:00 p.m. To control the heat of reaction, water was poured into the Tank using the foam pourer besides continuing the external cooling.

The Technical Committee obtained a statement of the Shift in Charge in the night shift on 6th May 2020. As per the Technical Report (Volume I) the sequence of Operations carried out immediately on noticing the gas detector alarm in the night shift (early hours 7th May 2020) as follows:

[20] Occupier of the factory under the Factories Act,1948

- 02:54 a.m.: Gas detector alarm noticed in DCS
- 03:02 a.m.: High VOC alarm noticed in DCS
- 03:02 a.m.: Immediately DCS operator informed to operator/ safety person/night duty officer
- 03:02 a.m.: M6 Tank Temperature Started to rise
- 03:03 a.m.: Night Duty Officer informed everyone about the high vapours at tank farm area
- 03:03 a.m.: Immediately night duty officer tried to go reach the fire hydrant sprinkler valve to open. But due to high vapour cloud, it was impossible to go
- 03:04 a.m.: Alerted all other members to bring SCABA Sets to assemble point
- 03:07 a.m.: Informed to plant safety head/Dir (O) & others about the emergency
- 03:07 a.m.: Alerted security in charge to get the help from outside agencies. (Fire service & ambulance etc.)
- 03:30 a.m.: Dir(O) & Safety heads & plant officials arrived at site
- 04:30 a.m.: Two members went to open fire hydrant sprinklers using SCABA Sets for M5/M6/Pentane storage tank
- 04:32 a.m.: Emergency chemicals such as NDM, TDM, Antioxidants, Erganox & other inhibitors arrangements done
- 05:15 a.m.: Chemical inhibitors dosing arrangements started immediately one after one
- 06:00 a.m.: M6 Styrene transfer to FPT/FST & 1221A arrangements started
- 06:30 a.m.: 25 Tons of Styrene pumped to FST & FPT
- 07:30 a.m.: 70 Tons of Styrene pumped to 1221 A The following chemicals were added to M6 Tank
    1. n-dodecyl mercaptan (NDM) : 1059 Kgs
    2. Tertiary Dodecyl Mercaptan (TDM): 2487 Kgs
    3. Eunox-76 : 289 Kgs

The Technical Committee obtained the sequence of events also from the Director (Operations) which is presented below (Volume I):

- 02:54 a.m.: M6 Tank gas detector alarm A & B noticed in DCS by Boardman (Mr. Chakarapani) & Shift In Charge (Mr. Atchyut)
- 02:55 a.m.: SIC called safety person Mr. Ganesh (through Walkie) to check the reason for alarm. Same message was acknowledged by NDO (Mr. P Balajee) and asked SIC to come to tank farm
- 03:00 a.m.: Mr. Ganesh of EHS, Security person (on bicycle), Mr Atchyut, Mr. Chakarapani of GPPS and Mr. Ravi Krishna of EPS reached the alcohol plant building and confirmed leak from top of M6 Tank
- 03:02 a.m.: Mr. Balajee came near HR learning center and met the other team returning due to dense vapour coming from M6 Tank
- 03:03 a.m.: Mr Atchyut of GPPS went to GPPS plant and informed his operators (Mr. Jayaram and UV Ramana) to get down from the control room
- 03:05 a.m.: Mr. Ganesh of EHS brought SCBA set from GPPS control room to the canteen area
- 03:05 a.m.: Mr. Balajee informed the safety officer (Mr. Patnaik) about vapour leak from M6 Tank
- 03:07 a.m.: GPPS team returned to the canteen area, and all the people moved towards Security
- 03:09 a.m.: Mr. Balajee (NDO) called Dir (O) & informed about emergency
- 03:09 a.m.: Alerted security in charge to get the help from outside agencies (Fire services and ambulance etc.)
- 03:50 a.m.: Dir (O) & Safety heads & plant official arrived at the site
- 04:30 a.m.: Two members went to open the fire hydrant sprinklers using SCABA sets for M5/M6/Pentane storage tank
- 04:32 a.m.: Emergency chain retardant chemicals/ inhibitors such as NDM, TDM, antioxidants, Eunox-76, Hydroxy Quinone & other inhibitors arrangements done
- 05:15 a.m.: Chemical inhibitors/ polymer chain inhibitors NDM/TDM followed by antioxidants and Hydroxy Quinone dosing started immediately one after the other
- 06:00 a.m.: M6 Styrene transfer to FPT/FST & 1221A arrangements started
- 06:30 a.m.: 25 tons of Styrene pumped to FST& FPT
- 07:30 a.m.: 25 tons of Styrene pumped to 1221A

The following chemicals have been added to M6 Tank (up to evening)

1. NDM: 1059 Kgs
2. TDM: 700 Kgs
3. Eunox-76: 489 Kgs
4. Hydroxy Quinone: 100 Kgs

- The stocks of inhibitors namely NDM & TDM with us were exhausted by evening
- Water poured through foam pourer & hydrant water sprinklers kept open for M6 Tank to cool down the Tank

- 10:45 p.m.: M6 Tank temperature reached max 153.7°C

The Committee found a number of gaps in the different versions of narration, which are discussed in the following sections.

3.1.2 Inept handling of Emergency Response

The Committee is of the view that handling of emergency response by LG Polymers was inept. LG Polymers claim that they carried out emergency response operations once the Occupier arrived (03:30 a.m.) by operating the sprinkler systems, followed by adding high-temperature inhibitors like TDM & NDM into storage M6 Tank. Thereby the intensity of the reaction was drastically brought down.

The temperature profile of the M6 Tank is available in the Graph 2.1. The rate of increase in temperature slightly reduced between 05:00 a.m. to 09:00 a.m., post which, it started increasing again. The temperature profile graph shows that temperature was mostly stable below 20˚C until about 3:00 a.m. on 7th May 2020 and started increasing thereafter. It is to be noted that the temperature rose to 65˚C (the temperature at which Styrene Monomer runaway reaction takes place, in normal circumstances) at about 03:00 p.m. on 7th May 2020. It means the runaway reactions at the bottom of the Tank occurred only around 03:00 p.m. on 7th May 2020. This implies that there was nearly twelve hours available for controlling the runaway reactions in the full tank. The runaway reactions could have been limited to the upper layers, and uncontrolled Styrene vapour release would have been arrested, if there were sufficient addition of NDM and

TDM or any other terminating chemicals in the intervening period between 05:15 a.m. and 01:00 p.m. on 7th May 2020. However, the stocks of TDM, NDM reportedly got exhausted. The LG Polymers did not utilize available chemicals like ethylbenzene which were in stock in the factory, on site, and could have been utilized as long as the temperature in the M6 Tank was below 100˚C. The opportunity to arrest the uncontrolled Styrene vapour release and thereby mitigating the environmental damage was lost. From 3:00 p.m. on 7th May 2020, there was steady increase in temperature and finally the maximum temperature of 153.7°C was recorded at about 10:00 p.m. on 7th May 2020. This shows that runaway polymerisation continued for nearly 24 hours as no effective action was taken by the company. The arrival of TBC stocks on 7th May 2020 night made no difference as already runaway reactions had led to very high temperature.

Also, as seen from the sequence of events as furnished by LG Polymers, the Safety Head of the Company reached the spot by 03:23 a.m. Dir (O) came at 03:55 a.m. GM Maintenance came at 03:56 a.m. and GM productions came at 4:40 a.m. But, upon re-verification with the Police Department, it was observed that none of the mentioned officers arrived at the spot before 05:00a.m. The Committee noted that this needs further investigation.

3.2 Rescue and Evacuation Operations in the affected areas

The Police Control Room at Visakhapatnam Police Commissionerate received an alert at 03:26 a.m. on 7th May 2020, about leakage of a pungent gas at R.R. Venkatapuram Village[21]. Simultaneously, the Gopalapatnam Police Station and Night Rounds Staff were alerted through VHF set. The Gopalapatnam Police Station House Officer, along with police staff, reached the site around 03:30 a.m. and observed thick gas vapours near the main gate. They were unable to enter the factory through the main gate. Meanwhile, Fire Services, including fire services of other factories, were alerted.

Sri. Mohan Babu, ACP, Harbor, who was the night in-charge at the time, rushed to the accident area within 15 minutes after receiving the information. He stated that residents who were seen

[21] As per the report submitted by the Commissioner of Police to the Committee

collapsed on the roads were shifted to nearby hospitals using 108 ambulance services. He promptly asked fire tenders of other factories to reach LG Polymers factory.

The Fire Control Room of Visakhapatnam was alerted at 03:30 a.m. on 7th May 2020 by primary informer named Sri. Manikanta, mentioning that some gas was leaking from LG Polymers, as a result of which, he was unable to breathe properly[22]. Fire Station, Marripalem, the jurisdictional Fire Station, was alerted immediately.

Accordingly, the Foam Tender of Marripalem reached the accident spot at about 03:51 a.m. The Station Fire Officer informed the District Fire Officer at 03:58 a.m. that the “Styrene” gas has been leaking and emitting a lot of smell due to which the crew was unable to enter the premises. They further informed that there was no fire.

In the meantime, the Commissioner of Police (CP), Deputy Commissioner of Police (DCP) and other police officers, staff, armed reserve etc. reached the affected villages / areas. People who were found unconsciousness, semiconscious and others those who were affected by exposure to the toxic gas were shifted to various hospitals by ambulances, police vehicles and other available vehicles. The Committee was informed by the public during the interaction held on 8th June 2020, that the LG Polymers did not arrange any vehicle for evacuation and transportation of the affected people. Press reported the initiative and action taken by police and the local volunteers (Volume IV: Annexure-4.6). The District Collector, along with the officials and staff of other departments viz., Revenue, Municipal, Health, NDRF, SDRF etc. also reached the spot and monitored the rescue and relief operations.

Police responded swiftly during the emergency to carry out evacuations and rescue operations. Along with NDRF staff, the Police teams went door to door to evacuate the residents in the affected areas. The local volunteers also actively participated in the rescue and evacuation.

[22] As per the report submitted by the AP State Disaster Response & Fire Services Department

20,000 persons from 17,000 houses/residences belonging to RR Venkatapuram, Nandamuri Nagar, Kamparapalem, Padmanabha Nagar, SC/ BC Colony, Meghadripeta Colony were evacuated to 23 rehabilitation centres maintained by GVMC and Simhachalam Devasthanam authorities. The District Administration commenced a second phase of the evacuation on the upwind side of the factory for a radius distance of about 1 km as they anticipated the risk of an explosion of the affected tank (M6 Tank) on 7th May 2020 night. Many residents beyond the said zone also moved out of their villages due to panic caused by circulation of false messages on social media.

As a result of the uncontrolled Styrene vapour release, the animals in the surrounding areas were affected, and several residents also lost their cattle. 12 Rapid Response Teams were deployed by the Animal Husbandry Department to tackle the situation[23]. 242 affected animals were provided with treatment. The Veterinary teams deployed in the affected habitations monitored the health of the animals continuously.

3.3 Assessment and Mitigation

To assess the situation and to assist the district administration in mitigation of the accident, a joint team of 9 experts from CBRN of 5th Battalion, National Disaster Response Force (NDRF) and CSIR - National Environmental Engineering Research Institute (CSIR- NEERI) were deputed by the National Disaster Management Authority (NDMA). The team arrived at the accident spot at 11:05 p.m. on 7th May 2020. The team observed that there was a hazy cloud of Styrene inside the factory, and the aroma of Styrene could be sensed. There was white haze in the factory premises.

The team inspected ambient temperature in the plant premise and surveyed surrounding areas of the Plant. Measurement of Styrene in the atmosphere was carried out at ground level (to assess risks of people who might sleep on the floor), 1.5 feet above the ground (for those sleeping on cots) and 4.5 feet above the ground (an approximate level at which a standing person would

[23] As per the report submitted by the Animal Husbandry Department

inhale ambient air). The team collected water samples from the nearby reservoir and undertook sampling and survey of the area near the LG Polymers factory.

On 10th May 2020, based on measurement of Volatile Organic Compound (VOC) levels, a set of recommendations was sent to District Magistrate office so that occupants could return back to their houses. Water fogging was undertaken.

As per the recommendation of the High-Power Committee, the joint team of CSIR-NEERI and CBRN, NDRF conducted joint survey of areas nearby, to observe the effects of Styrene exposure on vegetation and other infrastructure in the area of about 5 km radius around the LG Polymers factory.

The District Collector’s Office in Visakhapatnam (Rc. No. 679/2020/D3 dated 10.05.2020) in consultation with the expert team, and in line with documented EU practices, allowed the residents of affected areas to return by 04:00 p.m. on 11th May 2020 following guidelines for decontamination. Additionally, medical camps were set up in each of the six residential colonies to meet health emergencies, if any. Thus, normalcy was restored by 11th May 2020 evening.

As per the direction of the District Collector, the expert team conducted door to door briefing of inhabitants in localities around the LG plant and briefed about hygiene and sanitation following the guidance of NEERI scientists. Andhra Pradesh Pollution Control Board (APPCB) team implemented the due protocols and explained on external & internal sanitisation of entire residential colonies, Cleaning of floor, windows & household items. The team also took precautionary measure during the transfer of approximately 12900 tons of Styrene from T-2, T-23, M5, 111A & 111B tanks at Vizag port and LG Polymers plant in Vizag onto vessels.

As per the Preliminary Report by Dr. Anjan Ray & Shri Shantanu Gite, the NDRF-deputed experts who reached the site on 9th May 2020 at about 6:30 p.m., the temperature of the affected storage tank, M6 Tank, started receding by 03:30 a.m. on 8th May 2020. It was brought under complete control by inhibitor (TBC) dosing, water spraying, water injection and removal of external tank insulation to allow heat loss to the surroundings. The ambient Styrene levels in the affected residential areas had dropped well below 1ppm, which is significantly below the Time Weighted Average (TWA) levels of 20 ppm that could be considered risky for exposure.

3.4 Relief

In accordance with the assurance given by the Hon'ble Chief Minister of Andhra Pradesh, the victims of the accident were provided with payment of compensation/ ex- gratia. The Government vide GO. Ms.No.449, Revenue (CMRF & FWC) Dept, Dt.08.05.2020 issued orders releasing ex-gratia / financial assistance to the deceased / victims as a measure to provide immediate relief to the victims of the accident.

Special Enumeration Teams were constituted to conduct door to door survey and verification for listing all the victims. Similarly, a committee consisting of the Principal, Andhra Medical College, Visakhapatnam, Superintendent King George Hospital, Visakhapatnam, the District Controller of Health Services, APVVP, Visakhapatnam and the District Medical and Health Officer, Visakhapatnam was formed to validate the claims of the hospitalised persons under various categories.

Post verification, the Committee submitted a detailed report on the number of persons who were eligible under the provisions of the above GO. Further, the Sub Divisional Magistrate was directed to submit a detailed report pertaining to the deceased persons and their legal representatives for granting the relief amounts. After completing the above exercise, the ex gratia amount was paid to the persons affected.

3.5 Evaluation of execution of Onsite and Off Site-Emergency Plan

LG Polymers prepared its Onsite Emergency Plan[24] in April 2020 in accordance with Rule 13 of Manufacturing, Storage and Import of Hazardous Chemical (MSIHC) Rules, 1989. Onsite

[24] The Onsite Emergency Plan deals with measures to prevent and control emergencies within the factory, so that outside public or environment is not affected

emergency plan was prepared by the EHS department of the LG Polymers in consultation with the operations team and is approved by the Plant competent authority. As reported by the Director of Factories, the District Administration has prepared its Offsite Emergency Plan[25] in accordance with Rule 14 of MSIHC Rules, 1989 under E(P) Act, 1986.

3.5.1 Lack of preparedness for Vapour Release

The Technical Committee has reported that on 7th May morning around 03:00 a.m. the night duty officer affirmed (during the investigation on 16th May 2020) that the staff on duty could go only to a distance of about 300 m from the Tank because of the Styrene cloud fast spreading over the whole area in the Plant. Due to Styrene vapour inhalation, most of them began to feel sick and ran towards the security room/gate. Most of the staff on duty were in panic mode. The night duty officer was in a semiconscious state.

The safety officer and another operator stated that they were able to get two SCBA. Two safety suits have been used, although nine SCBAs were available at different locations as given in Table 3.1.

Table 3.1: Details of Self-Contained Breathing Apparatus (SCBA)

S. No.	Area	No of sets
1	ETP	1
2	EPS CONTROL ROOM	2
3	GPPS CONTROL ROOM	1
4	ECC	2
5	HIPS CONTROL ROOM	1
6	NEW FCT	2
	Total	**9**

The sprinklers were switched on at 04:30 a.m. after the arrival of AGM (Safety). The Technical Committee pointed out that since the M6 Tank is an insulated tank, mere spraying of water on the Tank would not have been effective.

[25] The Offsite Emergency Plan lists down the measures to prevent and control emergencies affecting public and environment outside the premises of a factory and to be in order to be in the state of preparedness to respond to the accidents and minimise the adverse impacts on the offsite population. A copy should be available with the Company to implement its provisions effectively during the emergencies. Agencies involved in the implementation of the offsite plan are industry, Government and public

The shift in-charge and the night duty officer could have started planning of charging shortstop chemicals or high-temperature inhibitors known as terminators into the Tank dissolving them in a solvent like ethylbenzene to arrest the polymerisation of Styrene in the Tank. The Director of operations stated that these chemicals were available and provided their inventory. Moreover, they could have pumped ethylbenzene (About 130 MT was available in the stores at that time), a known inhibitor for polymerisation to the bottom of the Tank. After the addition of these chemicals in the Tank, the recirculating pumps could have started to circulate Styrene through the refrigeration unit to bring down the bottom temperature of the Tank to a level of <10˚C. They did not use their basic engineering knowledge coupled with wildly available specific information on Styrene to arrest the radical polymerisation with shortstop chemicals, terminators and cooling at least bottom contents of the M6 Tank.

The inability of the operating personnel to implement the onsite emergency procedures reflected in the continuous release of Styrene vapour, which prolonged for several hours.

The Technical Committee has noted that the Onsite Emergency Plan prepared by LG Polymers lacked the procedures to handle emergencies for toxic chemical release and runaway reactions in tanks/ reactors/ pipelines. Instead, the Onsite Emergency Plan was prepared only for fire occurrences and other accident scenarios. Thus, it is not surprising that though there was no fire, the LG Polymers management performed a firefighting action in place of onsite emergency for vapour release. According to Hazard Identification System developed by the National Fire Protection Association (NFPA) 704, Styrene Monomer is classified as hazardous[26]. Onsite Emergency Plan for the LG Polymer Plant that handles Styrene in large storage tanks and processes Styrene should have been based on hazardous nature of Styrene rather than emphasising only on firefighting. It is observed that the LG Polymers did not follow any standard guidelines for Emergency Plan, which caused a lack of clarity in emergency response at time of accident.

[26] Styrene is highly flammable, moderately toxic and reactive

The gas detector for M6 Tank was set at 2200 ppm, 20% of Lower Explosive Limit (LEL) taking fire/explosion scenarios only as emergencies. It is a lacuna in safety management. As observed, the high concentrations of Styrene vapour engulfed the surrounding areas before the gas detector detected 2200 ppm level. The gas detector should have been set for 100 ppm, the permissible exposure value.

The LG Polymers did not respond swiftly by adding a shot-stopper chemical or ethylbenzene or toluene. The management topped the affected Tank with NDM and TDM for a limited period; and that too got exhausted or the process was stopped. There were no TBC stocks in the factory and by the time it was airlifted, the temperature in the M6 Tank had already reached 153.7°C. Water pouring through the foam pourer, while cooling from outside through water sprinklers was undertaken. It appears, once runaway reaction set in on a large scale, no action was taken for arresting the reactions. While the conditions in the Tank were not favouring the addition of inhibitors, the management did not utilise the alternate possibilities of using ethylbenzene or toluene.

3.5.2 Failure in Switching on the Siren

As reported by the Director of Factories, there are five Emergency Sirens at following locations, in the premise of LG Polymers: 1) High Impact Polystyrene (HIPS) control room top, 2) HIPS Packing Section top, 3)Finance Building top, 4)EPS Packing Section top and 5)GPPS Packing Section top. There are 36 Manual Call Points (MCPs) distributed across the Plant for siren activation. 23 MCPs were provided at the EPS plant premise, where the accident took place. 7 out of 23 MCPs are installed in the main road of the Plant, between the main gate and the Styrene storage tank farm (Volume VI: Part A Annexure 6.5).

As per the statement of the production in-charge; by the time he came to the factory around 03:30 a.m., he found people escaping from neighbouring residential areas and thereby felt that the emergency had already been declared. He did not think of alerting the public via Emergency

Siren[27] He assumed that switching on the emergency siren was unnecessary as they had already informed the district authorities, including police and health services. This statement reflects a very casual attitude towards safety protocol.

The officers on duty whose responsibility was to alert the public via Siren failed in doing so. From the report by the Department of Factories, it is well established that the mock drills taken by the industry included using Siren during the drills. Therefore, there is no question of ignorance of the officers about the significance of Siren.

Details of specific lacunas in adhering to the protocols during the emergency are briefed in the table below:

Table 3.2: Responsibilities and Failures of LG Polymers Staff

Role	Responsibility in Brief	Duty Performed
Plant / Dept. head (Sri P. Balajee, Manager (Production) & Night Duty Officer**)**	Emergency shall be declared by the Plant/ Dept. in-charge of the affected area by raising Fire alarm available at the nearest point.	Failed in declaring the emergency by raising Siren
Site Emergency Controller (SEC) (Night Duty Officer Sri P. Balajee, Manager (Production), was to perform the duties from the time of alarm in DCS at 02:54 a.m. till Director (O) had reached the site at 03:30a.m.	▪ Rush to Emergency Control Centre (ECC) & Take charge of SEC ▪ Establish communication with Site Incident controller. ▪ Assess the magnitude of Hazard. ▪ To ensure that the outside emergency services and mutual help are called in case of major emergency. ▪ To continually review and assess possible developments and determine the most probable causes of events. ▪ To arrange for hospitalization of victims and additional help if required. ▪ To ensure that the relatives are advised. ▪ To provide advice on possible effects on areas outside the factory. Arrange for evacuation of neighboring population if required.	Failed to activate the siren. Called for SCBA, Alerted others & Security in Walkie talkie. Informed the security, Director (O) and GM(Production). Stated that he failed in other duties as the accident scenario was beyond his imagination and he was overwhelmed by the Styrene Vapour Exposure.

[27] Statements of Witnesses is enclosed in Volume III Annexure 3.3.

Role	Responsibility in Brief	Duty Performed
Site Incident Controller (Sri S. Achuyut, GPPS Plant Shift-in-charge was on duty till HOD/ Divisional Head of concerned plant reached the accident site)	▪ Rush to the spot & Assess the situation. ▪ Start prevention & control measures. ▪ Send a person to raise siren. ▪ Be available at conspicuous place at accident spot. ▪ Ensure initial communication to all key personnel through his control room operator. ▪ Observe wind direction. ▪ Arrange shutdown and power isolation of effected area. ▪ Properly guide all team leaders & teams viz., Fire squad officer, Plant maintenance in-charge, Search and Rescue team leader, Security person, Electrical person. ▪ Ensure evacuation of unwanted personnel. ▪ Guide Fire Squad to perform their operations. ▪ Keep on reporting status to SEC at ECC. ▪ Direct all operations within the affected area for personal safety and minimizing the damage to Plant and environment	▪ Failed to send a person to raise siren ▪ Wind direction was not observed, and downwind side alert was not given.

The officers on duty, as mentioned above, were responsible for declaring Emergency Siren immediately after they understood the gravity of the situation. Before reaching out to outside Emergency Services, the officers should have instructed one of the operating / security personnel to switch on the emergency siren to caution the public, once spotting the Styrene vapour release from the M6 Tank.

Factories Department officials inspected the functioning of the Siren on 7th May 2020, and they found that the sirens were in working condition. During the second round of evacuation of public in vicinity, the same emergency Siren was activated between 10:00 p.m. and 10:30 p.m. in the presence of officials.

Despite having the availability of switches for activating Emergency Siren at 36 locations, the officers on duty did not follow the protocol. Instead, they assumed it unnecessary as they had already informed the Emergency Services. This lapse on the part of the industry turned out to be a fatal one, reflecting failure by the Occupier of LG Polymers to adhere to the onsite and offsite emergency plans, as enunciated under The Manufacture, Storage and Import of Hazardous Chemical Rules, 1989 resulting in loss of human lives and damage to the environment. Any reasonable person of ordinary prudence would have blown the Emergency Siren to save the life of residents in the neighbourhood.

3.5.3 Ineffective Mock Drills to handle emergency

It is observed by the Committee that LG Polymers also could not manage onsite control of the accident until the District Administration and other departments had reached the spot. Having its team trained only for firefighting, they activated the water sprinklers even though there was no occurrence of fire. It indicated a lacuna in mock drill experience of the LG Polymers team.

As reported by the Petroleum and Explosives Safety Organisation (PESO), it is noted that the industry has undertaken mock drills on surprise basis as part of the Onsite Emergency Plan[28]. The mock drill conducted was also witnessed by the third-party auditor during the safety audit for the year 2018(Volume VI: Part A Annexure 6.5.13). The table below provides details of the mock drills conducted by the safety department (Volume II: Part C Annexure-2.84)

Table 3.3: Mock Drill Calendar at LG Polymers

S. No.	Plant	Date of Mock Drill	Description
1	GPPS	25.02.2019	Tower bottom pump failure
2		06.03.2019	Kettle emergency
3		12.09.2019	Thermic fluid hot oil outlet flange leak
4		26.11.2019	USG centrifugal drier shaft break
5	HIPS	07.03.2019	Styrene recirculation inlet flange leak
6		25.04.2019	Overflow of Dope Solution tank A
7		06.09.2019	Rx-1A Uncontrollable Mass Temperature
8	EPS	07.03.2019	Pentane leak through manhole
9		16.05.2019	Suspension failure during M90 Phase
10		07.11.2019	HCL Leak
11		07.02.2019	Fire at Pentane Tank C while venting

[28] As per rule MSIHC Rules, 13(4) the Occupier shall ensure that a mock drill of the Onsite Emergency Plan is conducted every six months

S. No.	Plant	Date of Mock Drill	Description
12	Onsite Emergency	22.08.2019	HIPS Solution tank A overflown & caught fire
13		18.02.2020	GPPS TRS Tank sample point de-choking & caught fire

From the above table, it is observed that there are 3 cases of mock drills related to onsite emergency and 3 cases related to minor leaks of equipment. However, the mock drills conducted did not cover scenarios related to uncontrolled releases or spillages of Styrene vapour from storage tanks. This is a lapse from the part of the factory in view of large storage of Styrene in the Plant. It is evident that manpower lacked training to handle the worst-case scenarios of releases or spillages of Styrene accidents.

3.5.4 No role of the factory in evacuation and relief / Incompetence of Management in handling emergency

Whenever any accident occurs, the management should try to control the situation and if possible, eliminate the cause as part of the Onsite emergency plan and respond to minimise the loss of property and alert the neighbourhood to safeguard life and the environment. Additionally, timely rescue and evacuation operations should be taken up. In this case, LG Polymers not only failed to alert the residents of neighbouring habitations but also did not take up rescue and evacuation operations. The arrangement for treatment of the affected people was also not taken up by the management.

Therefore, it is observed that the responsible persons on duty during the intervening night of 6th May 2020 & 7th May 2020 failed in responding to the emergency as per the protocol in their Onsite Emergency Plan. Without the support of the District Administration and other agencies, the Company could not have managed the emergency response.

As per the Company's statement to the Technical Committee, all employees dealing with the emergency at the site were exposed to Styrene vapours got affected mildly, and two firemen sustained skin allergy after 48 hours of the accident due to chemical exposure (Inhibitor) while attending the emergency. It is observed that LG Polymers did not take part in any rescue operations and shirked-away from their responsibility as part of offsite emergency management. The Company did not arrange any vehicles for transportation of the affected or aided in immediate medical assistance of the needy. The situation was such that the Company handed over the complete responsibility of rescue, evacuation and relief to the district administration and *other agencies.*

As reported in the National Green Tribunal (NGT) Joint Monitoring Committee headed by Justice Seshasayana Reddy, one of the LG Polymers employees who was present during the emergency, explained *"that he along with workmen made some efforts to add 'para tertiary butylcatechol (TBC) to reduce the intensity of the situation. He produced inhibitor stock to substantiate in his plea. We did not see any substance in his statement for the reason that two of the persons (Annexure XI) who attended the duty, viz., (1) M Atchyut S/o. Gopi, aged 27 years, Shift Incharge; (2) P Balajee, S/o. Amanna Setty, Manager., stated that the moment they saw dense vapour coming from the Tank, they ran out from the Plant and they did not see anyone making any efforts to subside the intensity of the vapours. Had any workmen present at the affected tanks, he should have been the victim of vapour and he should have been shifted to hospital for treatment."*

This observation was corroborated on 8th June 2020, during the interaction held with representatives of Print and Electronic Media. The press representatives informed that all 15 employees who were present during the emergency had escaped from the accident site without trying to help the affected residents.

3.5.5 Failure in conducting awareness in the neighborhoods

The management had neither conducted any awareness activities among the neighbourhoods, nor ensured the participation of the public in any mock drills. The local community were not informed about emergency measures to be taken in case of accidents like toxic releases, vapour release, fires and explosions. NGO and public during the hearing with the Committee stated that the Company should have conducted local public awareness about Dos/Don'ts during an emergency, which was never done.

3.5.6 Avoidance of Fire & Explosion in M6 Tank

LG Polymers in its reports has stated that because of the Emergency Response steps taken by them including spraying of water, inhibitor (NDM & TDM) addition and later addition of water into the Tank, fire and explosion was prevented. Accordingly, they have contended that the Emergency Response was significant success.

Styrene monomer is classified as a Class IC flammable liquid. The National Fire Protection Association (NFPA) Code30 also defines Styrene monomer as a Class IC flammable liquid. Styrene monomer has a flashpoint of 31.9°C (90°F). Styrene monomer vapours are explosive in the air at concentrations between 0.9 and 6.8 per cent by volume if an ignition source is present. The flammability region (blue shade) is shown in the figure below:

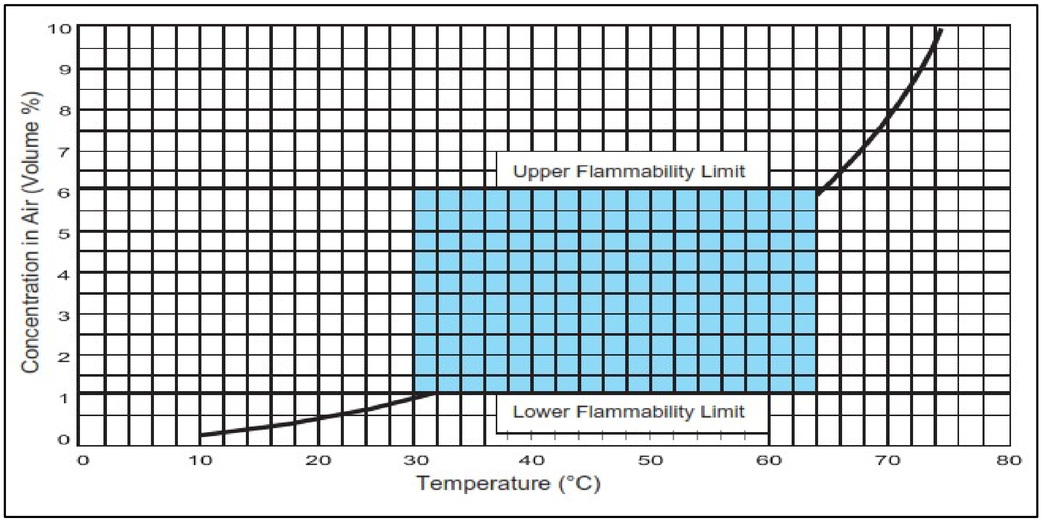


Figure 3.1: Flammability Region for Styrene Monomer

Styrene monomer vapour is heavier than air and may travel a considerable distance to a source of ignition and then flash back. Therefore, all precautions are necessary for the safe handling and storage of a volatile flammable vapour of Styrene.

Runaway reactions and thermal radical polymerisation should not occur in Styrene Monomer if the temperature and other parameters are under control. However, if polymerisation and runaway reactions does occur, it causes heat and pressure to increase in the vapour space. The resultant increase in heat and pressure can cause storage containers to rupture and, if ignited, explode. The experts sent by NDMA also indicated that the situation could have been far worse had the affected M6 Tank ruptured in a Boiling Liquid Expanding Vapour Explosion (BLEVE).

However, in this case, the M6 Tank was an atmospheric Tank and had vents open to the atmosphere. Therefore, upon an increase of Styrene vapour pressure, there was an uncontrolled release of Styrene vapour into the air. It is indeed providential that the explosion did not take place due to the high pressure, as sufficient pressure did not develop in the Tank to cause an explosion.

As the M6 Tank was atmospheric and air was present in the vapour space over the liquid Styrene surface, there were existed possibilities of flammable mixtures forming and causing Styrene fire. The Technical Committee observed that the fire hazard did not occur during the release, either because the flammable mixture did not form in the Styrene cloud, or because the mixture did not find an ignition source to get ignited.

The Technical Committee found that favourable conditions did not exist in the Tank or in the moving Styrene vapour cloud for the fire or explosion to occur. The Committee observed that the initial reaction of spraying with water might have helped in the dispersal of the vapour cloud near the M6 Tank. It would have helped in the Emergency operations as visibility would have improved. Further, by the process of dispersal, indirectly it would have prevented ignition near the Tank.

Overall among the various emergency measures, this is the only point of positive element that there was no fire or explosion during the accident.

3.6 Total breakdown of Onsite and Offsite emergency plans

The Committee has observed the following lacunas in the Emergency Response by LG Polymers in handling the uncontrolled release of Styrene vapour:

- Lack of an effective Onsite emergency plan. The Onsite Emergency Plan of LG Polymers had no strategies to face a situation of Styrene vapour release from storage tank and was never considered for emergency mock drill.
- The LG Polymers failed absolutely in implementing Onsite Emergency Response. It could have arrested the uncontrolled release of Styrene vapour if it had taken effective steps in the period from 05:15 a.m. to 01:00 p.m. on 7th May 2020.

- The LG Polymers depended on the District Administration even for Onsite control of the accident.
- The LG Polymers did not take part in any of the rescue or evacuation activities; rather, passed the entire responsibility to the District Administration and the local community.
- The LG Polymers failed to alert residents in the neighbourhoods by activating the Siren, although the siren was in a working condition and had multiple activation points, including near the factory gate. This was a fatal lapse.

In view of the above, the Committee is of the view that there was total breakdown of the Emergency Response Plans.

4.0 Adverse impact on the areas affected in the short-term and the long-term

As per the second term of reference, the Committee studied the various long-term effects of the gas leakage on the surrounding villages. The Committee also examined the immediate impacts of the uncontrolled Styrene vapour release on humans, other living beings, environment and their likely impact in the long-term.

4.1 Short-term Impact on the Human life, Flora, Fauna and Environment

Uncontrolled Styrene vapour release affected the surrounding habitations. As reported by the District Administration, 12 people lost their lives due to the accident while 585 were injured. Many were found unconscious, semi-conscious and faced nausea, breathing difficulties, skin rashes, sore eyes etc.

About 600 residents of the neighboring villages were rescued under the rescue and evacuation operation carried out by the Police with assistance of local people. Those who were affected were immediately shifted to various hospitals by ambulances, Police vehicles and other available vehicles.

Nearly 20,000 people from 17,000 houses/residences of RRV Puram, Nandamuri Nagar, Kamparapalem, Padmanabha Nagar, SC/ BC Colony, Meghadripeta Colony evacuated, and arrangements were made at 23 rehabilitation centres maintained by GVMC as well as Simhachalam Devasthanam authorities[29].

[29] The detailed report by the Commissioner of Police is provided in Volume VI: Part A Annexure-6.2.2.

Figure 4.1: People affected due to Styrene vapour

As reported by **the Animal Husbandry Department**[30], a total of 34 animals died due to the effect of Styrene vapour between 7th May 2020 and 9th May 2020.

The joint **team of NEERI & CBRN, NDRF**[31] reported that all the trees near the M6 Tank have turned either fully or partially dry. The team observed that wherever the relatively heavy mixture of monomer and polymer Styrene flooded green plants, they got dried. All the trees were dried up to the level of Styrene vapour engulfing the affected area.

As reported by the Agriculture Department[32], there were no crops in the agriculture fields except few vegetables and agro-forestry crops like casuarina and eucalyptus in the neighboring villages adjoining LG Polymers.

Table 4.1: Details of Crop pattern, damage to crop and soil sample analysis

S. No	Village	Details of the crop pattern around the unit		Crop damage and persistence of contamination on the crops		Analysis reports of the soil samples	
		Crop	Extent in Acres	Extent of damage	Quantity of fresh (fodder, grass etc.) produce available for biomedical destruction (qty. in Mts.)	No. of Soil samples collected	Analysis report obtained
1	Venkatapuram	No agriculture cropping pattern observed		No damage		18	The soil samples collected on 13.05.2020, will be analysed for 14 fertility parameters
2	Venkatadri Nagar						
3	Nandamuri Nagar					16	
4	Pydimamba colony					13	

[30] The detailed report by Animal Husbandry Department is provided in Volume V: Annexure-5.9
[31] The detailed report by NEERI-& CBRN, NDRF is provided in Volume VI: Part A Annexure- 6.1.3
[32] The detailed report by the Agriculture Department is provided in Volume V: Annexure- 5.10 and 5.13

S. No	Village	Details of the crop pattern around the unit		Crop damage and persistence of contamination on the crops		Analysis reports of the soil samples	
		Crop	Extent in Acres	Extent of damage	Quantity of fresh (fodder, grass etc.) produce available for biomedical destruction (qty. in Mts.)	No. of Soil samples collected	Analysis report obtained
5	BC colony	Fodder (No regular Cropping, urbanised)	0.1		0.8	16	and result will be submitted after analysis (within a week)
		Total	**0.1**		**0.8**	**63**	

In addition, the scientists from Rural Agriculture Research Station (RARS), Anakapalli conducted an assessment to study suitability of soil for cultivation after the accident. The team analysed soil quality parameters i.e., Chemical and physical properties like pH, E.C, Available nutrients (macro and micronutrients), Heavy metals, Bulk Density, Hydraulic Conductivity, Infiltration rate etc. and for assessment of Biological properties of Soil, total bacterial population, total fungal population, Beneficial microorganisms (Nitrogen fixers and phosphate solubilizes), Enzyme activity. Soil samples were collected at random and assessed for nutrient status parameters for pH, Electrical Conductivity (E.C), Organic Carbon, Nitrogen, Phosphorus, Potassium, Zinc, Iron, Manganese, Copper, Sulphur and Boron. The results received are, pH ranges from 6.9 to 8.7 i.e., slightly Alkaline and the E.C ranges from 0.08 to 0.2 milli mhos, which is normal. It has been advised that Paddy, Vegetables and other crops should be cultivated by reclaiming the soil.

The **Horticulture Department**[33] has analysed the impact of Styrene vapour on the horticulture crop pattern around the company for 5 km radius area. It is reported that 50% of crop damage, i.e., charred and rotting symptoms were observed in vegetable crops, 90% in papaya and no

[33] The detailed report by Horticulture Department is provided in Volume V: Annexure- 5.8 and 5.14

damage in Banana, Drumstick, Sapota, Mango, Cashew, Tamarind and Coconut. The farmers were advised to destroy the crop and not to sell the produce as they were not safe for consumption.

The **GVMC**[34] reported disruption in the drinking water supply due to toxic contamination scare because of release of Styrene vapour. Accordingly, GVMC took immediate remedial measures to sanitise the 6318 houses (HH) in the affected areas with mobile water tankers on 11th May 2020, when the evacuated residents returned. On 12th May 2020, Godavari drinking water was made available from 2000 KL GLSR and was released to the public of 5 affected villages, after conducting disinfection and sanitization in all distribution main lines and reservoirs.

In accordance with the assurance given by **the Hon'ble Chief Minister of Andhra Pradesh**, the victims of the accident were provided with payment of compensation/ ex- gratia. The Government vide GO. Ms.No.449, Revenue (CMRF & FWC) Dept, Dt.08.05.2020 has issued orders releasing ex-gratia / financial assistance to the deceased / victims as a measure to provide immediate relief to the victims of the accident.

Details of the ex gratia paid are as follows:

Table 4.2: Details of payment of compensation/ ex- gratia

S. No	Particulars	Amount announced	Affected	Amount paid
1.	Ex-gratia to the kin of the deceased	1 crore	12	12 Crores
2.	People on ventilators	10.00 Lakhs	1	10 Lakhs
3.	Hospitalized for 2/3 days	1 Lakh	485	485 Lakhs
4.	People undergone primary treatment	25,000	99	24 Crores
5.	To affected villagers	10000	19893	19 Crores
6.	Died animals		25 Animals (8 owners)	8 Lakhs

[34] The detailed report by GVMC on Drinking Water is provided in Volume VI: Part C Annexure- 6.12.3

4.2 Immediate impact on the environment viz. air, water, soil, biodiversity

4.2.1 Monitoring of Air Quality by CSIR-NEERI & CBRN of NDRF

The Team of CSIR – NEERI[35] and Chemical, Biological & Radiological and Nuclear (CBRN) of 5th Battalion, National Disaster Relief Force (NDRF) conducted monitoring to measure Styrene levels in the air on 9th – 10th May 2020 at 6 locations. Styrene levels ranged from 1.2 ppm to 12.8 ppm. The concentration of Styrene was also measured at ground level, 1.5 feet and 4.5 feet above the ground. Based on the results, the NEERI team advised the District Collector for permitting the residents to return to their homes along with protocol of Do's and Dont's.

The Team collected air samples at 6 locations in and around the company premises. The results are tabulated as below:

Table 4.3: Details of air samples collected with location

S. No.	Location	Date of Sampling	Styrene in ppm
1.	M6 Tank Top	May 10, 10:30AM	12.8
2.	At ground level near M6 Tank	May 10, 11:30AM	7.3
3.	Inside the LG Polymers plant near office	May 9, 11:00AM	4.9
4.	Residential area, Venkatapuram Colony	May 10, 11:00AM	1.2
5.	Meghadri Gedda Reservoir	May 9, 2:30 PM	2.3
6.	Fishpond Site, Narvakota	May 10, 3:00 PM	2.7

4.2.2 Monitoring of Water Quality by CSIR-NEERI & CBRN of NDRF

The impact on water bodies in nearby areas of the company were conducted by joint team of NEERI & CBRN[36] of 5th Battalion, NDRF.

The Team collected water samples of the surface & ground water sources and Spillage Samples in and around LG Polymers from 9th -10th May 2020. The results are tabulated as follows:

[35] The detailed report by NEERI-& CBRN, NDRF is provided in Volume VI: Part A Annexure- 6.1.3
[36] The detailed report by NEERI-& CBRN, NDRF is provided in Volume VI: Part A Annexure- 6.1.3

Table 4.4: Details of water sampling locations in and around LG Polymers

S. No.	Sample Code	Water Source	Location	Styrene (mg/L)	MCL/Guideline Value (mg/L)
1.	LG-1	Reservoir	Meghadri Gedda Reservoir	1.74	EPA - 0.1 WHO – 0.02
2.	LG-2	Lake	Narava Kota Reservoir Village Narava	3.76	
3.	LG-3	Dug Well	Dug Well in Premises of LG Polymers	0.723	
4.	LG-4	Dug Well	Near House of G Appa Rao, (V) Venkatpuram	0.181	
5.	Spillage Sample	Spillage Sample	LG Polymers M6 Tank	ND	

The concentration of Styrene in dug wells and reservoirs was found in the range of 0.181 mg/L to 3.76 mg/L. The Styrene monomer concentration was found to be higher as per the WHO, and EPA guideline values of 0.02mg/L and 0.1 mg/L respectively stipulated for drinking water standard. However, it was quite below the toxicity causing concentration of 9 mg/L. The spillage sample collected on 10th May 2020, had no Styrene.

The same water samples were analysed for finding the Physico-Chemical Characteristics. The results are tabulated as follows:

Table 4.5: Analysis of water samples

S. No.	Parameter	Result					BIS 100500:2012 Acceptable/ Permissible Limit
		LG-1	LG-2	LG-3	LG-4	LG-5	
1.	pH	7.9	7.5	7.8	8.1	7.8	6.5-8.5
2.	EC µS/cm	571	878	940	2440	2610	-
3.	TDS (mg/L)	343	527	564	1464	1565	500-2000
4.	Turbidity (NTU)	2.8	4.9	0.9	0.6	0.4	1-5
5.	Total alkalinity as $CaCO^3$ (mg/L)	214	188	416	702	592	200-600
6.	Total Hardness as $CaCO^3$ (mg/L)	116	256	236	230	508	200-600
7.	Calcium as Ca^{2+}(mg/L)	25	49	31	27	5	75-200

S. No.	Parameter	Result					BIS 100500:2012 Acceptable/ Permissible Limit
		LG-1	LG-2	LG-3	LG-4	LG-5	
8.	Magnesium as Mg^{2+} (mg/L)	13	32	38	39	119	30-100
9.	Chloride as Cl^- (mg/L)	54	66	50	202	262	250-1000
10.	Sulphate as SO_4^{2-} (mg/L)	14	356	40	104	168	200-400
11.	Nitrate as NO_{3-} (mg/L)	BDL	6	BDL	102	237	45
12.	Sodium as Na^+(mg/L)	52	108	84	307	241	-
13.	Potassium as K^+ (mg/L)	12	26	8	39	60	-
14.	Phosphate as PO_4^{2-} (mg/L)	0.2	0.3	0.1	0.1	0.1	-

The values of pH were found to be within the permissible limits of groundwater meant for drinking purpose. Total Dissolved Solids (TDS) were found to be ranging between 527 and 1565 mg/L in samples LG-2 to LG-5 which are within the permissible limits of BIS. In Sample LG-1, TDS was observed to be below the acceptable value prescribed by BIS.

Total alkalinity and total hardness were observed to be ranging within the permissible limits of BIS. Magnesium was found to be of the order of 119 mg/L in LG-5 which exceeds the permissible limit of 100 mg/L laid down by the BIS. Samples LG-4 and LG-5 were found to have excessive levels of Nitrate with concentrations of 102 mg/L and 237 mg/L respectively exceeding the acceptable limit of 45 mg/L as per the BIS standards for potable water.

The above samples were also analysed for finding the metal concentrations. The results are tabulated below:

Table 4.6: Analysis of water samples for finding Metal Concentrations

S. No.	Sample code	As	Cr	Fe	Mn	Ni	Pb	Zn
	BIS Limit	10 µg/L	0.05 mg/L	0.3-1.0 mg/L	0.10- 0.30 mg/L	0.02 mg/L	0.01 mg/L	5.0- 15 mg/L
	ICP detection Limit	7 µg/L	0.01 mg/L	0.0003 mg/L	0.0001 mg/L	0.005 mg/L	0.009 mg/L	0.001 mg/L
1	LG-1	0.4	0.02	0.9	0.1	BDL	0.02	0.03
2	LG-2	0.2	BDL	4.6	0.3	BDL	BDL	0.02
3	LG-3	0.1	BDL	1.9	0.1	BDL	BDL	0.03
4	LG-4	0.08	BDL	0.2	0.008	BDL	BDL	0.01
5	LG-5	0.05	BDL	0.2	0.006	BDL	BDL	0.02

Arsenic was found within the BIS Acceptable limit of 10 ppb; ranging from 0.05 to 0.4 ug/L in all the five samples. In samples LG-2 and LG-3, Iron was found to be high with concentrations of 4.6 and 1.9 mg/L respectively. In LG-1, Lead was found to be 0.02 ppm which is above the BIS limit.

4.2.3 Monitoring of Soil Quality by CSIR-NEERI & CBRN of NDRF[37]

The NEERI collected the soil samples to study the impact of Styrene vapour on soil quality. The Styrene concentrations were found in the range of 109 mg/kg to 5950 mg/kg. The concentrations were on a higher side as per the Canadian Council of Ministers of Environment (CCME) guideline values of 0.1 mg/kg and 50 mg/kg for agriculture and industrial activities of the soils respectively.

The soil sampling location details in and around the LG Polymers, Vishakhapatnam and its results are tabulated below:

Table 4.7: Details of soil sampling locations in and around LG Polymers

S. No	Sample Code	Soil Source	Location	Styrene (mg/kg)	MCL/Guideline Value (mg/kg)
1.	LG-1	Meghadri Gedda Reservoir (Surface soil)	Meghadri Gedda Reservoir	318.1	0.01mg/kg (Agricultural) and 50mg/kg (Industrial) as per
2.	LG-2	Meghadri Gedda Reservoir (Deep soil)	Meghadri Gedda	444.6	

[37] The detailed report by NEERI-& CBRN, NDRF is provided in Volume VI: Part A Annexure- 6.1.3

S. No	Sample Code	Soil Source	Location	Styrene (mg/kg)	MCL/Guideline Value (mg/kg)
			Reservoir		Environmental guidelines for contaminated site remediation criteria by CCME
3.	LG-3	Narava Kota Reservoir Village Narava (Surface soil)	Narava Kota Reservoir Village Narava	109.0	
4.	LG-4	Narava Kota Reservoir Village Narava (Deep soil)	Narava Kota Reservoir Village Narava	1215.1	
5.	LG-5	Opposite to M-6 tank of LG Polymers (Surface soil)	LG Polymers M-6 Tank	342.7	
6	LG-6	Opposite to M-6 tank of LG Polymers (Deep soil)	LG Polymers M-6 Tank	827.6	
7.	LG-7	Near House of G Appa Rao (Surface soil)	Village Venkatapuram	731.3	
8.	LG-8	Near House of G Appa Rao (Deep soil)	Village Venkatapuram	1427.8	
9.	LG-9	Opposite to M-6 tank of LG Polymers (surface)	LG Polymers M6 Tank	5950.1	

4.2.4 Forensic Study of M6 Tank and disposal of the contents

The Committee has already suggested a forensic study of the M6 Tank on various parameters in Chapter 2. The Committee is of the view that forensic study has to be carried out for M6 Tank to also know the quantity and nature of material remaining in the M6 Tank. The leftover polymer content in M6 Tank shall be analysed and based on the characteristics, the waste shall be disposed to appropriate recycler / utilizer / incineration after examining the comprehensive analysis, conducting Ductility Test, etc. as per Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.

4.3 Long-term impact on the Human life, Flora, Fauna and Environment

The Styrene vapour release may have long term impact on human health, soil, water, flora & fauna.

4.3.1 Impact on Human Health

According to the US Environment Protection Agency (EPA)[38], there may be an association between Styrene exposure and an increased risk of leukaemia and lymphoma. The International Agency for Research on Cancer (IARC)[39] has determined that Styrene is a possible carcinogen and can cause cancer under prolonged exposure. However, the Committee is of the view that the literature on the Long-term effects on human beings need further study by medical experts.

The District Collector constituted a group comprising of 10 Doctors under the Chairmanship of Principal, Andhra Medical College for conducting long term study on the health effects on the 585 people who got affected and had received treatment in the hospital and the others living in the vicinity of the factory. This group of doctors would monitor the following:

a. Baseline investigations, of each and every patient before discharge, by departments of General Medicine, Pulmonology, Ophthalmology, Dermatology, Gastroenterology, Pediatrics with the required Pathology.
b. In addition to the above, the Committee advised the District Collector to also include women health in the above investigations.
c. Baseline status of other Departments like Neurology as may be required.
d. The Committee also emphasized that monitoring of pregnant women with the outcome of the pregnancy and 1 year follow up of newborns may be compulsorily done.

The Committee is of the view that Indian Council for Medical Research (ICMR) may be entrusted with the task to study the long-term effects of Styrene monomer vapour on the health of the people. ICMR may also look into the various parameters of affected patients, a spectrum of symptoms reported by the exposed people, the impact of acute inhalation of Styrene during the period of the accident and its impact on the vulnerable group like pregnant women, new-bom

[38] https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/styrene.pdf
[39] https://monographs.iarc.fr/wp-content/uploads/2018/06/mono93.pdf

and children and senior citizens. The ICMR can also study impact on the reproductive system, Styrene-induced genetic disorders and also conduct epidemiological study.

4.3.2 Impact on Livestock and Animals

The livestock owners were advised by the District Administration, following the advice of NEERI, not to feed the fodder and feedstock available with them that are exposed to the Styrene vapour. The farmers were advised to milk the animals but to discard the same till further directions. The Committee is of the view that a study needs to be conducted by the Animal Husbandry experts to find out the long-term impact on the livestock and animals due to exposure to Styrene vapour.

4.3.3 Impact on Air

Styrene vapour being heavier than air settles down. It condenses and becomes liquid / polymerised. In the atmosphere, Styrene is rapidly dispersed, especially in the presence of sunlight.

4.3.4 Impact on Water

Styrene is insoluble in water and is lighter than water in liquid form. It would float at the top and would drain away in case of water flow. The stagnant water points where there is no flow needs to be monitored continuously. However, where Styrene polymerises and becomes stable, it may settle down or disperse in the water in the form of micro plastics. Such water bodies also need to be monitored.

The GVMC and the APPCB need to conduct these studies continuously, in association with experts to monitor the water quality.

4.3.5 Impact on Drinking water

Styrene evaporates readily from water to air. Water for drinking purpose can only be used if Styrene concentration drops below the guideline value of WHO, i.e. 0.02 ppm. Also, atmospheric degradation products of Styrene may persist in water bodies as part of measured total organic carbon (TOC) and chemical oxygen demand (COD). Periodic monitoring of drinking water sources for Styrene and relevant water quality parameters should be carried out, intensely with the assistance of experts for at least two years or till it reaches the stipulated guideline level on natural attenuation.

4.3.6 Impact on Soil

Styrene volatilises rapidly from the top layer of soil surface and volatilises slowly when present in deeper strata. Styrene biodegrades in soil and sediment[40]. Styrene has low mobility in soil and thus is not expected to move substantially through the soil. It will be broken down by soil microorganisms.

Soil quality and underground water quality needs to be monitored. One needs to be careful about agriculture, horticulture, etc. such that it should not enter the food chain of either human beings or animals. Therefore, soil quality monitoring at regular intervals for a period of two years needs to be conducted.

4.3.7 Impact on Flora & Fauna

Styrene being a hazardous chemical, there are imminent dangers in the long term to the flora & fauna existing around the LG Polymers. The officials from the Forest Department have informed about the locations of forest area and zoo. Hence, there is a need for long term studies on local flora and fauna, including a continuing assessment of local biodiversity and wildlife in the area.

A committee comprising of experts from the field of Forestry, Wildlife, Ecology & Environment may be formed to undertake long-term impact assessment study and to suggest the mitigation steps.

Forest Department and Horticulture Department may also analyse the impact on Forestry / Tree cover in the affected area to examine the repercussions on the tree growth in the area and effects due to Styrene vapour leakage.

[40] R.J. Parod, in Encyclopedia of Toxicology (Third Edition), 2014 (Environmental Fate and Behavior)

The Forest Department also suggested to assign the task of evaluating the impact of Styrene vapour release on animals within the zoo to the Zoo Health Committee along with an expert from the relevant field.

4.4 Dispersion of Styrene Vapour: Modelling & Simulation[41]

The Technical Committee in its report (Vol I) has undertaken a detailed analysis of the dispersion of Styrene vapour to estimate the extent of Styrene vapour released and assess the threat zones through different modelling and simulation methods.

The Styrene Monomer Vapour (SMV) got emitted from the M6 Tank of LG Polymers Pvt. Ltd. (LG Polymers) plant which contains around 1800 MT of Styrene Monomer (SM) as on 6th May 2020 as stated by the industrial personal. Habitations are located at a distance of approximately 210 m to 220 m from the storage tank in the South West, West and North West direction with reference to the M6 Tank as shown in Figure 4.2.

Figure 4.2: The Styrene Monomer Storage Tank of LG Polymers and Its Proximity to Human habitations

The toxic vapours were emitted from the M6 Styrene Monomer (SM) storage tank in the company before around 02.54 a.m. on 7th May 2020, and the occurrence of vapour emissions

[41] The report by the Technical Committee is provided in Volume I.

continued till 8th May 2020 morning. As observed and described by the LG Polymers plant personnel present at that time, the vapour cloud with an approximate height of around 2.4 m (8 feet) occupied the entire industry and the approach road which is at a distance of more than 380m from the main gate of SM storage tank area.

The Styrene vapour cloud, as per the physical description of the plant staff on duty at that time, occupied the plant area within 15 to 20 minutes. It simultaneously entered the nearby habitations from the vertical and inclined emissions from the M6 Tank. The cloud advanced from the SM storage tank area towards the main gate with less than 15 to 20 minutes even when a relatively stable atmosphere condition. As per version of the affected people, the SM vapour cloud spread densely up to a height of around 12-14 feet.

Based on the plume behaviour observed, and the description of the cloud progression, it may be stated that the wind might have pushed the vapour cloud towards West, North West and North-East direction. The meteorological data observed at the monitoring station in LG Polymers industry on 7th May 2020 is shown in Table 4.8.

Table 4.8: The Meteorological Data Observed by the existing Monitoring Station on 07-05-2020 in LG Polymers, Visakhapatnam

Time	Temperature, ^{o}C	Relative humidity, %	Wind Direction, ^{o}
02:00 a.m.	25.97	90.99	71.3
03.00 a.m.	25.85	89.95	172
04:00 a.m.	25.37	92.91	171.83
05:00 a.m.	25.09	94.83	172
06.00 a.m.	25.51	94.74	144.8
07:00 a.m.	27.48	87.48	118
08:00 a.m.	29.81	79.13	184.18
09:00 a.m.	31.54	72.20	278.78
10:00 a.m.	32.91	66.40	188.7
09.00 p.m.	31.40	82.00	248
10.00 p.m.	31.10	83.00	245

The wind speed was not recorded until 08:00 a.m. The observed wind speeds on 8th May 2020 in this area between 03:0 a.m. to 05:00 a.m. is 0.5m/s to 0.6 m/s (typical early morning wind speed range) respectively[42]. The wind speed recorded at 09.00 a.m., and 10:00 a.m. is 1.67 m/s and 1.7 m/s respectively. The observed wind direction between 03:00 a.m. till 05:00 a.m. is around 172˚. From 03:00 a.m. till 07:00 a.m. the wind direction is between 90˚ and 180˚. At 02:00 a.m., the wind direction is approximately 71˚. These conditions may be one of the reasons for the movement and dispersion of the vapour towards the villages.

The observed wind speed in the industry at 9:00 p.m. and 10:00 p.m. on 7th February 2020 is 0.7 m/s and 0.6 m/s respectively. The Styrene Monomer vapours were emitted from the top of the M6 Tank from two different vents as evident from the photographs from various media sources, CCTV footages and these are marked and presented in Figure. 4.3. The height of the vents through which the SMV emissions took place is approximately 12.5 m. This data is useful in assessing the area of influence of the SMV emissions.

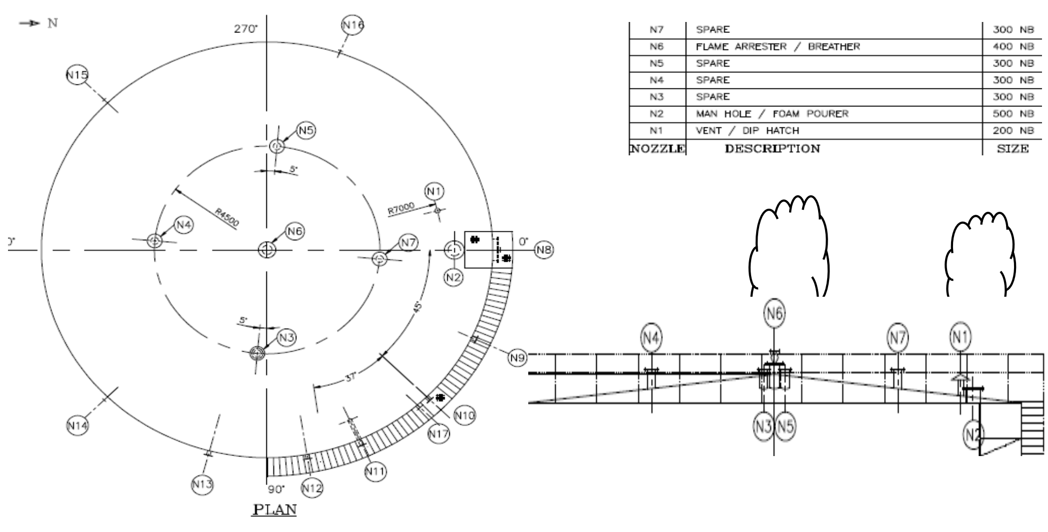


Figure 4.3: The Vents from where the SM Vapour Emissions entered into the Ambient Atmosphere

42 As recorded by the APPCB measuring station

4.4.1 Loss of Styrene from the M6 Tank

The level recorder in the M6 SM storage tank recorded the per cent volume of SM in the M6 Tank from time to time, and the data is shared by the LG Polymers management. This data is available from the continuous recording system of LG Polymers industry. In addition to the first SMV release accident at around 02.54 a.m. of 7th May 2020, there is a second event of a high release of SMV on the same day night from around 09.00p.m. onwards and some intermittent loss of material was observed for one minute each. It may be considered as impulse release.

The level of SM in the M6 Tank, between 02.50 a.m. & 03.47 a.m. and 08.12 p.m. & 10.00 p.m. is used to estimate the loss of SM in M6 Tank. The data is provided by the industry only, which is based on continuous recording systems. It is used to compute the loss of Styrene from 03.03 a.m. till 03.47 a.m. of 7th May 2020 as it is the initial as well as the peak period of release of SMV from the M6 Tank. It is assumed that Styrene got lost through conversion/polymerisation and no other loss from any other sources such as leaks or escape of liquid or removal of Styrene liquid took place during the period considered to assess the loss of Styrene from the M6 Tank.

The industry report states that water was sent into the Tank from the afternoon/evening of 7th May 2020. However, the tank temperature at the measuring point is more than 109˚C. Hence, the water pumped into the M6 Tank might have evaporated as the temperature at 8.45 p.m. reached 125˚C and increased further to approximately 150˚C by 09.38 p.m. The observed reduction or loss of SM in the M6 Tank during 3.05 a.m. to 03.20 a.m., 03.20 a.m. to 03.35 a.m. and 03.35 a.m. to 3.47 a.m. on 7th May 2020 are 30.91 MT, 42.14 MT, and 8.43 MT respectively. The reduction or loss of SM observed on 7th May 2020 in the M6 Tank between 21.14 hours (09.14 p.m.) to 22.13 hours (10.13 p.m.) is 16.86 MT. The quantum of above-mentioned Styrene monomer releases is used for the ALOHA model-runs, assuming that these were converted into vapours and released from the M6 Tank.

During 08.25 p.m. to 09.20 p.m. the emission is intermittent at different timings with an emission duration of 1 to 3 minutes only as per the level recorder data. Hence, it may not be taken as a reference emission rate as there is a gap between each release which may be treated as impulse release.

Table 4.9. provides details of the level records, used for assessing the Styrene loss from M6 Tank. There is withdrawal or pumping of 95 MT Styrene from the M6 Tank on 7th May 2020 before 07.30 a.m. If this is taken into account, then the total loss of Styrene material up to 07.40 a.m. on 8th May 2020 (657.43 MT – 95 MT) is approximately 562.43 MT. The total loss of Styrene till 11:52 a.m. on 9th May 2020 (913.16 MT – 95 MT) is about 818.16 MT. The additions into and removal from the Tank to either terminate or inhibit the polymerisations and other hazard management handling are assumed to be negligible.

Table 4.9: The Loss of Styrene from the M6 Tank During Different Periods

Date and Time	% Level	Temperature, °C	Volume, m^3	Volume lost, m^3	Weight of SM lost, T
07-05-2020 02:50	56.80	17.40	1755.688	-	-
07-05-2020 07:00	52.80	31.40	1632.05	123.64	112.38876
07-05-2020 10:00	48.71	38.61	1505.51	126.54	115.0228716
07-05-2020 12:00	47.10	44.60	1455.86	49.65	45.13111144
07-05-2020 15:00	45.30	51.20	1400.22	55.64	50.574942
07-05-2020 18:00	42.90	70.80	1326.04	74.18	67.433256
07-05-2020 22:00	41.10	145.60	1270.40	55.64	50.574942
08-05-2020 02:00	33.90	153.70	1047.85	222.55	202.299768
08-05-2020 06:00	33.70	122.20	1041.67	6.18	5.619438
08-05-2020 03:07	33.60	143.90	1038.58	3.09	2.809719
08-05-2020 07:40	33.40	125.55	1032.44	6.13	5.574763468
09-05-2020 11:52	24.30	99.60	751.11	281.33	255.7291035
	Total volume lost *		1004.58	1004.58	913.158675
	Volume lost upto 7.40 a.m. on 8th May 2020.			723.24	657.4295715

** There are inconsistencies in the level records between 08th May 2020 07:40 to 09th May 2020 11:52 (Ex. The loss of volume in the M6 Tank between 11.2 a.m. and 11.52a.m. on 9th May 2020 is 550.17MT as per the level recorder data).*

4.4.2 Dispersion Modelling

The SMV emitted from M6 SM storage tank dispersed to the surrounding areas and affected the environment in the vicinity of LG Polymers, including the human, animal and plant life in the surrounding villages. The measurements of the actual amount of SMV emitted from the M6 storage tank into the ambient atmosphere are not available. The odour was observed beyond NAD junction, Muralinagar, Marripalem etc. area which is more than 3 km away from the industry.

The actual receptor level concentrations of Styrene were not available at the time of the accident and during the toxic cloud dispersion or spread time. Several models are available to model such a phenomenon. Hanna, S. et. al. [6] compared the performance of ALOHA, HG SYSTEM, SLAB, SCIPUFF, PHAST and TRACE models for that are used for the dispersion studies of Styrene vapour leak. Hanna, S. et al. [6] found that the results of these models are in agreement with the model's simulations of the plumes. Styrene vapour is heavier than air. Hence, an attempt is made to predict or assess the concentrations and affected area through modelling the dispersion using available ALOHA and PHAST Lite model software.

The required data for the modelling for the present dispersion studies is given in Table 4.10. Stability Classes E and F were considered for the present study as it happened in the early hours and generally, the meteorological conditions in the early hours of a day result in a stable in the study region.

Table 4.10: The Data Used for the Modelling of the Dispersion of the Styrene Vapour

Parameter	Data used / Detailed description
Chemical	Styrene Monomer
Wind Speed, m/s	0.6, 0.65, 0.86, and 1.67
Wind Direction, ^{0}	118 to 145, 172, 278.78, 246
Relative humidity, %	72, 87, 92, and 94
Ambient temperature, ^oC	25.5, 27.5, 31.2, and 31.54
Emission Quantity, Tons	9 to 31, 42, 46, and 50
Height of the source, m	12.5
Stability Classes	E and F

ALOHA uses 60-minute Acute Exposure Guideline Levels (AEGLs) as the default Levels of Concern. It is assumed that the assumptions made in the model hold good in this SMV emission case. Any model available for such dispersion modelling studies will have its assumptions and limitations. Hence, the ALOHA model assumptions hold good for the present analysis also. The AEGL-1 (60 minutes), AEGL-2 (60 minutes), and AEGL-3 (60 minutes) concentrations are 20 ppm: 130 ppm and 1100 ppm respectively. The Immediately Dangerous to Life and Health (IDLH), and LEL considered in the ALOHA is 700 ppm, and 11000 ppm respectively. The Styrene concentrations in reference to the Emergency Response Planning Guidelines (ERPG), Short Term Exposure Limit (STEL), Temporary Emergency Exposure Limit (TEEL), and Time Weighted Average (TWA) are given in CAMEO Chemicals' chemical datasheet. It is presented in Figure 4.4. The interim AEGLs for Styrene are shown in Table 4.11.

The people of the affected area got exposed to a period of around 2 hours to 4 hours for different concentrations. The model predicts the extent of threat zone along with concentrations at different locations of interest. The anticipated results will have uncertainties associated with the limitations of the model applicability and the measurements or data available. The model will not give the actual values of the areas of influence or concentrations at different distances from the source. There could still be some deviations from the actual area or concentrations. This limitation is true with any of the dispersion models.’’

Styrene monomer, inhibited
CAS 100-42-5
UN 2055
GUIDE P128 - Flammable liquids (non-polar / water-immiscible)

Colorless liquid; aromatic odor

NFPA Information

Health (Blue): 2 Hazardous
Fire (Red): 3 Flash Point < 100°F
Instability (Yellow): 2 Violent Chemical Change

Physical and Chemical Properties
Formula: $C_6H_5CH=CH_2$
Molecular Weight: 104
Flash Point: 88°F
Lower Explosive Limit: 0.9%
Upper Explosive Limit: 6.8%
Auto Ignition Temp.: 914°F
Boiling Point: 293°F
Melting Point: -23°F
Rel Vapor Density @68°F: 1.1 (Heavier than air)
Vapor Pressure @68°F: 0.01 atm
Liquid Specific Gravity: 0.91 (Lighter than water)
Ionization Energy: 8.43 eV
RAE Systems PID correction factor for 9.8 eV: 0.45
RAE Systems PID correction factor for 10.6 eV: 0.4
RAE Systems PID correction factor for 11.7 eV: 0.4
Yield Factor: 0.03

Toxic Levels of Concern
IDLH: 700 ppm (2977.51 mg/m^3)
TWA: 50 ppm (212.68 mg/m^3)
STEL: 100 ppm (425.36 mg/m^3)
ERPG-1: 50 ppm (212.68 mg/m^3)
ERPG-2: 250 ppm (1063.39 mg/m^3)
ERPG-3: 1000 ppm (4253.58 mg/m^3)
TEEL-1: 50 ppm (212.68 mg/m^3)
TEEL-2: 250 ppm (1063.39 mg/m^3)
TEEL-3: 1000 ppm (4253.58 mg/m^3)

Figure 4.4: The levels of concern for Styrene Monomer. (Source: CAMEO chemicals' chemical data sheet (https://cameochemicals.noaa.gov/chemical/4553))

Table 4.11: Interim Acute Exposure Guideline Levels (AEGLs) for Styrene for Different Exposure Periods

Exposure Period	AEGL-1	AEGL-2	AEGL-3
10 minutes	20 ppm	230 ppm	1900* ppm
30 minutes	20 ppm	160 ppm	1900* ppm
60 minutes	20 ppm	130 ppm	1100* ppm
4 hours	20 ppm	130 ppm	340 ppm
8 hours	20 ppm	130 ppm	340 ppm

**The lower explosive limit (LEL) of Styrene in the air is 1.1 % (11,00 ppm). The AEGL-3 value of 1900 ppm (8090 mg/m^3) for 10 minutes and 30 minutes is higher than 1/10 of the LEL. Therefore, safety considerations against the hazard of explosion must be taken into account. (Source: https://www.epa.gov/aegl/styrene-results-aegl-program)*

4.4.3 Threat Zone Area

The areas of influence of the chemical vapour/gas are classified in the ALOHA model into three zones. i.e. Red, Orange, and Yellow zones. These zones are defined as areas that may cause environmental impacts in the vicinity based on the Styrene concentrations limits of 1100 ppm, 130 ppm, and 20 ppm. The Red zone represents a Styrene concentration higher than 110 ppm, which may cause life-threatening health effects or death for a 60min exposure to these concentrations of Styrene monomer vapours. Similarly, the Orange zone represents a concentration between 130 ppm to 1100 ppm at the zone of influence outer boundary. Exposure to these concentrations could experience serious adverse health effects or an impaired ability to escape from the area. The Yellow zone represents an area with a concentration ranges from 20 ppm to 130 ppm at the outer boundary of the zone of influence which may cause notable discomfort, irritation, or certain asymptomatic non-sensory effects. The vulnerable zones defined above are based on the US Environment Protection Agency's Acute Exposure Guideline Levels for acute exposure to Styrene monomer concentrations normally for the general public. The affected zones are the ones where the actual dispersion took place.

The ALOHA model applicability was first verified with the observed Styrene concentration at LG Polymers main gate monitoring point. It helps at the assessment of possible input data used as per the existing setting in the area for the present scenario.

4.4.4 Observed Ambient Styrene Concentrations

The ambient Styrene concentrations are measured at different selected locations, i.e. Venkatapuram village, Janata Colony, LG Polymers industry-main gate etc. in the vicinity of the LG Polymers plant. The concentrations measured at these locations during the second significant release during the night of 7th May 2020 are available and given in Table 4.12.

Table 4.12: The Ambient Styrene Concentrations Measured at the said Locations

ID	Date	Time of Measurement	Styrene Concentration, ppm	Observed Wind Direction, ^{0} APPCB/LGP
Venkatapuram village	07.05.2020	16.30	75.4	
		17.30	151	
		18.00	123	
		19.00	11.2	
		20.00	77	222/193
		21.00	54	248/201.2
		22.00	461	245/196.5
	08.05.2020	02.00	374	224/194.18
		03.00	170	202/196
		04.00	45	154/196
		05.00	11.7	
LG Polymers industry main gate	07.05.20	15.10	28.4	
		20.00	54	
		21.00	43	
		22.00	365	
	08.05.20	02.00	242	
		03.00	142	
		04.00	37	
		05.00	14.2	

Based on the measured wind directions, it can be inferred that the wind direction is varying between 193° (180 + 13) and 248° (180 +68). On 7th May 2020, onwards, several people felt the chemical smell even beyond 3 km to 4 km. Though located far away, many residents belonging to that area moved away that night.

Any release of SMV during 08.00 p.m. of 7th May 2020 till 03.00 a.m. of 8th May 2020, the dispersion predominantly takes place towards North-East direction i.e. towards the LG Polymers main gate. Both Venkatapuram and LG Polymers main gate locations are more or less at comparable distance i.e. 400 m and 380 m respectively. But, the direction of Venkatapuram village monitoring location is towards North-West and the distance between both the LG Polymers main gate location and the Venkatapuram monitoring location is more than 0.5 km. The meteorological data observed at 09.00 p.m. and 10.00 p.m. is taken into consideration as input for the ALOHA model to verify the observed concentrations at 10.00 p.m. at LG Polymers main gate and the Venkatapuram village. The observed wind speeds at 09.00 p.m. and 10.00 p.m. on 07th May 2020 are 0.7 m/s and 0.6 m/s respectively. The observed temperature and wind direction are shown in Table 4.8.

The reduction or loss of SM observed on 7th May 2020 in the M6 Tank during 21.14 (9.14 p.m.) to 22.13 (10.13 p.m.) is 16.86 MT. Hence, the same is considered as emission quantity. The predicted concentration at 380 m from the source is 422 ppm. Whereas the observed concentration at 380 m is 365 ppm. The difference in predicted and observed concentration at comparable distance is approximately 15%.

Therefore, it may be concluded that the ALOHA model is fairly correct in capturing Styrene concentrations. Hence, the same location settings are considered for the prediction of concentrations at other events of loss of Styrene during initial incident i.e. between 03.05 a.m. and 03.35 a.m. on 07th May 2020 which resulted in severe impact including the death of human and animal life.

The threat zones and the threat point concentrations at 600 m, 400 m and 200 m are predicted from the ALOHA model for different SM loss during the period. Threat zone areas for the emission of 31 MT, 42 MT and 46 MT with the meteorological data observed in the LG Polymers industry in the early morning during the initial time of the accident are identified. Predicted distances of zones of influence and the concentrations at 200 m and 400 m are given in Table 4.13 for a wind speed of 0.6 m/s. An increase in the peak loss of Styrene by 10%, which amounts to 46 MT, is also considered with an assumption that the error in the measurement in the estimation of loss of Styrene from M6 is approximately 10%. This is considered as the worst scenario case for the present study. It was assumed that the loss of SM during a given period is released into the atmosphere. The limitations or assumption of ALOHA are applicable.

The predicted threat zones for this case with different wind directions of 120°, 145°, and 172° are shown in Figure 4.5. However, the areas of influence are all predicted one which may not match with the exact boundaries of the area of influence. The affected area was identified through field visits and interactions with the people around the LG Polymers industry in the West and North-West and North-East affected areas. Based on these field visits, it is accepted that both the predicted and the actual regions of influence are reasonable.

Table 4.13: Predicted Zones of Influence and the Concentrations at 200 m and 400 m for wind direction of 246°

Source Strength, MT	Predicted Distances of Threat Zones, km			Predicted Concentration of Styrene, ppm			
				at 200 m from source		at 400 m from source	
	Red	Orange	Yellow	Outdoor	Indoor	Outdoor	Indoor
31	0.333	0.976	2.5	3300	146	754	33.3
42	0.398	1.1	2.8	4820	214	1090	48.2
46	0.421	1.2	2.9	5400	240	1220	54
50	0.441	1.3	3.6	5970	519	1360	117

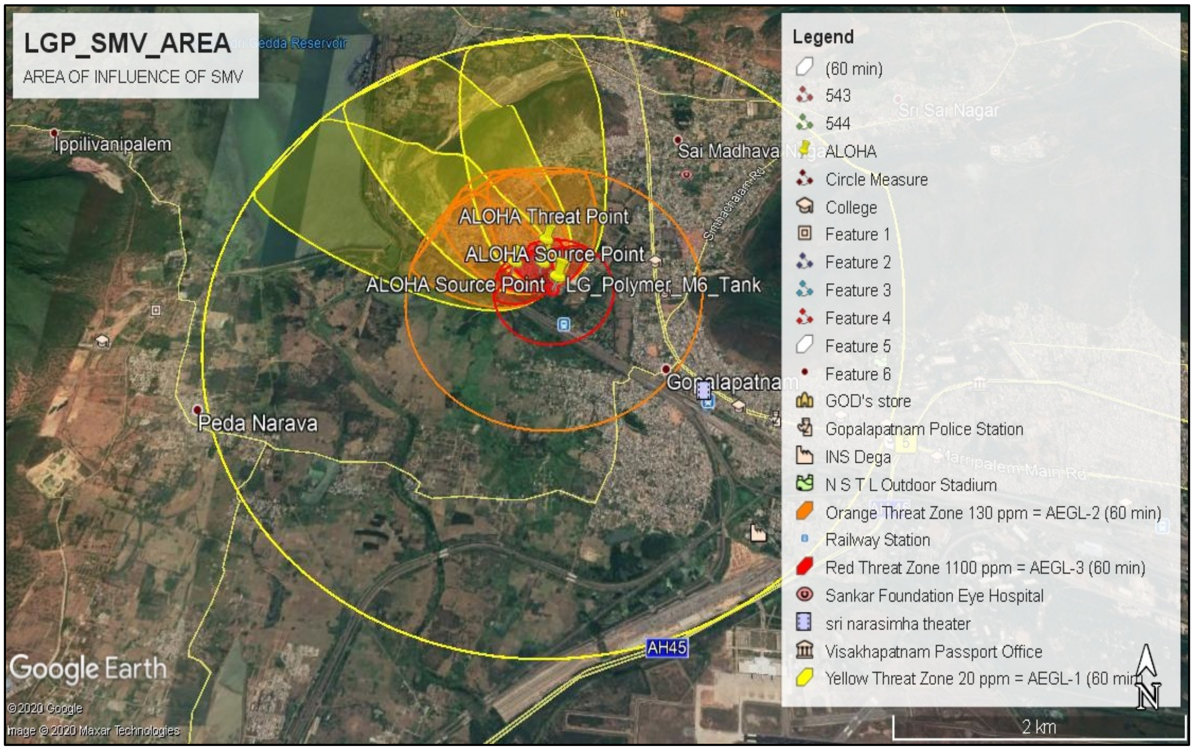


Figure 4.5 (a): The Threat Zones for the ALOHA Model Runs with Styrene Loss / Evaporation of 46MT with Change in Wind Direction. (Google Earth)

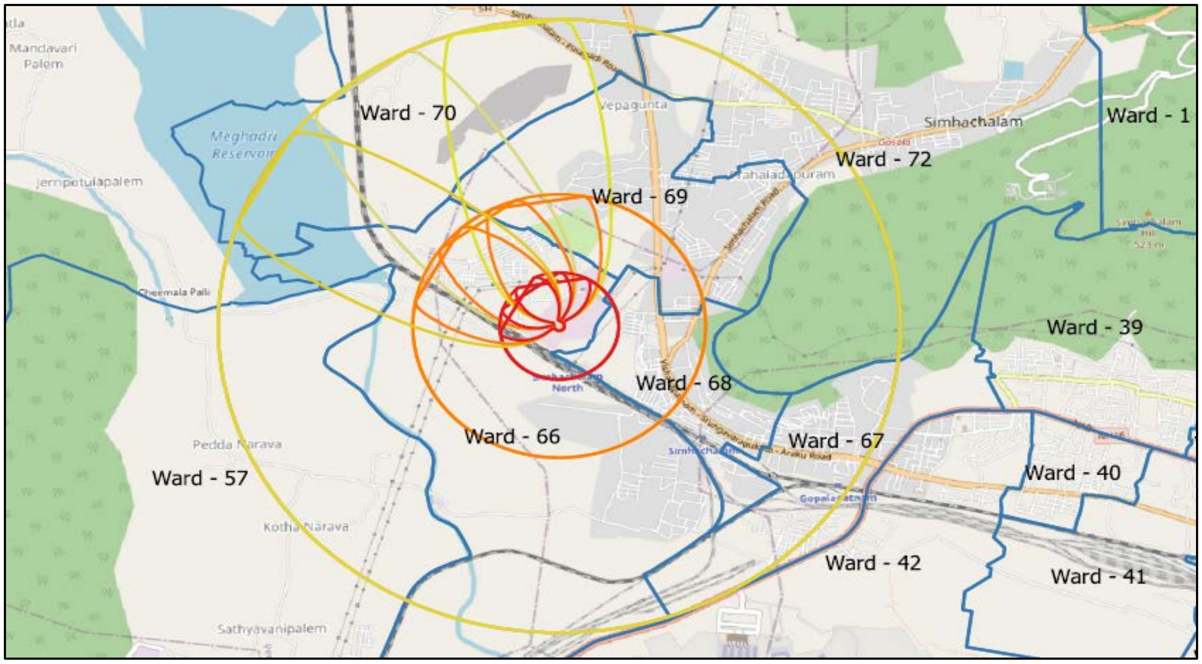


Figure 4.5 (b): The Threat Zones for the ALOHA Model Runs with Styrene Loss / Evaporation of 4MT with Change in Wind Direction. (GVMC Map)

4.4.5 Aloha Model Results

The threat zones, i.e. Red, Orange, and Yellow zones and the threat point concentrations can be predicted from the ALOHA model for different SM emissions scenarios. The observed wind direction from 03.00 a.m. to 05.00 a.m. on 7th May 2020 is approximately 172˚. The prevailing wind direction resulted in the spread of the Styrene monomer vapour cloud towards the villages in that direction. The observed average ambient temperature and relative humidity during the early hours of 7th May 2020 are observed to be approximately 25.5˚C and 92% respectively. The wind speed is not recorded, hence in the model runs a minimum speed of 0.62 m/s was considered taking the general meteorological conditions at that time in that area. Different emissions occurred during the accident. These may be less than the peak emissions observed in the early hours of 7th May 2020. But these will be useful to predict the possible Styrene concentrations in the affected area. The model was used for different SM vapour emissions for better understanding the dispersion characteristics.

The observed meteorological data is used for the prediction of distances of influence of Styrene ambient concentrations with the help of The ALOHA model. The distances of the various zone and the concentrations of the Styrene monomer at 600 m and 200 m for the above wind direction are presented in Table 4.14.

Table 4.14: The details of the results showing various Zones and their areas of influence along with the concentrations at 200 m and 600 m from the source

ID	Wind Speed, m/s	Source Strength, MT	Predicted Distances of Threat Zones, m			Predicted Concentration of Styrene, ppm			
						at 200 m from source		at 600 m from source	
			Red	Orange	Yellow, km	Outdoor	Indoor	Outdoor	Indoor
LGP_W4T1	0.62	15	318.1	933.2	2.7	2960	637	303	54.1
LGP_W4T2		18	352.8	1033.7	2.9	3720	801	372	66.6
LGP_W4T3		24	417.7	1216.5	3.4	5270	1140	521	93.7

ID	Wind Speed, m/s	Source Strength, MT	Predicted Distances of Threat Zones, m			Predicted Concentration of Styrene, ppm			
						at 200 m from source		at 600 m from source	
			Red	Orange	Yellow, km	Outdoor	Indoor	Outdoor	Indoor
LGP_W4T4		30	476	1381	3.9	6800	1470	681	123
LGP_W4T5		50	643.5	1930	4.99	11600	2510	1270	233
LGP_W4T6		60	715.6	2100	5.64	13700	2970	1590	293
LGP_T2	0.86	9	192.9	588.6	1.8	1030	241	126	24.8
LGP_T1		11	216.6	655.3	1.9	1300	306	153	30.2
LGP_T3		15	259.6	776.9	2.3	1920	451	210	41.4
LGP_T4		18	287.9	857.3	2.6	2160	507	254	50.2
LGP_T5		24	304.4	909.4	2.7	2700	639	283	56.4
LGP_T6		30	387.5	1138.8	3.2	4080	960	449	89.1

The results are represented on Google Earth, and the images are given in Figure 4.6 to Figure 4.9. Typical concentration profile and the threat zone graph are shown in Graph 4.1 and Graph 4.2, respectively.

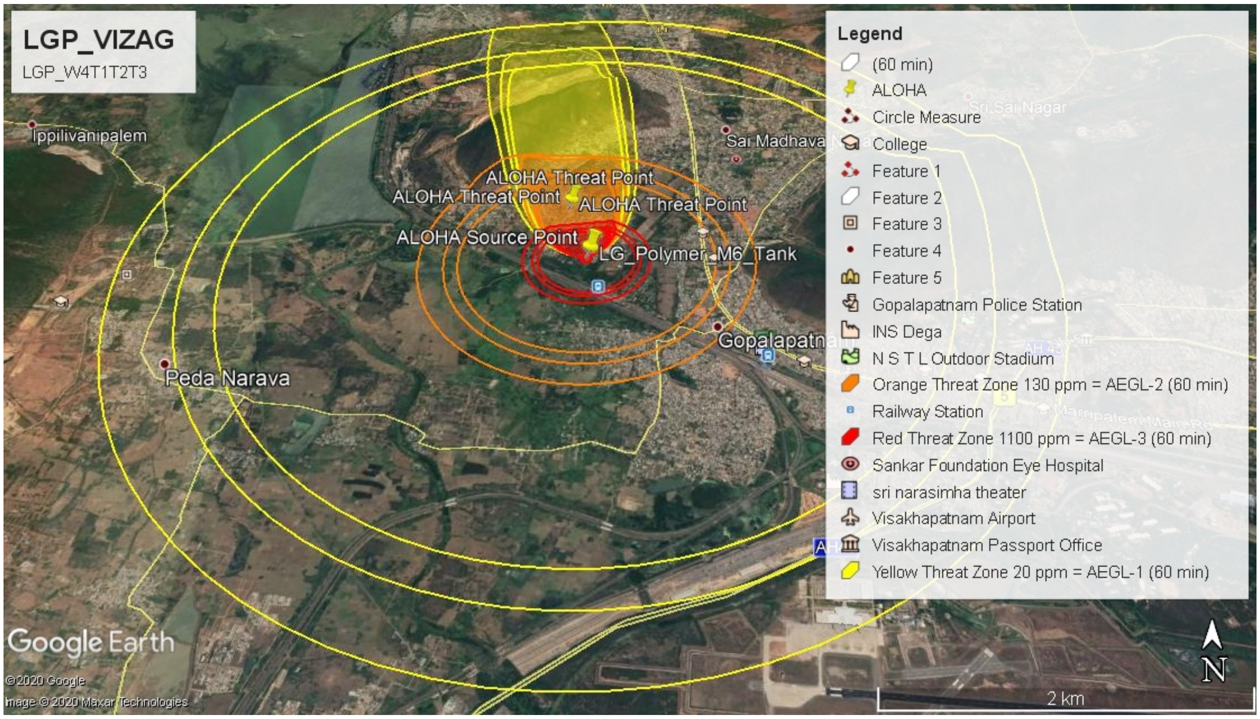


Figure 4.6: The Threat Zones for the ALOHA Model Runs with ID LGP_T1, LGP_W4T2 and LGP_W4T3

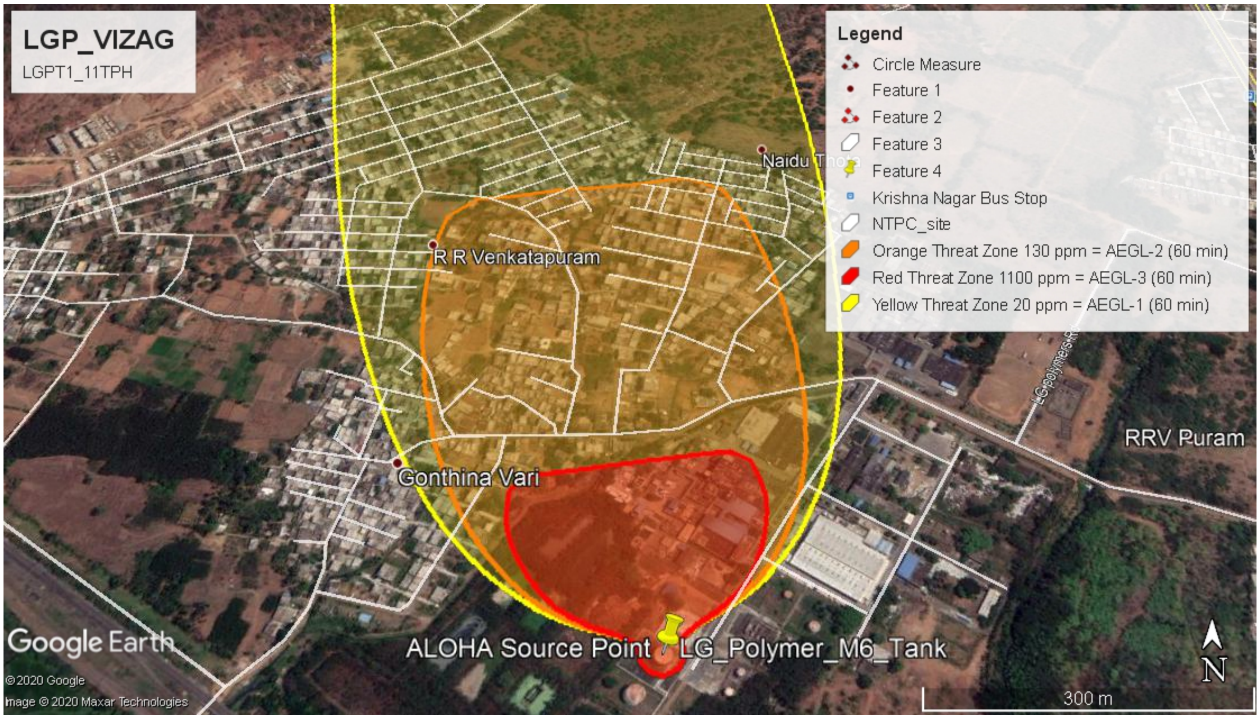


Figure 4.7: The Threat Zones for the ALOHA Model Runs with ID LGP_T1

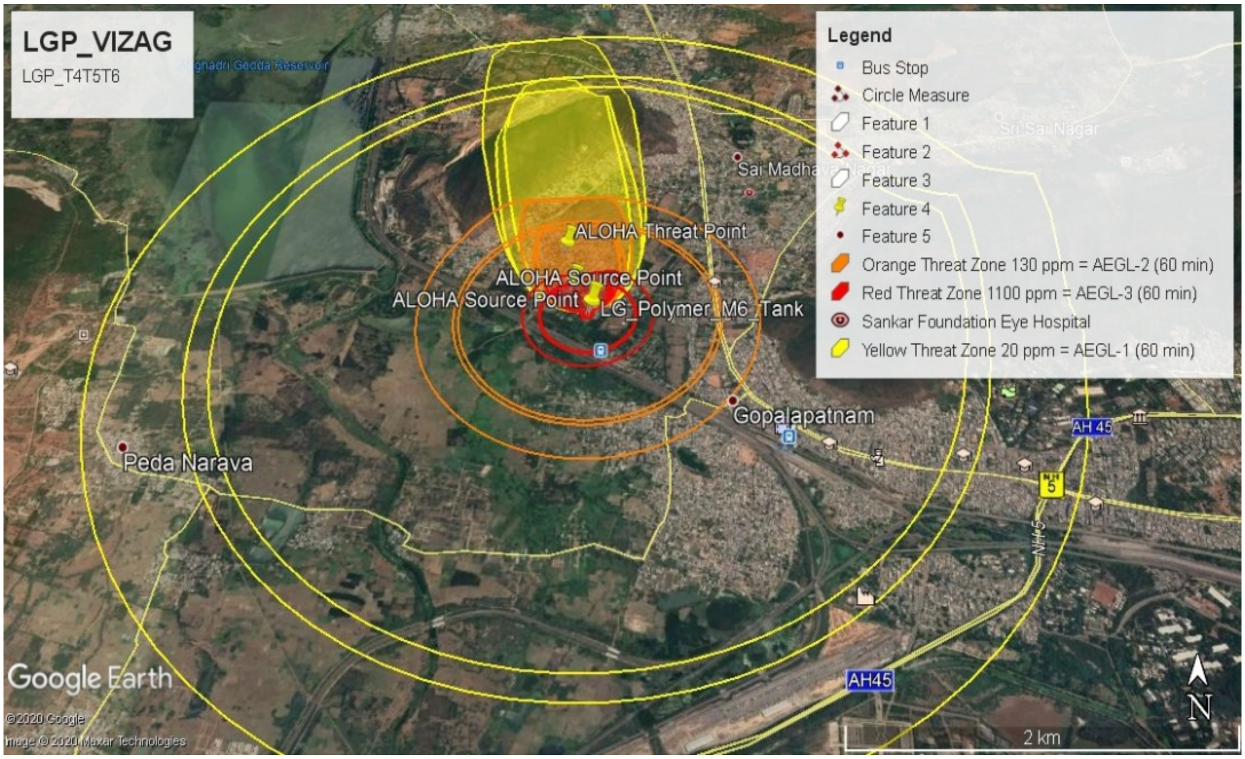


Figure 4.8: The Threat Zones for the ALOHA Model Runs with ID LGP_T4, LGP_T5, and LGP_T6

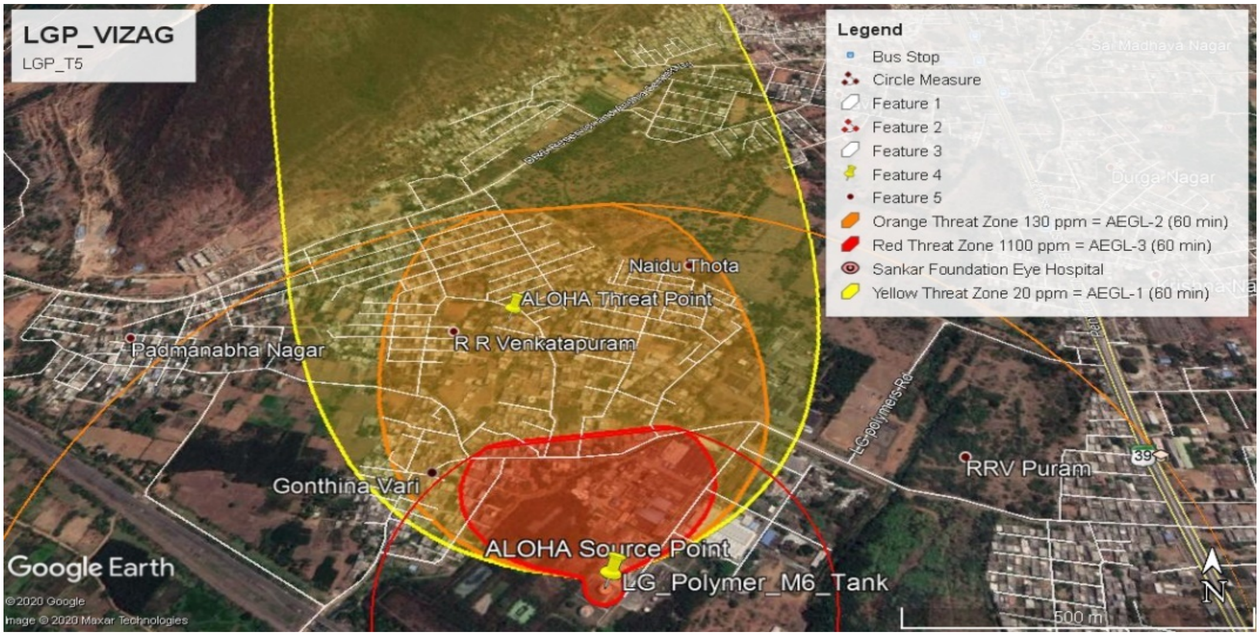
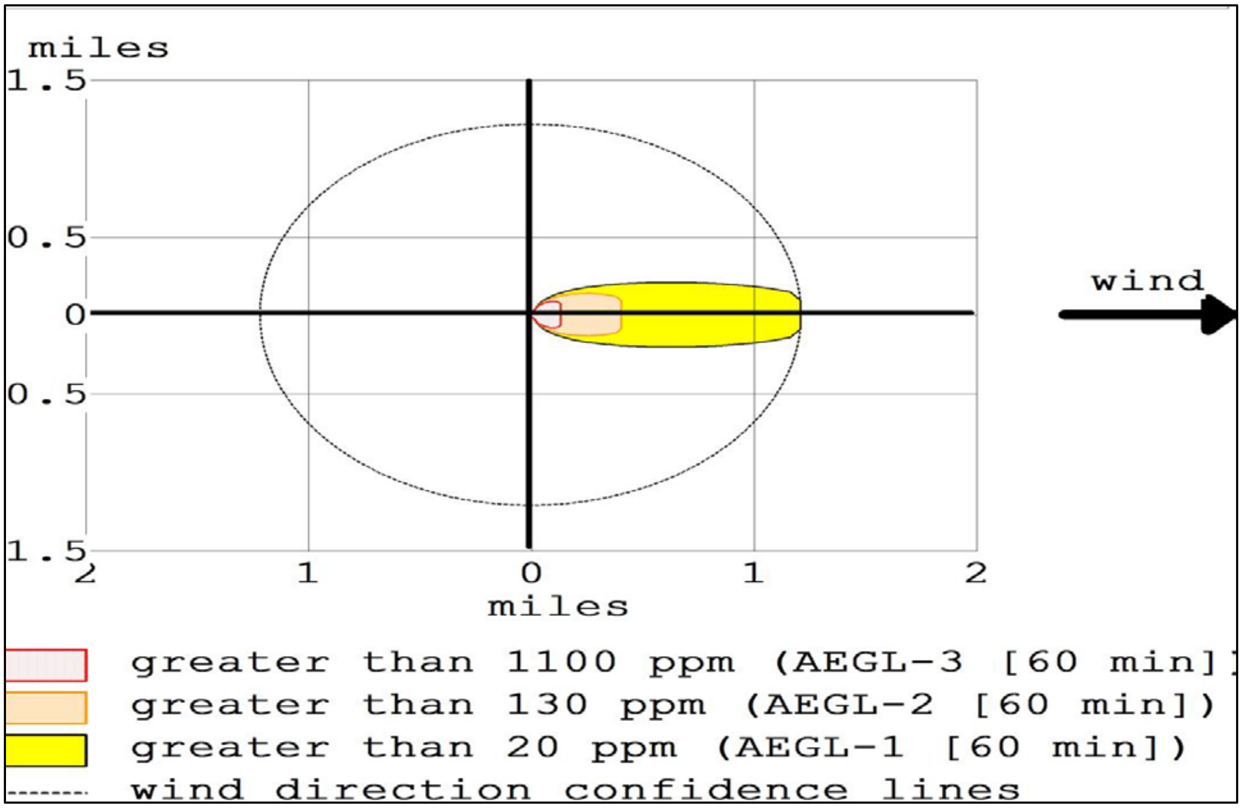
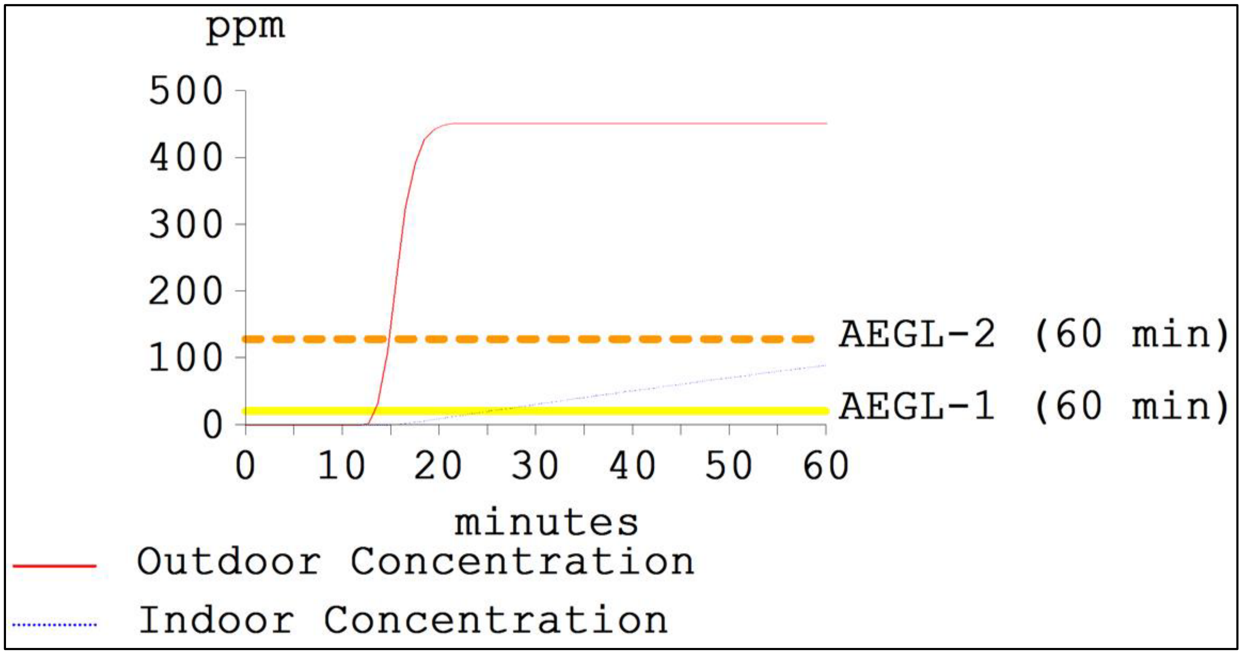


Figure 4.9: The Threat Zones for the ALOHA Model Runs with ID LGP_T5



Graph 4.1: Typical Threat Zone Diagram for the ID LGP_T1 Showing the Area of Influence in the Windward Direction



Graph 4.2: Typical Concentrations at 600m Downwind Direction from the source for the ID LGP_T6

The observed wind directions recorded at 06.00 a.m., 07.00 a.m. and 09.00 a.m. are 144.8°, 118°, and 278.78°, respectively. The observed wind speeds at 08.00 a.m., and 09.00 a.m. is 0.82 m/s and 1.67 m/s respectively. Hence, for the second set of ALOHA model, the wind velocity of 0.86 m/s that was taken earlier and 1.67 m/s were used along with the recorded wind directions. The relative humidity observed during these times is 94%, 87.5% and 72.2%. It will provide a better understanding of the dispersion of the SM vapour cloud during these times as the actual plume was observed to be changing its directions till early morning. The distances of the various zone and respective concentrations of the Styrene monomer at 600m and 200 m for the above wind direction are presented in Table 4.15.

Table 4.15: The results showing various Zones and their areas of influence along with the Styrene concentrations at 200 m and 600 m from the source

ID	RH %	Wind speed, m/s & direction	Source strength MT	Predicted distances of threat Zones, m			Predicted concentration of Styrene, ppm			
							at 600 m from source		at 200 m from source	
				Red	Orange	Yellow, km	Outdoor	In door	Outdoor	In door
LGP_WT1	94	0.86	10	233.1	622.4	1.9	139	27.4	1050	246
LGP_WT2		144^0	15	259.6	776.0	2.3	210	41.4	1910	449
LGP_WT3			20	306.2	908.5	2.6	284	56.3	2750	647
LGP_WT4			25	306.2	1028.3	2.9	364	72.1	3650	859
LGP_WT5			30	387.5	1137.9	3.2	448	88.9	4570	1080
LGP_W2T1	72	1.67	10	152.6	522.8	1.8	72.6	25.4	100	37.2
LGP_W2T2		278.78^0	15	191.0	642.5	2.1	125	43.8	324	121
LGP_W2T3			20	223.0	285.2	2.4	176	61.1	712	264
LGP_W2T4			25	252.3	832.7	2.6	225	78.1	1170	432
LGP W2T5			30	278.8	915.8	2.9	270	93.8	1680	622
LGP_W3T1	87	0.86	15	260.5	763.2	2.3	211	45.7	1930	497
LGP_W3T2		118^0	20	308.0	912.2	2.7	287	62.1	2770	714

ID	RH %	Wind speed, m/s & direction	Source strength MT	Predicted distances of threat Zones, m			Predicted concentration of Styrene, ppm			
							at 600 m from source		at 200 m from source	
				Red	Orange	Yellow, km	Outdoor	In door	Outdoor	In door
LGP_W3T3			25	350.1	1032.8	3.1	367	79.6	3670	947
LGP_W3T4			30	388.5	1143.4	3.2	452	98.2	4610	1190

The results are represented on Google Earth, and the images are given in Figure 4.10 to Figure 4.13. Typical Styrene concentration profile and the threat zone diagrams are shown in Graph 4.3 and Graph 4.5, respectively.

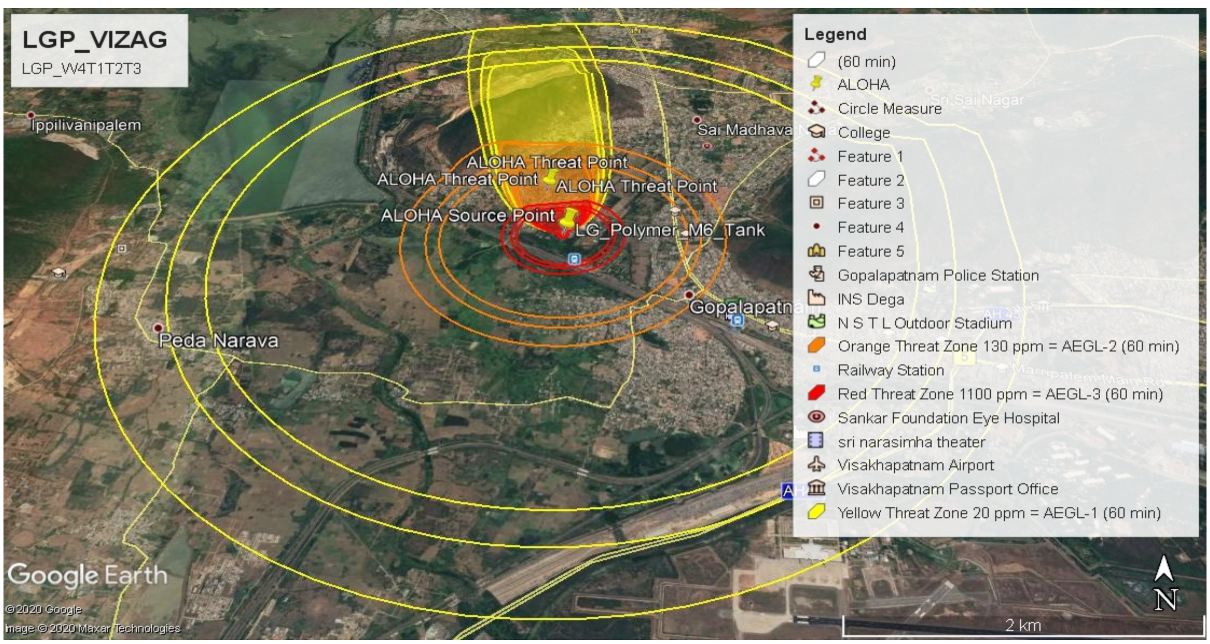


Figure 4.10: The Threat Zones for the ALOHA Model Runs with ID LGP_T1, LGP_W4T2 and LGP_W4T3

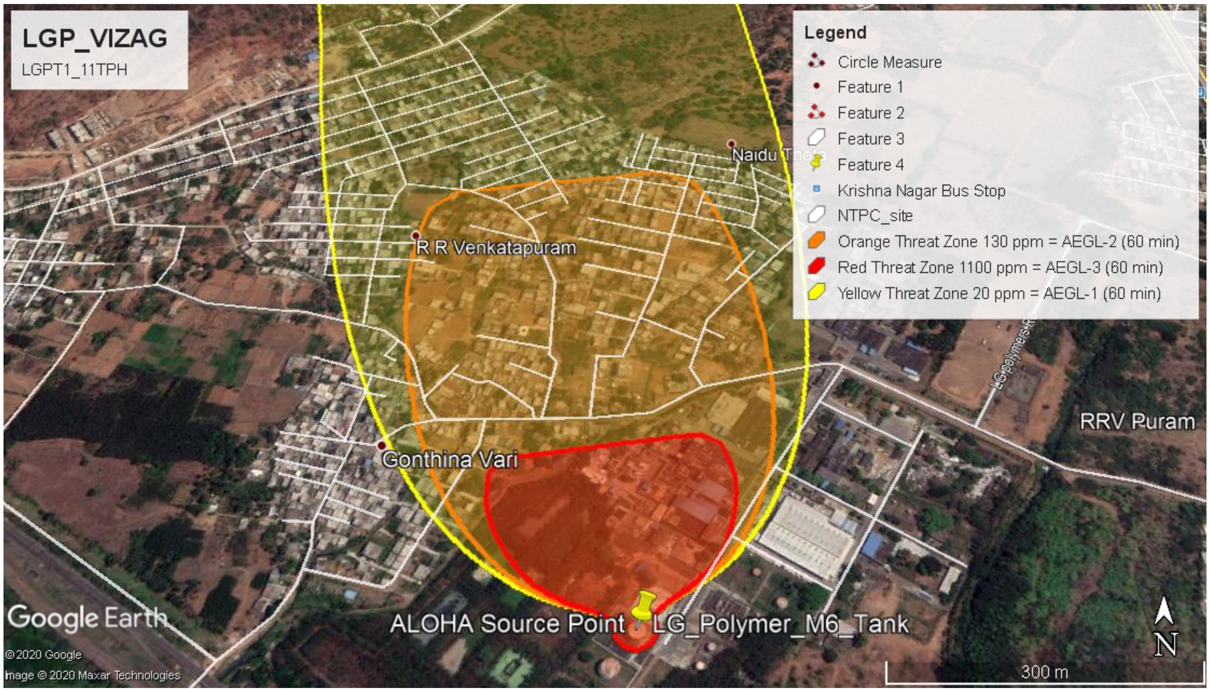


Figure 4.11: The Threat Zones for the ALOHA Model Runs with ID LGP_T1

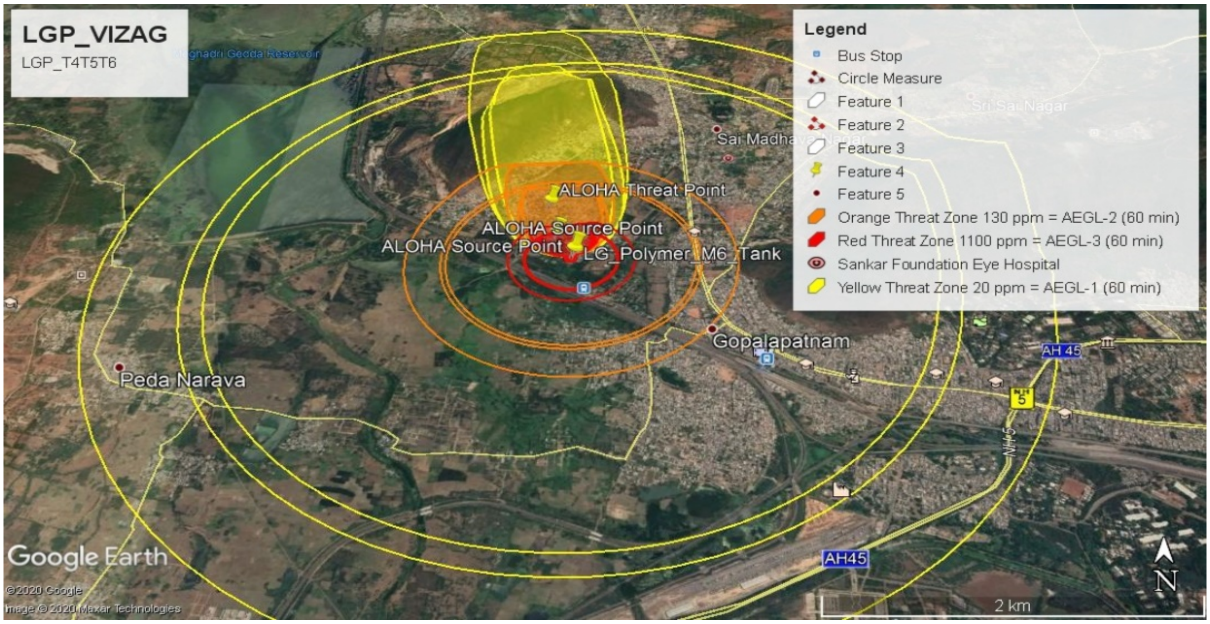


Figure 4.12: The Threat Zones for the ALOHA Model Runs with ID LGP_T4, LGP_T5, and LGP_T6

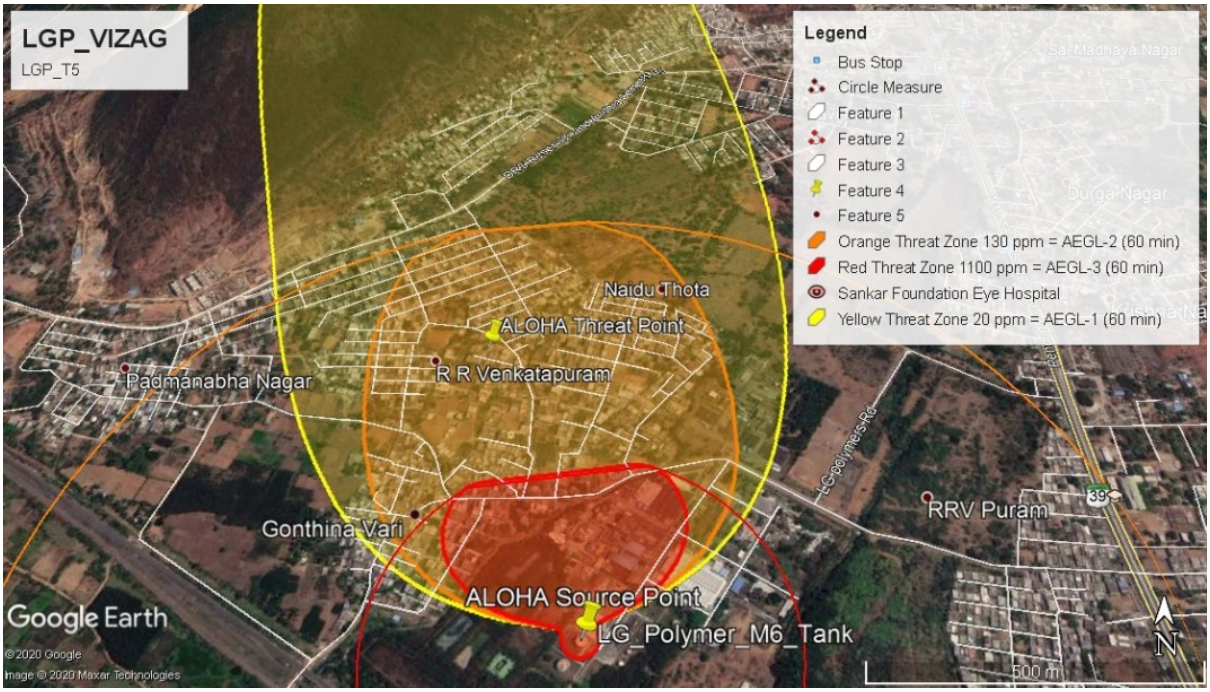
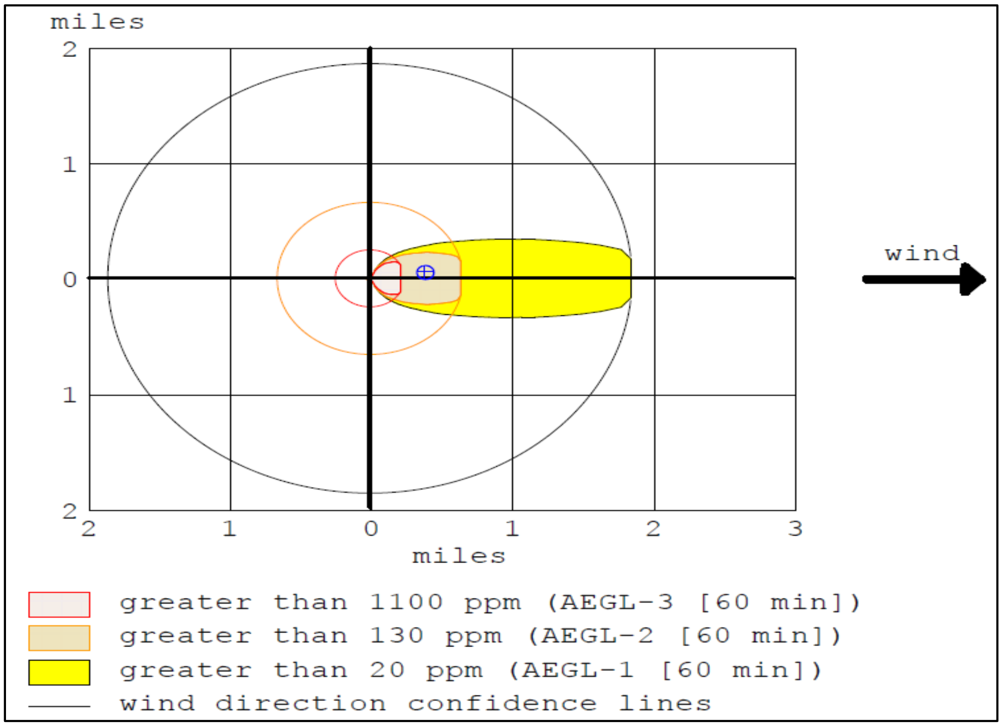
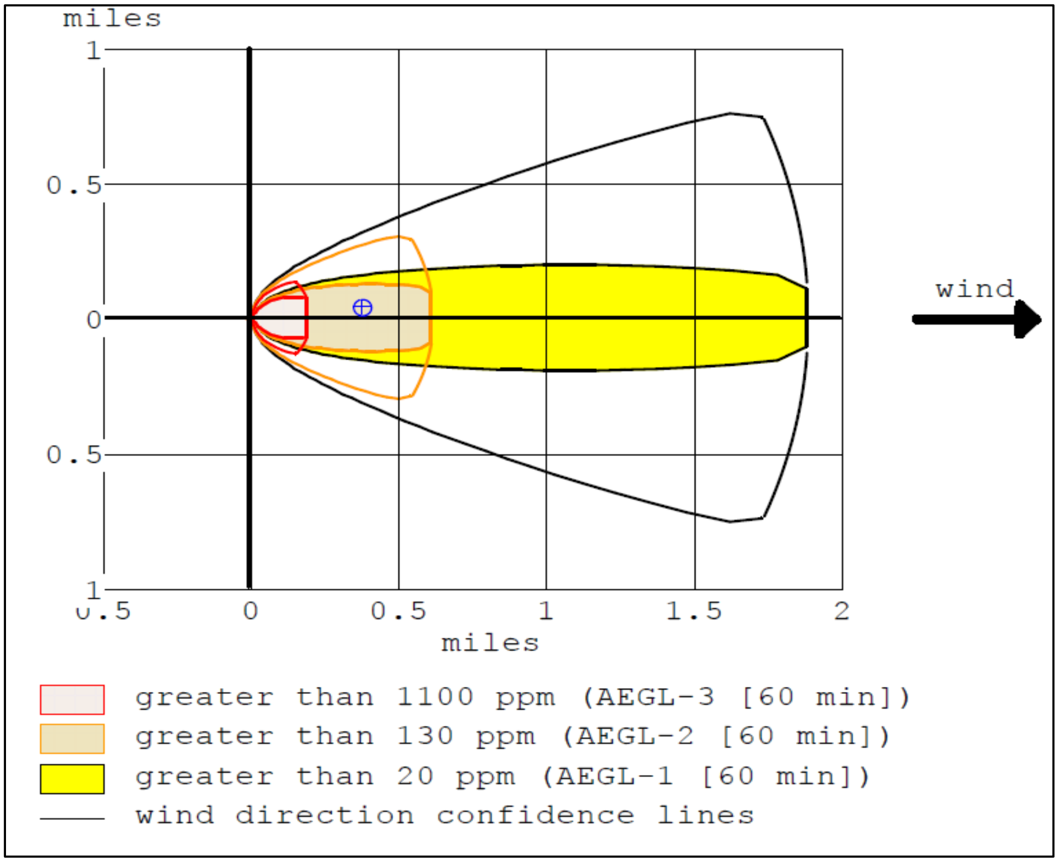


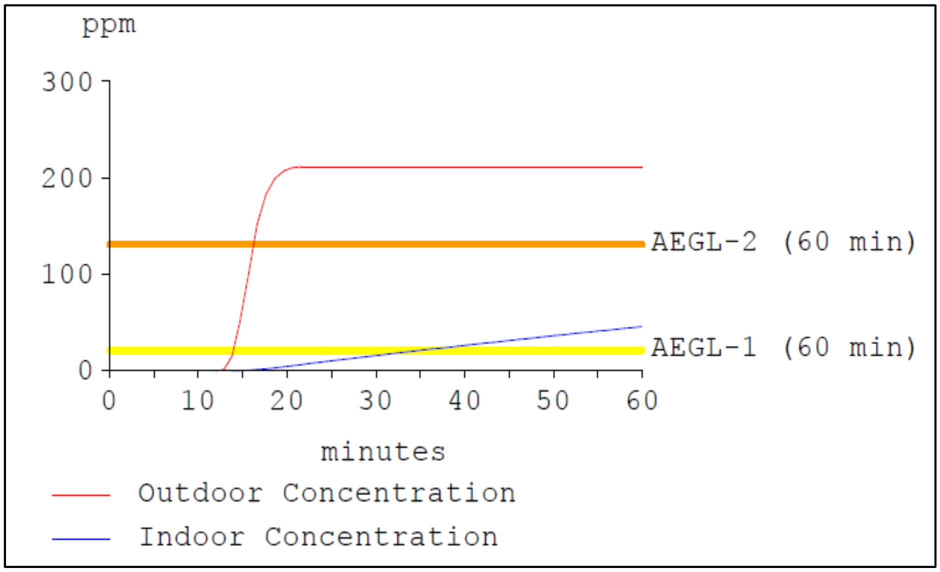
Figure 4.13: The Threat Zones for the ALOHA Model Runs with ID LGP_T5



Graph 4.3: Typical Threat Zone Diagrams for the ID LGP_WT4 Showing the Area of Influence in the Windward Direction



Graph 4.4: Typical Threat Zone Diagrams for the ID LGP_W2T4 Showing the Area of Influence in the Windward Direction



Graph 4.5: Typical Concentrations at 600m Downwind Direction from the source for the ID LGP_W3T1

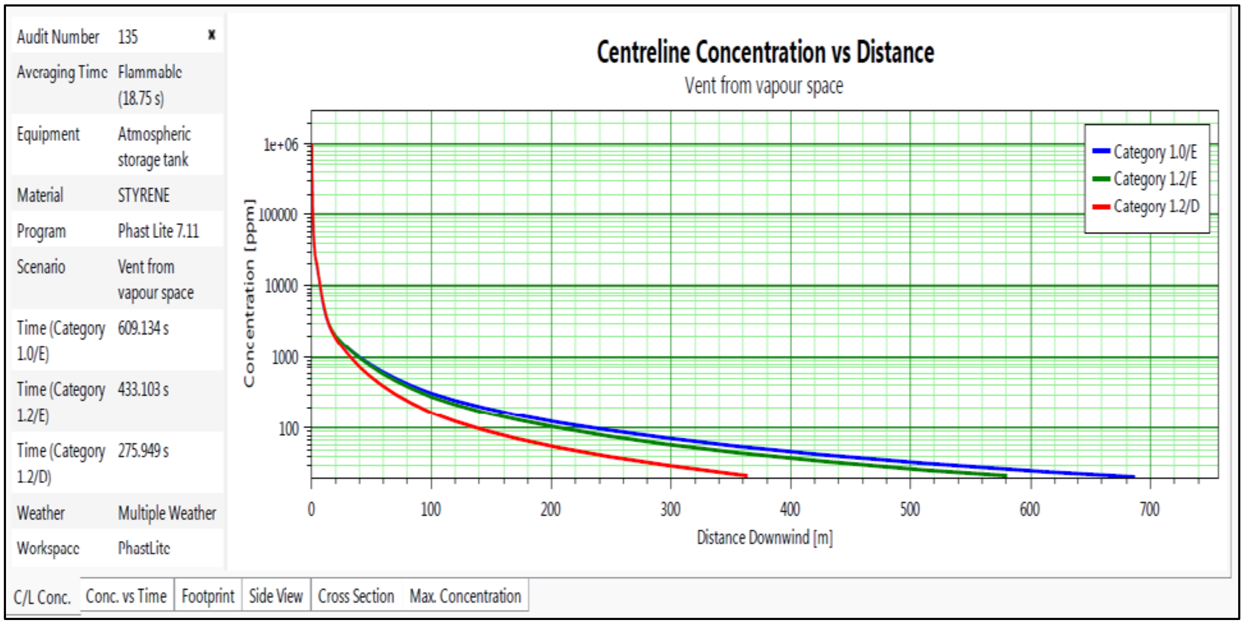
4.4.6 PHAST Lite Model

The PHAST lite model is also used to assess the dispersion of the SM vapours. The wind speeds considered are 1.0 m/s, 1.2 m/s and 1.7 m/s. Minimum velocity accepted by the PHAST lite model software is 100 m/s. The results obtained from the PHAST lite models is given in Table 4.16. The PHAST lite model is used to predict the concentrations for wind speeds slightly more than the observed up to 08.00 a.m., and the actual wind speed observed at 10.00 a.m. The observed wind directions and the relative humidity are considered for these model runs. The vapour emissions is in terms of volume, which is in contrast to the ALOHA model, which takes into account the emissions rates in terms of MT. The results are shown in Graph 4.6 to Graph 4.8.

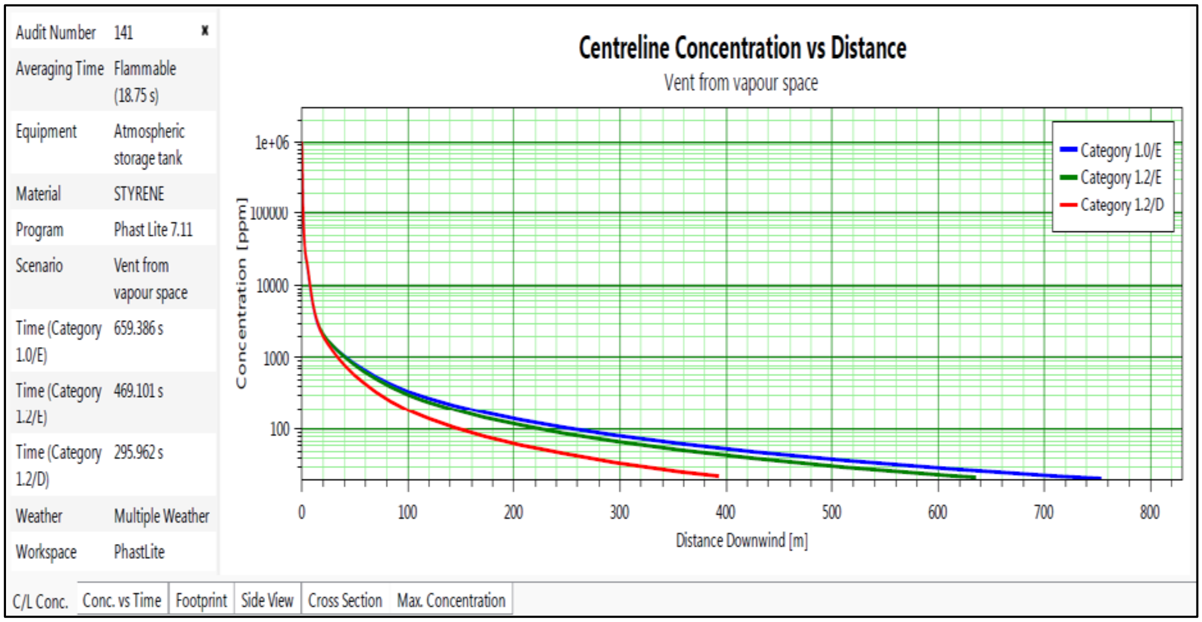
Table 4.16: The Concentrations at different distances predicted from the PHAST Lite Model

Vapour emission Volume, m^3/h	Concentrations for different wind speeds, ppm			Distance, m
	1 m/s	1.2 m/s	1.2 m/s	
60	113.93	98.99	53.83	100
	38.89	33.06	16.93	200
	21.13	17.19	8.58	300
90	159.16	139.2	77.7	100
	58.3	48.3	24.97	200
	31.4	25.58	12.78	300
120	199.78	175.79	99.77	100
	75.68	62.86	32.67	200
	41.44	33.69	16.85	300
150	237.1	209.8	121.64	100
	92.31	76.95	40.37	200
	51.17	41.65	20.95	300
180	271.1	242.12	141.21	100
	108	90.6	47.6	200
	60.3	49.45	24.92	300
220	312.8	280.64	167.86	100

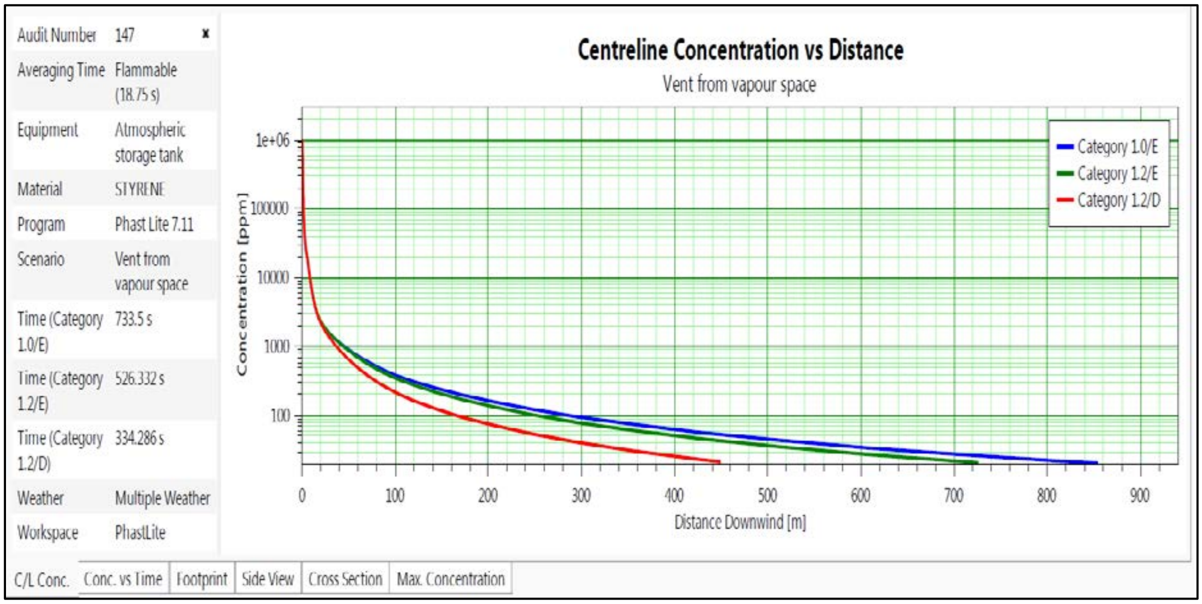
Vapour emission Volume, m³/h	Concentrations for different wind speeds, ppm			Distance, m
	1 m/s	1.2 m/s	1.2 m/s	
	127.78	107.64	57.35	200
	72.24	59.33	30.21	300
250	342.3	308.1	182.6	100
	142.04	119.98	64.24	200
	80.86	66.68	34.1	300
300	386.83	349.96	216.1	100
	164.17	139.41	75.76	200
	94.66	78.1	40.34	300



Graph 4.6: The centerline concentration at different distances from the source for a Styrene vapour release of 220 m³/ hour



Graph 4.7: The centerline concentration at different distances from the source for a Styrene vapour release of 250 m³/ hour



Graph 4.8: The centerline concentration at different distances from the source for a Styrene vapour release of 300 m³/ hour

4.4.7 Analysis of Model Results

The Styrene Monomer Vapour (SMV) emitted from the M6 storage tank of LG Polymers, Visakhapatnam started dispersing before 02.54 a.m. on 7th May 2020. The vapour cloud dispersed towards the surrounding areas, including Venkatapuram village. People residing at around 210 m away from the M6 Tank location got affected. This resulted in adults and kids turning unconscious, and also leading to deaths of human and animals. People located up to a distance of around 4 to 4.5 km experienced strong odour of the chemical vapours.

Taking the loss of Styrene into consideration, which is estimated based on the level record data, the model was run with varied SMV emissions in a given duration i.e., between 03.05 a.m. to 03.35 a.m. It was found that the emission of 31 MT in 15 minutes (03.05 a.m. to 03.20 a.m.) predicts a dispersion distance of 2.5 km[43]. The boundary (minimum) concentration of yellow zone as per the ALOHA model is 20 ppm. Hence, the concentrations realised at the distances beyond 2.5 km maybe around the odour threshold limit. The predicted red zone extends up to 0.333 km. It is also verified as per data Venkatapuram village where the influence was strong falls under the predicted red zone as its proximity to the SMV release source. The orange zone extends up to 0.98 km.

The predicted outdoor and indoor SM concentrations at 200 m from the source are 3300 ppm and 146 ppm respectively for the SMV release of 31 MT for the duration of 15 minutes. The predicted outdoor and indoor SM concentrations at 400 m from the source are 754 ppm and 33.3 ppm, respectively.

The area of influence for the emission of 46 MT in 15 minutes predicts a dispersion distance of 2.9 km from the source that falls under the yellow zone. Gopalapatnam, Naiduthota, Megadri Gedda etc. fall under the vulnerable areas. The predicted red zone extends up to 0.421 km. Venkatapuram villages also fall in the predicted red zone. The predicted red zone and

[43] Area falls under the Yellow zone

Venkatapuram villages are located equidistant from the SMV release source. The occurrence of death cases is also observed to be within this zone of influence which is around 0.42 km.

The orange zone extends up to 1.2 km. Hence, the areas up to 1.2 km might have experienced a concentration more than 130 ppm up to 1100 ppm. The predicted outdoor and indoor SM concentrations at 200 m from the source are 5400 ppm and 240 ppm respectively for the SMV release of 46 MT (10% more than the observed loss of Styrene between 3.20 a.m. and 3.35 a.m.) for 15 minutes duration. The predicted outdoor and indoor SM concentrations at 400 m from the source are 1220 ppm and 54 ppm respectively. The orange zone, which is predicted to be extended up to 1.2 km, encompasses areas like Gopalapatnam, Naidu Thota, etc. as vulnerable areas. The vapour cloud dispersion is towards the areas depicted in Figure 4.5.

The Yellow zones cover most of the area in West, North West direction including part of Meghadri Gedda reservoir area. The area of influence for emission of 50 MT for 15 minutes duration, which is approximately 20% more than the estimated loss of Styrene between 03.20 a.m. and 3.35 a.m., predicts that the Yellow zone extended up to a distance of 3.6 km from the source. The predicted Red zone extends up to 0.441 km. The Orange zone extends up to 1.3 km. Hence, these areas might have experienced a concentration of more than 130 ppm up to 1100 ppm. The predicted outdoor and indoor SM concentrations at 200 m from the source are 5970 ppm and 519 ppm respectively for the SMV release of 50MT for 15 minutes duration. The predicted outdoor and indoor SM concentrations at 400 m from the source are 1360 ppm and 117 ppm respectively. The Orange zone is predicted to get extended up to 1.3 km that encompasses areas like Gopalapatnam, Naidu Thota, etc. as vulnerable areas.

The final predicted areas of influence are estimated based on 46 MT Styrene release for 15 minutes duration. These areas are shown in Figure 4.5. It may be surmised that most of the people in the nearby villages within approximately 0.42 km area got exposed to such high concentrations and deaths occurring in the same zone testifies. The areas where people fell unconscious on the road also falls within this Red zone as predicted for the emission of 46 MT.

Due to the Styrene Monomer Vapour (SMV) emissions from the M6 storage tank of LG Polymers, Visakhapatnam, people residing at around 210 m away from the M6 Tank location got affected. This resulted in adults and kids turning unconscious, and also leading to deaths of human and animals. The impact was sensed up to a distance of around 4 to 4.5 km, where people experienced strong odour of the chemical vapours. Keeping this scenario in view, using the observed field meteorological conditions and the emission height, the ALOHA model was used to model the dispersion phenomenon with different emission rates from 9 MT to 60 MT for the study of dispersion phenomenon in the area. The results are presented in Table 4.14 and Table 4.15. It helps in understanding the dispersion characteristics.

The results show that the SMV dispersed up to a distance of around 1.8 and 1.9 km for an emission rate of MT and 11 MT in 60 minutes with a wind speed of 0.86 m/s. The dispersed SMV cloud covered the North-West–North area, as shown in Figure 4.13, Graph 4.3 to Graph 4.4. The red zone got extended up to 200 m. The influence of SMV concentrations at various receptor points or locations for these emission rates is extended up to 2 km. The field verification indicates that the pungent odours were felt even beyond NAD Kotha Road, Marripalem, Marriot Fair filed hotel, Muralinagar area, Airport area and so on.

Hence, attempting to capture the actual scenario, the model was run with varied emissions. The emission rate of 30 MT predicts a dispersion distance of 3.9 km from the source that falls under the yellow zone with a change in the settings of the area. The boundary concentration of yellow zone as per the ALOHA model is 20 ppm. The odour threshold limit for the SM is 70 mg/m^3. Hence, the concentrations realised at these distances, i.e. beyond 4km may be more than 70 mg/m^3. The increase in wind speed with time reduced the area of influence because of better dispersion characteristics than that prevail during the early hours of that day, i.e. from 03.00 a.m. to 05.00 a.m. When the wind speed reached around 1.7 m/s, the area of influence for an SMV emission rate of 30 MT got reduced to approximately 3 km from the earlier 4 km range.

The SMV emission rate initially might be even more than 30 MT during the first few minutes as there will be a lag between the source and the receptor points. The ALOHA model predicted threat zones from the source that falls under red category extending up to 476 m and the predicted orange zone extended up to 1.4 km and the yellow zone got extended to 3.9 km as per the model case with ID LGP_W4T4 in which the wind speed is 0.62 m/s. Venkatapuram villages fall under the red zone as its proximity to the SMV release source. The predicted outdoor and indoor SM concentrations at 200 m reached 6800 ppm and 1470 ppm respectively for the SMV release of 30 TPH at a wind speed of 0.62 m/s. The predicted outdoor and indoor SM concentrations at 600 m form the source are 681 ppm and 123 ppm respectively. The orange zone which is predicted to be extended up to 1.4 km encompasses areas like Gopalapatnam, Naidu Thota, Meghadri Gedda Reservoir etc. as vulnerable areas. Hence, parts of these areas might have experienced a concentration of more than 130 ppm up to 1100 ppm. As the predicted zone is up to 476 m from the source, the residents in the Venkatapuram village within this distance got affected, resulting in the death of human beings, animals, and discolouration of plant life. The yellow zone, which was predicted up to 3.9 km covered several areas around NAD Kotha road area. At 0.86 m/s wind speed, the predicted outdoor and indoor concentrations at 200 m area are 4080 ppm and 960 ppm respectively. The predicted outdoor and indoor concentrations at 600 m area are 449 ppm and 89.1 ppm respectively. It also reveals that the people in the nearby areas, within 600 m area who got exposed to such concentrations got affected.

The wind speed increased with time and reached around 1.7 m/s as observed at 9.00 a.m. and 10.00 a.m. The relative humidity got reduced to 72.2% from the nineties. The temperature got increased to 31.54˚C. The increased wind speed, temperature, and reduced relative humidity are used to model the dispersion in the morning around 9.00 a.m. For this data, the ALOHA model predicted threat zones from the source that falls under red category extending up to278 m and the predicted orange zone extended up to 915 m and the yellow zone got extended to 2.9 km as per the model case with ID LGP_W2T5 in which the wind speed is 1.67 m/s. The predicted outdoor and indoor SM concentrations at 200 m reached 1680 ppm and 622 ppm respectively for the SMV release of 30 MT at a wind speed of 1.67 m/s. The predicted outdoor and indoor SM concentrations at 600 m form the source are 270 ppm and 93.8 ppm respectively. The rescue and relief operations in these areas were carried out during daytime because of the relatively lesser concentrations predicted and probably realised at the receptor levels in the affected area and the reduction in the threat zone distances. Its demonstrated that the dispersion increased with time thereby reducing the affected area and attaining at diluted concentrations than those observed during the initial times of SMV emissions i.e. since around 3.00 a.m.

The ALOHA model for 50 MT emission case with ID LGP_W4T5predicts an outdoor and indoor SM concentration at 200 m from the source as 11600 ppm and 2510 ppm respectively. The predicted outdoor and indoor SM concentration at 600 m from the source is 1270 ppm and 233 ppm respectively. The Venkatapuram village will fall under the red category as the predicted red zone extended up to 643 m from the emission source. The predicted orange zone extended up to approximately 1.93 km (say 2 km) within which most of the areas like Gopalapatnam, Meghadri Gedda reservoir region, Naidu Thota etc. are located. It might be the reason for the appearance of patches of floating matter observed on the water surface of the Meghadri Gedda reservoir. However, the results from the samples collected from the reservoir on 11th May 2020 doesn't show any concentration of Styrene. Probably, the Styrene might have gotten disappeared during this lag. The predicted yellow zone extended up to approximately 5 km within which most of the areas like NAD, Hotel Fairfield area, Marripalem, Narava, Simhachalam areas etc. are located. Hence, these areas are vulnerable. The people in this area experienced strong odours. Hence, the SMV released might be around 50 MT during the initial hours around 03.00 a.m. on 7th May 2020.

The increases in wind speed, temperature, and decrease in humidity reduce the predicted area of influence and the concentrations with distance. The rescue and relief operations in these areas were carried out during daytime because of the relatively lesser concentrations predicted and probably realised at the receptor levels in the affected area and the reduction in the threat zone distances. It demonstrated that the dispersion increased with time thereby reducing the affected area and attaining at diluted concentrations than those observed during the initial times of SMV emissions during initial periods since around 03.00 a.m. to 03.35 a.m.

The duration of the existence of / exposure to these concentrations needs to be ascertained through field happenings. The interim Acute Exposure Guideline Levels (AEGLs) for Styrene for different exposure periods are given in Table 4.11. The AEGL-3 exposure for 4 and 8 hours is 340 ppm, and for one hour it is 1100 ppm. The predicted concentrations within the area of influence are higher than these limits within red and orange zones. The effect is significant until 7 a.m. Then onwards the impact slowly got reduced. However, another spike was experienced once again by the residents beyond 4 km during the night of 7th May 2020. It may be another event of similar emission scenario. Fortunately, the timely evacuation might have reduced the impact on the people of these areas as evacuation includes the area within a distance of 400 m to 500 m from the SMV emission source.

The predicted areas of Red, Orange and Yellow zones for 46 MT emissions for different wind directions are measured using Google Earth. The areas of influence for Red, Orange and Yellow zones, the wind direction is 19.7 ha, 95.4 ha and 331 ha respectively. The predicted total Red, Orange and Yellow zone areas of influence for the possible changes in wind directions are 31.1 ha, 166.3 ha, and 715 ha respectively. The uncertainties, due to the data inconsistencies, will induce an error in the model results. The prediction is based on the available data shared by the industry. This may be the area of influence of the SMV emissions from the M6 Tank as per the ALOHA model and the estimated SMV releases.

4.4.8 Other Model Results

The predicted concentrations obtained from the PHAST Lite model results with a wind speed of 1 m/s and 1.2 m/s shows that the concentration of Styrene for an emission rate of 300 m^3/hour at 200 m distance is 164.17 and 139.41 ppm. These low concentrations predicted need further analysis. The results predict based on this model at this distance are not in agreement with the actual happenings in the nearby villages where the death of human and animals is already reported. It seems that predictions by this model are not depicting the actual scenario in the field. Hence, it is necessary to study it in detail for better representation of the ground reality through this model.

In addition, it is proposed to use DNVs ‘safeti’ for further verification of the areas of influence. The results of the DNVs ‘safeti’ model are also to be verified with the ground scenario where the people got affected immediately.

4.4.9 Conclusions

Based on the dispersion study using the models, the following conclusions may be drawn with reference to the influence of the SMV emissions from the M6 SM storage tank in LG Polymers, Visakhapatnam.

a. The area of influence with a predicted Styrene concentration more than 1100 ppm got extended to approximately 420 m from the SMV source. Because of the same, the effect on the people, animals and plants became significant.
b. The predicted Styrene concentrations for an emission rate of 31 MT, which is the estimated emission/loss of Styrene, the possible exposure concentrations, ranging from 130 ppm to 1100 ppm occurs within 0.98 km from the SMV emission source.
c. The predicted Red, Orange and Yellow zones for an SM loss/emission of 46 MT from the M6 Tank during 3.20 a.m. to 3.25 a.m. is extended from the source up to 0.421 km, 1.2 km, and 2.9 km respectively. The maximum concentration is predicted in the red zone. The predicted ambient Styrene concentration at 200 m and 400 m is 5400 ppm and 1220 ppm respectively.
d. The yellow zone where the Styrene predicted concentration is more than 20 ppm got extended up to 3 km from the SMV emissions source because of which most of the areas beyond NAD Kotta Road, Marripalem, Muralinagar experience pungent chemical odours.
e. The total areas of influence classified as Red, Orange, and Yellow are 31.1 ha, 166.3 ha, and 715 ha, respectively.
f. The exposure time and the concentrations are to be assessed to know the long-time effects of the Styrene concentrations on the environment.
g. The dispersion increased with time, thereby reducing the affected area and attaining at relatively lesser concentrations than those observed during the initial times, i.e. around 03.00 a.m. to 5.00 a.m. of SMV emissions from the source.
h. Industrial safety systems are not properly organised or maintained. The concerned department or organisation of the regulatory systems looking after the safety issues of storage and O & M in the LG Polymers are neither informed by the industry nor inspected properly as per requirements.

The above conclusions are based on scientific modelling. Like any other modelling, these have some limitations/assumptions. The Technical Committee has done ground proofing of the modelling results to validate the findings, on the request of the High Power Committee. Keeping the above in mind, the Committee has summarized the above modelling results as follows:

Table 4.17: Predicted distances of various Zones of Influence and the Concentrations at 200 m and 400 m for wind direction of 172°

Source Strength, MT	Predicted Distances of Threat Zones, km			Predicted Concentration of Styrene, ppm			
				at 200 m from source		at 400 m from source	
	Red	Orange	Yellow	Outdoor	Indoor	Outdoor	Indoor
31	0.333	0.976	2.5	3300	146	754	33.3
42	0.398	1.1	2.8	4820	214	1090	48.2
46	0.421	1.2	2.9	5400	240	1220	54

The ALOHA model uses 60-minute Acute Exposure Guideline Levels (AEGL) with the following concentrations as AEGL-1:20 ppm; AEGl-2:130 ppm, AEGL-3: 1100 ppm. The Immediately Dangerous to Life or Health (IDLH) level is 700 ppm. The above modelling estimates indicate that the IDLH limits were significantly crossed upto 200 m from the source and even upto 400 m.

Table 4.18: Predicted Affected Areas in the Threat Zones for Each of the Emissions

Source Strength, MT	Predicted Affected Areas in the Threat Zones, ha.		
	Red	Orange	Yellow
31	12.3	48.5	164.2
42	17	68.4	217.6
46	19.7	75.8	238.5

While the above indicates the threat zones, as observed during the ground assessment and statement of public, the impact was sensed up to a distance of 4 to 4.5 Km, where people experienced strong odour of the Styrene vapour.

Further, the predicted threat zone areas, affected in hectares, with different wind directions of 120^{o}, 145^{o}, and 172^{o} is given in Figure 4.14 (a). The total or combined area covered under these three wind directions for emission of 46 MT is given in Table 4.19.

Table 4.19: Predicted Area of Influence, ha

Source Strength, MT	Predicted Area of Influence, ha		
46	Red	Orange	Yellow
	31.08	166.29	715

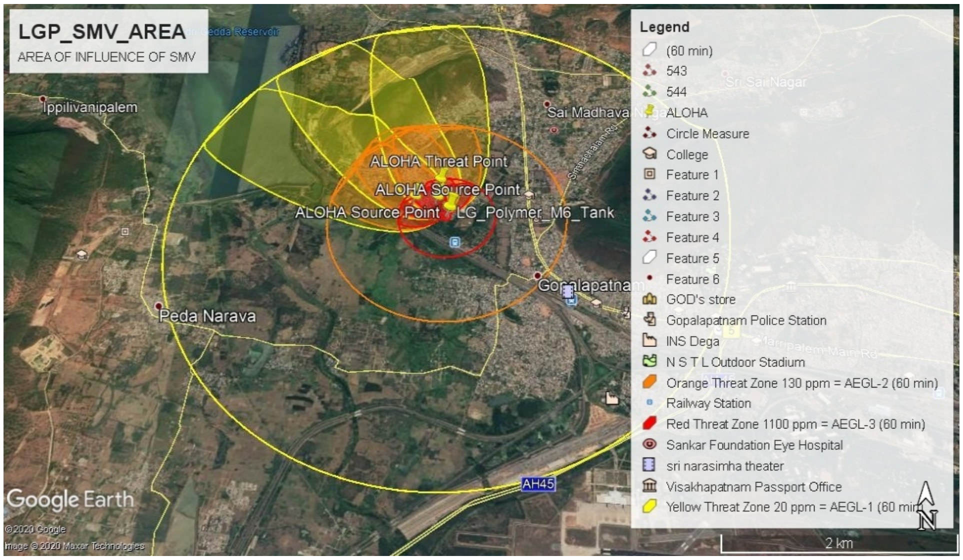


Figure 4.14 (a): The Threat Zones and Area of Influence for the ALOHA Model Runs with Styrene Loss / Evaporation of 46 MT with Change in Wind Direction

The Committee with the assistance of the Technical Committee and the GVMC has also superimposed the above threat zones and area of influence on GVMC map which is shown below in Fig 4.14 (b).

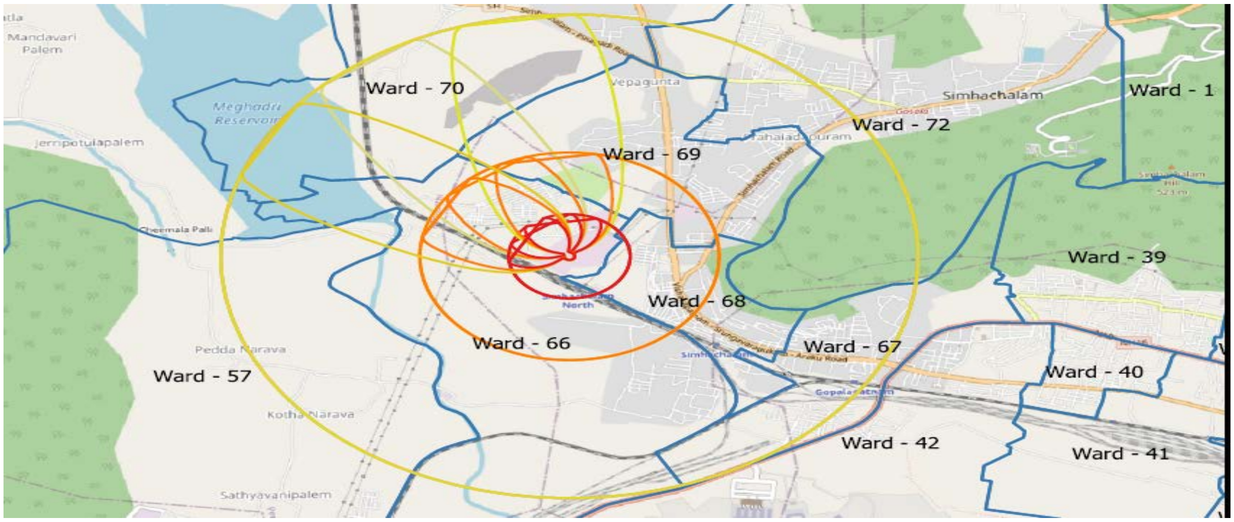


Figure 4.14 (b): The Threat Zones for the ALOHA Model Runs with Styrene Loss / Evaporation of 46MT with Change in Wind Direction (Blue Lines Are Ward Boundaries)

It will be helpful for the District Administration and the GVMC to map these red, orange and yellow areas on the ground so as to continuously monitor the affected areas and the population on all the parameters discussed above. This is also important to undertake all necessary remediation measures.

The Committee further observed that once the forensic study of the M6 Tank and the solidified Styrene Polymer available in the Tank is arrived at, the assessments can be further refined based on the actual results.

Further, the Committee suggests to conduct an in depth study to estimate the damage caused to the environment and the cost of remediation.

5.0 Negligence and Liability

The term of reference (clause c) provides that the Committee shall recommend the proposed action to be taken against the unit by the Government, in case of any negligence on the vapour leak incident in Visakhapatnam.

5.1 Negligence, Responsibility and Violations

Nothing is more paramount than safety, security, health and environment for any industry. The company management should evolve protocols and SOPs to maintain the operating parameters within safe limits that do not lead to accidents, which go out of proportions to harm people, property and environment.

Despite multiple requests by the regulators, LG Polymers did not provide any documentation showing standard practices for storage of Styrene during extended periods of storage at LG Chemical facilities outside India. It raises the concern that less stringent standards may have been applied to the Indian facility, due to negligence, leading eventually to the disaster.

The Committee also observed that sufficient qualified and competent persons were not engaged by management of LG Polymers. In public interaction, most of the people represented that LG Polymers was on a cost-cutting drive and not recruiting qualified and technical people. People with inadequate qualifications like ITI and Diplomas were designated as engineers and given high posts. The Technical Committee reported that even some intermediate pass staff were designated as “Senior Engineer”. The regular officers and staff of the company was being continuously downsized. Most of the workers are on contract basis. The responsibility for the absence of competent and qualified employees lies squarely with the management.

The Technical Committee has submitted the list of failures attributable to the Management and Employees as elaborated in the table below:

Table 5.1: The list of negligence/failures

S. No.	Root Cause	Negligence/Failure	Responsibility Attributed To
1	Change in Tank design	A modification in Tank design was carried out by December 2019. Change in design not only disturbed the chemical circulation system, but it also led to significant thermal stratification in the M6 Tank. This change in design, in a way, sowed the seeds of disaster.	Management
2	Shortcomings in Tank Design	No provision to thoroughly mix the contents of Styrene Monomer in the Tank	Management
2	Insufficient and improper cleaning of Tank	The inner side of the Tank is not lined; rust might have formed at the inside wall. Last time, the Tank was cleaned in 2015 as per the records. The presence of contaminants inside the Tank initiates polymerisation of Styrene.	Management
3	Poor design of the roof of the Tank	The design of the roof of M6 Tank is poor as the structure supporting the roof of this Tank is inside the Tank, which is more prone for stalactite formation.	Management
4	Presence of Spare Nozzles	The M6 Tank has many spare nozzles which caused contamination and has the potential to initiate the runaway polymerisation reaction.	Management
5	Storing of Hazardous Chemical in Old Tank	It is not advisable to store a hazardous chemical in an old Tank without implementing any life extension program, creating the potential for risk.	Management
6	Non-adherence of guidelines regarding the material of construction of Tanks	The Styrene Tanks and pipelines of the plant are made of mild steel, which is a severe non-conformance to the laid down standards and guidelines for using lined carbon steel Tanks.	Management
7	Absence of flare system or cryogenic system in M6 Tank	The M6 Tank should have had either a flare system or a cryogenic system as is the case with modern Tank designs.	Management
8	Absence of Temperature measurement system at Top & Middle zones	The temperature measurement is restricted to the bottom zone liquid only.	Management

S. No.	Root Cause	Negligence/Failure	Responsibility Attributed To
9	Manual operation of Refrigeration System and inadequate time duration for refrigeration	The non-provision of this system has permitted the human error and onset of reactive hazard.	Management
10	Non-adherence of Standard Industry Practice with respect to the analysis of Styrene sample	Samples of Styrene Monomer from the bottom of the M6 Tank analysed once in 4 days approximately by LG Polymers as against the standard industry practice of daily measurement.	SOP by Management
11	Negligence towards the addition of inhibitor	The LG Polymers, as a standard practice, did not follow the method of adding TBC in the Tanks. The company has not added TBC in the M6 Tank even for the last 10 years. The company also failed to consider the TBC stratification.	SOP by Management
12	Non-availability of TBC	Non-availability of TBC in the factory exacerbated the condition of Styrene Monomer, resulting in polymerisation.	SOP by Management
13	No monitoring system in place to measure the quantum of Dissolved Oxygen in the Styrene monomer	There was no monitoring system in place to measure the quantum of Dissolved Oxygen in the Styrene monomer in M6 Tank or any of the other Tanks. The Dissolved Oxygen is a critical input in the effectiveness of the inhibitor.	Management
14	Stalactite formation observed, but no action has been taken	At the time of the piping design change, it was noted that the float got stuck to the stalactite. No action is taken to clean up the Tank.	Management
15	Disregard to the increase in polymer content	The company management had ignored the rise in polymer content from 4th April 2020 and then the sharp rise on 25th April 2020 / 28th April 2020. The management considers polymer content as a quality measure for Styrene rather than a safety measure.	Management
16	Inadequate knowledge and skills among the	There is a lack of knowledge and competency among the top, middle and shift management in LG Polymers.	Management

S. No.	Root Cause	Negligence/Failure	Responsibility Attributed To
	top/middle management		
17	Non-adherence of SOP during an emergency situation	LG Polymers was closed during the Covid-19 lockdown period as it is a non-essential industry. Styrene was stored for a long duration without periodical cleaning. TBC addition to M6 Tank was not done during the lockdown. SOPs for regular days were followed for lockdown period as well.	--
18	Spike in polymer content in Styrene	On 25th April, a spike in polymer content in Styrene revealing the onset of runaway polymerisation was neglected.	SOP by Management
19	Non- compliance of Offsite Emergency plan	Emergency siren was not activated. As a result, many inhabitants outside the plant area got engulfed in a Styrene vapour cloud.	Management
20	Lack of Technical and Emergency handling capabilities	Field personnel is lacking the basic knowledge of Process safety and emergency handling procedures.	Management and Employees
21	Absence of formal Pre-start-up Safety Review (PSSR)	PSSR was not done while trying to start the operation.	Management

Because of the above, the accident in the LG Polymers Styrene storage tank, M6 Tank can be attributed to the poor design of Tank, inadequate refrigeration and cooling system, absence of circulation systems, inadequate measurement parameters, weak safety protocol, poor safety awareness, inadequate risk assessment and response, poor management, slackness of management, insufficient knowledge amongst staff, insufficient understanding of the chemical properties of Styrene, especially during storage under idle conditions and total breakdown of the emergency response procedures. The accident was further aggravated by the staff on shift duty who failed to alert the residents of the nearby colonies, through emergency siren, which led to the loss of human and animal lives and damaged flora and fauna in the nearby areas.

5.1.1 Criminal liability under Indian Penal Code (Action: Police Department)

A case in Cr. No. 213/ 2020 was registered at Gopalapatnam Police Station, Visakhapatnam City on Officials of LG Polymers U/ s 304-II (Non-bailable) for causing deaths by negligence, U/s 278 for making atmosphere noxious to health, U/s 284 for negligent conduct with respect to a poisonous substance, U/s 285 for negligent conduct with respect to fire and combustible matter, U/s 337 for causing hurt by act endangering life or personal safety of others, U/s 338 for causing grievous hurt by act endangering life or personal safety of others, of Indian Penal Code (IPC).

In this case, the Police Department has examined the 280 witnesses so far, including the statement of 16 officials, security and technical persons who are employed in LG Polymers. The Police authorities have seized the passports of the Directors of the LG Polymers and also notices have been issued directing them not to leave the country.

It is essential that the police take up the investigation in the matters with full speed, collect all the required information, investigate the case thoroughly and take the necessary action as per law.

5.1.2 Liability under Petroleum Act, 1934 and MSIHC Rules (Action: PESO, Govt. of India)

As per the report from the Deputy Chief Controller of Explosives, PESO, Visakhapatnam, PESO granted four licenses under provisions of the Petroleum Act, 1934 and the rule made thereunder bearing license no.;

- P/HQ/AP/15140 (P3488)
- P/HQ/AP/15/788(P4249)
- P/HQ/AP/15/618(P4078)
- P/HQ/AP/15/408 (P3874)

All four licenses are valid up to 31.12.2021. PESO granted a license under provisions of the Gas cylinders, 2016 bearing license no. G/SC/AP/06/835(G5877), valid up to 30.09.2024. Presently all the above licenses issued by PESO are in favour of LG Polymers.

Table 5.2: Acts/Rules Violated

S. No.	Negligence	Responsibility Attributed To	Act / Rule Violated
1	As per rule 13(4) of MSIHC Rules, 1989, the occupier shall ensure that a mock drill of the on-site emergency plan to be conducted every six months.	Company & Management	As per rule 13(4) of MSIHC Rules, 1989

5.1.3 Liability under Factories Act, 1948, MSIHC Rules, 1989 and The Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996 (Action: Department of Factories, Govt. of Andhra Pradesh)

The details are submitted in Table 5.3 below:

Table 5.3: Acts/Rules Violated (2)

S. No.	Negligence	Responsibility Attributed To	Act / Rule Violated
1.	Failure to provide, maintain and monitor safe and risk-free work environment by ensuring that the permissible limits of exposure of Styrene monomer.	Occupier & Factory Manager	Factories Act Section 41-F
2.	Tank Design: ▪ No provision for mixing the contents for uniform distribution of heat or chemicals added. ▪ Only one temperature measurement at the bottom of a Tank with 12.18 m height.	Occupier & Manager	Factories Act: Sec 7- A (2)(a) AP Factories Rules- ▪ Rule 61-F (3) ▪ Rule 95 Sch XV Part-II Para 5 (3)
3.	The plant has not implemented any training programme covering entire management representatives, staff and workers, at least once in every year, consisting of the following training modules: ▪ Properties and health hazards of Styrene. ▪ Styrene physical hazards including the potential for fire and explosion. ▪ Styrene's primary routes for entry into body.	Occupier & Manager	Factories Act: Sec 7- A (2)(c) AP Factory Rules: ▪ Rule 61(SB)C ▪ Rule 95 Sch XV part-II Para 4

S. No.	Negligence	Responsibility Attributed To	Act / Rule Violated
	▪ Safe work and good housekeeping practices. ▪ The importance of protection from Styrene contact; the proper clothing and cleaning requirements. ▪ Signs and symptoms of Styrene exposure and action to be taken and medical conditions aggravated by exposure to Styrene. ▪ The care that must be taken whenever and wherever Styrene is used, handled, stored and transported. ▪ The availability of standard procedures for Styrene usage, health hazard and training. ▪ Emergency procedures for leaks, spills, and fires, including protective clothing to be worn in such instances.		
4.	Inadequate knowledge and skills among the top/middle management.	Occupier & Manager	Factories Act: Sec 7- A (2)(c) AP Factory Rules: ▪ Rule 61(SB)C ▪ Rule 95 Sch XV part-II Para 4
5.	Non–maintenance of required temperature in Tank by refrigeration.	SOP by Occupier & Manager	Factories Act: Sec 7- A (2)(a) & (b) Sec 41-B (7) AP Factories rules: ▪ Rule 95 Sch XV Part-II Para 5 (3): ▪ Rule 61-F (3) ▪ Rule 61-F(4)
6.	Improper measurement of Tank temperature	SOP by Occupier & Manager	Factories Act: Sec 7- A (2)(a) & (b) Sec 41-B (7) AP Factories rules: ▪ Rule 95 Sch XV Part-II Para 5 (3): ▪ Rule 61-F (3) ▪ Rule 61-F(4)

S. No.	Negligence	Responsibility Attributed To	Act / Rule Violated
7.	Tank contents were not mixed thoroughly by circulating for more extended period.	SOP by Occupier & Manager	Factories Act: Sec 7- A (2)(a) & (b) Sec 41-B (7) AP Factories rules: ▪ Rule 95 Sch XV Part-II Para 5 (3): ▪ Rule 61-F (3) ▪ Rule 61-F(4)
8.	TBC addition to M6 Tank was not done during the lockdown. Depletion of TBC in Styrene samples was not detected.	SOP by Occupier & Manager Employees / Management	Factories Act: Sec 7- A (2)(a) & (b) Sec 41-B (7) AP Factories rules: ▪ Rule 95 Sch XV Part-II Para 5 (3): ▪ Rule 61-F (3) ▪ Rule 61-F(4)
9.	Spike in polymer content in Styrene monomer in M6 Tank and non-measurement of Dissolved Oxygen in Styrene	SOP by Occupier & Manager Employees / Management	Factories Act: Sec 7- A (2)(a) & (b) Sec 41-B (7) AP Factories rules: ▪ Rule 95 Sch XV Part-II Para 5 (3): ▪ Rule 61-F (3) ▪ Rule 61-F(4)
10.	Absence of formal Pre-start-up Safety Review (PSSR)	Management	AP Factories rules
11.	Process Safety Management (PSM) system and a system of Management of Change (MOC) has not been implemented.	Management	AP Factories rules
12.	No provision of buffer Tank to transfer Styrene during an emergency.	Occupier & Manager	AP Factory Rules: Rule 95 Sch XV Part – II Para: 9
13.	Non – labeling of the Styrene storage Tanks with Hazardous Material Information System (HMIS).	Management	AP Factory Rules: Rule 61(SB)B Rule 17 of MSIHC Rules, 1989

S. No.	Negligence	Responsibility Attributed To	Act / Rule Violated
14.	No qualified medical practitioner approved by the Directorate of Industrial Safety and Health, Andhra Pradesh.	Occupier & Manager	AP Factory Rules: Rule 61(SC) B (2)
15.	No competent supervisors to handle Styrene in the plant.	Occupier & Manager	Factories Act Section 41-C (b)
16.	No scenario of Styrene vapour release or spillage was considered in On-site emergency plan.	Occupier & Manager	AP Factory Rules: Rule 61(SB)D-13 Rule – 13 of MSIHC Rules, 1989
17.	Non-compliance of Offsite Emergency Plan.	Occupier & Manager	Factories Act: Sec 41-B (4) AP Factory Rules Rules 61(SB)D13
18.	Non-dissemination of information to the persons liable to be affected by a major accident.	Occupier	Rule 15 of MSIHC Rules, 1989

5.1.4 Liability under Environment (Protection) Act, 1986 (Action: MoEF&CC, Government of India; APPCB; Director of Factories)

The Central Government enacted an umbrella Act i.e., Environment (Protection) Act, 1986 for protection and improvement of environment. As per the section 7 of E(P) Act, 1986 no person carrying on any industry, operation or process shall discharge or emit or permit to be discharged or emitted any environmental pollutant in excess of such standards may be prescribed. As per the section 8 of E(P) Act, 1986 no person shall handle or cause to be handled any hazardous substance except in accordance with such procedure and after complying with such safeguards as may be prescribed. Similarly, Section 9 also provides for the action to be taken in cases where the discharge of any environment pollutant in excess of the prescribed standards occurs.

The company failed to comply with the above-mentioned sections of the E(P) Act, 1986. It released large quantities Styrene vapour into the atmosphere which is a serious lapse by the LG Polymers, which led to the loss of human and animal life.

It is essential that the MoEF&CC, Government of India examine the failure to comply and contravene the provisions of E(P) Act, 1986 by LG Polymers (India) Pvt. Ltd. under the provisions of Section 15 read with Section 16 of Environment (Protection) Act, 1986 and other relevant Sections and take necessary action as per the law. Further, the other authorized regulatory bodies, like APPCB, Director of Factories, etc. may also examine the issue and take necessary action in accordance with the provisions of E(P) Act.

5.1.5 Liability under Air (Prevention and Control of Pollution) Act, 1981 (by APPCB)

As per the section 22 of the Air Act, 1981, no person operating any industrial plant, in any air pollution control area shall discharge or cause or permit to be discharged the emission of any air pollutant in excess of the standards laid down by the State Board under clause (g) of sub-section (1) of section 17. Further as per the section 23 (1) of the Air Act, 1981, the emission of any air pollutant into the atmosphere in excess of the standards laid down by the State Board occurs or is apprehended to occur due to accident or other unforeseen act or event, the person in charge of the premises from where such emission occurs or is apprehended to occur shall forthwith intimate the fact of such occurrence or the apprehension of such occurrence to the State Board and to such authorities or agencies as may be prescribed.

The company failed to comply with the above-mentioned sections of Air Act, 1981, and it released large quantities of Styrene vapour into the atmosphere, which is a serious lapse by the LG Polymers, which led to the loss of human and animal life.

The APPCB must examine the failure to comply and contravene provisions of the Air Act, 1981 by LG Polymers under the provisions of Section 37 and Section 39 read with Section 40 of Air Act, 1981 and other relevant Sections and take necessary action as per the law.

5.1.6 Liability under Water (Prevention and Control of Pollution) Act, 1974 (by APPCB)

As per the section 24 (1) of the Water Act, 1974, no person shall knowingly cause or permit any poisonous, noxious or polluting matter determined in accordance with such standards as may be laid down by the State Board to enter (whether directly or indirectly) into any Stream or well or sewer or on land. Further, as per the section 31 (1) of the Water Act, 1974, if any industry, operation or process, or any treatment and disposal system or any extension or addition thereto is being carried on, due to accident or other unforeseen act or event, any poisonous, noxious or polluting matter is being discharged, or is likely to be discharged into a stream or well or sewer or on land and, as a result of such discharge, the water in any stream or well is being polluted, or is likely to be polluted, then the person in charge of such place shall forthwith intimate the occurrence of such accident, act or event to the State Board and such other authorities or agencies as may be prescribed.

The company failed to comply with the above-mentioned sections of the Water Act, 1974 and it released large quantities of Styrene into the water bodies and caused contamination of drains, water bodies and groundwater sources which is a serious lapse by the LG Polymers leading to the water pollution, including in Drinking water sources.

The APPCB must examine the failure to comply and contravene provisions of the Water Act, 1974 by LG Polymers under the provisions of Section 43 and Section 45 A read with Section 47 of Water Act, 1974 and other relevant Sections and take necessary action as per the law.

5.1.7 Liability under the Andhra Pradesh Fire Service Act, 1999, (by AP State Disaster Response and Fire Services Department (APSDRFSD))

The Andhra Pradesh State Disaster Response and Fire Services Department (APSDRFSD) accorded NOC to LG Polymers for three blocks (a) General Purpose Polystyrene Plant (b) High Impact Polystyrene plant and (c) Expandable Polystyrene Plant, and the same was renewed on 4th December 2019 up to 3rd November 2020.

The main conditions stipulated by the department in the NOC are:

- All occupants shall be trained to operate the fire safety equipment during an emergency,
- Mock drills shall be conducted once in three months for initial two years and thereafter once in every six months,
- Raise the alarm if the fire cannot be controlled, evacuate the area completely at once with nearest safe exit.

The company failed to comply with the main condition of raising the alarm stipulated by the department, which is a serious lapse by the officers of LG Polymers on duty. The LG Polymers did not raise the alarm to alert the residents of the nearby colonies and also did not take any action to evacuate them to the nearest safe place leading to the loss of human and animal life.

It is essential that the APSDRFSD take-up the inquiry into the matter, as per the conditions stipulated in the NOC and take necessary action as per law.

5.2 Liability of LG Polymers as per Environmental Jurisprudence

The Bhargava Committee set up by the Supreme Court[44] affixed an absolute and non-delegable duty on the Polluter (Industrial Unit) to the community, to ensure that no harm results to anyone on account of its activity. In other words, if any harm does result from the activity of the Polluter, then the enterprise is absolutely liable to compensate for such harm, and it is no answer to say that it had taken all reasonable care or that the harm occurred without any negligence on its part.

Further, M.C. Mehta and Anr vs Union of India & Ors 1987 AIR 1086, 1987 SCR (1) 819 - (upon gas leak in Delhi) is a landmark judgment relating to the concept of absolute liability. According to the rule of absolute liability, if any person is engaged in an inherently dangerous or hazardous activity, and if any harm is caused to any other person due to an accident which occurred while carrying out such inherently dangerous and hazardous activity, then the person who is carrying out such activity will be held absolutely liable.

The LG Polymers is also accountable under the Precautionary Principle for remedying the damage caused. The Precautionary Principle further leads to the requirement, that LG Polymers, being the generator of pollution and causing damage to the environment bears the *burden of proof.*

The Chapters 2,3 and 4 have discussed in detail the main causes of the accident, the breach of the safety protocols, negligence in operations, the breakdown of the Emergency Response systems, the impact on environment with full details. In this case, the uncontrolled Styrene

[44] (on Rural Litigation and Entitlement Kendra Dehradun & ORS vs State of UP & ORS 1985 AIR 652, 1985 SCR (3) 169)

vapour release from LG Polymers of large quantities of Styrene vapour, the negligence by the LG Polymers is clear. Thus, it is absolutely liable to compensate for harms caused by the accident. As per the Polluter Pays Principle and Precautionary Principle, the absolute liability for harm extends not only to compensate the victims of pollution but also for the cost of restoring the environmental degradation caused by the accident.

6.0 Role of Regulatory Bodies

6.1 District Collector, Visakhapatnam

The District Collector is the head of the Revenue Administration in the District and supervises general administration in the District. The Collector is in fact, the general controlling authority over all the Departments in the District. As District Magistrate, the District Collector exercises the general supervision over the Law & Order and co-ordinates with the Police Department to maintain peace in the District jurisdiction.

The District Collector is entrusted with a wide range of regulatory and development functions to perform, including Disaster Management during natural calamities, relief and rehabilitation and crisis management during disruptive and unexpected emergencies.

The District Collector, Visakhapatnam has submitted reports and are annexed (Volume VI: Part A Annexures- 6.1.1-6.1.4). As per the report, an accident took place on the intervening night of 7th May 2020 at around 03.00 a.m. at LG Polymers. The Styrene gas was spread to a radius of nearly 0.6 km of surrounding colonies in the westward direction predominantly. At one point of the day on 7th May 2020, the temperature in the Styrene storage tank of M6 Tank shot up to at least 154˚C, well over the boiling point of Styrene, which is 145˚C, causing the emission of high volatile organic contaminants and the Styrene gas spread in the vicinity of the plant, which became hazardous and affected people with symptoms of breathing difficulties, skin rashes, sour eyes, vomiting and unconsciousness.

Styrene vapour leak affected the immediate colonies/villages of Venkatapuram, Venkatadri Nagar, Padmanabhapuram, SC BC Colony, Nandamuri Nagar, R.R.Venkatapuram and the residents of the other colonies in the neighbourhood have left their houses for safety.
The District Collector further reported that the Commissioner of Police and other officials were alerted immediately and rushed to the affected areas. The following rescue and relief teams were deployed with officials of Police, GVMC, Disaster Response & Fire

Services Department, NDRF teams, SDRF teams and public transport for conducting rescue and relief operations to the victims.

Table: 6.1: Rescue and Relief Teams

S. No	Relief & Rescue teams	Relief measures
1.	NDRF	Attended with 34 members & 1 Doctor
2.	Medical	108 vehicle - 15 & Ambulances – 22
3.	APSRTC	40 Buses
4.	Fire Department	21 fire tenders & 120 teams
5.	GVMC	Supplied 12,000 food packets & 14,000 water bottles
6.	Simhachalam Devasthanam	Provided shelter and also supplied food to 800 people

The Hon'ble Chief Minister of Andhra Pradesh immediately visited KGH Visakhapatnam on 7th May 2020 and consoled the family members of the deceased and the patients undergoing treatment. The Hon'ble Chief Minister announced a Special Relief Package for the victims/affected people as follows:

Table: 6.2: Special Relief Package

S. No	Particulars	Amount announced
1.	Ex-gratia to the kin of the deceased	₹ 1 Crore per person
2.	Patients undergoing treatment on the ventilator	₹ 10 lakhs per person
3.	Patients hospitalized for 2-3 days	₹ 1 Lakh per person
4.	Patients who have undergone primary treatment	₹ 25,000 per person
5.	Affected villagers	₹ 10,000 per person
6.	Ex-gratia for the dead animals	₹ 20,000 per animal

The Chief Secretary to Government, Andhra Pradesh camped at Visakhapatnam and supervised & monitored the situation. The Chief Secretary and Group of Ministers convened a meeting at Collector's Office, Visakhapatnam on 7th May 2020 with the District officials. Instructions were issued to the concerned and constituted following committees to enquire into the situation:

- Constituted Internal Committee, to verify whether the procedure is being followed in the Industry in controlling the emissions.
- Committee constituted with Four Andhra University professors from the academic side to study the present scenario and to advise the District Administration.
- Committee for gravity check of the leakages for every hour
- Committee for testing of food grains, millets and pulses in the vicinity of affected areas
- Committee for free treatment in hospitals.

Further, in accordance to the assurance of the Hon'ble Chief Minister of Andhra Pradesh for payment of compensation / ex-gratia to the victims of LG Polymer Gas leakage accident, the Government vide GO.Ms.No.449, Revenue (CMRF & FWC) Dept, Dt. 8th May 2020 issued orders for releasing ex-gratia / financial assistance to the deceased/ victims. The following amounts are paid as detailed below:

Table: 6.3: Ex-gratia / Financial Assistance to the Deceased / Victims

S. No	Particulars	Amount Announced (₹)	Members	Amount paid (₹)
1.	Ex-gratia to the Kin of the deceased	1 Crore	12	12 Crores
2.	People on ventilator	10 lakhs	1	10.0 Lakhs
3.	Hospitalized for 2-3 days	1 Lakh	485	485 Lakhs
4.	People have undergone primary treatment	25,000	99	24.75 lakhs
5.	To affected villagers	10,000	19893	19.893 Crs
6.	Died Animals		25 Animals (8 Owners)	8.75 lakhs

The Central Government has also deployed an Expert Committee from National Disaster Relief Force (NDRF), Pune and Environmental experts from National Environmental Engineering Research Institute (CSIR-NEERI), Nagpur along with reduction material to control the emission of gas through the air. The team reached the accident spot on 7th May 2020 midnight and advised to bring down the temperature of the M6 Tank by a multi-pronged strategy of inhibitor dosing, water spraying and water injection. Accordingly, the temperature of the tank and emissions were reduced by 9th May 2020.

An Expert Group was constituted with 10 doctors under the Chairmanship of Principal, Andhra Medical College for offering an opinion to give inputs regarding the follow up of patients admitted with Styrene poisoning and to advise the consequences in the affected colonies. This expert group made the following recommendations:

- Base Line Study of the population and establishment of registry with different cohorts.
- Data Analysis of all patients admitted in KGH and available hospitals.
- Formulation of a medical cell in the nearby villages
- For carrying out baseline investigations suggested by departments of General Medicine, Pediatrics, Gastroenterology and Pathology.
- Monitoring of pregnant women with the outcome of the pregnancy and 1 year follow up of newborns.
- To study and obtain the baseline status of other Departments like Neurology, Pulmonology & Ophthalmology and their recommendations.
- To include technical experts from Pollution Control Board & Dr. Bhatnagar, BIRAC.
- To monitor the change in the health status of individuals by Individual Departments.

Accordingly, 6 Static Medical Camps in all the villages along with 6 ambulances have been arranged with one Medical Officer and 2 Specialists in 6 locations at Venkatapuram, Nandamurinagar, Padmanabha Nagar, Kamparapalem, Pydimamba Colony and SC-BC Colony. A permanent clinic is proposed to organize in the central location of all affected villages. A provision of 20 beds for admission for any health complaints about their primary care with physician & paramedical staff to attend the needy and make available basic medicines.
The District Collector directed the private hospitals for providing medical aid to the affected persons/victims duly meeting the expenditure by the State Government.

Necessary measures have been taken at relief camps for maintaining the social distance, in the prevailing situation of Covid-19 as part of the rehabilitation of the victims. The Greater

Visakhapatnam Municipal Corporation (GVMC), Visakhapatnam have taken up sanitation activities like cleaning of streets & drains, removal of debris and spraying of bleaching. Also carried out internal sanitation like opening of houses, cleaning floors with water, opening windows, drained out the well water in all houses and provided drinking water and masks to all inhabitants of the affected area.

The Government of Andhra Pradesh has constituted 4 Teams with Deputy Chief Inspector of Factories as a convener, officers from Boilers Department, Pollution Control Board, Industries Department and Two Professors from Andhra University to study the status of remaining factories in Visakhapatnam city to determine the future risks, if any.

The Government of India constituted a team of two experts by name Mr. Shantanu Gite, Industrial Expert in the handling of Styrene from Supreme Petrochem Ltd, Mumbai and Dr. Anjan Ray, Director, CSIR-Indian Institute of Petroleum, Dehradun after the incident on 7th May 2020. They have visited LG Polymers and other Styrene storage tanks and submitted a report in the matter. The Central Committee recommended the Styrene material in the tanks located offshore and at LG Polymers premises and recommended to ship all Styrene inventory in the storage tanks of LG Polymers and two outsourced shore tanks. As per the recommendations, Styrene available in the tanks was dispatched to Seoul, South Korea via two vessels i.e., by ARHANT (7642 MTs) on 14th May 2020 and NORD MAGIC (5438 MTs) on 18th May 2020 to avoid untoward incidents.

The Committee observed that the District Administration reacted to the accident immediately and started rescue operations of the people and also taken immediate steps to arrest further release of Styrene gas vapours. The ex-gratia was distributed in time to the affected people.

The Committee observed that the District Administration deployed all concerned departments for attending the relief operations under crisis management and also co-ordinated with NDMA, Experts deputed by NDMA, the CBRN team, the team from NEERI, and also formed Expert groups / internal Committees for various emergency responses.

The Committee observed that under the Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996, there is a mandatory requirement for the formation of District Crisis Groups and Local Crisis Groups. It is essential that Visakhapatnam, with its cluster of large number of Industries, focuses on making the District Crisis Group and the Local Crisis Groups effective and active at all times. The District Administration should take lead along with the industry bodies, workmen unions and academic and technical experts to have a permanent body of District Crisis Group. This will imply that in case of any accident, there is already a team of experts ready to assist the District Administration in the form of District Crisis Group.

In addition, there is a necessity for activating the Local Crisis Group under the Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996, for each and every Hazardous Chemical Industry as defined under the Manufacture, Storage and Import of Hazardous Chemical Rules, 1989 and also explosive / inflammable under the Petroleum Act, 1934. The District Administration should make each of the Industry under the above categories set up of Local Crisis Group. The Local Crisis Group should definitely include the Local Police, the Local Fire and SDRF personnel, the Workmen representatives of the Industry, the Technical and Safety Experts of the Industry, the local body representatives and a group of local youth residing in the vicinity who are willing to participate.

The District Administration should also take a lead, along with the Large Industry Representatives, Industry Bodies like CII and especially from the Industries covered under the Manufacture, Storage and Import of Hazardous Chemical Rules, 1989 and Petroleum Act, 1934 to either on their own or in association with the State Disaster Response Force (SDRF) and the Police to set up specialized Chemical Accidents Disaster Response Force, with adequate required equipment and training.

In the present case of uncontrolled Styrene Vapour release from the LG Polymers, the District Administration has to take lead in setting up of Institutional structures for monitoring and studying the effects of Styrene vapour released at LG Polymers in the immediate future, in the medium term and the long term, duly obtaining advice from the experts.

The District Administration has already constituted an expert health group under the supervision of Andhra Medical College to carry out the health monitoring and check-ups of affected people of the LG Polymers in surrounding villages. These checks include baseline measurement and monthly check-up of all patients who were treated during the accident in the fields of General Medicine, Paediatrics, Gastroenterology, Pathology, Neurology, Pulmonology & Ophthalmology. Concern was also raised in the public hearing about Gynaecological issues and it is suggested that women health also be included in the parameters being checked.

The Committee also feels that the Indian Council of Medical Research (ICMR) should also be actively associated with this health monitoring of all affected population so that the data is scientifically analysed and assessed. This study should also include epidemiological study. There is also a need for the District Administration to set up Institutional structures to monitor and measure the following for the long-term effects:

- Air, Water and Soil
- Health of animals
- The health of flora and fauna and Biodiversity
- Forest and Wildlife

There may be an association between Styrene exposure and health effects on people exposed to the Styrene vapour of higher concentrations, on the health of the flora and fauna of the surrounding areas. Since the accident is unique and rare, it is always advisable to study the long-term effects of Styrene vapour by constituting appropriate institutional monitoring mechanism for at-least two years. Particular focus is required on the health of the pregnant women and newborn and health of residents of the affected villages. In addition, there may be long term effect on fodder, feedstocks and milk of cattle etc. Though at present, Styrene levels are found to be at acceptable limits in air, it requires long term study as there is no confirmed information about effects on the health of people, animals, flora and fauna and the general environment in the long term.

The Committee recommends that individual departments of Medical & Health, Veterinary, Horticulture, Forest & Environment be made responsible for the studies. The Committee also recommends that each of these monitoring studies should be done by Competent Bodies, ably supported and aided by Experts / Expert Institutions. This is essential as this accident is a unique accident in which such a large quantity of Styrene vapour was released in the air.

The District Administration has done a commendable job in implementation of rescue, relief & rehabilitation measures by which they could reduce the fatalities and it's time for them to take up next phase of challenges.

6.2 The Commissioner of Police, Visakhapatnam

As is a generally known, the Police Department is primarily responsible for Crime prevention, Crime registration, Crime investigation and in prosecution. It's also responsible for maintenance of law and order, traffic and general law implementation.

The Police Department with its service of "Police Help Line 100" has mostly become the first point of contact in any accident/crime. The Department maintains a strong connect with the citizens in the area of their jurisdiction.

The Commissioner of Police, Visakhapatnam has submitted reports and are annexed (Volume VI: Part A Annexures-6.2.1 & 6.2.2). He has reported that on 7th May 2020 at night at 02.54 a.m., the Styrene rapidly vaporized due to the sudden rise in temperature in the M6 storage tank because of polymerisation reaction of the Styrene Monomer and it resulted into venting of vapour through these vents and spread across the nearby residential areas on downwind direction (West side).

This Vapour affected the adjoining six colonies/villages of Venkatapuram, Venkatadri Nagar, Padmanabhapuram, SC & BC Colony, Nandamuri Nagar, R.R. Venkatapuram. On inhalation of the gas, the residents of the above areas started showing symptoms like breathing difficulties, skin rashes, sour eyes, vomiting and unconsciousness.

The police officials along with the staff have alerted the residents of the surrounding villages who were asleep and started rescue operations i.e. shifting the unconscious, semiconscious and sufferers of Gas exposure to various hospitals by the number of ambulances, Police vehicles, other available vehicles besides taking steps for controlling the leakage of Gas with the available technical staff of LG Polymers. About 600 villagers of R.R. Venkatapuram, Padmanabhanagar, Kamparapalem, SC BC Colony and Nandamuri Nagar were rescued. In addition to the Technical staff of LG Polymers, who were on shift duty, other technical staff of LG Polymers also arrived in the industry and tried to arrest the leakage of Gas with the officials of Fire and Safety departments.

The Commissioner of Police has reported that after the accident Sri M.V. Subba Rao, VRO, RRV Puram Cluster, Gopalapatnam has complained Gopalapatnam P.S., Visakhapatnam city on 7th May 2020 at 07:00 a.m. stating that "at about 03:30 a.m., some pungent smoke came out of the LG Polymers due to which the neighbouring villagers were affected and people felt bad smell and thought that the smell is endangering to human life. The surrounding villagers inhaled the leaked gas and became unconscious. In that accident, 5 persons died, and the remaining are felt sick, who are being shifted to hospitals."

Basing on the above report, a case in Cr.No. 213/ 2020 was registered at Gopalapatnam Police Station, Visakhapatnam City on Officials of LG Polymers U/ s 304-II (Non-bailable section) for causing deaths by negligence, U/s 278 for making atmosphere noxious to health, U/s 284 for negligence conduct with respect to poisonous substance, U/s 285 for negligence conduct with respect to fire and combustible matter, U/s 337 for causing hurt by act endangering life or personnel safety of others, U/s 338 for causing grievous hurt by act endangering life or personnel safety of others, of Indian Penal Code (IPC).

The Commissioner of Police has further reported that, during the course of the investigation, the Investigation Officer i.e. the Asst. Commissioner of Police, West Sub Division visited King George Hospital along with her team of officers, recorded the statements of the victims, held an inquest over the dead bodies of 11 deceased at Mortuary Room, KGH, Visakhapatnam, examined and recorded the statements of the witnesses and relatives of the deceased and sent the bodies to autopsy before the Professor, Forensic Medicine, Andhra Medical College, Visakhapatnam.

During the course of further investigation, the ACP-West has visited the scene of offence at LG Polymers and its surrounding areas along with mediators and inspected the same and seized the physical evidence from the scene of offence with the assistance of clues team. Later she recorded the statements of 300 witnesses and continued investigation.

The Deputy Chief Controller of Factories, Pollution Control Board Officials, the District Fire Officer and other officials also visited the scene of the offence, conducted the enquiry and also collected material objects and records of the LG Polymers.

During the course of the investigation, the Commissioner of Police, Visakhapatnam city has endorsed the investigation to Asst. Commissioner of Police, Dwaraka Sub-Division, Visakhapatnam city who in-turn taken up the investigation and continuing further.

The Police authorities have seized the passports of the Directors of the LG Polymers and also notices have been issued directing them not to leave the country.

Regarding the status of the investigation, the Commissioner of Police has stated that in this case, the Police Department has examined the 280 witnesses so far including the statement of 16 officials, security and technical persons who are in LG Polymers. Held inquest over the 11 dead bodies of the deceased on 7th May 2020 and 8th May 2020. Later in due course, an inquest was held over 3 dead bodies of the deceased and another Inquest was also held over the dead bodies of the deceased by the SHO, Kothavalasa PS of Vizianagaram District. So far inquest was held over the 15 dead bodies of the deceased persons. The viscera preserved by Professor, Forensic Medicine, Andhra Medical College of 15 deceased were sent to Assistant Director, Regional Forensic Science Laboratory, Visakhapatnam for chemical analysis and opinion. Addressed letters to Deputy Chief Inspector of Industries, District Fire Officer, Visakhapatnam, Deputy Chief Controller, Explosives Department and to the District Pollution Control Board Officer to know the technical aspects in leakage of the Styrene Gas from M6 Tank at LG Polymers. The material objects seized at the scene of offence were sent to Director, FSL, Mangalagiri, AP for chemical analysis and opinion. The passports of CEO & Directors of LG Polymers are seized and passports are kept under custody.

The Commissioner of Police has also reported that the investigation is pending on the following aspects:

- The reports are yet to be received from Dy. Chief Inspector of Factories, PCB and DFO, Visakhapatnam.
- The reports from Director, FSL and Asst., Director, RSFL are awaited and Police Department reported that soon after receipt of all reports and opinions, the case will be finalized as per the merits of the evidences and necessary arrest will be affected.

The Police have stated in their report that a team of 8 South Korean Nationals including came to Visakhapatnam on 13th May 2020 after the date of the accident and made observations about the incident. Mr. Sunkey Jeong, Managing Director, L.G. Chem, L.G. Polymers communicated a letter on 26th May 2020 at 07.45 p.m. The Department sought information about their observations/findings on 29th May 2020 and reply is pending with LG Polymers.

The Police Department suggested giving instructions to the Director of Factories to interact with the above team about Technical aspects and their (Team) Findings/observations so far. The Commissioner of Police has also informed that soon after receipt of all reports and opinions, the case will be finalized as per the merits of evidences and necessary arrests will be affected. The Commissioner of Police has specifically stated the investigation does not indicate any sabotage.

The teams from the National Disaster Response Force (NDRF) and the National Environmental Engineering & Research Institute (NEERI) made thorough check-in and around the plant and found no further damage. The Department alerted the people in and around 2 km of radius and also kept fire engines and foam lighters on standby as precautionary measures.

As can be observed from the report of the Commissioner of the Police, the actions can be classified under 3 categories:

6.2.1 Immediate relief operations

The Police responded fast to the accident. The Control Room had received the call at 03:26 am on 7th May 2020 and the night duty staff was alerted by the Police Control Room through Very High Frequency (VHF) sets. The Police Control Room also alerted Gopalapatnam Police Station. The Police also alerted the Fire Department Services and also rushed to the spot. Deputy Commissioner of Police (DCP), Zone-II, Visakhapatnam has shown his presence of mind, directed the police personnel to alert the people in 5 Colonies/villages by using the siren of Police patrol vehicles. Many residents were evacuated to safer places with the assistance of Police, 108 Ambulance Services, Medical and Health Ambulance Services, Private Vehicles and Local volunteers. From the press reports, the public were very appreciative of the efforts put in by the Police staff including the DCP.

The police are the first point of contact and in places having hazardous chemicals, it is essential that they are trained in dealing with Hazardous Chemicals disasters and also equipped with the required equipment, especially in the police stations covering hazardous factories.

6.2.2 Registration of the case

The Police have already registered a case under Crime No.213 / 2020 at Gopalpatnam Police Station, Visakhapatnam City.

6.2.3 Investigation and status of the case

The Commissioner of Police has specifically ruled out any sabotage.

It is essential that the police take up the investigation in the matters with full speed, collect all the required information, investigate the case thoroughly and take the necessary action as per law.

6.3 Andhra Pradesh State Disaster Response and Fire Services Department (APSDRFSD)

The APSDRFSD regulates and enforces the following: The Andhra Pradesh Fire Service Act, 1999. The Director General, Vijayawada and the District Fire Officer, Visakhapatnam of APSDRFSD submitted reports and are annexed (Volume VI: Part A Annexures- 6.3.1 - 6.3.5). The APSDRFSD reported that Section 13 (1) of the Andhra Pradesh Fire Service Act, 1999 deals with the issue of "No Objection Certificate" (NOC) to buildings of residential/commercial/business/schools /cinema halls/function halls/amusement places etc., which exceed stipulated height and area. As per the above section, industries are not covered. However, the Department accords NOCs to industrial establishments, whoever applies for NOC. The main conditions stipulated by the Department in the NOC are that all occupants shall be trained to operate the fire safety equipment during an emergency, mock drills shall be conducted once in three months for initial two years and thereafter once in every six months, raise the alarm if the fire cannot be controlled, evacuate the area completely at once with nearest safe exit.

The APSDRFSD further reported that LG Polymers applied for NOC and was accorded NOC for three blocks i.e. (a) General Purpose Polystyrene Plant, (b) High Impact Polystyrene Plant and (c) Expandable Polystyrene Plant on 4th November 2013 of the Director-General and the same was renewed on 4th December 2019 up to 3rd November 2020.

The Committee noted that among the conditions of NOC, there is a specific condition for raising alarm if the fire is not controlled. The Committee observed that although there was no fire in this accident, the non-use of the emergency siren is a serious lapse on the part of the LG Polymers and all the Officers and staff who were on duty at that time.

The Fire Department reported that in response to the fire accident in LG Polymers, the local Fire Department personnel responded and activated the sprinkler system within the factory to defuse the effect of the gas duly using 3 Self-Contained Breathing Apparatus (SCBA) sets available. On enquiry with the Fire Department, it is learnt that the officials have proceeded to accident spot with three SCBA sets and two were used by the Fire department officials and the other one was used by factory employee to reach the affected storage tank and to start sprinkler system.

Subsequently, the sets available with the factory were filled with oxygen and some more sets from outside also reached the spot which was used by the personnel in the relief operation and, in total, 18 SCBA sets were used in the operation.

Fire Staff were also called for from surrounding fire stations and evacuated the victims to the safer places with the assistance of local police and local youth. Water was sprayed in the most affected village RR Venkatapuram to defuse the effect of Styrene gas.

The Standing Fire Advisory Council (SFAC) laid down norms for setting up of Fire Stations. The criteria for setting them up are as follows:

- Response Time (5 minutes in urban areas and 20 minutes in rural areas.
- The area to be covered (10 km^2 in urban areas and 50 Square km for rural areas).

The Committee noted that the Department received 1st telephone call to the fire station at 03.30 a.m. and the Fire Tender from Marripalem reached the LG Polymers site by 03.51 a.m. as per the Fire Department report. Hence, a total response time of 21 minutes was taken by the Department against the SFAC advisory of 5 minutes in urban areas.

The available strength of the A.P. State Disaster Response and Fire Service Department at Visakhapatnam is highly inadequate when compared to the requirement.

The Committee opined that till now the Fire Department has only focused on emergency arising out of fire accident. It is to be noted that the Fire Services Department has been renamed as Andhra Pradesh State Disaster Response and Fire Services Department. Hence, it is essential that it starts functioning as a State Disaster response force, not only for natural calamities but also for industrial accidents, chemical accidents, fire accidents, gas leaks, explosive accidents etc. for the state of Andhra Pradesh, on the lines of National Disaster Response Force (NDRF). It is also to be noted that along with Police, the Fire Department is generally the first point of the emergency call. Hence, on this account also, the State Government should take all necessary steps to equip the State Disaster Response Force (SDRF) for all types of calamities and accidents by providing the necessary infrastructure.

The Committee recommends that SDRF become an integral part of Onsite Mock Drills and Off-Site Mock Drills and the implementation of the Emergency Plan of all hazardous industries. It should compulsorily be a member of the State, District and Local Crisis Group. Through the mock drills, the SDRF should ensure that the personnel working in the industry should be aware of the preventive measures needed to avoid disasters as well as the Standard Operating Procedure in case of any disasters. The Company Technical Personnel, the Fire Department personnel, SDRF Personnel, and the local officials of the Police Department, along with local volunteers should become the first line of response in an emergency and should take an active role in the Local Crisis Group.

The APSDRF should build its capacity on the lines of NDRF and become the primary force dealing with all types of Disasters in the State of Andhra Pradesh.

The Officers and personnel of the A.P. State Disaster Response and Fire Service Department should be trained regularly at the institutions which provide advanced training in measures to combat chemical, nuclear and biological disasters in the institutions like National Fire Service College (NFSC), Nagpur, National Institute of Disaster Management (NIDM) New Delhi, Disaster Management Institute (DMI), Bhopal.

6.4 A.P. State Disaster Management Authority (APSDMA)

A.P. State Disaster Management Authority (APSDMA) regulates and enforces the following:

- Disaster Management Act, 2005
- Andhra Pradesh State Disaster Management Rules, 2007

The Disaster Management Act, 2005 has been enacted as the Central Act to deal with the management of disasters. This Act envisaged a three-tier Disaster Management structure in India at National, States and District levels.

As per the Disaster Management Act, 2005, "Disaster" means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results in substantial loss of life or human suffering or damage and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area.

The functions of the State Disaster Management Authority include laying down the State disaster management policy; Approve the State Plan in accordance with the guidelines laid down by the National Authority; Approve the Disaster Management Plans prepared by the departments of the Government of the State; Laying down guidelines to be followed by the departments of the Government of the State for the purposes of integration of measures for prevention of disasters and mitigation in their development plans and projects and provide necessary technical assistance; Co-ordinate the implementation of the State Plan; Recommend provision of funds for mitigation and preparedness measures; Review the development plans of the different departments of the State and ensure that prevention and mitigation measures are integrated therein; Review the measures being taken for mitigation, capacity building and preparedness by the departments of the Government of the State and issue such guidelines as may be necessary. In line with the formation of APSDMA, Government of Andhra Pradesh has also formed District Disaster Management Authorities (DDMA) in all districts with District Collector as Chairman of DDMA.

The Managing Director, APSDMA has submitted reports and is annexed (Volume VI: Part A Annexure- 6.4.1). The Managing Director, APSDMA reported that APSDMA will approve the Disaster Management Plans of the concerned Departments and take up capacity building programmes like mock exercises, training and workshops in coordination with National Disaster Response Force (NDRF), National Institute of Disaster Management (NIDM), United Nations International Children`s Emergency Fund (UNICEF), United Nations Development Programme (UNDP). The NDRF requested APSDMA to arrange for organizing mock drills as per annual action plan in coordination with District Administration in the selected Major Accident Hazard (MAH) units on random basis with the prior intimation to the District Administration. The NDRF has organized 10 mock exercises from 2015 to till date in Andhra Pradesh at various places among them include mock drills in HPCL, NTPC in Visakhapatnam.

The Committee noted that the APSMDA is limited to the role of an advisory body. It is essential that it expands its role to all types of Disasters, natural and manmade, as provided in the Disaster Management Act, 2005. For this, the provisions regarding the formation and implementation of the Crisis Group requirement under The Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996 must be made as one of the pillars of AP Disaster Management Authority. The constitution, operation and management of the State Crisis Group, the District Crisis Group and the Local Crisis Groups should be made as an integral responsibility of the APSDMA.

The Committee opined that it is essential that the APSDRF is brought under the control of APSDMA so that it has an effective arm to deal with the disasters. This structure would be similar to the structure of NDMA and NDRF. The APSDMA should develop a strong knowledge base of various types of disasters, in association with the Experts who can assist in those fields and Agencies which can provide emergency response. This network of the database would be able to assist the State Government in responding to any Disaster.

The Committee recommends that the APSDMA should have close coordination with NDMA and NDRF for Disaster Response and knowledge sharing. This is especially important as Andhra Pradesh has a long coastline and the prevalence of cyclones and floods are very common. Further, with increasing Industrialization and increase in Chemical Units, there is always a need for a strong Disaster Response structure in the State.

6.5 Department of Factories, Govt of Andhra Pradesh

The Factories Department regulates and enforces the following:

- Factories Act, 1948 & AP Factories Rules, 1950
- Manufacture, Storage & Import of Hazardous Chemicals Rules, 1989 (MSIHC Rules, 1989) in respect of Factories covered under the Factories Act.
- Assist the State, District and the Local Crisis Groups as formed under Chemical Accidents (Emergency Planning, Preparedness & Response) Rules, 1996.

The Director of Factories (Full Additional Charge (FAC)) has reported that the Factories Department works for the safety, health and welfare of 9.58 lakh workers employed in 25,279 registered factories by implementing the above legislations.

The major roles and responsibilities of the Department as reported by the Director of Factories (FAC) include approval of plans of the factories at the pre establishment stage in Single Desk Portal; grant of licenses to the factories at the operational stage; inspection of factories based on random allocation of factories & Inspectors for monitoring the compliance; ensuring Risk Assessment & Preparation of Emergency Plans by hazardous factories and supervision of the Mock Drills of these On-site Emergency Plans; organizing safety training programmes for creating awareness; empanelment of competent third parties for certification of plant and machinery; Safety Audits in hazardous factories by third party experts; need based special safety drives by team of Departmental officers; ensuring implementation of Standard Operating Procedures (SOPs) like ‘Permit to Work System’ for high risk works.

The Director of Factories (FAC) & the Deputy Chief Inspector of Factories, Visakhapatnam, Factories Department have submitted reports on the accident and the reports are annexed (Volume VI: Part A Annexures- 6.5.1 - 6.5.6). The Director of Factories (FAC) reported that the LG Polymers situated at R.R.Venkatapuram, Visakhapatnam in Andhra Pradesh was granted license under Factories Act, 1948 in the year 1967 in the name of "Hindustan Polymers Ltd" for manufacturing Polystyrene and its Co-polymers at Visakhapatnam. Thereafter, it was renewed every year till 1997. In the year 1997, the license under the Factories Act, 1948 was amended in the name of the LG Polymers and the same was renewed annually till 1999. Thereafter, as per the amendment in the AP Factories Rules, 1950, it was made as a permanent license.

The Director of Factories (FAC) has reported that the plans of the LG Polymers were approved at various times as per details in the table below:

Table 6.4: Details of approved plans

S.No.	Constructions/Installations	Plan Approval No
1.	PS1 Packing Section, De-humidification system, GPPS Plan, EPS Plant	R.Dis A.no. 1679/1999, dated 30-06-1999
2.	PS1 Building, Pentane storage facility, DG Set 4 & 5	D3/VSP-I/28074/2000, dated 31-03-2001
3.	Packing & Processing Section, PS2 Plant, Polystyrene/Rubber Godown in HIPS Plant, PS1 HIPS Plant, Ground Floor layout.	D3/VSP-1/26610/2002, dated 1/04/2002
4.	PS1 Plan Building, EPS Plant, Equipment layout, Process Building	D.Dis D3/VSP-1/14034/2003, dated 23/07/2003.
5.	Packing & Process Section, Utility Section, PS2, Process Building, EPS Plant	D.Dis D3/VSP-I/ 10703/2004, dated 22/09/2004
6.	Styrene Storage Facility, Laboratory, GPPS Product Godown, Fire water pump house, DG Pump house,	D.Dis D3/VSP-I/14830/2005, dated 29/03/2006
7.	CT Layout at EPS Plant, Air Compressor at GPPS Plant, PRS Silos at Hips plant, Rubber Godown – Hips Plant, Extension of GPPS product Godown Plant, ETP Plant, RCC details of ETP plant.	D.Dis A1/VSP-I/17446/2007, dated 5/10/2007
8.	Proposed Relocation of HCL tanks from Old boiler house to EPS Plant, Construction of Gas Analysed room in bet-ween heater & new boiler house.	D.Dis A1/Vsp-I/4841/2010, dated 2/4/2010
9.	Packing & Processing section, GPPS building plan, Installation of Pre-expender for EPS.	D.Dis A1/VSP-II/11432/2010, dated 10/08/2010.
10.	PS1 Ground floor, Coloration plant, Mezzanine floor extruder in coloration at GPPS Plant.	D.Dis A1/VSP-II/1831/2011, dated 30/05/2011
11.	High speed mixer EPS plant, Laboratory, ETP phase-2, Relocation of existing pre expander, installation of scrubber at 5 TPH boiler.	D.Dis A/VSP-II/12435/2011, dated 22/08/2011
12.	Process building, cooling tower layout at EPS plant, Reinforcement details of foundations	D.Dis A1/VS-II/179/2013, dated 30/01/2013
13.	Proposed Sewage treatment plant-40 kld, PS1 plant building	D.Dis A1/VSP-II/17528/2013, dated 31/12/2013
14.	EPS Godown 1 & 2 and sieving room, Cooling tower & Decanter layout at EPS plant.	D.Dis A1/VSP-II/3849/2014, dated 01/08/2014
15.	Process building Layout- EPS Plant, Proposed construction of Ambient air quality monitoring, Installation of Scrubber at 8 TPH boiler,	D.Dis A1/VSP-II/9101/2015, dated 10/12/2015.
16.	EPC plant Shed, EPPS Plant, EPC Storage shed, SM storage tank, GPPS heater shed, Refrigeration shed, printer room	LAE05- 11021(35)14/2019, dated 28.03.2019

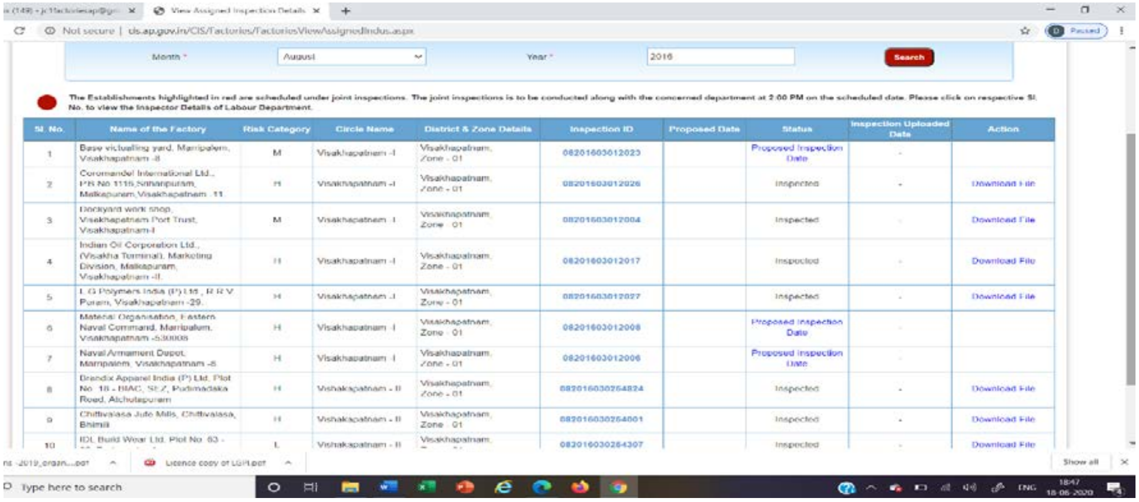
As per the report of the Director of Factories (FAC), the latest plan of the factory was approved vide Lr.No. LAE05 11021(35)/14/2019- A SEC-DOF, dated 28th March 2019 which is annexed (Volume VI:Part A Annexure- 6.5.7). These plans are approved for additional constructions, installations namely Refrigeration Shed, M5 Tank, Engineering Plastic Compounds (EPC) Storage Shed, EPC Scrap Shed, Extension of GPPS Heater Shed, Cooling Tower modification, Ash Silo removal, DG Shed extension with 1500 KVA Generator etc. No conditions are imposed while approving the plans.

As per the report of the Director of Factories (FAC), the LG Polymers was given license in the year 1967. The copy of the permanent license under the Factories Act, 1948 and Rules issued in favour of LG Polymers India Pvt. Ltd. on 4th September 2004 is annexed (Volume VI: Part A - Annexure: 6.5.8).

The Director of Factories (FAC) reported that duplicate license was issued on 4th September 2004, while the original date of license is indicated as 18th September 2000. The duplicate license also shows the license No.43858 and registration number 2027. This license was issued to Sri S.K. Bhowmik, Occupier on 18th September 2000. Subsequently, the license was transferred in favour of Sri M. Prasad Babu, Director, Operations on 4th September 2004. Again, the license was transferred in favour of Sri S.V. Praveen, Director of Operations on 07th May 2008. Again, the license was transferred in favour of Sri P.P.C. Mohan Rao, Director (Operations) with effect from 3rd February 2017. No conditions are indicated in the license.

The Director of Factories (FAC) further reported that, under the Factories Act, 1948 and Rules, it is not explicitly provided for compulsory annual inspection. However, the Factories Department have classified industries as High Risk, Medium Risk and Low Risk industries. The High-Risk industries are inspected annually, the Medium Risk industries once in two years and the Low Risk industries as once in three years. However, under the Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 (MSIHC Rules, 1989), it is provided under Rule 3(a) that inspections will be carried out annually for those factories having the inventory of hazardous chemicals more than the threshold quantities prescribed in Schedule 3 of the MSIHC Rules, 1989. The hazardous and High-Risk category, the Medium Risk category and the Low Risk categories have been appropriately captured in the Central Inspection System (CIS). The CIS procedures was introduced vide G.O. Ms No. 135, dated 12th October 2017 (Volume VI: Part A Annexure- 6.5.9). As regards to inspections, the Director of Factories (FAC) reported that the LG Polymers was inspected last three times on 11th May 2016 (Special Drive), 31st August 2016 and 18th December 2019 and the details of inspections are as follows:

- The inspection report for the inspection made on 11th May 2016 is annexed (Volume VI: Part A Annexure- 6.5.10). The important observations are relating to periodical training & increase in training hours for the workers with proper record maintenance, updating of the Safety Committee members, increase in safety budget, check list for internal plant inspection, display of SOPs, provision of emergency equipment, testing of equipment and instruments, and provision of Personal Protective Equipment (PPE). The inspection report was communicated to the LG Polymers as reported by the Director of Factories (FAC).
- Central Inspection System (CIS) was introduced from August 2016 onwards and the inspections were carried on 31st August 2016 and 18th December 2019. The CIS at present provides for uploading of inspection details online within 24 hours. The factories can view / download the report from the CIS portal.
- The CIS portal snapshot is placed below. It indicates that the inspection was carried out on 31st August 2016; however, the inspection report cannot be downloaded. On inquiry, the Director of Factories (FAC) has reported that the inspection report of inspection on 31st August 2016 was uploaded in the CIS portal. However, in August 2016, when the CIS portal was introduced, initially the inspection reports was scanned and uploaded by the inspecting officer. This procedure was followed. However, the CIS portal shows the status as “inspected” even today and it was informed by TCS (Software developer) when enquired now, that the said file was corrupted. The following screen shot of the portal shows the same. However, the CIS portal shows that the Inspection Report has not been uploaded. Hence, the Factories Department should examine this aspect immediately.



Month * August Year * 2016 Search

The Establishments highlighted in red are scheduled under joint inspections. The joint inspections is to be conducted along with the concerned department at 2:00 PM on the scheduled date. Please click on respective Sl. No. to view the Inspector Details of Labour Department.

Sl. No.	Name of the Factory	Risk Category	Circle Name	District & Zone Details	Inspection ID	Proposed Date	Status	Inspection Uploaded Date	Action
1	Base victualling yard, Marripalem, Visakhapatnam -8	M	Visakhapatnam -I	Visakhapatnam, Zone - 01	08201603012023		Proposed Inspection Date	-	
2	Coromandel International Ltd., PB No 1115,Sriharipuram, Malkapuram,Visakhapatnam -11	H	Visakhapatnam -I	Visakhapatnam, Zone - 01	08201603012026		Inspected	-	Download File
3	Dockyard work shop, Visakhapatnam Port Trust, Visakhapatnam-I	M	Visakhapatnam -I	Visakhapatnam, Zone - 01	08201603012004		Inspected	-	Download File
4	Indian Oil Corporation Ltd., (Visakha Terminal), Marketing Division, Malkapuram, Visakhapatnam -II.	H	Visakhapatnam -I	Visakhapatnam, Zone - 01	08201603012017		Inspected	-	Download File
5	L G Polymers India (P) Ltd , R R V Puram, Visakhapatnam -29.	H	Visakhapatnam -I	Visakhapatnam, Zone - 01	08201603012027		Inspected	-	Download File
6	Material Organisation, Eastern Naval Command, Marripalem, Visakhapatnam -530008	H	Visakhapatnam -I	Visakhapatnam, Zone - 01	08201603012008		Proposed Inspection Date	-	
7	Naval Armament Depot, Marripalem, Visakhapatnam -8	H	Visakhapatnam -I	Visakhapatnam, Zone - 01	08201603012006		Proposed Inspection Date	-	
8	Brandix Apparel India (P) Ltd, Plot No. 18 - BIAC, SEZ, Pudimadaka Road, Atchutapuram	H	Vishakapatnam - II	Visakhapatnam, Zone - 01	082016030254824		Inspected	-	Download File
9	Chittivalasa Jute Mills, Chittivalasa, Bhimili	H	Vishakapatnam - II	Visakhapatnam, Zone - 01	082016030254801		Inspected	-	Download File
10	IDL Build Wear Ltd. Plot No. 63 -	L	Vishakapatnam - II	Visakhapatnam,	082016030264307		Inspected	-	Download File

Figure 6.5.1: Screenshot of CIS portal

- As per the inspection report of 31st August 2016 annexed (Volume VI: Part A Annexure-6.5.11), there were 32 orders issued, with some of them containing more than one observation. The important observations are labelling & colour coding, ventilation, training need analysis for workers, occupational health centre upgrading with full time medical officer appointment, reconstitution of Safety Committee, LPG Gas detection, display of notices, condition monitoring of plant & equipment, Safety Survey Report, revision of Onsite Emergency Plan etc.
- In the year 2017, inspection was allotted to Sri G.V.S. Narayana, Deputy Chief Inspector of Factories, Srikakulam and in the year 2018, it was allotted to Sri Ch. Shailendra Kumar, Deputy Chief Inspector of Factories, Vizianagaram. It is true that neither of them carried out the inspection and no report was uploaded. Though the allotment has been done, the inspections were not carried on. The Director of Factories (FAC) informed that explanation of the individuals in this regard has been called for their failure in inspecting this factory.

The Director of Factories (FAC) has further informed that on the inspection made on 18th December 2019, there were 34 orders issued, with some of them containing more than one observation and the copy is annexed (Volume VI: Part A Annexure- 6.5.12). Among them, 16 orders are repeated from the inspection orders of the inspection made in the year 2016 as they were found not complied during the inspection in the year 2019. Besides these 16, there were another 18 orders freshly issued raising the total orders issued to 34. Among them, additional installations without plan approval, conducting safety audit for the year 2019, compliance report for the safety audit report 2018 observations, revision of Onsite Emergency Plan duly including all possible scenario, dyke walls to Styrene process tanks, corrosion to Styrene M6 Tank & Pentane pipelines, Sprinkler systems for HIPS Packing Area, High Noise levels, License amendment for man power increase and welfare officer etc., are freshly added in 2019 inspection.

The Director of Factories (FAC) has informed that the Safety Audit report of the year 2018 has been done by M/s Lumen Engineering Associates (Volume VI: Part A Annexure- 6.5.13) and it was examined. The main observations of the audit with compliance status reported is annexed (Volume VI: Part A Annexure- 6.5.15). As observed from the compliance status, only 13 out of the 23 major observations were complied with and the datelines were fixed for the remaining.

The Director of Factories (FAC) has also informed that the Safety Audit report of the year 2019 has been done by Sri T.E.C. Vidyasagar (Volume VI: Part A Annexure- 6.5.14) and it was examined. The main observations of the audit are annexed (Volume VI: Part A Annexure- 6.5.16). It was further informed that this audit report was submitted in the office of Deputy Chief Inspector of Factories, Visakhapatnam on 13th May 2020 (after the accident). It is noted that the management received the safety audit report during the lockdown period and the exact date, or the action taken status by them on the observations is not known.

The Director of Factories (FAC) reported that the Onsite Emergency Plan was prepared internally and revised by the LG Polymers in the year 2016. The Onsite Emergency Plan was reviewed by Sri. M. V. Rao, Sr. Manager (Safety) and approved by Sri S. S. Prasanth Kumar, GM-Process Technology, B.E.(Mech). Sri S.S.Prasanth Kumar, GM-Process Technology is also "Manager" under Factories Act 1948, thereby he was the custodian for compliance of Factories Act. The Onsite Emergency Plan was updated in response to the inspection orders issued on the inspection made on 31st August 2016 and submitted to the Factories Department on 13th December 2016 along with compliance report of Inspection orders issued. The scenario of chemical leak with respect to toxicity was not identified as one of the possible emergencies in Onsite Emergency Plan, but leaks resulting into fire accident was identified. Styrene vapour release was not identified as an emergency.

The details of Mock Drills conducted once in every 6 months furnished by the Factories Department along with details of functioning of siren are submitted below:

Table 6.5: Details of Mock Drills

S. No.	Date & Time	Scenario & Location	Who Conducted	Who Participated	Observation on Siren
1.	18.02.2020 10:24 a.m.	Fire at samples point during operation de-chocking the bleeder at GPPS process plant.	PPC Mohan Rao, G Raju Satyanarayana, HMP Naveen, Ch V Rao	S Rambabu, AK Goswamy, VS Pawan, A Rajanna, S. Subrahmanyam, G Satish, KGSN ramu, E siva Shankar, P Jaya Sai Krishna, J Ramesh, PA Raju, G Sankar, E Jagadish, GVM Rao, EV Ramana,	Yes. Blown but Emergency siren was not cut off after 2 minutes Duration.
2.	22.08.2019 09:30 a.m.	Overflow of solution tank –A and caught fire at feed preparation section in HIPS plant	PPC Mohan Rao, G Raju Satyanarayana, HMP Naveen, Ch V Rao	N Prebabu, M Pavan Kumar M Mohana Rao UV Ramana M Rajesh Sagar Bora DJ Ganesh A Rupesh Y manoj G Sankar K BalaVenkata Rao G Satish D Gourish V Srinivasa Rao	Yes

S. No.	Date & Time	Scenario & Location	Who Conducted	Who Participated	Observation on Siren
3.	07.02.2019 02:35 p.m.	Fire on Pentane tank form.	P Prasad, Bvva Kumar, Yvln Rao, S Rambabu. In addition to above the following are the third-party observers: Narasimha Raju, Robbin	S. Subrahmanyam, Ch Ramakrishna, G Satish, K Appala Raju, K SudharshanBabu, APG Babu PA Raju, N Jayaram Kumar Ch V Ch Sekhar, A Gopi, P Nageswara Rao, EV Ramana D Satish, E Srinu	Yes
4.	03.08.2018 08: 35 a.m.	HIPS tank form, flash flame occurred while changing the filters.	MV Rao N Satyanarayana VS Pavan KVNR Patnaik	D Kamal Tej N Dhan Sai G Satish K Appla Raju KA Naidu G Sankara Rao RK Prasad PA Raju D Satish GVM Rao	Yes. But Emergency siren was not audible inside Control room.
5.	30.03.2018 08:30 a.m.	Leaking Diesel pump at SMH diesel storage tank.	Fire Squad Technical Advisor Mr. K Srinivas Rao DO Mr. Venugopal	MvRamayya N Dhana Sai Gvm Rao Pv Raju S Anil Kumar Ka Raju MvsTeja KgsnRamu N Satya Srinivas E Shiva Sankar G Sankar RK Prasad Durga Prasad Srinivasa Rao	Yes. Emergency Siren was not audible in GPPS packing section
6.	18.12.2017 11:40 a.m.	Workshop Area	Director (Operations)	A Sriram R Ramesh PA Raju	Yes

S. No.	Date & Time	Scenario & Location	Who Conducted	Who Participated	Observation on Siren
			Technical Advisor AgmHr&Ir G Sankara Rao S&E	M Srinivas Rao G Srinu G Pydi Raju KBV Rao B Sai Mahesh KGSN Ramu D Ramu Ch Srinivas M Srinivasa Rao	
7.	17.05.2017 03:25 p.m.	Minor Fire at FO day tank area.	Mr. Raju Mr. Prasd Mr. DH Lee	KV Rao M Mohan Rao G Sankara Rao R Sarath G Pydi Raju Pa Raju ApGowrinath P Bhaskara Rao UV Ramana SK Patro KGSN Ramu E Venkata Rao E Jagadish D Ramu G Sankara Rao RK Prasad P Gowri Sankar M Srinivas Rao	Yes
8.	10.02.2017 10:30 a.m.	HIPS scrape yard fire.	Director (Operations) Technical Advisor AgmHr G Sankara Rao S&E	M Mohan Rao KGSN Ramu P Raj Kumar B Sai Mahesh S Patro N Kanna Rao A Janardhan Rao G Sankara Rao VN Bhaskar PA Raju RK Prasad	Yes
9.	22.12.2016 08:00 a.m.	Upper dissolvent area at HIPS plant.	Mr. B. Suresh Babu Mr. DH Lee	Mb Aditya UvRamana E Venkata Rao Ch Chandra Sekhar	Yes

S. No.	Date & Time	Scenario & Location	Who Conducted	Who Participated	Observation on Siren
			Mr. K Srinivasa Rao Mr. Ch. Venkateswara Rao	D satyanarayana M Harish Kumar M Srinivas Rao RK Prasad S Nageswara Rao K Naveen	
10.	29.09.2016 02:30 a.m.	Fire at M6 SM tank	Mr. KVNR Patnaik, Night Duty Officer & Mr. TR Durga Rao	V A S Srinivas M P Kumar N Jai Ram Kumar Ch Rajesh K Naveen Sudharshan Madan Prasad KBV Rao ChAppalaSwamy DJ Ganesh	Yes
11.	25.06.2016 01:30 a.m.	Pentane tank flange leak.	Mr. N Satyanarayana Night Duty Officer	Kr Prasad D Ravi Kumar A Rupesh K Chakrapani Ch Rajesh K Surya Rao VN Bhaskar PA Raju CH C Sekar	Yes
12.	28.04.2016 12:55 p.m.	Fire at SM tank (111A) form at HIPS plant.	Technical Advisor AGM – E&I	SVRS Raju CH R Krishna PS Sampath J Ramesh R Ram Tej R Sarath G Sathish Madusudan K Santosh KGSN Ramu D Naveen A Janardhan M Srinivas	Yes
13.	29.03.2016 11:20 a.m.	Gas caught fire at Pentane tank.	MR. SV PRaveen Mr. DH Lee	L Anandam R Ramesh PS Sampath UV Ramana	Yes

S. No.	Date & Time	Scenario & Location	Who Conducted	Who Participated	Observation on Siren
				R Ram Teja A Gowrinath G Satish BYK Reddy P Bhaskara Rao KGSN Ramu G Dhan Raj P Surya Rao PA Raju	
14.	15.10.2015 08:15 a.m.	Pentane tank form.	Not Available in records	SVRS Raju CH R Krishna PA Raju K Santosh Kumar Samba Siva Rao J Ramesh G Srinu E Rajesh N Jay Ram Kumar KGSN Ramu M Surya Rao	Yes
15.	16.09.2015 08:10 a.m.	Pentane tank form.	Not Available Records	L Anandam Ch Rama Krishna PA Raju G Paidi Raju D Satyanarayana J Ramesh M Pavan Kumar G Madhusudhan N Jay Ram Kumar KGSN Ramu	Yes
16.	13.01.2015 08:15 a.m.	EPS abandoned acid handling area.	Mr. E. Appa Rao Mr. DT Rao Mr. BYK Reddy Mr. R Ramesh	S Subrahmanyam Ch Rama Krishna R Ramesh SS Prakash UV Ramana RS Prakash KBY Reddy E Appa Rao D Satyanarayana D Tata Rao JC Sekhar J Appa Rao	Yes

The Committee observed that the Director of Factories (FAC) has reported that the Onsite Emergency Plan was not displayed in the website of the LG Polymers. An important point regarding the mock drills to be noted is that the siren was tested nearly in all the mock drills. However, it was not used in the real emergency.

The Director of Factories (FAC) has reported that, the MSIHC Rules (Rule No.14 and AP Factory Rules (Rule No.61(SB)D.14) provide for preparation of Offsite Emergency Plan. The District Collector is the concerned authority for preparation of Offsite Emergency Plan as per Rule 14 read with Schedule 5 of the MSIHC Rules, 1989. Hence, there is no separate Off-site Emergency Plan required to be done by LG Polymers. However, creating awareness to public in the nearest vicinity and alerting them in case of emergency falls in the responsibility of LG Polymers Management as a part of Onsite Emergency Plan under rules.

The Offsite Emergency Plan for Visakhapatnam District was prepared by Environment Protection, Training and Research Institute (EPTRI), Hyderabad and Indian Institute of Chemical Technology (IICT), Hyderabad in association with Safety Service Centre, Netherlands. The report was submitted to District Collector, Visakhapatnam and the same was forwarded to Factories Department with an endorsement in the year 2007. The experts have not identified the Styrene Vapour release as a scenario in the Off-site Emergency Plan for LG Polymers. The LG Polymers was considered for Fire Emergency.

The Director of Factories (FAC) has reported that, Mock Drills on Off-site Emergency Plan are being conducted every year involving Government Departments & Industries. However, he has also reported that none of the last five mock drills was conducted with the scenario of an accident in LG Polymers. Further, the LG Polymers also has not conducted any mock drill involving nearby community. No Off-site Mock Drill was conducted in respect of scenarios related to LG Polymers.

The Director of Factories (FAC) has reported that the responsibility for the use of Siren for Emergency alert vests solely with the respective factories. In any scenario of offsite emergency, the factory shall first activate their onsite emergency protocol wherein the Emergency Siren activation becomes part and parcel of the protocol. Alerting the public next to the factory shall be with the respective factory as well. The LG Polymers had not put in any infrastructural arrangements to alert the community in case of an emergency, other than Siren at the factory, which was also not activated at the time of accident. The Offsite Emergency Plan was also not displayed in the website of the LG Polymers. No notice pertaining to important actions of the off-site emergency mitigation was displayed near main gate of the LG Polymers.

The Director of Factories (FAC) reported that in accordance with the MSIHC Rules, 1989 (Rule 7 to 9), site notification in Schedule 7 was found not submitted in the recent past. As per the Schedule 3 of the MSIHC Rules, 1989 conducting Safety Audit by Expert third party and preparation of Safety Report are mandatory if the inventory of the Styrene (being the major raw material) is 20,000 tons or more. Even for the other hazardous raw material i.e., Pentane, the threshold quantity for these reports is 10,000 Tons. Hence, conducting third party safety audits and preparation of Safety Reports are not mandatory for this factory. However, the third-party safety audits are being organized by the management every year, each time with a different third party.

It is further reported that in accordance with Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996 (CAEPPR Rules, 1996), State Crisis Group was constituted vide GO Rt No.540 LET&F (Lab-II) Department, dated 20th July 2016. The meeting of State Crisis Group was held on 13th September 2017. District Crisis Group (DCG) was constituted and reconstituted in the year 2010 and 2017. DCG meetings were conducted on 06th January 2017, 02nd March 2013, 15th September 2010 & 19th February 2010. Off-site mock drills were being conducted once in a year. Recent off-site drills were conducted on 23rd March 2019, 23rd March 2018, 24th March 2017, 29th March 2016, 08th June 2015, 20th February 2015. Local Crisis Group (LCG) related to the LG Polymer area is not yet constituted, hence no Local Crisis Group meetings were conducted.

The Director of Factories (FAC) further reported that the Director of Factories (FAC), the Joint Chief Inspector of Factories, Visakhapatnam, the Deputy Chief Inspector of Factories, Visakhapatnam and Inspector of Factories –I, Circle have been there in the accident scene from the day of the accident and worked in tandem with district administration, Members of different Committees, Experts who visited from different intuitions both inside and outside the state etc. and enquired into various aspects of the accident. Assisted the district administration in management of technical aspects of this accident. Internal Technical Committee had been constituted by the District Collector for monitoring the accident scene and to update the District administration under the Chairmanship of the Director of Factories (FAC), Andhra Pradesh with the Deputy Chief Inspector of Factories, Visakhapatnam along with two other experts as members. The committee had worked with effect from 7th May 2020 onwards till the situation has come to normal. Further, the Director of Factories (FAC) had submitted a report in this regard to the District Collector, Visakhapatnam. Investigated into the accident and submitted a preliminary report on 17th May 2020 and detailed report on 13th June 2020 to Government and the High-Power Committee. Further, continuously assisted in the proceedings of High-Power Committee whenever it was required. Arranged for collection and transfer of data to the different committees investigating the accident. Coordinated with Advocate General office in connection with Writ Petitions filed in Hon'ble High Court in W.P. No.112/2020, W.P. No.117/2020 and W.P. No. 119/2020 and the interim reliefs filed by the LG polymers on the accident. Prohibitory order was issued duly prohibiting all operations involving usage of Styrene. Orders were issued for not disturbing the scene of accident until further orders. Inspection orders shall be issued based on the findings in the investigation along with a Show cause notice and necessary legal action will be initiated through court of law.

The Committee observed that in the year 2017, inspection was allotted to Sri G.V.S.Narayana, Deputy Chief Inspector of Factories, Srikakulam and in the year 2018, it was allotted to Sri Ch. Shailendra Kumar, Deputy Chief Inspector of Factories, Vizianagaram. However, they did not conduct the inspection. The Committee opined that this a serious lapse and the Factories Department, Government of AP have to take action in this regard.

The Committee also observed that the Industries & Commerce Department, Government of Andhra Pradesh should develop a system in the CIS of alerting the Head of the Departments of the concerned regulatory Departments, if any inspection is not carried out within the due date.

On review of the compliance of the inspection notes, it is observed that 16 orders from the inspection made in the year 2016 were found not complied during the inspection in the year 2019. Although three years had elapsed, the LG Polymers had not carried out the required compliances. Besides the above 16, there were another 18 orders freshly issued in 2019. It is not known whether they have been complied with. The reactions of the LG Polymers on the orders in the inspections carried out in 2016 by the Factories Department and not being implemented till 2019, reflects poorly on the safety culture in LG Polymers. Further, it is not known whether the orders arising out of the 2019 inspection have been carried out. Further, the Chapter 2 brings out the details of the lapses in the safety protocols.

Clearly, the Directorate of Factories has not been effective in implementing the provisions of the Factories Act and the other governing laws. It has failed to ensure that LG Polymers abides by all the safety protocols, the Factories Act and the other governing Acts, Rules and Regulations. The State Government should take necessary action in this regard.

On the other hand, the Committee also observed that there exists a very weak institutional structure of Factory Safety compliances in the Factories Department. The Committee observed that there are significant regulatory gaps in plan approvals, issue of licenses, safety audits and compliances. The Committee felt that there is need for structural changes in the manner of implementation of the safety protocol and regulations. This issue has been dealt in detail in Chapter 8.

Further, the Factories Department has not taken action to constitute Local Crisis Group under the Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996. It was informed that it has not been done in many cases. The Committee observed that immediate action should be taken by the State Government to constitute Local Crisis Groups for all industries covered under the MSIHC Rules, 1989 and hold regular mock drills in the Local Crisis Groups.

The non-use of siren in such an emergency on 07th May 2020 is an inexcusable lapse on the part of the LG Polymers in implementation of its Onsite Emergency Plan.

The non-display of the Emergency Plans either in website or at the factory gate or publicizing in the community in any manner are also serious lapses.

6.6 Petroleum and Explosives Safety Organization (PESO)

Petroleum and Explosives Safety Organization (PESO) as statutory authority regulates and enforces the following:

- Explosives Act, 1884
- Petroleum Act, 1934
- Petroleum Rules, 2002
- Explosive Rules, 2008
- Manufacture, Storage & Import of Hazardous Chemical Rules, 1989 (MSIHC Rules, 1989 under E(P) Act,1986)
- Static & Mobile Pressure Vessels (Unfired) Rules, 1981
- Gas Cylinder Rules, 2016
- Ammonium Nitrate Rules, 2012
- Calcium Carbide Rules, 1987

The Deputy Chief Controller of Explosives, PESO, Visakhapatnam submitted reports and are annexed (Volume VI: Part A Annexures- 6.6.1 - 6.6.5).

PESO granted four licenses under provisions of the Petroleum Act, 1934, and the rules made thereunder bearing license No. i) P/HQ/AP/15/40 (P3488) ii) P/HQ/AP/15/788(P4249) iii) P/HQ/AP/15/618(P4078) and iv) P/HQ/AP/15/ 408 (P3874). All the four licenses are valid up to 31st December 2021. PESO granted license No. G/SC/AP/06/835(G5877) valid up to 30th September 2024 under the provisions of the Gas Cylinders Rules, 2016. All the above licenses issued by PESO are in favour of LG Polymers.

The Deputy Chief Controller of Explosives, PESO, Visakhapatnam reported that Styrene storage installation is covered under the Petroleum Act, 1934, Petroleum Rules, 2002 & MSIHC Rules, 1989. As per section 2(bb) under Petroleum Act, 1934, the Petroleum having a Flash Point of 23˚C and above, but below 65oC is classified into "Petroleum class-B". Styrene is having Flash Point of 31˚C, thus it falls under the Petroleum Class-B category. As per rule 13(4) of the MSIHC Rules, 1989, the occupier shall ensure that a mock drill of the On-Site Emergency Plan to be conducted every six months. A detailed report of the mock drill conducted shall be made immediately available to the concerned authority.

The Deputy Chief Controller of Explosives, PESO reported that the Refrigeration system is not mandatory as per the Petroleum Act, 1934, and Rules. Switching off Refrigeration systems every day at 05.00 p.m. does not violate any of the Petroleum Act, 1934, and Rules. The periodicity of inspection of licensed premises is not defined in the Petroleum Rules, 2002. As per Rule 3 (a) of MSIHC Rules 1989, the concerned authority shall inspect the industrial activity at least once in a year. PESO inspection covers conformity of the premises as per the approved plan in accordance with Petroleum Rules, 2002, and deviations with respect to addition/alteration and violations under the provisions and conditions of the said Rules.

The premises of LG Polymers (Storage Tanks areas) was inspected by Deputy Chief Controller of Explosives on 25th November 2015 and observed the following violations:

- Earthing was found connected from the tank to earth pit, but the latest test results have not been displayed at the site. However, data available in the official record. Please update the data at the site.
- Jumpers were found heavily painted at the connecting point. Please avoid the painting at this place to make continuity.
- The hindrance in electric continuity may result in danger to safety.
- The flow direction of the product is missing in some places. Please do the needful to provide it at important turnings as per the provision mentioned in the rules.
- Some vegetation (grass) was found nearby the premises. Please arrange for the cleaning of the area all around.

- The operation manuals were not found displayed on the premises. Please display it in the local language for the ready reference to the technicians.
- Some lose glands electrical control panel observed. Please make it rectified.

Subsequently, Deputy Chief Controller of Explosives reported that rectification notice was issued on 2nd December 2015 and then LG Polymers was inspected on 18th December 2018 and no major violations were recorded. It is also reported that there were no instances of violations from 1997 to till date.

The Oil Industry Safety Directorate (OISD) standards are applicable to various petroleum products, but Styrene was not included. The Committee opined that in view of this accident, the OISD standards should be relooked into.

The PESO reported that the license was issued to LG polymers for storage of Styrene as per the Petroleum Act, 1934. After issuing a license, the PESO officials inspected the industry during 2015 and the latest in 2018. In the year 2018, the officials mentioned that no major violations were noticed. In the year 2015 inspection, the officials mentioned minor violations, but not recorded anything regarding the fitness of the Styrene storage tank. It is also reported that the refrigeration system is switched off at 05:00 p.m. every day at LG polymers whereas no refrigeration system is existing in East India Petroleum Ltd., (EIPL). Further, the officials reported that in accordance with the Petroleum Rules, 2002, the refrigeration system in the petroleum storage tank is not mandatory as per the flashpoint.

The Committee opined that, when the Flash Point of Styrene as per the Indian Standard (IS) 14631:1999 "Styrene-code of safety" is 31˚C, the provision of refrigeration and cooling system should be re-examined in view of the preferred storage temperature of Styrene monomer to be below 20˚C and the tropical conditions prevailing in the country with summer temperatures far in excess of 40˚C being quite prevalent.

Further, the classification of Styrene as a "Petroleum Class-B" product under the Petroleum Act, 1934, and Rules also needs to be revised as the literature on liquid Styrene monomer strongly suggests that the storage temperature should be maintained below 20°C and in no case should exceed 25°C.

PESO reported that after the accident, the Deputy Chief Controller of Explosives, Visakhapatnam vide letter dated 8th May 2020 requested the District Magistrate of Visakhapatnam to conduct Magisterial Enquiry as per Section 28 of the Petroleum Act, 1934. The Deputy Chief Controller of Explosives, Visakhapatnam vide letter dated 8th May 2020 advised LG Polymers to submit documents such as purchase details of Styrene, name of the supplier, tank wise product details, its capacity stored during shut down period, plant wise maintenance record for the last six months, and other details to the Office of the Deputy Chief Controller of Explosives, Visakhapatnam. Further, LG Polymers was advised to undertake instant corrective safety measures to cope up with the accident scenario & to avoid re-occurrence of a similar accident. Letter dated 9th May 2020 was issued by Deputy Chief Controller of Explosives, Visakhapatnam to LG Polymers to constitute an expert committee to study cause; circumstances and other factors led to the accident and also advised to submit the safety measures undertaken by them during shut down period of the premises and to understand the lapses, circumstances and possible methods to handle the situation safely and effectively.

The Deputy Chief Controller of Explosives, Visakhapatnam reported that they have only 4 no. of officers for entire Andhra Pradesh and there are nearly 14,000 registered PESO Units in Andhra Pradesh apart from the mobile tankers. It is also reported that it is the only organization of its kind directly overseeing the safety requirements for over 3 lakhs of hazardous units in India.

The Committee noted that clearly, the Organization is small in size with very limited capacity. The Committee observed that this Organization has become more of a licensing authority than a safety regulatory authority.

The Committee opined that there is a need for a total overhaul of the safety regulatory system, as safety is of paramount importance. At present, safety does not seem to be given full importance and is being treated more like a licensing provision. Chapter 8 discusses this issue in detail.

6.7 Boilers Department

The Boilers Department is governed by the following Acts and Rules:

- The Boilers Act, 1923
- Indian Boilers Regulations, 1950
- Andhra Pradesh Boiler Rules, 1967
- Andhra Pradesh Economiser Rules, 1959
- The Boiler Attendants Rules, 2011
- The Boiler Operation Engineers' Rules, 2011

The Director of Boilers submitted reports and are annexed (Volume VI: Part A, Annexure- 6.7.1 - 6.7.3). The Director of Boilers, Visakhapatnam has represented before the Committee on 10th May 2020. The Director of Boilers has reported that the Boiler Department is a Regulatory Department and the main functions of this Department are to carry out statutory inspections of Boilers and issue fitness certificates periodically in the State to avoid Boiler explosions by implementing the above Acts, Rules, and Regulations.

The Director of Boilers reported that as per the Boilers Act, 1923, any Boiler will be inspected by the officer of the department within 15 days from the date of receipt of the application and the fitness certificate is issued for a period of one year if the condition of the boiler is satisfactory. Criteria for coverage of the boiler as reported by the Director of Boilers are furnished below:

"All Boilers are covered as per the definition under Sec. 2 (b) of the Boilers Act, 1923.

Sec. 2(b): "boilers" means a pressure vessel in which steam is generated for use external to itself by application of heat which is wholly or partly under pressure when steam is shut off but does not include a pressure vessel,

(i) with a capacity less than 25 liters (such capacity being measured from the feed check valve to the main steam stop valve).

(ii) with less than one kilogram per centimeter square design gauge pressure and working gauge pressure; or

(iii) in which water is heated below one hundred degrees centigrade”

The Director of Boilers has reported that 3140 Boilers operating in Andhra Pradesh State covered under the above definition. LG Polymers is having 2 number of Fire tube boilers with Registration Nos. AP 3185 and AP 3963. Boiler No. AP 3185 was installed in the year 1998. Boiler No. AP 3963 was installed in 2004. Boiler No. AP 3963 is operated continuously, and Boiler No. AP 3185 is operated very sparingly. These boilers are inspected regularly and certified every year since installation.

Certificate validity details of boilers as reported by the Director of Boilers are as below:

Table: 6.6: Certificate Validity Details of Boilers as reported by the Director of Boilers

S. No.	Boiler No.	Validity	Remarks
1	AP 3185	1st April 2020	Inspection exempted vide G.O. Rt No.356 dated 21st April 2020 of Labour, Factories, Boilers & Insurance Medical Services (Labour.II) Department due to lockdown
2	AP 3963	1st December 2020	Inspection is due in December 2020

The Director of Boilers, the Deputy Chief Inspector of Boilers, Visakhapatnam region, and the Inspector of Boilers, Visakhapatnam Circle visited the LG Polymers on 8th May 2020, 9th May 2020, and 10th May 2020, inspected both the boilers. Boiler No. AP 3963 was lighted up for testing on 6th May 2020 at 10:00 am and stopped on 6th May 2020 at 03:00 p.m. Boiler No. AP 3185 was in idle condition. The LG Polymers kept both the boilers under wet preservation during the lockdown period. Boilers were not affected because of the accident that occurred on 7th May 2020 in the plant. At present the condition of boilers is satisfactory.

The Director of Boilers reported that, no safety audit is required as per the Boilers Act. If any accident occurs to the Boiler, the owner has to inform the Boilers Department within 24 hours as per the Act. No accident occurred to either of the Boilers right from the beginning of operations. Issuance of license for Styrene storage tanks is not under the purview of the Boilers Department. No complaints are received by the Department in the last five years against the operations of the Boilers.

The Committee noted from the above that there is a valid Boiler license, especially for boiler no AP 3963, which is being operated continuously as per the report of the Boiler department. Even in respect of the other boiler AP 3185, the boiler license is valid up to 1st April 2020 and it has been permitted and extended, in view of the Covid-19 Lockdown. It is also observed from the report of the Director of Boilers that all annual inspections have been carried out except the one which became due in the lockdown period.

The Director of Boilers has also reported that both the boilers were kept under wet preservation during the lockdown period. It is very important to note that the Director of Boilers has stated "Boiler No. AP 3963 was lighted up for testing on 6th May 2020 at 10:00 a.m. and stopped on 6th May 2020 at 03:00 p.m.". The Managing Director and other Senior Officers who had represented before the committee on 7th June 2020 had stated that the company had mainly taken up Covid-19 sanitation measures and preparing the factory for starting. They had not mentioned anything about the lighting of the Boilers for testing. From the above, it can be construed that the factory management had indeed taken some technical steps towards starting the factory.

The Director of Boilers reported that there were no accidents in either of the boilers. He further reported that boilers are not affected because the accident occurred in the plant. He has also confirmed that no complaints are received by the department against the operations of the boilers in the last 5 years.

The Committee opined that the boiler is potential equipment for accidents to occur ranging from fatal to minor accidents. The accidents may be due to structural failure of the Boiler, failure to follow Standard Operating Procedure (SOP) by the operators, etc. The accident may trigger fire or gas leakages in other parts of the industry culminating in a bigger accident. Hence, Boiler safety is of utmost importance in terms of safety as a whole. However, the Boilers Department in Andhra Pradesh is manned with 14 field officers consisting of Director of Boilers, five Deputy Chief Inspectors of Boilers, eight Inspectors of Boilers with very minimum facilities. The department is very weak at present to monitor 3140 boilers in the State and is in dire need of strengthening and restructuring. The restructuring is discussed in detail in Chapter 8.

6.8 Labour Department, Government of Andhra Pradesh

The Labour Department regulates and enforces the Labour laws which include the following:

- Employees Compensation Act,1923
- Trade Unions Act, 1926
- Industrial Employment Standing Orders Act, 1946
- Industrial Disputes Act,1947
- Minimum Wages Act, 1948
- Contract Labour (Regulation & Abolition) Act, 1970
- Payment of Gratuity Act, 1972
- Equal Remuneration Act, 1976
- Inter-State Migrant Workers Act, 1979
- A.P. Labour Welfare Fund Act,1987
- A.P. Integrated Registration Act, 2015

The Joint Commissioner, Labour Department, Visakhapatnam submitted reports and are annexed (Volume VI: Part A Annexures- 6.8.1 - 6.8.3, 6.8.5 & 6.8.6). The Joint Commissioner, Labour Dept., has also made his oral submissions in the hearing before the Committee on 10th May 2020.

The Department is the registering and licensing authority under the Contract Labour Act, 1970. In the report, the Labour Dept has stated that the management who engage contract workers have to Register their Factories under Section 7(1) of Contract Labour Act and obtain the principal employer certificate under Section 7(2) of the Contract Labour (R&A) Act from the Labour Department.

The contractor engaged by the principal Employer should take the prescribed license from the Labour Department under Section 13(2) of the Contractor Labour (R&A) Act, 1970. Due to the policy of the Government on Ease of Doing Business, all the management, and the contractors can get their certificates or licenses directly from on-line through the eSeva portal under the Integrated Registration Act, 2015 without approaching Labour Department. Further, the contractor employing less than 50 workers need not take any license under the Contract Labour Act.

Labour Department has not issued any clearances to the management of LG Polymers, Visakhapatnam for contract labour. However, during the various statements to the Committee, it is observed that a large portion of the employees has been taken on a contract basis. The Labour Department needs to verify whether all the required Rules and Regulations have been followed by LG Polymers in respect of contract employees.

The report of the Joint Commissioner, Labour further states that the main role of the Labour Department is to maintain peace in the industry and act as conciliation authority under Section 4 and clause (b) of Sub Section (1) of Sec 25 No of Industrial Disputes Act, 1947 to resolve the issues between the management and its employees.

The Department also acts as Commissioner under Section 20 of the Employees Compensation Act, 1923. According to Section 3(1) of the said Act, the employer is liable to pay the compensation, if the personal injury caused to a workman by accident arising out of and in the course of employment.

In this regard, it is to be noted that the Labour Department has not reported personal injury to any workman due to the accident in its report dated 24th May 2020.

LG Polymers communicated copies of Form No: 18 (2 Nos) [prescribed under Rule 96 and under Regulation 68 of Employees State Insurance Act, 1948] through e-mail dated 16th May 2020 (Volume VI: Part A Annexure- 6.8.4) to the Regional Office, APPCB, Visakhapatnam along with the copies of the Form – 10 [under Rule 19 (1): Manifest for Hazardous and Other Waste] regarding disposal of liquid waste to M/s Ramky Pharmacity (I) Ltd., Parawada, Visakhapatnam District.

From the details of Form – 18, it is noticed that 2 nos. of contract workers namely Sri. Gantala Sankara Rao, 34 years (ESI No. 7005598261), Kottavalasa, Vizianagaram District, and Sri. Pedapudi Appala Raju, 34 years (ESI No 7009855172), Kancharapalem, Visakhapatnam District were injured at 9.30 a.m. on 7th May 2020 while pouring NDM (Normal Dodecyl Mercaptan) in FCT to charge in M6 Tank through foam pourer. It is also mentioned in Form-18 that after opening the drum cap while pouring in the FCT tank, material spilled on the body and treatment was given at Apollo Hospital, Health City, Arilova, Visakhapatnam District for skin allergy rashes on the body.

Though the injuries to two contract workmen reported to be happened on 7th May 2020 at 09:30 a.m., the LG Polymers furnished Form-18 (2 Nos) only on 16th May 2020 through mail along with two Hazardous Waste Manifest copies (Form-10) to Regional Office, APPCB, Visakhapatnam. Further, the management has not informed about injuries to two contract workmen to the Labour Department. It is also not clear as to why the Form-18 were communicated to the Regional Office of the APPCB. The Labour Department needs to investigate this issue.

The Labour Department has informed that it has not done any inspections and not issued any notices to the management of the LG Polymers for the last ten years. As part of the Ease of Doing Business (EoDB) 2019 reforms, it is mandatory to conduct a joint inspection of an establishment by the Inspector of Labour, Factories, and Boiler at a time. No inspections were conducted by the department as per EoDB 2019.

The Central Inspection System (CIS) portal was verified and it is noticed from August 2016 there is no inspection by the Labour Department. Further, the Joint Commissioner vide letter dated 14th June 2020 informed that it is mandated to conduct joint inspections of an establishment by the Inspector of Labour, Factories, Boilers at a time. The Labour Department has stated that no inspections were allocated on the on-line portal or any message from the Factories and Boilers Inspectorates. However, it is to be noted that both the Factories and the Boilers Department have conducted their inspections as seen from their reports. It is only the Labour Department which has not conducted any inspection and the Labour Department needs to explain the above.

Non-inspections of the factory, from the labour point of view for the last 4 years from 2016 definitely raise concerns about the system being followed in the Labour Department. The Labour Department should immediately verify the inspection systems followed in the department, along with the systems adopted in the CIS and take corrective action.

It is also stated by the Labour Department that it has not conducted the inspection and not issued any notices to the management of LG Polymers in the last 10 years. This issue is also of serious nature as there is neither an inspection nor a third-party audit of compliance. It is suggested that the Labour Department look into this issue seriously for the introduction of a third-party annual compliance audit system for the labour laws. Inspections can be limited only for cases that are in violation of the audit reports or on any specific complaints.

From the statement and report of the Joint Commissioner, Labour, the Committee also feels that the Labour Department considers itself as a very peripheral department in the new environment of ease of doing business. The Ministry of Labour, Government of India is also in the process of bringing out consolidated labour codes. It is desirable that the role and function of the Labour Department be clearly defined in the following three Codes:

- The Code on Wages, 2019: Role and function in the implementation of minimum wages and other compensations.
- The Industrial Relations Code: Role and function in Reconciliation and dispute resolution.
- The Code on Social Security: Workers' welfare including medical and provident fund facilities.

6.9 Department of Industries, Government of Andhra Pradesh

The department implements the following Acts:

- Industries Development & Regulation Act, 1951.
- Andhra Pradesh Industrial Single Window Clearance Act, 2002
- Micro, Small, and Medium Enterprises Development (MSMED) Act, 2006
- Andhra Pradesh Public Services Delivery Guarantee Act, 2017.

Reports of Department of Industries are annexed (Volume VI: Part A Annexures- 6.9.1 - 6.9.4). The Department of Industries promotes industrial development in the State of Andhra Pradesh. The Department guides the entrepreneurs and expedites the processing of various Licenses, Clearances, and Certificates required for setting up of Industrial Undertakings and also provides for an Investor friendly Environment. As per Single Window Clearance Act, every entrepreneur shall submit application forms to the Nodal Agency (Industries Department). Under Section 14 of the Single Window Clearance Act, the Government prescribed time limits for processing and disposal of applications by the competent authorities and under Section 15 (1), failure of the competent authority to pass final orders on the application within the stipulated time results in deemed approval, for certain clearances only. However, the list of deemed approvals does not cover the safety and pollution related approvals of APPCB, Factories and Labour Departments.

The State Government by notification constituted a District Single Window Clearance Committee under the Chairmanship of the District Collector and also State Committee under the Chairmanship of Commissioner of industries to review and monitor the speedy processing of single window applications by the Competent Authorities.

The Director of Industries reported that the Government of Andhra Pradesh has issued the Andhra Pradesh Public Services Delivery Guarantee Rules, 2018 vide G.O.MS. No. 101 dated 4th September 2018 (Volume VI: Part A Annexure- 6.9.3.1) for delivery of transparent, efficient, and timely public services to the eligible persons/Applicants in the State of Andhra Pradesh. 73 services including approvals/license/consent/permissions pertaining to regulatory Departments, namely APPCB, Factories Department, Boilers, Municipal Administration, etc. Under the Public

Service Delivery Guarantee Act (PSDGA), every applicant seeking to apply for public services required for establishment and operation of the industry shall apply online on Single Desk Portal for services covered therein, in the Prescribed Formats for such public services relevant to industries available on Single Desk Portal.

The Director of Industries further reported that LG Polymers has proposed expansion in the year 2017 i.e to manufacture a new product "Engineering Plastic" through the Single Desk Portal. Clearances were issued by the respective departments. Basing on the investments in plant and machinery, LG Polymers is classified as a large enterprise i.e. the value of plant and machinery is more than ₹ 10.00 Crores. The unit holder has taken Industrial Entrepreneurs Memorandum (IEM) from the Ministry of Industries and Commerce Department, Government of India on 27th January 2000. The Industries Department will visit the industries of those filed applications for scarce raw material, marketing support, incentives or any other Government support. As no proposals were received from the LG Polymers for incentives, no inspection was conducted by the Industries Department so far.

It is further reported that the District Industries Centre, Visakhapatnam has not received any request from the LG Polymers to issue passes for the employees of the unit to attend the industry during the lockdown. But the Industry has submitted a representation on 23rd March 2020 to the District Collector requesting permission for operations. The District Collector has forwarded the same to the General Manager, District Industries Centre, Visakhapatnam. In this connection, it is submitted that no operational guidelines were issued by the Government as on 23rd March 2020 but guidelines were issued vide Lr.No.I&C Dept/SPL.CS/171, dated 24th March 2020 (Volume VI: Part A Annexure- 6.9.3.2) allowing the operations for essential Industries only. The manufacturing of Polystyrene & Expandable polystyrene and Engineering Plastics is not an essential industry and hence it was not permitted.

The Director of industries reported that the District Collector, Visakhapatnam has constituted Essential Committee vide Pro. No. 651/2020/C1, Dt. 25th March 2020 with members such as the Joint Collector (VG), Visakhapatnam; Revenue Divisional Officer, Visakhapatnam; the Revenue

Divisional Officer, Anakapalli; the Revenue Divisional Officer, Narsipatnam; the General Manager, DIC; the EE, APPCB, Visakhapatnam; Inspector of Factories; and Zonal Manager, APIIC(Regular).The committee shall examine all essential Industries of the District on case to case basis and ensure that permission is granted for minimal movement of employees for essential Industries and essential Government Departments by way of issuing necessary ID cards to attend their duties. LG Polymers has submitted a letter to Joint Collector on 28th March 2020 stating that based on the District Collector order dated 23rd March 2020 they have stopped / shutdown continuous process Plant on 23rd and 24th March 2020 and requested to issue passes for 60 persons to monitor the raw-material inventories round the clock as the raw- material are need to be maintained in refrigerated condition. The Joint Collector has instructed the Essential Committee to issue 15 personal passes per shift. Accordingly, the Essential Committee has issued 45 Personal / duty passes for 3 shifts.

The LG Polymers submitted representation through mail on 4th May 2020 addressed to the District Collector requesting permissions to resume Plant Operations on the relaxations given in the Lockdown 3.0. The Director of Industries reported that the Government has issued GO Rt.No. 98, Industries & Commerce (P&I) Department Dt. 3rd May 2020 (Volume VI: Part A Annexure-6.9.3.10) allowed all the industries in Urban and Rural areas to restart their operations duly submitting Self-Declaration in the www.apindustries.gov.in/COVID19 that their unit is not in the Containment Zone and will follow all the social distancing and hygiene norms for Covid-19. But on verification, it is found that they have not filed any application in the portal.

The Committee noted from the above narration that during the Covid-19 lockdown period, the LG Polymers was not given permission to operate, as it was considered as a non-essential industry. However, it was issued 45 passes at the rate of 15 per shift for maintaining the critical operations. The Technical Committee has pointed out that the company has never made any special application to the Collector to get permitted to operate in the lockdown period in view of the hazardous nature of the chemicals. Even after the issue of the GO Rt.No. 98, Industries & Commerce (P&I) Department dated 3rd May 2020 although the company in its oral depositions informed that they were planning to start the company, it is noted that no-self declaration was filed till the time of the accident. As seen from the notes of the Industries Department, they state that e-mail was sent on 4th May 2020. However, no self-declaration was made by them as per the provisions of GO Rt.No. 98, Industries & Commerce (P&I) Department dated 3rd May 2020.

A very important feature of the LG Polymers accident is that the residential areas have come up next to factory boundaries. The buffer zone with tree cover was also available with a limited width. It is strongly suggested that in the development of chemical industrial areas by the Industries Department/APIIC, a buffer zone of minimum 100 – 500 mts shall be maintained within the factory / industrial park premises all along the periphery. Further, there should be strict Town Planning guidelines so that residential areas will not develop near to the industrial establishment for a specified distance, which can be prescribed based on the hazard and pollution potential.

6.10 Andhra Pradesh Pollution Control Board (APPCB)

AP Pollution Control Board is a regulatory body constituted in the year 1976 for the state of Andhra Pradesh and was established under Section 4 of the Water (Prevention and Control of Pollution) Act, 1974 (Water Act, 1974).

The guiding legislations of A.P. Pollution Control Board are as follows:

- Water (Prevention and Control of Pollution) Act, 1974 (the Water Act, 1974)
- Air (Prevention and Control of Pollution) Act, 1981 (the Air Act, 1981)
- Environment (Protection) Act, 1986 (E (P) Act, 1986)

The main functions of the Board include prevention and control of water pollution and air pollution for which various provisions have been made in the Water Act, 1974 and the Air Act, 1981. The Central Government enacted an umbrella Act i.e., Environment (Protection) Act, 1986 for protection and improvement of Environment. The Central Government is empowered to make rules under this Act on various environment related issues such as the Hazardous and Other Waste (Management and Trans-boundary Movement) Rules, 2016, the Bio Medical Waste Management Rules, 2016, the Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 (MSIHC Rules, 1989) and the Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996 (CAEPPR Rules, 1996) etc. The Environment Impact Assessment (EIA) Notifications of 1994 and 2006 were also issued under the E (P) Act of 1986. The State PCBs are authorized agency in respect of some rules issued under the E(P) Act.

The APPCB submitted reports on 10th June 2020 and 15th June 2020 and are annexed (Volume VI: Part B Annexures- 6.10.1 & 6.10.2). The APPCB reported that Consent for Establishment (CFE) and Consent for Operation (CFO) was issued to the LG Polymers from time to time. Details of Consents for Establishment and Consents for Operation issued by the APPCB to the LG Polymers from 1993 onwards is annexed (Volume VI: Part B Annexure-6.10.1.4). The Committee noted that the present CFO Order dated 19th January 2017 (Volume VI: Part B Annexure- 6.10.1.28) is valid up to 31st December 2021 for the manufacture of Polystyrene @ 313 Tons Per Day (TPD), Expandable Polystyrene @ 102 TPD; and for production of Engineering Plastics @ 36.67 TPD up to 30th April 2023, as per CFO Order dated 20th June 2018 (Volume VI: Part B – Annexure: 6.10.1.31).

The Committee noted that the CFO for Polystyrene and Expandable Polystyrene was issued under normal renewal procedure on 25th November 2015 (Volume VI: Part B – Annexure: 6.10.1.25) with validity up to 31st December 2016 for production of Polystyrene - 315 TPD (Limited to 1,10,000 Tons Per Annum (TPA) and Expandable Polystyrene - 100 TPD (35,000 TPA). Subsequently, the APPCB, with a view to promote Ease of Doing Business (EoDB), introduced an Auto-Renewal System vide circular dated 5th February 2016 (Volume VI: Part B Annexure- 6.10.5) for combined Consent for Operation (CFO) and Hazardous Waste Authorization (HWA) to all categories of Industries / Projects / Activities based on self-certification subject to certain conditions. Further, the APPCB vide Circulars dated 23rd July 2015 & 24th February 2016 (Volume VI: Part B – Annexure: 6.10.6 & 6.10.7) has taken a stand to renew the CFO of Red category of industries for 5 years, Orange category of industries for 10 years and for Green category of industries for 15 years. The LG Polymers obtained CFO renewal through Auto Renewal System from the APPCB on 24th October 2016 for validity up to 31st December 2021 (Volume VI: Part B Annexure- 6.10.1.26). There was no change in the production capacity in the Auto Renewal CFO.

However, the LG Polymers again applied for CFO for change of product mix for Polystyrene from 315 TPD to 313 TPD (Limited to 109000 TPA) and Expandable Polystyrene from 100 TPD to 102 TPD (36000 TPA), which was accorded CFO by the APPCB as per normal procedure on 19th January 2017 (Volume VI: Part B Annexure- 6.10.1.28). However, this change was carried out with the same validity up to 31st December 2021. This is the CFO presently valid for the production of Polystyrene and Expandable Polystyrene.

The Committee also noted that subsequently, the LG Polymers again applied for setting up of a new product i.e., Engineering Plastics and the APPCB issued CFE on 4th May 2017 as per the normal process. The LG Polymers carried out the establishment of Plant for production of Engineering Plastics and the APPCB granted CFO for this new product line, i.e., Engineering Plastics with the production capacity of 36.67 TPD on 20th June 2018 valid up to 30th April 2023 (Volume VI: Part B – Annexure: 6.10.1.31). This is the CFO presently valid for the production of Engineering Plastics. The LG Polymers again approached for expansion of the Engineering Plastic Unit for additional production of 25.83 TPD and CFE was issued by the APPCB on 27th December 2018 (Volume VI: Part B Annexure- 6.10.1.32). The LG Polymers has not applied for CFO for this expansion till now. As noted from local information, the expansion works are not started.

The Committee observed that the process of Auto Renewal for Environmental issues is fraught with danger and should be relooked in to. Further, the Committee also felt that for such critical parameters like Air Pollution and Water Pollution and other Environmental concerns, the validity period of CFO for 5 years for a Red category Industry and 10 years for an Orange category Industry are extremely long periods. Instead, the Committee felt that the system of annual Environment Statement from the Red and Orange category Industries (duly audited by Competent Environmental Auditors for large Industries) should be introduced and the CFO should be linked to this Audited Annual Environmental Statement. The CFO should be renewed every year automatically, only if the Audited Annual Environmental Statement states that all the Environmental norms are strictly followed and the Compliances for all the conditions in the CFO are fully met.

The Committee examined the present valid CFOs issued on 19th January 2017 for the products Polystyrene @ 313 TPD (Limited to 109000 TPA) and Expandable Polystyrene @ 102 TPD (36000 TPA) and the CFO issued on 20th June 2018 for 36.67 TPD of Engineering Plastics and noted the compliance of the main conditions. The Compliance as per the RO Reports, dated 2nd June 2018 & 7th December 2018 (Volume VI: Part B Annexure- 6.10.1.34) is as follows:

Table 6.7: Compliance as per the reports of Regional Officer, APPCB, Visakhapatnam

Conditions stipulated in Schedule-B of CFO Order	Compliance as per RO Reports, dated 02.06.2018 & 07.12.2018
The industry shall handover the original auto renewal consent order dated 25.10.2016 having valid up to 31.12.2021 to the RO, Visakhapatnam after receipt of this order and the same stands cancelled from the date of receipt of this order.	Complied
The industry shall not manufacture any products other than those mentioned in the order.	Complied
The industry shall maintain 2 CAAQM stations with networking facility to APPCB website. The industry shall maintain existing CAAQM station within the plant for online monitoring of $PM_{2.5}$, PM_{10}, SO_2 & NO_X.	Complied Provided and connected to the APPCB website.
The industry shall maintain the VOC analysers with recording facility and maintain records.	The industry provided mobile VOC analyser with recording facility.
The industry shall comply with the CPCB directions dated 05.02.2014/ 02.03.2015 and guidelines issued regarding online monitoring systems from time to time.	Complied
System of leak detection and repair of pump/ pipeline shall be installed in the plant and immediate response team shall be identified for preventive maintenance.	Complied
The industry shall provide wet scrubber as air pollution control equipment to control process emissions.	The industry has installed high frequency dust and fume collector in place of wet scrubber.

The APPCB officials inspected the LG Polymers every 6 months through the allocation of inspections by a Central Inspection System (CIS) under EoDB. The inspection reports were uploaded in the CIS of Industries Department and the report is available on the CIS Portal for the industry to view/download and take corrective steps on the non-compliances observed by the inspecting officer. The industry was inspected on 16th September 2016, 21st March 2017, 27th October 2017, 23rd April 2018, 12th October 2018, 22nd April 2019 & 25th November 2019. The inspection reports are annexed as (Volume VI: Part B Annexure - 6.10.3).

The recommendations of the latest inspection details conducted on 22nd April 2019 and 25th November 2019 (Volume VI: Part B Annexure- 6.10.1.34) and the comments submitted by the APPCB, in its report dated 10th June 2020 is given below:

Table 6.8: Recommendations of the latest inspection details and the comments of the APPCB

S. No.	Date of Inspection	Recommendations of the Inspecting Officer	Compliance Summary provided by the APPCB in its report dated 10.06.2020 (Complied or not)
1.	25.11.19 and 26.11.19	▪ The industry may be directed to provide above ground level effluent collection tanks. ▪ The industry may be directed to provide filter press for separation of sludge. ▪ The industry shall increase the percentage of treated water into the process. ▪ The industry may be directed to provide fixed VOC analysers with auto recording facility.	▪ There is no condition in the consent order for construction of above ground level effluent collection tanks. However, the inspecting officer suggested for above ground level tanks as an additional measure. ▪ The industry is having sludge drying beds which are adequate as per consent conditions. As a part of the latest technique, the inspection officer suggested for providing filter press. ▪ As reported during the inspection the industry is re-circulating about 30 KLD (13%) of treated effluent. It was increased to 25%. ▪ A fixed VOC analyzer is installed near the Styrene storage tank (unloading point) and the data is connected to their DCS system directly. The interval of the record is 1 Minute. Another portable VOC analyser is used for monitoring of Styrene within industry premises wherever required.
2.	22.04.19	▪ Industry shall dispose of the hazardous waste and other solid waste regularly per CFO order stipulations.	▪ The industry has sent hazardous waste to TSDF till December 2019. The industry is permitted for onsite storage of Hazardous waste for 90 days. Due to lockdown, the industry did not send the

S. No.	Date of Inspection	Recommendations of the Inspecting Officer	Compliance Summary provided by the APPCB in its report dated 10.06.2020 (Complied or not)
		▪ Further action required to strengthen of green belt specially in ETP area and wherever gaps existed.	waste in 2020 till the time of the accident on 07th May 2020. ▪ As per consent condition, the industry has to develop green belt in 33% of the total area i.e., about 70 acres out of total 213 acres. However, the industry developed greenbelt in 91 acres.

The Committee observed that the industry has not provided elevated effluent collection tanks above ground level and also not provided fixed Volatile Organic Compounds (VOC) analyzers with auto recording facility except at the unloading point. The loading/unloading point is about 15 meters away from M5 and M6 Tanks towards inside of the LG Polymers (East side of the M6 Tank) and essentially captures the VOC data if there is any spillage during the tanker loading/unloading operations. There were no VOC analysers with auto recording facility on the West/North West/North direction, as a result of which the Styrene vapour released during the accident could not be measured. Availability of the VOC analysers in this wind direction would have provided accurate data for the presence of VOC (including Styrene vapour) which was not the case during the accident. The VOC data from the loading/unloading point located on the East side of the Tank (opposite side of the Styrene vapour movement) at a distance of about 15 meters cannot be relied upon due to the wind direction. The effect of non-compliance of the direction is important in terms of measurement of impact. The APPCB should take necessary action in this regard.

The MoEF&CC has notified the Standards for Process Emission (General Pollutant) for 'Petrochemical (Basic and Intermediates)" vide amendment G.S.R. 820 (E), dated 9th November 2012 (Volume VI: Part B Annexure- 6.10.4) and stipulated standards for process emissions (General Pollutant) of the VOC [EB, Styrene, Toluene, Xylene and Aromatic, EG and PG] for Ethyl Benzene, Styrene, Toluene, Xylene, Aromatic, EG, PG plants as 100 mg/Nm3. However, the standard for Styrene Vapour emissions was not stipulated in the CFO Orders of APPCB issued any time after the issue of the G.S.R.820 (E) dated 09th November 2012. There is a general condition as below:

"The industry shall comply with all the Rules, Regulations, Standards and Directions issued by CPCB, MoEF&CC and APPCB".

The M5 and M6 Tanks are atmospheric tanks, which would have Vapour emission quite frequently depending upon the temperature conditions, even in normal operating conditions. However, the APPCB has not stipulated this condition regarding Styrene Vapour standards in its Air Consent Order.

This is a serious lapse on the part of the APPCB and the APPCB shall take immediate steps to amend CFO issued to LG Polymers, duly taking into account the possibility of Styrene Vapour emission from the atmospheric M5, M6 Tanks during the regular operations. The APPCB should also examine why the CFEs/CFOs were issued without the provision and take action against concerned.

LG Polymers submitted Environmental Statement in Form-V on 24th September 2019 (Volume VI: Part B Annexure- 6.10.1.35) for the year ending 31st March 2019 which was not audited by accredited Environmental Auditors. The said Environmental Statement mentions that:

- Water consumption for the process was reduced from 185 Kilo Liters Per Day (KLD) to 173 KLD; Cooling water was reduced from 355 KLD to 313 KLD and domestic water consumption was reduced from 42 KLD to 37 KLD.
- Wastewater generation for the production of Polystyrene was reduced to 0.55 Kilo Liter (KL) Per Metric Tons (MT) from 0.64 KL per MT and for Expanded Polystyrene to 2.05 KL Per MT from 2.20 KL Per MT compared to the previous years.
- Planted 25000 saplings at Indian Maritime University & Simhachalam Hills in Green Visakha Programme.
- Practicing monthly 5 drills, conducting half yearly mock drills, and surprise mock drills as preparedness for emergencies.

The Committee observed that the above Environmental Statement is a very perfunctory statement and does not qualify to be an Environmental Statement of a Multi-National Company. The uncontrolled high Styrene vapour emissions from the tank of the LG Polymers resulted in an excessive concentration of Styrene in the atmosphere, which is a violation of Section 22 of the Air Act, 1981. The water bodies in the area were also affected including the drinking water source Meghadrighata Reservoir. This amounts to the violation of Section 24 of the Water Act, 1974. As such APPCB should take necessary action under the provisions of the Air Act, 1981 and the Water Act, 1974 immediately in the matter.

Why was CFE/ CFO issued by the APPCB when the Company LG Polymers had not obtained Environmental Clearance:

As reported by APPCB in its report dated 10th June 2020 (Volume VI: Annexure- 6.10.1), the industry stopped the manufacture of Styrene Monomer in 1993 and started importing the same and continued manufacture of Polystyrene and Expandable Polystyrene. Polymerization process carried in the LG Polymers is not covered in the EIA Notification, 1994. The new EIA Notification, 2006 was issued suppressing the EIA Notification, 1994. The category of “Petroleum products and Petrochemical based processing such as production of Carbon Black and Electrode Grade Graphite (processes other than Cracking & Reformation and not covered under the complexes)” was mentioned in Schedule under 5(e) of the lists of projects that required Environmental Clearance.

The EIA Notification, 2006 was issued on 14th September 2006. The MoEF&CC vide circular F.No.J-11013/41/2006-IA-II (I), dated 14th December 2006 (Volume VI: Part B Annexure- 6.10.8) has given clarification to the operational guidelines that:

> “(i) In cases of change in product mix, changes in the quantities of numbers of products may be allowed without prior Environmental Clearance by the concerned State Pollution Control Board provided such changes in the quantities of products are in the same category and are within the previously granted overall total limits.
>
> (ii) Projects involving modernization of the existing unit with an increase in the total production capacity beyond the threshold limit specified in the Schedule to the

Notification through a change in the process or technology or change in the product mix or de-bottle necking or a combination of these, involving an increase in pollution load will obtain prior Environment Clearance from the concerned regulatory authority under the EIA Notification, 2006."

The MoEF&CC, GoI vide letter dated 15th May 2020 (Volume VI: Part B Annexure- 6.10.9) has given clarification stating that M/s LG Polymers (I) Pvt. Ltd., Visakhapatnam attracts the provisions of schedule 5(e) of the EIA Notification 2006, in reply to the letter addressed by the Zonal Officer, APPCB, Visakhapatnam on 12th May 2020. Accordingly, the issue of CFEs & CFOs by the APPCB, post 14th September 2006 has been examined in detail.

The LG Polymers was having CFO dated 25th March 2004 to manufacture Polystyrene of 235 TPD (70000 TPA) and Expandable Polystyrene of 45 TPD (15000 TPA) with validity up to 31st December 2006 and the same was renewed on 8th May 2007 with validity up to 31st December 2007.

Thereafter, the LG Polymers has applied to the APPCB for change in product mix/renewals/expansions and the present production capacity of Polystyrene was increased from 235 TPD (in 2006) to 313 TPD and Expandable Polystyrene increased from 45 TPD (in 2006) to 102 TPD after EIA Notification, 2006. The LG Polymers also added a new product Engineering Plastics and the present production capacity is 36.67 TPD. The various permissions are classified into three categories, as change in product mix applications with no increase in pollution load; expansion in production capacity and addition of new product. The routine renewals are mentioned wherever applicable. The three categories of applications are discussed below:

CFEs / CFOS issued for Change of Product Mix on no increase in pollution load:

The APPCB received CFE application on 10th October 2007 on ‘no-increase in pollution load’ for change of product mix, limiting the quantity of Polystyrene and increasing the quantity of Expandable Polystyrene. The CFE was issued on 18th March 2008 (Volume VI: Part B Annexure- 6.10.1.13), considering CFE Committee recommendations of no increase in pollution load to manufacture Polystyrene @ 235 TPD (limited to 63000 TPA) and Expandable Polystyrene to increase from (45 TPD to 65 TPD i.e., 22000 TPA) in the CFE Committee in its meeting held on 28th February 2008. Meanwhile, the CFO was renewed with the existing capacity on 19th May 2008 for the manufacture of Polystyrene of 235 TPD and Expandable Polystyrene of 45 TPD with validity up to 31st December 2009. Subsequently, an amendment to this order was issued on 04th January 2009 amending the product mix as per the CFE dated 18th March 2008 to manufacture Polystyrene @ 235 TPD (limited to 63000 TPA) and Expandable Polystyrene of 65 TPD (limited to 22000 TPA) without any change in validity. The Committee felt that this issue whether the EC should have been obtained at this stage be examined by the MoEF&CC, keeping in mind the circular issued by the MoEF&CC dated 14th December 2006, as these were applications for change in product mix with no increase in pollution load.

Similarly, the APPCB received CFE application on 25th November 2016 with 'no-increase in pollution load' for change of product mix for change in production capacity of Polystyrene from 315 TPD to 313 TPD and Expandable Polystyrene 100 TPD to 102 TPD. CFE was issued by the APPCB on 19th December 2016 (Volume VI: Part B Annexure-6.10.1.27) for change of product mix with no increase in pollution load to manufacture Polystyrene @ 313 TPD (limited to 109000 TPA) and Expandable Polystyrene @ 102 TPD (limited to 36000 TPA). The CFO for this change in product mix was issued on 19th January 2017. Like in above case, the committee felt that this issue whether the EC should have been obtained at this stage be examined by the MoEF&CC, keeping in mind the circular issued by the MoEF&CC dated 14th December 2006.

CFEs issued for Expansion for increasing the production capacities:

The industry submitted CFE application on 02nd November 2009 to increase production capacity of Polystyrene, by increasing the number of working days, from 63000 TPA to 80000 TPA (limiting the per day production capacity of Polystyrene @ 235 TPD) and Expandable Polystyrene from 22000 TPA to 25000 TPA (by increasing daily production from 65 TPD to 71.5 TPD). CFE for expansion was issued on 31st May 2010 after considering the recommendation of CFE Committee in its meeting held on 24th February 2010. The CFO for this expansion was issued on 17th

December 2011 with validity up to 30th June 2012. Either the CFE committee or the APPCB did not insist on Environment Clearance during this expansion.

The industry again applied for CFE (Expansion) on 20th January 2012 to increase further production capacity of Polystyrene from 235 TPD (limited to 80000 TPA) to 253 TPD (limited to 87000 TPA) and Expandable Polystyrene from 71.5 TPD (limited to 25000 TPA) to 100 TPD (limited to 35000 TPA). The APPCB processed the CFE Expansion application of the LG Polymers initially in the CFE Committee meeting held on 29th February 2012 and opined that the proposed activity comes under the purview of EIA Notification, 2006 which requires prior EC from MoEF&CC, GoI and directed the proponent to obtain EC and then approach the Board for CFE.

The issue was re-considered in the CFE Committee meeting held on 17th April 2012 on the representation of industry that the activity does not require EC for the following reasons:

- The industry is importing the raw material, Styrene Monomer, from overseas and they have dismantled their Styrene manufacturing unit in 2002 itself.
- The process of manufacturing of EPS resin and Polystyrene are based on the polymerisation of Styrene and does not involve any petrochemical process.
- For the existing plant, they have received CFE for expansion vide order dt. 31.05.2010 without considering EC.
- As per NIC Codes, their product are considered under 302.9 (Manufacturing of plastics) whereas other petroleum products are considered under 314 & 316.
- For producing a similar product, one of their competitor M/s Rattan Polymers in Faridabad near Delhi has gone ahead with the production operations by obtaining NOC / CFE the state PCB (without any EC requirements from MoE&F).

The CFE Committee examined the above representation on 17th April 2012 and recommended for the issue of CFE on the following observations:

- Presently, the industry is importing the raw material Styrene Monomer from overseas and they have dismantled their Styrene manufacturing unit.

- The process of manufacturing EPS resin and Polystyrene are based on the polymerisation of Styrene.
- For producing a similar product, one of their competitor M/s Rattan Polymers in Faridabad near Delhi has gone ahead with the production operations by obtaining NOC / CFE of the Haryana state PCB (without any EC requirements from MoE&F).

The APPCB issued CFE order on 28th April 2012 (Volume VI: Part B Annexure- 6.10.1.20) for expansion to produce Polystyrene @ 253 TPD (limited to 87000 TPA) and Expandable Polystyrene @ 100 TPD (limited to 35000 TPA). The CFO for this expansion was issued on 22nd May 2013 with a validity up to 31st December 2013. The Committee observed that the APPCB, initially, in its CFE Committee meeting on 29th February 2012 insisted for EC from MoEF&CC, GoI for considering CFE expansion of the LG Polymers. But, later the CFE Committee in its meeting on 17th April 2012 reviewed its decision on the representation made by the LG Polymers, dispensing with the applicability of EC and without any clarification from MoEF&CC, GoI. The CFE was issued by the APPCB dated 28th April 2012. Although in hindsight, the Committee felt that having taken a decision initially insisting on the Environment Clearance, the CFE Committee and the APPCB should have at least taken a clarification from the MoEF&CC before undertaking the review.

The industry applied for CFE (Expansion) again on 28th October 2013 to increase production capacity of Polystyrene from 253 TPD (limited to 87000 TPA) to 315 TPD (limited to 110000 TPA) without changing in the production capacity of Expandable Polystyrene 100 TPD (limited to 35000 TPA). The APPCB issued CFE order on 7th February 2014 (Volume VI: Annexure - 6.10.1.4) for expansion to produce Polystyrene @ 315 TPD (limited to 110000 TPA) and Expandable Polystyrene @ 100 TPD (limited to 35000 TPA). The CFO for this expansion was issued on 25th November 2015 with a validity up to 31st December 2016. Either the CFE committee or the APPCB did not insist on Environment Clearance during this expansion.

CFE issued to Engineering Plastics:

The industry applied for CFE (Expansion) on 8th April 2017 to manufacture additional product namely Engineering Plastics (36.67 TPD). The APPCB issued CFE on 4th May 2017 (for expansion to manufacture Engineering Plastics (36.67 TPD) in addition to the existing quantities of Polystyrene (313 TPD) and Expandable Polystyrene (102 TPD) with a condition that industry shall obtain clarification from MoEF&CC, regarding the applicability of EC for the Engineering Plastics.

The LG Polymers on 11th July 2017 requested the APPCB to delete the above condition from the CFE Order citing EIA Amendment Notification dated 25th June 2014 (Volume VI: Part B Annexure-6.10.1.38). As per the Amendment of EIA Notification issued on 25th June 2014, category of activity mentioned under Schedule 5(e), i.e. Petrochemical Based processing (Process other than Cracking & Reformation and not covered under complexes) was changed (from 2006 Notification) to "Petroleum products and Petrochemical based processing such as the production of Carbon Black and Electrode Grade Graphite (processes other than Cracking & Reformation and not covered under the complexes) with a note that “Manufacturing of Products from Polymer Granules is exempt”. The CFE Committee examined the same on 27th July 2017 and recommended to delete the condition from the CFE Order dated 4th May 2017. The APPCB issued CFE amendment order on 07th August 2017. The CFO for this expansion was issued on 20th June 2018 with a validity upto 30th April 2023. The Committee felt that this issue whether the EC should have been obtained at this stage be examined by the MoEF&CC, keeping in mind the circular issued by the MoEF&CC dated 25th June 2014.

Further expansion proposals were submitted by the LG Polymers to increase the production of Engineering Plastics from 36.67 TPD to 62.50 TPD on 29th November 2018 and the APPCB issued CFE for the expansion on 27th December 2018 considering the recommendation of earlier CFE Committee, based on the MoEF&CC circular dated 25th June 2014. As reported by the local officials, the LG Polymers has not started the proposed expansion works of Engineering Plastics from 36. 67 TPD to 62.50 TPD.

To summarize the above, the Committee felt that the issue of whether the EC should have been obtained under the EIA Notification, 2006 for **change in product mix applications by the LG Polymers with no increase in pollution load** vide CFEs issued by APPCB dated 18th March 2008 and 19th December 2016; AND addition of the **Engineering Plastics** (36.67 TPD) as new product

CFE issued by APPCB dated 04th May 2017 and CFE for the expansion of Engineering Plastics on 27th December 2018 be examined by the MoEF&CC, Government of India, keeping in mind the circular issued by the MoEF&CC dated 14th December 2006, and MoEF&CC circular dated 25th June 2014.

In so far as expansion in production capacity of Polystyrene from 235 TPD (in 2006) to 313 TPD and Expandable Polystyrene increased from 45 TPD (in 2006) to 102 TPD is concerned, it is quite evident that the EC under the EIA Notification, 2006 should have been obtained by the LG Polymers. The LG Polymers had not obtained the EC and has applied as a Violation Case to the State Environment Impact Assessment Authority (SEIAA) on 12th April 2018. This issue is further discussed in Chapter 6.11. The Committee observed that the MoEF&CC may take necessary action regarding not obtaining the EC by LG Polymers as per the EIA Notification, 2006.

The issue to be considered by the Committee is whether the APPCB should have continued issuing the CFEs & CFOs, although the EC under EIA Notification, 2006 was not obtained by the LG Polymers 2006 onwards. The APPCB in its report dated 15th June 2020 has reported that, there is no condition that CFE/CFO should not be issued by SPCBs until the issue of EC under the EIA Notification, 2006. The APPCB in its report has quoted the Ministry of Environment & Forest, Government of India in its circular dated 21st November 2006 clarified that no NOC from State Govt., / State PCB is required for EC process by the MoEF. The circular No. F.No.J-11013/41/2006-IA-II (I) dated 21st November 2006 (Volume VI: Part B Annexure- 6.10.2.4) states as follows:

> " i. No NOC from the State Government /SPCB is required for Environmental Clearance Process. Consent to Establish (NOC) and prior Environmental Clearance are separate legal requirements, any project proponent has to fulfil. NOCs required under Water and Air Acts are mandatory requirement under those Acts and will have to be taken as required and do not require to be linked to environmental clearance."

Based on the above, the APPCB has stated that CFEs (NOCs) issued by SPCB are a mandatory requirement under the Water Act & the Air Act and will have to be taken as required and do not require to be linked to EC issued under E (P) Act by the MoEF&CC.

The APPCB also reported that a team of officers from Zonal office, Central Pollution Control Board (CPCB), Bangalore inspected LG Polymers on 11th June 2010 and the Chairman, CPCB vide letter dated 20th October 2010 (Volume VI: Part B Annexure- 6.10.1.3) issued directions to the Chairman, APPCB, wherein, CPCB did not point out about the requirement of the EC to the LG Polymers.

In so far as the expansion by the LG Polymers from 2006 onwards is concerned, the first CFE for expansion was issued by the APPCB on 31st May 2010, after considering the recommendation of CFE Committee in its meeting held on 24th February 2010. Either the CFE Committee or the APPCB did not insist on Environmental Clearance. The second time APPCB processed the CFE Expansion application of the LG Polymers in 2012, initially, the CFE Committee meeting held on 29th February 2012 opined that proposed activity comes under the purview of the EIA Notification, 2006 which requires prior EC from the MoEF&CC, GoI and directed the proponent to obtain EC. However, the CFE Committee reviewed the decision in its meeting on 17th April 2012. The APPCB then issued CFE order on 28th April 2012. As mentioned earlier, the Committee felt that having taken a decision initially insisting on the EC, the CFE Committee and the APPCB should have at least taken a clarification from the MoEF&CC before undertaking the review. The third expansion order was issued by the APPCB in CFE order dated 7th February 2014. Either the CFE Committee or the APPCB did not insist on EC during this expansion. These issues may be examined in detail by the APPCB. The important issue that needs to be considered is whether the CFE under the Water Act and Air Act can be issued in parallel without the EC under the E(P) Act. The APPCB relies on the circular No. F.No.J-11013/41/2006-IA-II (I) dated 21st November 2006 (Volume VI: Part B Annexure- 6.10.2.4) which states that the mandatory requirement under the Water and Air Acts do not require to be linked to the Environmental Clearance. This is a strictly legal issue and the Committee is not in a position to comment on the above. The Committee suggested that this issue be examined in detail by the legal experts. However, if it is held that EC is required before considering CFE under the Water and Air Acts, then there is need to examine the APPCB CFEs issued on 31st May 2010 (CFE Committee meeting held on 24th Feb 2010); CFE order issued on 28th April 2012 (CFE Committee meeting held on 29th Feb 2012 and review held on 17th April 2012) and CFE order issued on 7th Feb 2014 (CFE Committee meeting held on 20th Jan 2014). The Committee mainly observed that having taken a decision initially insisting on the ECs in the CFE Committee meeting on 29th Feb 2012, the CFE Committee and the APPCB should have at least taken a clarification from the MoEF&CC before undertaking the review.

Why no action was taken by APPCB in spite of EC violation

The APPCB reported that the LG Polymers submitted an application to the SEIAA on 12th April 2018 under Category 'B', violation case as per S.O 804(E) dated 14th March 2017 of the MoEF&CC, GoI, New Delhi.

The clauses Nos. 13(3) & 13(4) read as follows:

> Clause 13(3): "In case of violation, action will be taken against the project proponent by the respective State or State Pollution Control Board under the provisions of section 19 of the Environment (Protection) Act, 1986 and further, no consent to operate or occupancy certificate will be issued till the project is granted the environmental clearance".
>
> Clause 13(4): "The cases of violation will be appraised by respective sector Expert Appraisal Committees constituted under sub-section (3) of Section 3 of the Environment (Protection) Act, 1986 with a view of assess that the project has been constructed at a site which under prevailing laws is permissible and expansion has been done which can be run sustainably under compliance of environmental norms with adequate environmental safeguards; and in case, where the finding of the Expert Appraisal Committee is negative, closure of the project will be recommended along with other actions under the law"

The APPCB further reported that, the SEIAA examined the application and concluded that the industry activity falls under Category 'A'. The SEIAA directed industry to approach the MoEF&CC, GoI, New Delhi. Then, the SEIAA also transferred the physical application to the Ministry on 07th January 2020.

The APPCB reported that the EC violation cases are examined by the MoEF&CC, GoI, New Delhi and SEIAA on complaint-based inspections reported by the CPCB, the MoEF & CC etc., and in cases of self-submission of violations by the industry. The EAC recommends for action to the concerned authority i.e., SEIAA/ MoEF&CC as applicable. The concerned authority issues directions to State Govt., / State PCBs for taking necessary action. No communication was received by the APPCB about violation from the MoEF&CC till date on the LG Polymers.

The APPCB also stated in its report that the compliance status of the concerned industries/projects is directly monitored by the MoEF & CC through its Regional Offices. In case of violations, the MoEF&CC on case to case basis is addressing the respective State Governments to take specified action against the defaulting projects. The State Government, in turn, is directing the concerned District Collector or SPCB for the issue of closure orders or launching prosecution/credible action case in 1st Class Magistrate Court. The competent authority to monitor, take note of the non-compliance and initiate action under Section 15 read with Section 19 is with the MoEF&CC, its Regional Offices the CPCB and the SEIAAs.

The APPCB also reported that the Hon'ble NGT in its Order dated 1st June 2020 in O.A. No. 73 of 2020 (LG Polymers Case) commented on EC monitoring at para 37 as below:

- The Tribunal has found the need to revamp the existing regulatory framework quantitatively and qualitatively after noting the status of current monitoring mechanism of the MoEF.
- The Secretary, MoEF&CC and Chairman, CPCB hold a meeting with such other experts for augmenting the institutional setups in MoEF&CC, CPCB and SEIAAs for meaningful monitoring of Category A and B projects. Report is yet to be filed.

The APPCB reported that from the above, it is clear that the EC monitoring responsibility is with the MoEF&CC, CPCB and SEIAAs.

The APPCB further reported that the SEAC and the SEIAA are constituted under provisions of Section 3 (3), of the Environment Protection Act. The SPCBs are not notified as Authority under Section 3 (3) like SEAC & SEIAA. Only in some cases like Bio Medical Waste Management Rules, 2016; Hazardous & Other Wastes (Management & Transboundary Movement) Rules, 2016;

Plastic Waste Management Rules, 2016 & E-Waste Management Rules, 2016 etc, the SPCBs have been authorized by the MoEF&CC. Only in respect of these Rules, the SPCBs are the prescribed authorities.

The APPCB also reported that under the EIA Notification, 2006, Clause 10 provides for Post Environmental Clearance Monitoring. Based on the letter from the Additional PCCF (Central), MoEF&CC, GoI, Regional Office (South Eastern Zone), Chennai, Lr.F. No. DP / 12.1 / 2016-17 / ROSEZ / Mon. SEIAA & DEIAA/1458, dated 12th September 2017, the Government of Andhra Pradesh issued G.O.Ms.No.120, Environment, Forests, Science and Technology (Sec.I) Department, dated 01st November 2018 (Volume VI: Part B Annexure- 6.10.10) wherein the APPCB is notified as the Monitoring Agency to monitor compliance with the terms and conditions of Environmental and CRZ clearance(s) granted by the SEIAA and the District Level Impact Assessment Authority of Andhra Pradesh. No such notifications have been issued for Category 'A' projects by the Government of India. The APPCB has also informed that the MoE&F, Government of India vide circular dated 03rd June 2009 (Volume VI: Part B Annexure - 6.10.2.5) informed that Regional offices of the MoE&F to monitor the implementation of stipulated conditions and environmental safeguards mentioned in the EC. The MoEF, GoI vide Office Memorandum dated 29th June 2010 (Volume VI: Part B Annexure- 6.10.2.6), directed the Regional Offices of the MoEF to send the monitoring reports on the status of conditions stipulated in the EC to the Monitoring Cell within one month in respect of those projects, which have been found in gross violations of EC conditions. The APPCB also reported that it takes action as and when directed by the MoEF&CC under Clause 3 of S.O.804 (E) dated 14th March 2017.

The actions taken by the APPCB under till now, as per the directions issued by the MoEF&CC, GoI / SEIAA to take credible action, the Regional Officers of the AP Pollution Control Board booked cases in 1st Class Judicial Magistrate Courts and the details of few cases are given below:

Table: 6.9: Cases booked by APPCB for EC violation cases

S. No	Name of the Plant	Activity	Direction Dated	Case No
1	M/s Rashtriya Ispat Nigam Ltd., Visakhapatnam Steel Plant, Visakhapatnam.	Steel Plant	MoEF & CC Lr.dt. 02.08.2018 EFS&T Lr.dt. 28.08.2018	200/2019
2	M/s Sri Kumaraswamy Silica Mines (136.944 Ha) has at Sy No. 695/22, 696 of Momidi Village, Chillakur Mandal, SPSR Nellore District	Silica sand mine	Lr. Dt.05.04.2018 from MoEF &CC, GOI, New Delhi.	456/2018
3	M/s Coromandal Mines of M/s India Cements, Yerraguntla V, Y.S.R.District.	Limestone Mine	MoEF&CC Lr.dt. 10.12.2018	250/2019
4	M/s Modern Minerals, Sy No.39/P, Addepalli Village, Chillakur Mandal, SPSR Nellore District	Silica sand	13.03.2017	228/2017
5	M/s B. Rajan Mine at Sy No.36/P, Addepalli Village, Chillakur Mandal, SPSR Nellore District	Silica sand	13.03.2017	227/2017

In addition to above, about 150 cases were booked by the officials of APPCB as per the directions of the MoEF&CC, GoI/SEIAA given to the State Government, during the last few years.

Accordingly, the Committee noted that the essential viewpoint that emerges from the stand of the APPCB that it's the responsibility of the MoEF&CC for monitoring and implementing the provisions of the E(P) Act, 1986 and the EIA Notification, 2006, except where the SPCBs have been authorized under the various Waste Management Rules listed above. The GO Ms. No.120 EFS&T Dept., dated 1st November 2018 also authorizes the APPCB only to monitor the compliances in ECs issued by the SEIAA. The Category 'A' industries where the EC is issued by the MoEF&CC is not within the scope of the APPCB. However, the APPCB takes action as and when directed by the MoEF&CC under Clause 3 of S.O.804 (E) dated 14th March 2017.

The Committee has already observed that atleast the APPCB should have addressed the MoEF&CC for clarification when the LG Polymers applied for CFEs from 2008 onwards, after issue of the EIA Notification 2006. This was not done by the APPCB even in 2012 when the CFE Committee had initially insisted for the EC Clearance but had subsequently reviewed the decision.

The Committee noted that the LG Polymers is operating without EC, as required under EIA Notification, 2006. Based on the circulars issued, there is presently a parallel processing of EC under the EIA Notification, 2006 and CFE under the Water Act, 1974 and Air Act, 1981. The Committee also observed that the implementing and monitoring agency of the E(P) Act, 1986 and the EIA Notification, 2006 has not been clearly spelt out and the areas are not clearly defined. There is a significant regulatory gap in Environmental regulations which need to be addressed. These issues have been discussed in detail in Chapter 8.

The Committee also observed that without waiting for the outcome of the above deliberations, the APPCB should link up its Air and Water Consents with the Environmental Clearance processes under the EIA Notification, 2006. The assessment of the Air pollutants and the Water pollutants can also be integrated with the Environmental Impact Assessments. The issue of CFE under the Air Act and Water Act should be done only after receipt of the EC clearance under the EIA Notification, 2006.

Further, the Committee opines that while considering CFE under the Air Act and the Water Act, the APPCB should take into account the residential areas in the vicinity of the proposed plant location. It should be made a mandatory practice that if the CFE has been accorded for a Red category industry or hazardous industry or an industry dealing with explosive substances, a buffer zone around the industry should also be demarcated and shared with the concerned local bodies. These areas should be strictly marked as prohibited for residential areas or any other type of habitations. It is always preferable that these areas are within the factory premises but earmarked as a buffer zone.

Where the habitations have already come up, like the LG Polymers, the APPCB should consider the factor seriously before considering any expansion especially in Red category industry or hazardous industry or an industry dealing with explosive substances. Further, these industries may be promoted to be relocated to notified industrial zones, away from the habitations, in association with the Industries & Commerce Department. Further, to minimize the likely effects of any accidents, the storage and handling of hazardous chemicals / explosive substances should be limited in the premises close to the habitations. The bulk hazardous chemical storage facilities for these industrial units can be located away from the habitation and transported through tankers/pipelines.

In the Red category industry or hazardous industry or an industry dealing with explosive substances, the APPCB should also consider introducing the system of submission of the audited annual environmental statement.

6.11 State Level Environment Impact Assessment Authority (SEIAA), Andhra Pradesh, MOEF&CC, GoI

The Ministry of Environment and Forest (MoEF), Government of India (GoI), constituted State Level Environment Impact Assessment Authority (SEIAA), Andhra Pradesh and State Level Expert Appraisal Committee (SEAC) vide Notification S.O.No.1105 (E), dated 4th July 2007 under the provisions of Sub-Section (3) of Section 3 of the Environment (Protection) Act, 1986 [E (P) Act, 1986] and in pursuance of the Environment Impact Assessment Notification 2006 [the EIA Notification, 2006]. The SEIAA, AP comprises of three Members including a Chairman and a Member Secretary. The term of the SEIAA is three years. The SEIAA issues prior Environmental Clearance (EC) for the projects or activities included as Category 'B' in the Schedule of the EIA Notification, 2006 including expansion and modernization of existing projects or activities or change in product mix. The SEAC is a committee of technical experts, which assists the SEIAA in the appraisal of the proposals. The SEIAA and the SEAC are re-constituted from time to time by the Ministry of Environment and Forest & Climate Change (MoEF&CC). Present SEIAA and SEAC of AP are functioning from 20th December 2017 as constituted vide Notification S.O.4001 (E) of MoEF&CC, dated 20th December 2017 for a term of three years and an amendment vide Notification S.O. No.666 (E) dated 12th February 2020. The list of the Chairman and members of the SEIAA and the SEAC from its inception are at Volume VI: Part C - Annexure 6.11.3.1.

The Member Secretary, SEIAA, AP has submitted reports on 27th May 2020, 28th May 2020, 7th June 2020 and 22nd June 2020. The reports are available in Volume VI: Part C Annexures 6.11.1 -

6.11.4. The Member Secretary, SEIAA has reported that the role of SEIAA is to examine the proposals submitted by the project proponent and to take suitable decision on the recommendations made by the SEAC after appraisal of the proposal in respect of issuing ECs.

6.11.1 Regarding LG Polymers

The Member Secretary, SEIAA has reported on 28th May 2020 that all the records in the Telangana State Pollution Control Board (TSPCB) {for the period prior to re-organization of Andhra Pradesh from 2006 onwards} as well as Andhra Pradesh Pollution Control Board (APPCB) have been examined and they have been able to access all the reports from 2007 till now, except records from November 2010 to October 2013 which could not be traced. The SEIAA has reported that there are no applications for Environmental Clearance (EC) at any time from the LG Polymers from 2007 till 12th April 2018.

6.11.2 Violation

The Committee has already gone through the expansion and change of product mix activities of the LG Polymers undertaken after the issue of EIA Notification, 2006 in Chapter 6.10. The LG Polymers has applied to the APPCB for change in product mix/renewals / expansions and the present production capacity of Polystyrene was increased from 235 Tons Per Day (TPD) (in 2006) to 313 TPD and Expandable Polystyrene increased from 45 TPD (in 2006) to 102 TPD after EIA Notification, 2006. The LG Polymers also added a new product Engineering Plastics and the present production capacity is 36.67 TPD.

In Chapter 6.10, the Committee has already opined that the issue of whether prior EC should have been obtained by the LG Polymers under the EIA Notification, 2006 for change in product mix with no increase in pollution load vide Consents For Establishments (CFEs) issued by the APPCB dated 18th March 2008 and 19th December 2016; and expansion with a new product of the Engineering Plastics (36.67 TPD) vide CFE issued by the APPCB dated 4th May 2017 be examined by the MoEF&CC, keeping in mind the Circular issued by the MoEF dated 14th December 2006 and the MoEF&CC Circular dated 25th June 2014.

In so far as expansion in production capacity of Polystyrene from 235 TPD (in 2006) to 313 TPD and Expandable Polystyrene increased from 45 TPD (in 2006) to 102 TPD is concerned, it is quite evident that the EC under the EIA Notification, 2006 should have been obtained by the LG Polymers and it is a serious lapse on the part of the management of the LG Polymers. It is a clear violation of the EIA Notification, 2006 issued under the E(P) Act, 1986.

The Committee also felt that not taking EC should not be seen merely as a procedural lapse, but which may have indirectly led to the accident resulting into death of human/animal and damage to the human health and environment. As per the EIA Notification 2006, the Expert Appraisal Committee (EAC) or State Expert Appraisal Committee (SEAC) constituted by the Central Government is required to determine detailed and comprehensive Terms of Reference (TOR) addressing all relevant environmental concerns for the preparation of an Environment Impact Assessment (EIA) Report. In case the LG Polymers had made an application on time, perhaps the TOR would have addressed the possibility of leakage of vapours/gas from the storage tanks/processes. However, it is understood that even in the application submitted by the LG Polymers dated 12th April 2018 for EC, the LG Polymers have not informed about the actual or perceived risks to the human health or risk of accidents. It is for the EAC / MoEF&CC to examine this issue.

6.11.3 Regularisation of Violation

Vide S.O. 804 (E), dated 14th March 2017 of the MoEF&CC, certain procedure has been stipulated in respect of violation cases which have started the work on site, expanded the production beyond the limit of EC or changed the product mix without obtaining prior EC under the EIA Notification, 2006 and is as follows:

> *"(2) In case the projects or activities requiring prior environmental clearance under Environment Impact Assessment Notification, 2006 from the concerned Regulatory Authority are brought for environmental clearance after starting the construction work, or have undertaken expansion, modernization, and change in product - mix without prior environmental clearance, these projects shall be treated as cases of violations and in such cases, even Category B projects which are granted environmental clearance by the State*

Environment Impact Assessment Authority constituted under sub-section (3) Section 3 of the Environment (Protection) Act, 1986 shall be appraised for grant of environmental clearance only by the Expert Appraisal Committee and environmental clearance will be granted at the Central level.

(3) In cases of violation, action will be taken against the project proponent by the respective State or State Pollution Control Board under the provisions of section 19 of the Environment (Protection) Act, 1986 and further, no consent to operate or occupancy certificate will be issued till the project is granted the environmental clearance.

(4) The cases of violation will be appraised by respective sector Expert Appraisal Committees constituted under sub-section (3) of Section 3 of the Environment (Protection) Act, 1986 with a view to assess that the project has been constructed at a site which under prevailing laws is permissible and expansion has been done which can be run sustainably under compliance of environmental norms with adequate environmental safeguards; and in case, where the finding of the Expert Appraisal Committee is negative, closure of the project will be recommended along with other actions under the law".

The Member Secretary, SEIAA further reported that the LG Polymers submitted an application for the EC through online on 12th April 2018 as a violation case under Notification S.O.804 (E), dated 14th March 2017. It is pertinent to note that the LG Polymers filed application on 12th April 2018 (Volume VI: Part C - Annexure 6.11.9), whereas the notification on violation cases was issued by the MoEF&CC on 14th March 2017, shows that the LG Polymers took almost one year to file EC violation application.

The SEAC in its meeting held on 23rd June 2018 resolved that

"All the violation cases will be filed with an affidavit by the proponent, format of which can be taken from SEIAA either from its office or on the screen. However, this will be in addition to all the existing norms which are already in vogue".

Later, the SEIAA in its meeting held on 02nd July 2018 agreed with the recommendation of the SEAC and took a decision that

"All the violation cases shall be filed with a notarised affidavit / sworn in affidavit by the proponent, in the prescribed format to the Member Secretary, SEIAA, Andhra Pradesh for consideration of TOR / EC as per the provisions of EIA Notification, 2006 and O.M dated 30.05.2018 issued by the MoEF&CC, Govt Of India. The proposals (violation cases) received after 14th April 2018, shall be returned to the project proponents, since the time limit prescribed by MoEF&CC, Govt of India, in its O.M dated 16.03.2018, got expired by 14.04.2018."

Accordingly, a communication was sent to the proponent to file a Notarized Affidavit / Sworn in Affidavit to the Member Secretary, SEIAA for consideration of TOR / EC as per the provisions of EIA Notification, 2006 and the O.M. dated 30th May 2018 issued by the MoEF&CC, Govt. of India. The affidavit was submitted by the LG Polymers on 10th May 2019 and a copy is annexed in Volume VI: Part C Annexure- 6.11.13. In the affidavit, the LG Polymers stated as follows:

"5. That prior environmental clearance was not taken for the said manufacturing activity as per the provisions of Environment Impact Assessment Notification, 2006 (hereinafter called as "EIA Notification 2006") as no clearance was obtained vide entry 5 (e) – "Petrochemical based processing (processes other than cracking & reformation and not covered under the complexes)" in the schedule to the EIA Notification,2006.

6. As on date industry does not have a valid Environmental Clearance substantiating the produced quantity, issued by the competent authority, for continuing operations. However, we are continuing our plant operations with valid consent for operation from State Pollution Control Board, Andhra Pradesh. Further I submit that the conditions specified in the CFE / CFO have been fulfilled to the satisfaction of APPCB."

The affidavit was accepted by the SEIAA on 11th May 2019 and forwarded for placing in the SEAC meeting. The SEAC in its meeting held on 21st June 2019 discussed the issue and recorded that

"The project proponent has informed that they have filed their application to the SEIAA, A.P. instead of filling to the MoEF&CC as their project comes under Category 'A' and requested to transfer the file to MoEF&CC. The committee recommended to transfer this proposal to the MoEF&CC, Government of India, New Delhi for further processing."

The SEIAA in its meeting held on 9th July 2019 discussed on the issue and has taken following decision:

"Agreed with the recommendation of the SEAC".

The SEIAA addressed a letter on 12th August 2019 to the Joint Director, Impact Assessment Division, MoEF&CC, New Delhi informing about SEIAA's recommendation to transfer the file of the LG Polymers for further processing, as the proponent filed their application to the SEIAA instead of filing to MoEF&CC under Category 'A' project. The LG Polymers requested the SEIAA to transfer their proposal to the MoEF&CC through PARIVESH on 23rd October 2019. On 27th November 2019, LG Polymers informed that they have pursued with the MoEF&CC on 22nd November 2019 to ascertain the process of transferring the file as there is no provision for transfer of file through online from the SEIAA to the MoEF&CC and requested to transfer the physical file. Later, the SEIAA transferred the physical file along with the application to the MoEF&CC, GoI, New Delhi on 7th January 2020 as the project falls under Category 'A' dealt by the MoEF & CC, GoI.

The Member Secretary, SEIAA has summarized the chronology of the events in relation to the application of the LG Polymers as below:

Table 6.10: Chronology of the events in relation to the application of the LG Polymers

S.No.	Date	Description
1.	12th April 2018	Application filed by LG Polymers
2.	23rd June 2018	116th SEAC Meeting on violation cases
3.	02nd July 2018	SEIAA Meeting on violation cases
4.	18th September 2018	Letter addressed to proponent through EDS to submit affidavit.
5.	10th May 2019	Proponent submitted affidavit
6.	11th May 2019	Affidavit accepted by SEIAA
7.	21st June 2019	SEAC, A.P. appraised the project in 128th SEAC, A.P. meeting
8.	09th July 2019 & 10th July 2019	120th SEIAA meeting Agreed with the recommendation of the SEAC to transfer this

S.No.	Date	Description
		proposal to the MoEF&CC, Government of India, New Delhi for further processing
9.	12th August 2019	A letter was communicated to the MoEF&CC, GoI, New Delhi.
10.	23rd October.2019	LG Polymers requested to transfer their proposal to the MoEF&CC through PARIVESH.
11.	27th November 2019	LG Polymers informed that they have pursued with the MoEF&CC on 22.11.2019 to ascertain the process of the transferring the file as there is no provision for transfer of file through online from SEIAA, AP to the MoEF&CC and requested to transfer the physical file.
12.	07th January 2020	The SEIAA, A.P. has transferred the Physical file to the MoEF&CC, GoI, New Delhi.

The Joint Chief Environmental Engineer, APPCB, Zonal Office, Visakhapatnam addressed a letter on 12th May 2020 to the MoEF&CC seeking clarification regarding the requirement of EC to the LG Polymers providing the details such as raw materials, products, storages etc. In reply, the Director, MoEF&CC, (IA Division) vide letter dated 15th May 2020 (Volume VI: Part C Annexure - 6.11.23) informed that the project of the LG Polymers attracts the provisions of Schedule 5 (e) of the EIA Notification, 2006 as amended from time to time. From the Government of India clarification, the Committee noted that it is clear that the LG Polymers requires EC under the EIA Notification, 2006 and the same has also been accepted by the LG Polymers as seen from the communications above and has also filed an affidavit.

The Committee also noted that as seen from the communications between the LG Polymers and the SEIAA pertaining to EC, the LG Polymers is at fault in filing application in SEIAA portal instead of the MoEF&CC portal causing delays.

The SEIAA is also at fault for accepting the application and took about 18 months to process the violation case application of the LG Polymers before forwarding to the MoEF&CC. The SEIAA should have rejected or forwarded the application to the MoEF&CC as soon as it noticed that project comes under Category ‘A’. From the chronology of events, it is noticed that the case of LG Polymers was considered in the SEIAA meeting held on 2nd July 2018. The Committee felt the concerned Chairman and Members of the SEIAA should be asked to explain as to why they asked for an affidavit and delayed the process, instead of rejecting or forwarding the application to the MoEF&CC, GoI on that day itself. Finally, this was decided in the SEIAA meeting held on 9th July/10th July 2019 and caused delay in the process.

The Member Secretary, SEIAA further submitted that as per the G.O. Ms.No.120, dated 1st November 2018 of the EFS&T Dept, GoAP, the APPCB is the Monitoring Agency to monitor compliance with the terms and conditions of EC granted by the SEIAA and hence, compliance on monitoring vests with the APPCB. However, as the APPCB has contended, the GO Ms.No.120, dated 1st November 2018 mandates APPCB to monitor compliance with the terms and conditions of the EC granted by the SEIAA. However, in this case, no EC has been issued to date by SEIAA.

Regarding, the unit operating without obtaining EC, which is an instance of violation, the SEIAA has reported that it is not concerned licensing authority for storing Styrene. Further, conducting inspections is not under the purview of the SEIAA. Further, the SEIAA will not come to know whether a company has obtained EC or not till they apply online to SEIAA for grant of EC. The SEIAA has no direct mechanism to see whether any company obtained EC or not.

The Committee considered the matter in detail and is of the opinion that the SEIAA is a very weak institutional structure for monitoring a very important aspect like Environmental Clearance (EC). The MoEF Notification S.O. 1105 (E), dated 4th July 2007 and subsequent notifications for the constitution of the SEIAA and the SEAC itself provide that all secretarial assistance shall be provided by the State Pollution Control Boards (SPCBs). The SEIAA is only a clearance authority, with no office of own and no field functionaries of its own. It is not in a position to carry out any monitoring or proper implementation of the provisions of the EIA Notification, 2006. The Regional Offices of the MoEF&CC are also not having sufficient strength and local presence to effectively implement the provisions of the EIA Notification, 2006 and the E (P) Act, 1986. While some strengthening of the Regional Offices can be attempted by the MoEF&CC, it is but essential and imperative that the structure of the EC system undergo a structural change and the issue is discussed in Chapter 8.

The Committee also observed that although the EIA Notification, 2006 was issued on 14th September 2006, there is no clear system for identification of factories/units which have not obtained the EC under the notification. Unless the units come forward with the application on its own, no agency is tasked to verify and monitor these industries. The MoEF&CC, Government of India issued Notification S.O. 804 (E), on 14th March 2017 for all these violation cases. It is understood that number of industries/units have applied as violation cases, while it is reported that some industries/units have still not applied, although the last date for application under the MoEF&CC Office Memorandum dated 16th March 2018 has already expired on 14th April 2018. The Committee observed that the MoEF&CC needs to take up this issue in a manner that all industries which require the EC are fully covered and there should be no industry operating in the country without the EC.

The Committee observed that the EIA Notification 2006 has been issued under the Environment Protection Act, 1986. The Section 15 of the Act clearly provides for the penalty for contravention of the provisions of the Act and the Rules, Orders and Directions. The Committee felt that the Government should invoke the provisions of Section 15 of the E(P) Act, so that all the industries/units obtain the required Environment Clearances.

6.12 Town Planning Regulation

The Town Planning Regulations have been examined with the reference to the reports of:

- Visakhapatnam Metropolitan Region Development Authority (VMRDA), Visakhapatnam;
- Greater Visakhapatnam Municipal Corporation (GVMC);
- Directorate of Town and Country Planning;

6.12.1 Visakhapatnam Metropolitan Region Development Authority (VMRDA), Visakhapatnam

VMRDA is governed by the following Acts and Rules: A.P Metropolitan Region and Urban Development Authorities Act, 2016 and subsequent rules thereof.

The Town Planning Trust (TPT), now VMRDA, was established in 1962. TPT was re-designated as Visakhapatnam Urban Development Authority (VUDA) in 1978. The powers of VUDA have been delegated to the Visakhapatnam Municipal Corporation (VMC), now Greater Visakhapatnam Municipal Corporation (GVMC), in 1991. GVMC was formed in 2005. Accordingly, GVMC is issuing development permissions and enforcing the Master Plan for all the development activities within the limits of GVMC from 1991 onwards. VMRDA Jurisdiction excludes GVMC limits.

The Metropolitan Commissioner has submitted the report and is annexed (Volume VI: Part C - Annexure - 6.12.1) that M/s Hindustan Polymers land (now LG Polymers) was earmarked as "Heavy Industrial Zone", as per G.O.Ms.No.703, MA&UD Dept, dated 29th August 1970. Subsequently, Government have changed the surrounding lands of Hindustan Polymers located in Venkatapuram Village and Gopalapatnam Village from "Heavy Industrial use into residential use vide G.O.Ms. No.398, MA&UD Dept., dated 3rd March 1987." Accordingly, in the 1st Master Plan approved vide G.O.Ms.No.274 MA, dated 23rd May 1989. As per the approved 1st Master Plan, M/s Hindustan Polymers area was earmarked as Industrial Use and surrounding lands are earmarked as Residential land Use.

The VMRDA further stated that different building expansion plans were approved by the then VUDA (Now VMRDA) during 1986 to 1989 within the factory premises subject to the conditions imposed by the APPCB.

Subsequently, M/s Hindustan Polymers (present LG Polymers) submitted representation dated 16th August 1989 to the VUDA (Now VMRDA) stating that keeping in view of existing Heavy Industrial land use, they have acquired additional land of Acres 145-40 Cts for expansion of unit and applied for building plan approval. The proposal was rejected due to proposed Survey Numbers are falling under residential land use as per 1st master plan approved in 1989.

The industry requested the VUDA (now VMRDA) for change of land use from residential land use to industrial land use and same was forwarded to the Government. The proposal was examined and approved by the Government for Change of Land Use vide G.O.Ms. No. 262, MA & UD, dated

3rd May 1991 to an extent of Acres 122.88 Cts out of Acres 145.40 Cts and the balance land was retained as residential land use.

In the 2nd Master Plan approved vide G.O.Ms.No.345, MA & UD Department dated 30th June 2006, the existing M/s LG Polymers area was earmarked as General Industrial Zone (1-2) and the surrounding lands are earmarked as Residential Land Use.

The Government vide G.O. Ms. No. 502 MA, Dt. 23rd October 1991 delegated the powers of Development permission and enforcement powers to Visakhapatnam Municipal Corporation, VMC (Now GVMC) in the GVMC limits.

Further, the same enforcement powers were reiterated by the Govt., vide G.O.Ms. No. 443 MA, dated 18th December 2017 to GVMC in respect of all buildings within the GVMC limits. Powers were also given to GVMC for layout approvals up to 10 Hectares and approval of layout beyond 10 Hectares in consultation with the VMRDA. Accordingly, the GVMC is issuing Development permissions and enforcing the Master Plan for all the Development activities within the limits of the GVMC from 1991 onwards.

The residential built-up area is located on the western side, the eastern sides of the Industry. On the South side, railway track is existing and open land is located on the North side. Significant residential density is detected in the N-NW direction in the last 15 years. 52 layouts were approved in 2 KM radius of LG Polymers.

The VMRDA further reported that all industrial permissions accorded as per the A.P. Building Rules, 2017 and sanctioned Master plan Land Use. There are no specific guidelines for according residential permissions around existing Chemical industries. Residential permissions are issued duly following AP Building Rules, 2017 as per the GO Ms. No. 119 MA dated 28th March 2017 and sanctioned Master Plan Land use.

The VMRDA further stated that there is no provision to notify Buffer Zone/no development zone around the major chemical industries.

As reported by the VMRDA, there are about 265 industries (Red-75, Orange-85 & Green- 105) existing within GVMC area, out of which 15 are Hazardous industries inside GVMC area.

6.12.2 Greater Visakhapatnam Municipal Corporation (GVMC), Visakhapatnam

GVMC is governed by the following Acts and Rules: Andhra Pradesh Municipalities Act, 1965 and subsequent Rules thereof.

The Visakhapatnam Municipality is an old Municipality, which was converted into Municipal Corporation in 1979 to cater to the civic needs of people of the city. The Municipality has been renamed as Greater Visakhapatnam Municipal Corporation (GVMC), which came into existence on 21st November 2005 by conglomerating adjoining Gajuwaka Municipality and 32 villages. The administrative area of the GVMC is about 615 Square. Kms. Services rendered include Urban Infrastructure Development, civic amenities such as Water Supply and Lighting, besides other activities of health and medical services, sanitation, solid waste management, education etc.

The Commissioner, GVMC has submitted reports and are annexed (Volume VI: Part C Annexure-6.12.2 & 6.12.3). The Commissioner, GVMC reported that after the accident occurred on 7th May 2020 at the LG Polymers, as per orders of the District Collector, Visakhapatnam, the water releases from the sources of Meghadri Gedda Reservoir (MGR) was stopped on 8th May 2020 due to suspicion that the Styrene gas might have dissolved in water of MGR, which is located in North-West side at about 1.50 km away from the LG Polymers. Alternative arrangements have been made from 8th May 2020 onwards to supplement water supply in 45 to 49 Wards at Malkapuram, Scindia, Mindi, Sriharipuram, Nakkavanipalem, Himachal Nagar, Industrial colony, YSR colony, Kakarlova, Chintalalova.

Suspecting contamination, the GVMC water supply department has collected the water samples from MGR and sent for analysis of chemical & bacteriological parameters and also for the presence of Styrene gas in the water of MGR. The analysis reports of 9th May 2020, 10th May 2020 and 11th May 2020 received from the Regional Laboratory and APPCB found that there is no Styrene gas detected in MGR water.

The affected areas of Venkatapuram, Nandamurinagar, Padmanabhanagar, SC & BC colony and Kamparapalem with 6318 houses were washed and cleaned with 30 mobile water tankers arranged on war foot basis by deploying all water supply staff on 11th May 2020.

The existing 378 open wells located in the above 5 affected villages were cleaned and removed of stagnated water by bailing out with 32 oil engines i.e., from the 12th May 2020 to 16th May 2020.

All the existing overhead tanks situated above houses which are exposed to air have been cleaned and removed stagnated of water in the 5 villages surrounded by the LG Polymers. The Hon'ble Minister of Municipal Administration & Urban Development (MA&UD) inspected the activities of GVMC in the areas where water was served with mobile tankers, over-head tanks washing and removal of stagnated water from open wells in affected areas on 12th May 2020.

Drinking water has been arranged to residents of the affected area by means of 30 mobile water tankers (5 KL/10KL capacity) with 75 trips per day. Water supply arrangement was made to 6 food courts of GVMC from 12th May 2020 to 19th May 2020.

Disconnected 79 public hand bore wells and 36 household bore wells and not allowed to the public for drinking purpose.

As per the directions issued by the District Collector and Hon'ble Minister for MA & UD Department on 12th May 2020, GVMC supplied drinking water every day for two hours in mornings and also in evenings to affected 5 villages from 12th May 2020 to 19th May 2020. Later on, the water supply has been continued to affected villages regularly for one hour in the morning time i.e., from 10.30 a.m. to 11.30 a.m.

The Commissioner, GVMC further reported that there were residential areas existed prior to the establishment of industry and due to notification of surrounding areas as Residential Land use, some more layouts were approved and development. Further in the present master plan approved vide GOMs No 345 MA UD dated 30th June 2006 also, the surrounding lands are notified as Residential land use. Further constructions are allowed keeping in view of the development regulations from time to time.

The main criteria for allowing development in any area including the subject area is: (a) Ownership documents (b) Revenue lands classification (c) Master plan land use (d) Zoning regulations clubbed with Master Plan land use (e) Any other specific regulations issued by the Govt.

In this particular case, Master plan document is observed and noticed that the factory site is shown as "Industrial use" and the surrounding areas were shown as "Residential use" in both the Master Plan approved vide GO Ms No 274 MA dated 23rd May 1989 & GOMs No 345 MA UD dated 30th June 2006. There is no buffer or green belt provided in the master plan and zoning regulations are also not mentioned in the master plan.

In 2006 master plan report, it was mentioned that all industries shall submit a request for permissions through General Manager, District Industrial Centre along with required NOCs including APPCB. In this particular case, it is found that no permission is obtained from the GVMC after merging these areas in the GVMC area i.e. after 2005.
Since there are no restrictions in the Master Plan land use and zoning regulations, permissions for building constructions for residential purpose are being issued by the GVMC. Total 49 building permissions were issued as per prevailing building rules from 2016 to till date.

6.12.3 Director of Town & Country Planning (DTCP)

The Town & Country Planning is governed by the following Acts and Rules: The Andhra Pradesh (Andhra Area) Town Planning Act, 1920 and subsequent Acts & Rules thereof.

The Regional Director, Town & Country Planning has submitted a report and is annexed (Volume VI: Part C- Annexure: 6.12.4). The Regional Deputy Director (RDD) of Town & Country Planning, Visakhapatnam reported that the development control around the LG Polymers does not come under the DTCP jurisdiction and it is under the VUDA (now VMRDA) jurisdiction. The urban development authority will prepare master plans indicating land uses to be permitted. The local authority has to take action on changes if any.

The processing of the expansion proposal of the LG Polymers does not arise as above the site under reference does not come under the DTCP jurisdiction.

The RDD, Visakhapatnam will issue only technical clearances for the constructions as per the indicative land use plan and master plan and as per rules in force (other than the GVMC and the VUDAs jurisdiction) subject to conditions that the applicant shall obtain NOC from the concerned departments.

The VMRDA has given the following suggestions to regulate the Habitation Development around the chemical industries:

- Since there are no specific guidelines in AP Building Rules -2017 issued vide G.O.Ms.No. 119 MA, Dt. 28th March 2017 for permitting Industrial buildings, A Category wise norm shall be formulated.
- Formulation of rules on industrial category wise development activity restrictions like Residential areas in surrounding/vicinity of the existing and proposed industries.
- Evacuation plans shall be proposed for all existing and proposed Red, Orange and hazardous industries.
- Buffer/ Green Belt shall be insisted within the periphery / all around industrial land and the same buffer land to be acquired by the Industrial companies.
- Rehabilitation of Shelter shall be arranged in case of emergencies.

The Committee noted that as seen from the reports of the above departments, residential permissions are issued without considering industrial activities in the proximity. The local bodies follow the approved Master Plans, which often fail to take in to account the Hazardous and polluting nature of the industries located in the Industrial Zones nearby.

The Committee also noted that in this case, the major lacuna is the change of the land use from industrial to residential ordered vide G.O.398, dated 3rd March 1987 and again the change to

Industrial use partially vide G.O.Ms.No.262, dated 3rd May 1991. The Master Plans reflected these changes. Hence, extra precautions need to be taken in earmarking of Industrial Zones and Residential Zones. It is absolutely essential that there is sufficient buffer zone between the Industrial Zones and the Residential Zones. Change of land use should not be done under any circumstances unless the buffer zone is properly maintained between the Industrial and Residential Zones. Frequent land use changes from Industrial area to residential area and vice-versa is strictly not desirable. There is an immediate need for a comprehensive approach in earmarking the Industrial areas so that the residential areas will not be affected in case of unforeseen incidents/accidents.

The Industries Department and the DTCP / MA&UD Department along with APPCB should work on creating earmarked Industrial zones which are suitable for Industries. A clear buffer should be provided from the Residential areas. This would also be helpful for the project proponents who would know in advance the areas available for Industrial development. There shall be restriction of residential developments around the Industrial zones especially those which deal with hazardous, explosive and polluting product and processes.

7.0 Suggestions

The terms of reference of the committee is to suggest measures to be taken by industries including safety audits to prevent such mishaps in future. The terms of reference also include that in case there are any observations and suggestions for similar industrial plants, those to shall be communicated in the report. The technical suggestions regarding LG Polymers, Styrene based industries and the similar industrial plants, viz. hazardous industries are discussed in this Chapter, and the administrative and regulatory suggestions are in Chapter 8.

7.1 M/s LG Polymers

M/s Sri Rama Mills established an industry at RR Venkatapuram (Village) Visakhapatnam District to manufacture Alcohol from Molasses in the year 1961. It started factory operations and obtained factory license in 1967. Subsequently, the industry was taken over by M/s LG Group in the year 1997 and changed the name to M/s LG Polymers India Pvt. Ltd. The present M/s LG Polymers Company situated in S.Nos. 2, 5/p, 6/p, 7/p, 8/p, 9/p, 11, 12, 13, 14/p, 15/p, 19/p, 22, 24, 25/p, 29, 30, 31, 32, 33, 34, 35/p, 36, 37, 38/p, 39/p, 40/p, 41, 42, 43, 44, 45, 47/p, 48/p, 49/p, 51/p, 58/p, 78/p, 171/p of Venkatapuram village, Visakhapatnam Rural Mandal & S.Nos. 77/p, 78, 79, 80, 81, 82, 83/p, 84/p, 85/p, 112, 113/p, 114, 115, 116/p, 117, 118/p, 119/p of Vepagunta village, Pendurthi Mandal, Visakhapatnam District in an extent of Acs. 213 Cts. The co-ordinates of the M/s LG. Polymers Pvt. Ltd. are 17°45'23.6"N; 83°12'40.8"E.

Figure 7.1: Map showing the location of M/s LG Polymers India Pvt. Ltd.

In the present applicable Master Plan of Visakhapatnam approved vide G.O.Ms.No.345 of the MA&UD Department 30.06.2006, the existing land area of M/s LG Polymers was earmarked as General Industrial Zone, and the surrounding lands were earmarked as residential land use. Accordingly, residential buildings have been permitted by the concerned local body in the residential zones over the years. The railway track is existing on the southern side.

Residential density around the North and North West direction of the M/s LG Polymers developed during the last fifteen years (2005-2020) is shown below in the map:

Figure 7.2: Google earth map 2005

Figure 7.3: Google earth map 2020

Residential layout development around the M/s LG Polymers (2 Km radius) is shown below in the map:

Figure 7.4: Residential layout development around (2 Km radius) of the M/s LG Polymers

Now the M/s LG Polymers industry is located in the thickly populated area of Visakhapatnam. In view of the chemical accident on 7th May 2020 in the M/s LG Polymers, basing on the safety considerations and Environmental aspects and the feedback received from the public and stake holders, the Committee suggests the following:

1. To shift the Hazardous Chemical industry of M/s LG Polymers from the present location and it may be relocated away from the human habitations preferably in the established notified industrial estates. Government/APIIC may allot suitable land in any industrial estates as per rules, for smooth shifting of the factory.
2. The present M/s LG Polymers industrial land may be used for either green or white category industry, subject to the outcome of Environment Clearance. In case this is not feasible, then conversion of the land for residential purpose/commercial purpose may be examined.
3. The concerned Revenue Department may examine the aspect of Ceiling surplus land, which has been raised in representations.

4. The M/s LG Polymers may be asked to continue the staff employed in the White or Green category industry at the same location or may be asked to provide employment to the staff in the new factory location.

7.2 Technical suggestions regarding Styrene industries

Based on the intensive examination of the reasons for the runaway polymerisation reaction and the causes of the accident, the Committee suggests the following regarding the storage, handling and processing of Styrene Monomer and the emergency response systems in case of an incident/accident:

1. The tank must have a floating valve circulation or any other technology which provides circulation for Styrene. The change in design was a critical aspect in the case of LG Polymers.
2. There must be provision for mixing in case of failure of the circulation system.
3. The material of construction of the tank should be carbon steel with coating inside.
4. Tank life should be clearly defined; tank cleaning and coating should be carried out once in two years.
5. The roof of the tank should be supported with outside structures.
6. The number of nozzles in the tank should be kept to the minimum required.
7. All Styrene monomer tanks should have flare system or cryogenic system so that there is no Styrene vapour release even under normal circumstances. These systems will also prevent pollution of air.
8. There must be multiple continuous temperature measurement probes at different levels of the tank linked to the control room.
9. Temperature monitors and Refrigeration system should be interlinked in such a way to maintain temperature of the entire tank below 20°C at any point of time.
10. The standards for the refrigeration system in terms of pumping capacity and cooling capacity should be clearly defined for the various mass of Styrene by the industry, duly taking into account the ambient condition of the city where the factory is located.
11. In case of failure of the operating refrigeration system, standby refrigeration system shall be started automatically.

12. Automatic monitoring of inhibitor content (in ppm) and measurement at different levels of the tank with data recording and alert facility in the control room is essential. Further, the industry standards need to define clearly the quantity of inhibitor to be added depending upon the ppm level of the inhibitor content at various levels. Similarly, the industry standards should define the action to be taken in case the inhibitor content increases above the threshold level.
13. Dissolved Oxygen measurement system must be available at different levels of the tank and linked to the control room. Further, the industry needs to define clearly the action to be taken in case the Dissolved Oxygen reduces below/increases above the threshold range.
14. Polymer content measurement (in ppm) must be available at different levels of the tank and linked to the control room. The acceptable range of polymer content in ppm also needs to be clearly defined by the industry standards. Further, the industry standards need to define clearly the action to be taken in case the polymer content increases above the threshold level. This was the critical gap in the case of LG Polymers.
15. Use of Siren even during minor emergencies should be made mandatory practice.
16. Safety protocol for units/factories storing/ processing Styrene Monomer must include vapour release, apart from the possibility of fire and explosion in the Emergency Plans. Besides, the possibility of leakage/spillage of liquid Styrene monomer must also be a part of the safety protocol and Emergency Plans.
17. Units/Factories storing/processing Styrene monomer must undertake an annual safety audit.
18. The PESO which has classified Styrene monomer as B category petroleum should look into this issue again and classify it as A category as it needs to be stored below 20°C, although the flashpoint is 31°C.
19. SCBAs and other equipment needed for dealing with chemical disasters should be made compulsory for the units storing/ processing Styrene monomer.
20. Vapour Detectors shall be provided at the boundary of the factory also, to indicate in DCS the Styrene vapour escape outside the factory premises.

21. The industry shall provide the Styrene detectors at unloading point, near all the vents, downwind, upwind directions and factory boundary, and the same shall be connected to the Control room with alert facility. In the case of exceedance, SMS alert shall be sent to the Plant Safety Officer, Plant Head, local Police Station and Fire Station, District Collector Control Room, Factories Department, APPCB etc.
22. Plant Control rooms shall be located at the strategically safe location and shall be made easily accessible and shall be made gas-tight and accident proof to the extent feasible.
23. Process safety management is a systematic, comprehensive approach towards various aspects of chemical safety with 19 elements; this shall be made mandatory for all factories which are covered by MSIHC Rules,1989. This is a regulation in Occupational Safety and Health Administration (OSHA) brought in the year 1992 in USA with similar criteria for application as in MSIHC Rules.
24. The industry may examine the possibility that the sprinkler system is interlocked with tank internal temperature measuring devices. The sprinkler system shall start automatically whenever there are an unacceptable thermal profile (both internal tank temp as well as external ambient temperatures).
25. The industry may examine the possibility to provide detachable insulation to the Styrene storage tank, in such a way that, it can be easily removed during any emergency.
26. The industry shall ensure that there will not be any reverse pumping from the reactor / pre-mixing tank to the main storage tank.

    There are a number of Styrene storage/processing/trading/importing units across India. It is essential that all these units should all have their safety features audited. Further, the PESO/Government of India may also consider regulations that no unit shall sell/trade in Styrene Monomer with any unit which does not have the required safety features for storage and handling of Styrene Monomer.

7.3 Technical suggestions regarding Hazardous Chemical Industries

1. Hazard and Operability Study (HAZOP) and its compliance shall be made compulsory for all Hazardous process factory/unit wherever there is processing/storage of hazardous chemicals.
2. The industry should arrange for Annual Safety Audit and Annual Environmental Audit. The recommendations of the audit shall be meticulously complied within a reasonable timeframe.
3. Industries handling hazardous chemicals shall compulsorily appoint a senior level safety officer with prescribed technical qualifications and experience. There should be a safety officer available in each shift viz., a safety officer should be available in the factory in 24 hours in the factory. The safety officer shall mandatorily undergo 1-year Diploma course on safety by recognized Institutes.
4. All officers working in regulatory departments dealing with factories shall undergo Safety course once in every 3 years. This is especially important for Fire Department and Police Department personnel posted in the areas having jurisdiction over the hazardous chemical units/factories.
5. All employees and people in the vicinity of the industry shall be made aware of the MSDS of hazardous chemicals.
6. The MSDS of the chemicals which has potential to create Offsite emergency should be displayed at the factory gate, on the website of the company and should also be informed during the Offsite emergency mock drill.
7. The hazardous industry should prepare a uniform standard format for the emergency plans with full details including the equipment and chemicals required in the event of an emergency.
8. Each State should develop a database of all industries/units handling, storing and processing hazardous chemicals as defined in MSIHC Rules,1989 including isolated storages and the respective Material Safety Data Sheets (MSDS) which should be available with the APSDMA, SDRF, Factories Department, Boilers Department, APPCB, Fire Department, Department of Industries, PESO, Transport Department etc.

9. The CPCB/MOEF, GoI shall stipulate standards for the fugitive emissions from the Tank farms and isolated storages as they are equally potential areas for release of toxic/hazardous gases/pollutants to the environment.
10. The industry shall identify Process Safety Competency-based training needs and shall develop training modules and the training to be imparted till the competency levels are improved.
11. The hazardous industry must undertake competency mapping for all the operating and maintenance staff. The gaps incompetency should not be tolerated in respect of hazardous chemicals industries at all.

7.4 Technical suggestions regarding Hazardous Chemical Industries located close to Residential areas/habitations

The Committee also suggests that wherever hazardous industries are located close to the residential areas/habitations, the following additional steps may be taken:

1. To store Hazardous Chemicals in small tanks, below 500 KL in the industry premises instead of huge tanks of capacity 2000 KL and above. The bulk Hazardous Chemical storage facilities may be shifted from the industrial premises to bulk storage facilities, which are away from habitations and can be transported to factory by tankers/pipelines.
2. There shall be Constant monitoring of onsite and offsite emergency plans in respect of such hazardous industries located close to the residential areas. There shall be regular conduct of the mock drill in the premises of the industries every six months and outside the industrial premises in the community every year. Local Crisis Group should be immediately constituted for each of the Hazardous industry as per the Chemical Accidents (Emergency Planning, Preparedness, And Response) Rules-1996. The Local Crisis Groups should be involved intensely in the mock drills and training for dealing with emergencies.
3. There shall be constant close watch on the online monitoring of the effluent and emissions by the APPCB/CPCB.
4. The following steps may be taken up for an early identification of any eventuality:

a. Adequate number of sensors attached with hooter system to identify the release of toxic / hazardous gases which are harmful to the human beings and property from the industry shall be installed not only inside the industry but also outside the industry within the identified impact zone, based on consequence modelling study.
b. The sensitivity of the above sensors shall be to the level of respective OSHA standards.
c. The sensor activation should alert the following offices:
    i. Local Police Stations.
    ii. Nearest Fire Station.
    iii. SDRF cell at Collectorate.
    iv. The Inspector of Factories
    v. The Regional Office, AP Pollution Control Board.
d. The local crisis group should be active and review every accident/incident to gain knowledge and expertise.

5. Compulsory Annual Safety Audit and Annual Environmental Audit by the respective regulatory bodies.
6. The industries and Commerce Department should take lead to develop industrial estates away from the habitations, with adequate buffer zone especially for hazardous industries.
7. Every Industrial estate should be provided with a buffer zone around it.

The buffer zone should not be diverted to any other purpose.

8.0 New Administrative Structure

The report in Chapters 2 to 7 reveals the massive regulatory gap in the monitoring and compliance of safety laws and parameters in the factories. Similarly, the report also brings out the concerns and the regulatory gaps in the monitoring and compliance of the Environmental Acts and Regulations.

8.1 Factory Safety Regulatory Gap

Implementation of all safety-related legislation on factories deal generally with the subject as (i) Prior approval as first phase, (ii) Grant of license as second phase, (iii) Monitoring of the compliance by the enforcement authorities and (iv) Renewal of licenses. The major legislation dealing with industrial safety in factories are the Factories Act-1948, Indian Boilers Act-1923, Indian Electricity Act- 1910, Petroleum Act-1934, Explosives Act-1884 and a different set of rules framed under these Acts. In addition to the above Acts, in state of Andhra Pradesh, A.P. Fire Services Act-1999 is being implemented by State Disaster Response & Fire Services Department, Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act,1996. Besides, there are many other sectors specific legislation, rules and regulations like MSIHC Rules, Chemical Accidents Preparedness Rules etc.

8.2 Distinctive features of safety laws

The distinctive features of the Safety Laws and Regulations in the factories are:

- Multiple Agencies
- Multiple Strong Laws.
- Weak Structure of the Concerned Organization/Department.
- Absence of Compliance monitoring / Third Party Verification Systems.
- More driven as License Permit System rather than in the spirit of Ease of Doing Business.

The Factories Department deals with all aspects of factory safety in general, while the other Departments deal with special acts with their domain-specific expertise in the area covered by their legislations.

Due to this multiple domain-specific enforcement activities, under their respective laws, with their specified procedures and timelines, the Departments are in parallel processing the applications and issuing licenses, subject to the approval of the other Departments. Similarly, the work of enforcement is happening in isolation in each Department, with no or very little coordination. The present Ease of Doing Business (EoDB) reforms have introduced a Single Desk Policy, with timelines for service delivery of the approvals by each of the regulatory Departments. Further, the EoDB has also introduced the concept of joint inspection by the Common Inspection System (CIS). In Andhra Pradesh, both the Single Desk System and the CIS system are fully computerized and monitored online. The Government of India is also conducting feedback studies on the efficacy of the above changes.

The Committee noted that as per the G.O.Ms.no 135, Industries & Commerce Department, dated 12th October 2017, the Government have constituted Central Inspection Monitoring Committee (CIMC) with the Commissioner of Industries as Chairman and Member Secretary, APPCB as Member Convener. All the Departments concerned are members of the Committee. The Committee opined that the CIMC should introduce necessary alerts to the licensing authorities for the timelines. Similarly, any non-inspection or any other failure in inspections should be adequately addressed. However, the Committee emphasizes that the Single Desk System or the CIS should not interfere/hamper with the compliance and safety protocols in any manner and should be strictly adhered to.

Government of India is contemplating to promulgate four Labour Codes by bringing all labour legislation together. One of the important codes is named "The Occupational Safety, Health and Working Conditions Code", which combines 13 safety-related legislations like Factories Act, Building & other construction workers Act, Dock safety workers (safety, health & welfare) Act, Mines Act etc. It appears that the Code is made by combining the existing laws with certain additions like the constitution of Advisory Boards to advise the Central Government at National level i.e., National Occupational Safety & Health Advisory Board with Secretary of Ministry of Labour & Employment as Chairperson and Joint Secretary of Ministry of Labour & Employment as Member Secretary along with members from the related departments like Mines Safety, CPCB, Labour, Explosives, ESI, eminent persons from Occupational Safety & Health and Four Principal Secretaries from the States on rotation etc. The Central Government may also constitute the Advisory Committee / Technical Committee to assist the National Board. Similarly, the State Government may also constitute the State Boards and the State Committees. Central Government shall declare by notification, standards for occupational safety & health for various workplaces like Factories, Mines, Dock work etc.

The proposed Code amalgamates the existing legislations. The Committee observed that while a National and State Advisory Boards have been added, the total process of safety in factories and the main drawbacks of the factory safety regulations have not been addressed. The constitution of the Advisory Boards, with the facility of constituting the committees, may enhance the ability of Government in creating more guidelines /standards etc. but the existing enforcement departments are badly crippled and suffering from lack of manpower, expertise and infrastructure for implementation of the existing guidelines or standards itself. Mere adding additional guidelines or standards may not bring about any change in the safety standards at the ground level. Hence, there is a critical need to create a strong unified regulatory body which combines the multidisciplinary functionaries in the field of industrial safety, for convergence of all the safety requirements in factories in one effort.

Hence, this Committee suggests constituting a State Factory Safety Board in each state and a Central Factory Safety Board at the national level. The Chairman and the Members of the Factory Safety Boards (FSB) shall be experts and technically qualified persons with adequate experience in dealing with the factory safety issues. These State Boards shall be made as a single point regulatory agency in each state for regulating all factories safety laws, rules and regulations. The Committee is suggesting a paradigm shift which can be brought about in the same Code i.e. the Occupational Safety, Health and Working Conditions Code or using separate legislation, to set up Factory Safety Board, both at the Central and State Level. The major difference is that this proposal is for a factory safety regulatory body and not an advisory body. The FSBs shall bring within its umbrella the implementation of all the factory safety-related laws, both at Central Level and State Level, and all the safety related departments will be integrated suitably in the Board as separate verticals.

A similar organization in USA i.e. The Occupational Safety and Health Administration (OSHA) regulatory body that functions under the Ministry of Labor, in the USA. Presently, the DGFASLI performs a similar role; however, this office needs to be strengthened substantially. The USA also has the Chemical Safety Board, which is an independent federal agency charged with investigating major industrial chemical accidents in the USA.

Occupational Safety and Health (OSH) Regulation is available in the United Kingdom. The core of the UK's regulatory framework for health and safety is contained in the Health and Safety at Work etc. Act 1974 and deals with the Management of Health and Safety at Work Regulations. The Act provides a unified institutional structure and legal framework for health and safety regulation and has proved to be both robust and enduring. It is based on the principle that those who create risks to employees or others in the course of carrying out work activities are responsible for controlling these risks.

The role of the proposed Central Factory Safety Board would primarily be in setting up of safety norms, setting up of standards, capacity building of the state boards and dealing with certain large size hazardous factories. The Board will have different verticals for the setting of i) equipment standards/machinery safety standards ii) process safety standards iii) Safety audit iv) Human resource development for safety officers and safety auditors.

One of the special functions of the Central Factory Safety Board would be investigating each and every major factory accident, mandatorily by law, which would make it a store-house of information and standard-setting. A similar provision exists in USA i.e. Chemical Safety Board which investigates all major chemical accidents and provides guidelines for future reference. This also helps in investigating all the chemical accidents, wherein an expert technical body to investigate a major chemical accident is already mandated by law and is available for undertaking investigation at a short notice. The smaller factory accidents can be investigated by the State Factory Boards in assistance with the Central Factory Safety Board, wherever required.

To overcome this limitation in the system of Industrial Safety regulation in factories, the constitution of a Factory Safety Board is proposed to create a common platform for all enforcement agencies to work towards convergence in all the four phases of their functions. The constitution of the Factory Safety Board functions as the single regulator for all factory safety / industrial safety-related matters, bringing in under its jurisdiction the implementation of all Central and State Laws relating to Factory Safety / Industrial safety. It is suggested to constitute the Factory Safety Board with sufficient competent manpower, and infrastructure, to deliver the solutions for all the existing safety aspects as a unified regulatory body.

8.3 Environmental Regulatory Gaps

The MoEF&CC, GoI, /SEIAA accords Environmental Clearance for various types of projects under EIA Notification of 2006 of E(P) Act 1986. Generally, the EC is given one time for the projects and is required again mostly when the factory/project undergoes expansion or change in product mix/change in the process.

The selection criteria for projects requiring EC are based more on the perceived pollution potential of the project and impact on various attributes of environment, i.e. water, land, air, flora-fauna, socio-economic aspect, noise etc.

The projects and activities are broadly categorized into two categories - Category A and Category B, based on the spatial extent of potential impacts and potential impacts on human health and natural and manmade resources and threshold limits.

In the case of Environmental Clearances, for Category A projects, the proposals are appraised by Expert Appraisal Committee in MoEF&CC, GoI and clearances are granted/rejected by the competent Authority of the MoEF&CC, GoI. In case of Category B projects, the EC applications are appraised by the State Expert Appraisal Committee (SEAC) and then Environmental Clearance (EC) will be issued/rejected by the State Environmental Impact Assessment Authority (SEIAA). The site inspections are not carried out for every project and only in certain cases, as decided by the Authority, the site inspection is done by a sub-committee constituted by the concerned Authority. The EC is issued considering the broader perspective of Environment including socio-economic aspects duly stipulating required conditions.

After the issue of EC, the status of compliance of the stipulated conditions of EC by the industries is directly monitored by MoEF&CC/SEIAA, through its Regional Offices located in various States. In the case of EC violations by the projects/industries, MoEF&CC/SEIAA address the respective State Governments to take specified action against the defaulting projects/industries. The State Government, in turn, is directing the concerned District Collector or SPCB to take action against the project/industries as per the directions of MoEF&CC/SEIAA i.e., closure orders or launching prosecution / and booking credible action case in 1st Class Judicial Magistrate Court.

The Consent for Establishment (CFE)/Consent for Operation (CFO) are issued under Water Act, 1974 and Air Act, 1981 by the State PCBs. The CFE is issued by the State Pollution Control Board (SPCB) for one time for the establishment of the project, whereas the CFO is issued for a specific period and it is renewed periodically, generally every year for the project. New CFE is needed for every expansion/change in product mix /change in the process.

EC and CFE / CFO are separate legal requirements under different Acts i.e. EC is given under E (P) Act, 1986 and CFE / CFO are issued under Water Act and Air Act for the projects/industries. As narrated above, the ECs are monitored by the Regional Office of MoEF&CC, GoI under E (P) Act, whereas CFEs / CFOs are monitored by SPCBs under Water Act and Air Act.

In this connection, it is submitted that the report of Comptroller and Auditor General of India on Environmental Clearance and Post Clearance Monitoring (Report No 39 of 2016 dated 26.12.2016 Chapter 7 & 8) observed certain issues between the SPCBs, CPCB under the Water Act & Air Act and EC issuing/monitoring authorities viz. MoEF&CC, GoI / SEIAA-GoI, Regional Offices of MoEF&CC and observed the following:

- "We observed that there were no clear-cut responsibilities assigned to State Pollution Control Boards/Union Territory Pollution Control Committees (SPCB/UTPCCs) under EIA Notification 2006 regarding post-EC monitoring. EC is granted by MoEF&CC on the recommendations of EAC after scrutiny of the EIA report which includes public consultation and also various mitigation measures and commitments made by the Project Proponents (PPs). MoEF&CC while granting EC to Project Proponents, marks copy to SPCBs, however, the exact role of SPCBs was not specified in the EC letter. MoEF&CC also had the power under Section 23 of the Environmental (Protection) Act, 1986 to delegate its powers to the State Governments and/or SPCBs by issuing notifications. MoEF&CC had not delegated the SPCB/PCCs with the responsibilities and powers for monitoring of EC conditions and hence compliance to various mitigation measures proposed by the Project Proponents in the EIA/EC was not checked by SPCBs.

- Further, it was also mentioned that ROs of MoEF & CC were not ensuring the Project Proponents for submission of half-yearly compliance reports timely and regularly. Project Proponents were also not uploading half-yearly compliance report on their website.
- There was a wide gap between the sanctioned strength vis a vis man in the position of scientists in all the Regional Offices (ROs). Consequently, MoEF&CC/ROs would not be able to monitor all projects under their jurisdiction even in five years.
- No power was delegated to ROs to take action against the defaulting Project Proponents and they had to report the violations of the EC conditions to the Ministry. The Ministry did not have a Database of cases received where the violations were reported by ROs. No penalty was imposed by the MoEF&CC for violating conditions of EC in the last two years."

In this regard, it is submitted that the **Hon'ble NGT Order in its order dt 01.06.2020 in OA No 73 of 2020 (LG Polymers Case) commented on EC monitoring at para 37 as below:**

- "Dealing with environmental issues, including unfortunate incidents, the Tribunal has found the need to revamp the existing regulatory framework quantitatively and qualitatively. The Tribunal has noted the observations of the CAG and parliamentary committees on the subject. Reference may be made to order dated 22.11.2019 in *O.A. No. 837/2018, Sandeep Mittal vs. Ministry of Environment, Forest & Climate Change & OR's.* after noting the status of current monitoring mechanism of the MoEF*:*
  - *Para 37 (16) Let the Secretary, MoEF&CC and Chairman, CPCB hold a meeting with such other experts as may be found necessary and establish and/or augment the institutional setups in MoEF&CC, CPCB and SEIAAs for meaningful monitoring of Category A and B projects in the light of the above observations. Compliance report may be filed before this Tribunal by e-mail at judicial-ngt@gov.in by MoEF&CC and CPCB. The MoEF&CC may also furnish compliance status by SEIAAs."*

In this connection, it is submitted that water is a State subject and hence Water Act, 1974 was issued under Article 252 of the Constitution by the Parliament on the authorization of the State legislatures. On other hand, Air Act, 1981 and E (P) Acts, 1986 are issued by the GoI, consequent to the Stockholm Conference, 1972 using list No 13 of Central list of Constitution in compliance of International Conventions and Agreements. It is interesting to note that although Air act, 1981 was issued consequent to the Stockholm Conference; the regulation was entrusted to the State Pollution Control Boards and Central Pollution Control Board. However, such provision was not introduced in the E(P) Act, 1986. After the issue of E(P) Act, 1986 and E(P) Rules, 1986 and the Government of India have issued many important rules and notifications under the E(P) Act, 1986. Some of the important rules and notifications are:

i. Environmental Impact Assessment (EIA) Notification, 2006.
ii. Hazardous & Other Waste (Management &Transboundary Movement) Rules, 2016.
iii. Bio-Medical Waste Management Rules, 2016.
iv. Plastic Waste Management Rules, 2016.

v. Solid Waste Management Rules, 2016.

vi. E-Waste Management Rules, 2016.

vii. Construction and Demolition Waste Management Rules, 2016.

In the E (P) Act - 1986, no clear responsibility/roles have been entrusted to the State Pollution Control Boards. Section 3(3) was utilized for nominating parallel SEIAA in the States and also the State Expert Appraisal Committee and Central Expert Appraisal Committee. Thus, each state has one SPCB and one SEIAA. Section 4 empowers the Central Government to appoint officers for implementation of the E(P) Act. However, neither the officers of the SPCBs or the Regional Officers of MoEF&CC has been appointed under this section, who could independently implement provisions of the E(P) Act including EIA Notification 2006. An issue on which the Central Government has delegated its powers is Section 5, under which, the State Governments have also been empowered to issue orders. Besides, the Government of India (GoI) has delegated inspection powers under Section 15 to 64 agencies, which include both Central and State Government agencies and under Section 19 to various officers to register complaints in the court. From the above, it can be seen that there are significant area of concerns in monitoring and implementation of the Environmental laws as brought out in the CAG report and also observed by the Hon'ble NGT in its Order dated 01.06.2020 in O.A. No.73 of 2020 (LG Polymers case).

The Committee has deliberated on the issue and suggest the following:

a) All SPCBs can be constituted as authorities under Section 3(3) of the E (P) Act; with the condition that all A Category projects will be sent with the recommendation of the SPCB to the MoEF&CC and for B category projects, SPCB shall be the final authority. In other words,
   - The SEIAA will not be separately constituted but will be part and parcel of the SPCBs.
   - However, to assist the SPCBs, there can be SEAC constituted under Section 3(3) of the E(P) Act.
   - Requirement / Grant of EC under E(P) Act and CFE / CTE under Air Act and Water Act will be simultaneously examined by the SPCB, for both categories A and B projects. For category B projects, EC and CFE shall be issued simultaneously by the SPCB. For category

A projects, the SPCB shall send the recommendation for EC to the MoEF&CC. It shall issue CFE for category A projects, after issue of EC by MoEF&CC.

- At present, the CFE/CFO are issued by APPCB under Water Act and Air Act, whereas ECs are issued under E(P) Act by MoEF&CC, GoI/SEIAA. By bringing the issue of CFE/CFO as well as EC (B category projects) under APPCB, it will save a lot of time and facilitate the project proponents to get their clearances in one place.

b) To effectively monitor and implement the provisions of the E(P) Act and rules and notifications issued thereunder, it is essential that all the officers of SPCBs are appointed as monitoring and competent officers under Section 4 of E (P) Act for all categories of industries including category A.

- Already the MoEF&CC has authorized the SPCBs to initiate criminal action under Section 19 and the proper notification of the SPCBs to monitor and implement the provisions of E (P) Act under Section 4 will lead to proper monitoring and implementation of the E(P) Act along with the Air Act and Water Act.
- In effect, it will imply that although the EC is given at two levels, for A category industry at GoI level and B category industries at SPCB levels, the monitoring and implementation is the responsibility of the SPCBs for both categories.
- SPCB can monitor CFOs and ECs in one visit to the project. Thus, by bringing all the Environmental legislations regulation and control under the single umbrella, it will Lead to good regulatory control as well as Ease of Doing business.

c) Section 5 of the E(P) Act provides for action for violation. This has been presently delegated to the State Governments. It is essential to delegate this function to the SPCBs, so that they can exercise the monitoring function effectively. In this regard, it may be noted

- The SPCBs are already authorized to take this similar action under section 33A of the Water Act and section 31 A of Air Act.
- The officers of the SPCBs are already delegated functions of inspection under Section 15 and file complaints under Section 19 of the E(P) Act and this will bring congruity in the implementation.

It may be noted that the none of the above changes require any modifications in the E(P) Act or the E(P) rules. It only needs certain notification under the relevant sections of the acts and issue of delegation orders.

The committee also observed that there is an urgent need to strengthen the infrastructure and manpower of the APPCB so that they monitor the conditions mentioned in the Environmental Permissions properly.

8.4 The new processes under the Factory Safety Board and SPCBs

The processes of safety clearances and Environmental Clearances can be further streamlined and modified duly considering the various aspects of Ease of Doing Business for the industrial development of the country, without compromising on industrial safety and environmental concerns. Hence, the cardinal principles are Ease of Doing Business along with industrial safety and environmental protection and sustainability.

8.4.1 Establishment of Factory/Industry

In light of the above, the changes proposed in the administrative system/processes for the establishment of a new factory or expansion are suggested below:

- Industries are to be located preferably in designated industrial zones. The industries like Chemical, Hazardous, Explosives, Radiation, Fire prone industries are required to maintain a minimum distance from habitation as a buffer. In this connection, the relevant section 17 of the Water Act, the Section 17 of the Air Act, the Section 3 of the E(P) Act and the relevant town planning/zoning regulations / Urban Development Authorities regulations can be utilized.
- Environmental impact for any new establishment/expansion of an existing can be assessed by the competent authority as per present rules/notifications under the E(P) Act. Similarly, the requirements under the Water Acts and Air Acts can be processed simultaneously. As mentioned earlier, for B category industries the final decision can be taken by the SPCBs and for A category industries, the proposal can be sent to the Government of India with the necessary recommendation of the SPCBs. On clearance of the EC, the SPCBs shall issue EC and CFE / CTE under E(P) Act and Air Act & Water Act

simultaneously. The suggestion is to conduct one environmental impact assessment under E(P) Act and Air Act & Water Act and get it reviewed by one authority.

- Similarly, wherever the factory needs plan approval and such other safety clearances which are needed before the commencement of the operations such applications shall be made to the State Factory Safety Board which shall normally be accompanied by the Factory Safety Report prepared by a competent safety auditor. After the due process, the State Factory Board shall provide the necessary clearances.
- Thus, for the opening of any factory which meets the zoning requirements, there will be only two clearances needed – Environmental Clearance from the SPCBs and the Factory Safety Clearance from the State Safety Factory Board.

8.5 Operation of Factory/Industry

8.5.1 First time at the time of starting and every year thereafter

Once, the factory is established as per the clearances accorded by the Factory Safety Board and the SPCB under the respective Acts, there shall be a requirement for submission of factory safety assessment report and environmental statement.

For the small and medium industries, an Environmental Statement, and for the large industries, Audited Environment Statement on the compliance of the CFE and EC conditions need to be filed with the applications for Consent for Operation. On process, the CFO will be issued by the SPCB. In this way, comprehensive monitoring of EC and CFE & CFO can be monitored by SPCBs, either carried out on its own or by the third-party accredited auditors of the SPCBs. The SPCBs can be made fully responsible for monitoring all the CFO conditions and full compliance with the environmental laws

Similarly, a new entrepreneur shall make an application to FSB for all operational requirements connected to Industrial safety. All the site inspections where mandatory shall be carried on by respective authorities and FSB will ensure the compliance of requirements through the Safety Assessment Report / Audited Safety Assessment Reports, which are to be submitted to the State

Factory Safety Board for the small & medium industries and large industries respectively and grant the final license to operate the factory. The Expert third party auditors shall be recognized by the board and entrepreneur shall draw the services from the auditors wherever required. Common inspections shall be organized by the board and Overall performance of a factory will be reviewed and any further orders shall be issued by the board directing concerned departments to proceed further. In this way, the Factory Safety Board can ensure the total safety aspect of the factory.

8.5.2 Manpower issues Related to Factory Safety Board

- The Director of Factories can be merged in the Factory Safety Board. As the staff is very less with Director of Factories, it is suggested that the Factories Department should be strengthened with additional staff to meet the demand for complete compliance of the Safety Regulations and the inspections. It is also suggested that no post shall be kept vacant in the departments dealing with safety regulations and all such vacancies shall be filed immediately.
- The State Disaster response force should be empowered to deal with industrial accidents by the Safety Industrial Board and will work under close co-ordination of the Factory Safety Board.
- The Board shall be constituted with experts in Factory Safety Board.
- The Board can constitute committees based on the nature of the industry to scrutinize the applications including external experts in the relevant field.
- The staff and officers, of the FSB and safety auditors shall be trained continuously in Factory Safety aspects.

Thus, by creating the Factory Safety Board for safety aspects and delegated powers to the SPCB on environmental aspects, the safety and Environmental aspects of the industries/projects can be protected effectively.

By developing and appropriate computer software, the monitoring of the safety and environmental parameters for each factory can be brought under a single platform with common online records related to safety, health, environment and occupational hygiene, once the consent to operate have been issued by the Factory Safety Board and the SPCB.

8.6 "Environment" to be included in the Concurrent List of Constitution

8.6.1 Historical background

The historical background of the issue is the best captured through the preamble to the Water Act, 1974, Air Act, 1981 and E(P) Act 1986.

8.6.1.1 Water Act Preamble

"An Act to provide for the prevention and control of water pollution and the maintaining or restoring of wholesomeness of water, for the establishment, with a view to carrying out the purposes aforesaid, of Boards for the prevention and control of water pollution, for conferring on and assigning to such Boards powers and functions relating thereto and for matters connected therewith.

Whereas it is expedient to provide for the prevention and control of water pollution and the maintaining or restoring of wholesomeness of water, for the establishment, with a view to carrying out the purposes aforesaid, of Boards for the prevention and control of water pollution and for conferring on and assigning to such Boards powers and functions relating thereto;

and WHEREAS Parliament has no power to make laws for the States with respect to any of the matters aforesaid except as provided in articles 249 and 250 of the Constitution;

and WHEREAS in pursuance of clause (1) of article 252 of the Constitution resolutions have been passed by all the Houses of the Legislatures of the States of Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Rajasthan, Tripura and West Bengal to the effect that the matters aforesaid should be regulated in those States by Parliament by law;

BE it enacted by Parliament in the Twenty-fifth year of Republic of India as follows"

Accordingly, Water Act came into existence during the year 1974.

8.6.1.2 Air Act Preamble

"An Act to provide for the prevention, control and abatement of air pollution, for the establishment, with a view to carrying out the aforesaid purposes, of Boards, for conferring on and assigning to such Boards powers and functions relating thereto and for matters connected therewith.

Whereas decisions were taken at the United Nations Conference on the Human Environment held in Stockholm in June 1972, in which India participated, to take appropriate steps for the preservation of the natural resources of the earth which, among other things, include the preservation of the quality of air and control of air pollution;

and Whereas it is considered necessary to implement the decisions aforesaid in so far as they relate to the preservation of the quality of air and control of air pollution;

BE it enacted by Parliament in the Thirty-second Year of the Republic of India as follows"

Accordingly, Air Act came into existence during the year 1981.

8.6.1.3 E(P) Act Preamble

An Act to provide for the protection and improvement of environment and for matters connected there with:

WHEREAS the decisions were taken at the United Nations Conference on the Human Environment held at Stockholm in June 1972, in which India participated, to take appropriate steps for the protection and improvement of human environment;

and WHEREAS it is considered necessary further to implement the decisions aforesaid in so far as they relate to the protection and improvement of environment and the prevention of hazards to human beings, other living creatures, plants and property;

BE it enacted by Parliament in the Thirty-seventh Year of the Republic of India as follows"

Accordingly, E(P) Act came into existence during the year 1986.

It is to be noted that Water, Land, Industry, and Public Health are the state subjects as shown below:

Water, that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and waterpower subject to the provisions of entry 56 of List I.

Land, that is to say, rights in or over land, land tenures including the relation of landlord and tenant, and the collection of rents; transfer and alienation of agricultural land; land improvement and agricultural loans; colonization.

Industries subject to the provisions of entries 7 and 52 of List I.

Public Health is a State subject, the primary responsibility to provide quality health care services to the people including in rural, tribal and hilly areas lies with State Governments.

From the above, it can be seen that 'Water' is a State subject, The Water [Prevention and Control of Pollution] Act of 1974 was enacted by Parliament, pursuant to consent resolutions passed by 12 State legislatures. In order to legislate on environmental matters, the Indian Parliament has relied upon yet two other constitutional provisions. These provisions are Article 253 and Article 51(c). Article 253 empowers Parliament to make laws for implementing any treaty, agreement or convention with any other country/countries or for implementing any decision made at any international conference, association or other body. Article 51(c) mandates that the State shall endeavor to foster respect for international law and treaty obligations.

8.6.2 Provision in the Constitution

Further, Article 48 (A) of constitution provides as follows:

Article 48(A) of the Constitution provides for Protection and improvement of environment and safeguarding of forests and wildlife. "State shall endeavor to protect and improve the environment and to safeguard the forests and wildlife of the country." **Article** 48A was added by the **Constitution** (42nd Amendment) Act, 1976.

As "Environment" as a subject is not listed in List I, List II or List III of the Constitution, it is treated as a residuary subject. However, there are concerns as mentioned above. Water, Land and Public Health, all fall under domain of the State List. Hence Environment is a very important subject and, ideally, it should be in the Concurrent List of the constitution.

8.6.2.1 Proposal

- The objectives of international environmental agreements would be effectively achieved if all the relevant states become party to them and rigorous implementation including monitoring of compliance was ensured.
- To fulfill the constitutional goal, it is necessary that the state should provide pollution free environment
- To enable the states to enact legislation to create its own authority/ entrust to any existing authority for extending environmental clearance in the event of minor minerals like stone and sand etc.
- While the central legislation will provide for the minimum environmental standards in the country, states which need higher degree of control can exercise through strong legislation, especially in certain areas which are highly polluted.

8.6.2.2 Conclusion

- Environment is a matter of concern for both State and Central Governments.
- To have more focus on local Environmental Issues. In majority of the cases (disposal of untreated effluents, improper disposal of solid wastes, fugitive air emissions etc.) the effect on environment would be confined to local region except in case of air pollution, cross boundary water pollution issues, climate change in global scale etc.
- If Environment is included in concurrent list, states will be empowered to enact laws as per the States requirement considering the local conditions, pollution problems as each state may have different environmental issues.

9.0 Conclusion

9.1 The Accident

- On 7th May 2020, an incident of uncontrolled Styrene vapour release, commonly referred to as “Vizag Gas Leak”, occurred at LG Polymers, RR Venkatapuram, Visakhapatnam from one of the Styrene storage tanks (M6 Tank). Styrene vapour release from a storage tank into the atmosphere happened for the first time in the India.
- The accident took the life of 12 persons in the immediate subsequent period and 585 persons were hospitalized, besides causing loss of livestock and damage to environment.
- **The uncontrolled Styrene vapour release from the M6 Tank at LG Polymers Visakhapatnam, qualifies as a major accident under MSIHC Rules, 1989.**
- The LG Polymers India Pvt. Ltd, Visakhapatnam is a subsidiary company of LG Chemicals India Ltd, which is a subsidiary company of LG Chem, South Korea.
- Rescue and evacuation operations during the accident were undertaken by the District Administration, NDRF, Police, Fire Services etc. with public support.
- The Hon’ble Chief Minister of Andhra Pradesh ordered payment of compensation/ ex-gratia as a measure to provide immediate relief to the victims of the accident.
- The Government of Andhra Pradesh constituted a High-Power Committee to submit a report with a detailed term of reference.
- The Committee toured Visakhapatnam twice for visiting the accident site and to have extensive discussions with all the stakeholders. The Committee also sought inputs from the public through a press notification.
- The High Power Committee constituted a 3-member Technical Committee comprising of experts from Visakhapatnam.

9.2 Reasons for Uncontrolled release of Styrene vapour

- Runaway Reaction: The Committee has observed that the uncontrolled release of Styrene vapour from M6 Tank was due to the high increase in temperatures in the M6 Tank. The increase in temperatures led to polymerization and the heat generated due to polymerisation finally led to runaway reactions. Increase in temperature to the boiling point of Styrene monomer viz 145°C led to the boiling of the liquid Styrene, leading to uncontrolled vapour formation. Further increase in temperature led to increase in the pressure of the vapour which led to the uncontrolled release of vapour from the vents into the atmosphere.

The Committee has identified the following as the main causes behind runaway polymerization reaction:

- The modified piping design carried out by December 2019, within the M6 Tank not only totally disturbed the Styrene recirculation system but also led to significant thermal stratification in the M6 Tank with high temperature gradient. Hence, the top level of the Styrene monomers in M6 Tank experienced much higher temperatures than the bottom layer.
- The refrigeration system was operated as a standard practice in LG Polymers from 08:00 a.m. to 05:00 p.m. only on all days manually. There was inadequate time duration for Refrigeration and cooling system to maintain the temperature of Styrene monomer below 20°C in the M6 Tank at all levels in the tank.
- The temperature measurement in M6 Tank is restricted to the bottom zone, while the top and central zones had higher temperatures. Thereby, the temperatures at the top level and the middle level were not available at all to detect the temperature rise in the upper levels. Further, the SOP followed by LG Polymers for the temperature limit of 35°C was improper. The prescribed frequency standards of polymer and TBC measurement were also not followed and the samples of Styrene monomer from the recirculation and refrigeration system viz., bottom of the M6 Tank was analysed once in 4 days approximately by LG Polymers.

- The high temperatures at the top levels of the tank led to Thermal Radical Polymerization. The high temperatures made the limited TBC available (due to Thermal Stratification) at the top layers ineffective.
- The M6 Tank was an old tank with old design structures. The inner side of the tank was not lined. Further, LG Polymers was complacent in cleaning the tank once in 5 years (last cleaned in 2015) resulting in the accumulation of contaminants, which acted as catalyst inside the tank, initiating polymerization of Styrene which overwhelmed the inhibition effects of TBC.
- The company management had ignored the increase of polymer content from 4th April 2020 and then the sharp rise on 25th April 2020 / 28th April 2020. The management considered polymer content as a quality measure for Styrene rather than a safety measure. The early indications of a runaway reaction shown in the rise in polymer content in the M6 Tank was totally ignored.
- Onset of runaway polymerisation reaction is the critical parameter in the root causes of the accident. There was only one sensor for temperature which measured only the local temperatures and did not indicate the temperatures at the higher level of the tank as the contents were not well mixed. The measured temperature reported by LG Polymer did not reflect any potential catastrophic high temperature hot spots in the tank. Polymerisation was ongoing and unnoticed in zones that are not near the lone temperature sensor for the quantity (1947 MT) of Styrene monomer in (in 18 m dia x 12.185 m tall vertical cylindrical fixed roof tank). The uncontrolled Styrene vapour release from the M6 Tank was due to high temperatures, well beyond the company's protocol temperature of 35°C.
- The company failed to consider the TBC stratification and measured TBC only from the samples from the bottom layer. Further, there was no stocks of TBC available in the LG Polymers at the time of accident. The quantity of high temperature inhibitors like TDM & NDM was also limited, which got exhausted after few hours and failed in preventing the runaway reactions.
- There was no monitoring device or no monitoring system in place to measure the quantum of dissolved oxygen in the Styrene monomer in M6 Tank.

- No process safety management system was followed in LG Polymers.
- There was a dearth of knowledge and talent among the top, middle and shift management in LG Polymers. Most of the present shift in-charges / engineers were not qualified engineers. Hence, their knowledge and skills were not adequate when faced with a challenge or an emergency.
- LG Polymers was closed during the Covid-19 lockdown period as it is a non-essential industry and the minimum staff were given permission to maintain the factory during the lockdown period. However, the LG Polymer management was irresponsible, as they followed the same SOP as applicable for regular steady state operational circumstances, during the lockdown period as well and did not consider the idling conditions in the M6 Tank. Further, they ignored the early indications in rise in polymer content.
- No separate SOP was created for the lockdown and restart operations (PSSR: Pre-Start up Safety Review). Thus, the LG Polymers did not at all consider the idling conditions in all the tanks including M6.
- The safety protocols were not followed. The Process Safety Management (PSM) systems were not implemented.
- Failure to submit HAZOP & Risk Assessment Reports
- The Onsite Emergency plan of LG Polymers did not take into account any likely scenarios of Styrene vapour release from storage tank and such a case was never considered for emergency mock drill.
- The Offsite Emergency plan was not followed. Even the Siren, which was in working condition and had multiple activation points including near the factory gate, was not activated at the time of the accident.

Root Cause: In the light of the above, the Committee is of the view that the root causes of the accident in the Styrene storage M6 Tank can be attributed to poor design of tank, inadequate refrigeration and cooling system, absence of circulation of mixing systems, inadequate measurement parameters, poor safety protocol, poor safety awareness, inadequate risk assessment and response, poor process safety management systems, slackness of management, insufficient knowledge amongst staff, insufficient knowledge of the chemical properties of Styrene, especially during storage under idle conditions and total breakdown of the emergency response procedures.

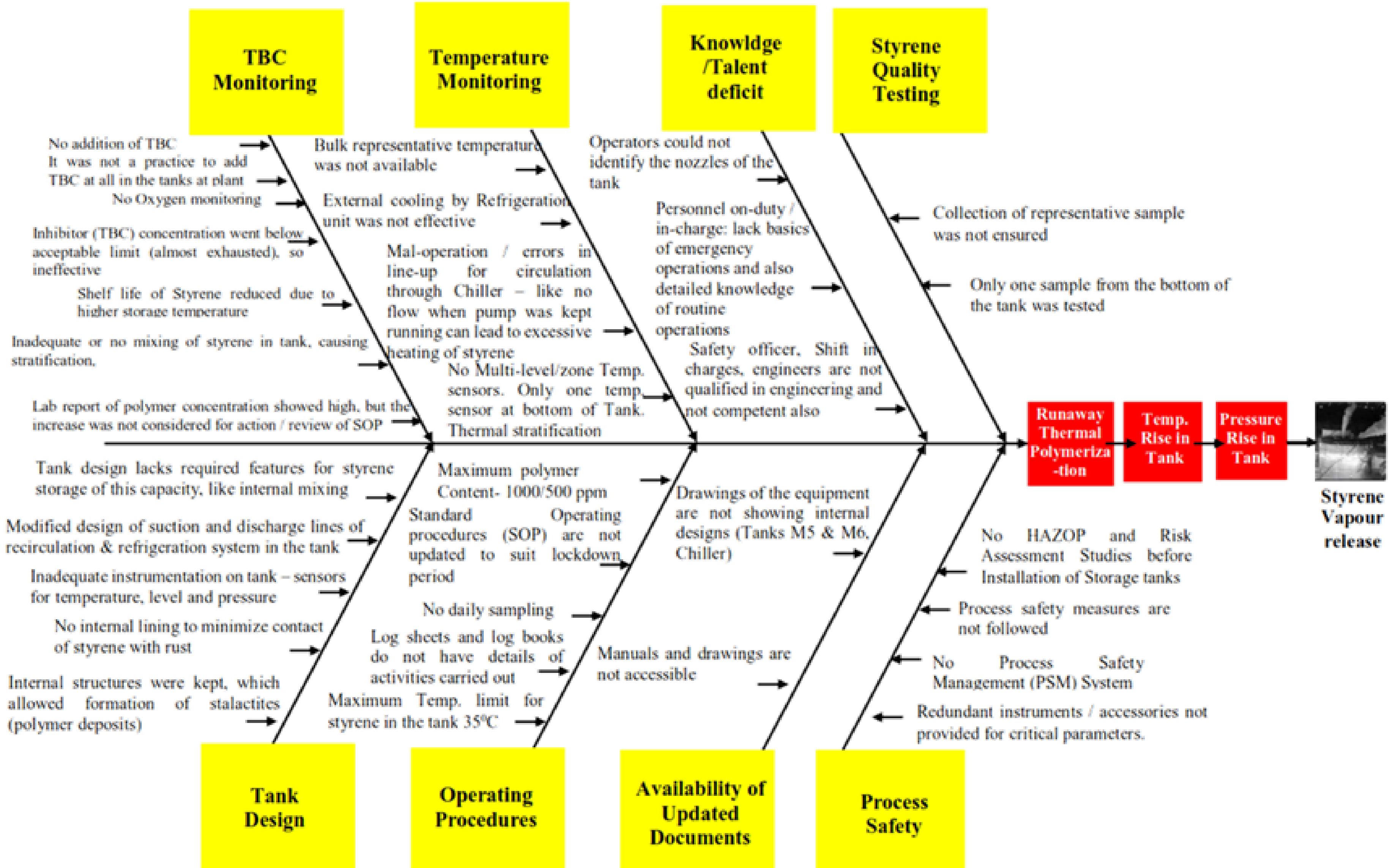


Figure 9.1: Ishikawa Fishbone diagram

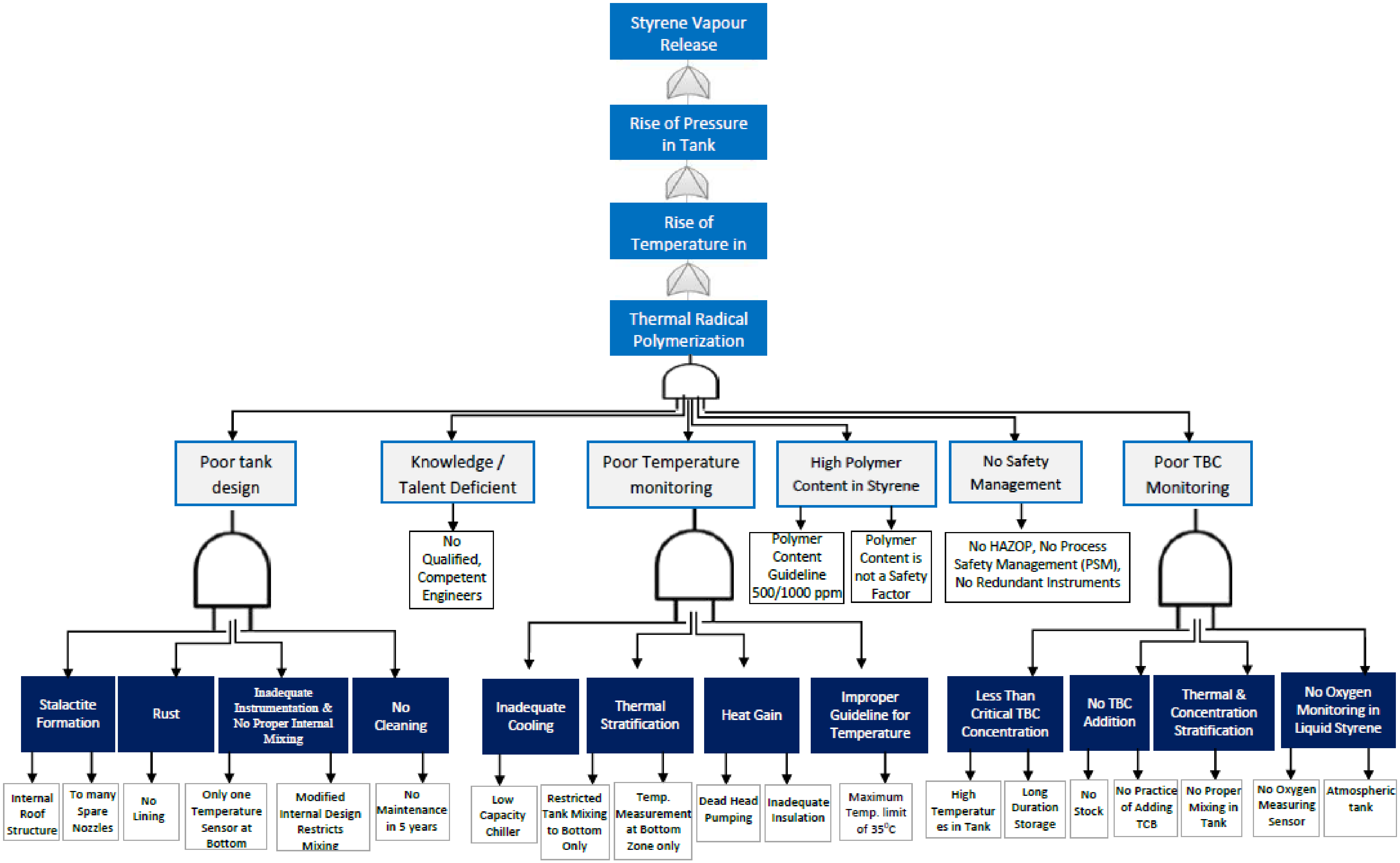


Figure 9.2: Fault Tree Diagram

9.3 Emergency Response

- Rescue and evacuation operations were primarily undertaken by the District Administration, NDRF, Police, with public support. No support from LG Polymers was received for rescue, evacuation, transport of the affected or relief.
- The committee observed the following critical lapses by LG Polymers on adhering to Onsite and Offsite Emergency Plan:
  - Lack of preparedness for vapour release: The Onsite emergency plan prepared by LG Polymers lacked any measures to combat Styrene vapour leak but only provided for fire occurrences and other accident scenarios. The LG polymers had no Emergency Plan for Styrene vapour release.
  - Failure in arresting the Styrene vapour release: If sufficient TBC/NDM stocks had been there, the runaway reactions could have been controlled. The LG Polymers did not respond swiftly by adding a shot-stopper chemical or ethylbenzene or toluene. They failed in taking scientifically right measures to mitigate the damages.
  - Failure in switching on the Siren: In-spite of having 36 Manual Call Points (MCP) for activating Emergency Siren, including at factory gate, the LG Polymers failed to alert the residents in the neighbourhood by activating the Siren.
  - Ineffective mock drills to handle emergency: The mock drill conducted by LG Polymers did not cover the scenario related to uncontrolled releases or spillages of Styrene from storage tanks.
- Failure in Conducting awareness in the neighbourhood
- Avoidance of Fire and explosion in the M6 Tank was a result of providence, absence of required conditions for fire and the factory taking steps for spraying of water.
- Total breakdown in Onsite and Offsite Emergency Plan implementation.

9.4 Impact in the short-term and long-term

The Committee has examined the short term and long term impact of the Styrene vapour release on humans, flora and fauna, and the overall environment.

- The accident claimed lives of 12 people while affecting 585 people. Six hundred people were immediately rescued, and the affected were shifted to the hospitals.
- The Hon'ble Chief Minister announced a Special Relief Package for the victims/affected people, ₹ 1 crore as Ex-gratia to the kin of the deceased, ₹ 10 lakhs to the people on ventilators, ₹ 1 lakh for those hospitalized for 2/3 days, Rs 25000 to the people undergone primary treatment, ₹ 10000 to the affected villagers and Rs 20000 for each dead animal. The amount was disbursed accordingly.
- The team of CSIR- NERI and CBRN, NDRF collected the air, water and soil samples in the affected areas and analysed. Further studies are required in this regard.
- The Committee is of the view that a detailed study may be entrusted to ICMR to study the long-term effects of Styrene vapour on the health of the people in the affected areas, especially in the vulnerable group of children, senior citizens and pregnant women.
- An attempt has been made to predict the concentrations of Styrene vapour & assessment of the influence area through modelling by ALOHA and PHAST Lite software. Based on the dispersion study using the models, the following conclusions may be drawn with reference to the influence of the SMV emissions from the M6 Tank SM storage tank in LG Polymers, Visakhapatnam.

Table 9.1: Predicted distances of various Zones of Influence and the Concentrations at 200 m and 400 m for wind direction of 172°C

Source Strength, MT	Predicted Distances of Threat Zones, km			Predicted Concentration of Styrene, ppm			
				at 200m from source		at 400m from source	
	Red	Orange	Yellow	Outdoor	Indoor	Outdoor	Indoor
31	0.333	0.976	2.5	3300	146	754	33.3
42	0.398	1.1	2.8	4820	214	1090	48.2
46	0.421	1.2	2.9	5400	240	1220	54

- The ALOHA model uses 60-minute Acute Exposure Guideline Levels (AEGL) with the following concentrations as AEGL-1:20 ppm; AEGl-2:130 ppm, AEGL-3: 1100 ppm. The Immediately Dangerous to Life or Health (IDLH) level is 700 ppm. The above modelling estimates indicate that the IDLH limits were significantly crossed upto 200 m from the source and even upto 400 m.

Table 9.2: Predicted Affected Areas in the Threat Zones for Each of the Emissions

Source Strength, MT	Predicted Affected Areas in the Threat Zones, ha.		
	Red	Orange	Yellow
31	12.3	48.5	164.2
42	17	68.4	217.6
46	19.7	75.8	238.5

- While the above indicates the threat zones, as observed during the ground assessment and statement of public, the impact was sensed up to a distance of 4 to 4.5 Km, where people experienced strong odour of the Styrene vapour.
- Further, the predicted threat zone areas, affected in hectares, with different wind directions of 120^{o}C, 145^{o}C, and 172^{o}C is given in Figure 1. The total or combined area covered under these three wind directions for emission of 46 MT is given in Table 3.

Table 9.3: Predicted Area of Influence, ha

Source Strength, MT	Predicted Area of Influence, ha		
46	Red	Orange	Yellow
	31.08	166.29	715

- The Committee with the assistance of the Technical Committee and the GVMC has also superimposed the above threat zones and area of influence on GVMC map which is shown below in Figure 1.

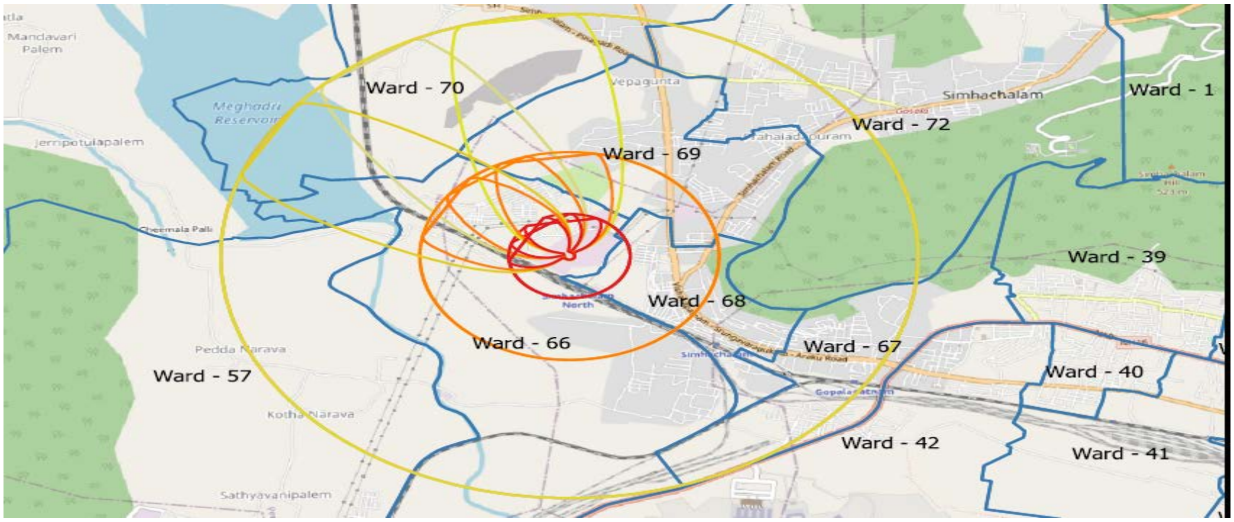


Figure 9.3: The Threat Zones for the ALOHA Model Runs with Styrene Loss / Evaporation of 46 MT with Change in Wind Direction (Blue Lines Are Ward Boundaries)

- The Committee suggests to conduct an in depth study to estimate the damage caused to the environment and the cost of remediation.

9.5 Negligence and Liability

- Despite multiple requests by the regulators, LG Polymers did not provide any documentation showing standard practices for storage of Styrene during extended periods at LG Chemical facilities outside India. It raises the concern that less stringent standards may have been applied to the Indian facility due to negligence, leading eventually to the disaster.
- The accident related to uncontrolled release of Styrene vapour from M6 Tank can be attributed to the poor design of the tank; inadequate refrigeration and cooling system; absence of circulation systems; inadequate measurement of parameters is a serious lapse by the Company.
- Further, weak safety protocol; poor safety awareness; inadequate risk assessment and response; poor management; slackness of management; insufficient knowledge amongst

staff; inadequate knowledge of the chemical properties of Styrene; especially during storage under idle conditions and total breakdown of the emergency response procedures aggregated the impact of the chemical accident.

- The liability of LG Polymers under various under the provisions of law have been indicated in the report.
- The LG Polymers bears absolutely liability as a polluter, based on the orders of the Hon'ble Supreme Court of India in the case of M.C. Mehta and Anr vs Union of India & Ors 1987.

9.6 Role of Government Departments

- The HPC has gone into all aspects of the accident vis-à-vis performance and compliance by the Regulatory Authorities. Each and every regulatory departments role have been studied in detail and in depth observations made. The details for each department is in Chapter 6.
- The role of the frontline Departments, who had carried out rescue and relief operations, such as District Administration, Revenue, Police, GVMC, Fire services etc. have also been examined. Necessary suggestions have been incorporated in Chapter 6.
- Lessons from the accident have been analysed and a policy and administrative framework has also been suggested in Chapter 8.

9.7 Technical Suggestions

- The Committee has conducted detailed study on the aspect of LG Polymers continuing its operations in the midst of residential areas. It is suggested that the company should be shifted away from human habitation. The existing land may be used for green or white category industries or residential purposes. The Committee suggests that the concerned department may examine the aspect of ceiling surplus land.
- Based on the main causes identified in the LG Polymers accident, the best national and international practices on Styrene Monomer storage, handling, and processing, the Committee has come up with the technical suggestions in Chapter 7 regarding Styrene based Industries.

- Similarly, the Committee has also come up with the technical suggestions on all Hazardous Chemical Industries.
- The Committee also suggests that wherever hazardous industries are located close to the residential areas/habitations, the following additional steps may be taken:
    - To store Hazardous Chemicals in small tanks, below 500 KL and bulk Hazardous Chemical storage facilities may be shifted far from habitations.
    - Strict implementation of onsite and offsite emergency plans. Local Crisis Group should be constituted immediately.
    - Adequate number of sensors attached with hooter system to identify the release of toxic / hazardous gases. The sensor activation should alert the local Police Station, Fire Station etc.
    - Compulsory Annual Safety Audit and Annual Environmental Audit by the respective regulatory bodies.
- The industries and Commerce Department should take lead to develop industrial estates away from the habitations, with adequate buffer zone especially for hazardous industries.
- Every Industrial estate should be provided with a buffer zone around it. The buffer zone should not be diverted to any other purpose.

9.8 Administrative and Regulatory suggestions

- The major legislations dealing with industrial safety in factories are the Factories Act, 1948, Indian Boilers Act-1923, Indian Electricity Act- 1910, Petroleum Act, 1934, Explosives Act-1884, A.P. Fires services, MSIHC Rules Act, 1999 Building and Other Construction Workers Act, 1996. and different set of rules framed under these rules.
- There are Factory Safety Regulatory Gaps due to the following:
    a) Multiple Agencies
    b) Multiple Strong Laws.
    c) Weak Structure of the Concerned Organization/Department.
    d) Absence of Compliance /Third Party Verification Systems.
    e) More driven as License Permit System rather than facilitating industries.

- The committee suggests to constitute a State Factory Safety Board in each state and a Central Factory Safety Boards with a single point regulatory agency for regulating all factory safety laws, rules and regulations.
  a) The role of the Central Factory Safety Board would primarily be in setting up of safety norms, setting up of standards, capacity building of the state boards and dealing with certain large size hazardous factories.
  b) One of the special functions of the Central Factory Safety Board would be investigating each and every major factory accident, mandatorily by law.
  c) It is suggested to constitute the Factory Safety Board with sufficient manpower and Infrastructure, to deliver the solutions for all the existing safety aspects as a unified regulatory body.
- To address the environmental regulatory gaps, the Committee has deliberated on the issue and suggest the following:
  - All SPCBs can be constituted as authorities under Section 3(3) of the E (P) Act; with the condition that all A Category projects will be sent with the recommendation of the SPCB to the MoEF&CC and for B category projects, SPCB shall be the final authority. In other words,
    i. The SEIAA will not be separately constituted but will be part and parcel of the SPCBs.
    ii. However, to assist the SPCBs, there can be SEAC constituted under Section 3(3) of the E(P) Act.
    iii. Requirement / Grant of EC under E(P) Act and CFE / CTE under Air Act and Water Act will be simultaneously examined by the SPCB, for both categories A and B projects. For category B projects, EC and CFE shall be issued simultaneously by the SPCB. For category A projects, the SPCB shall send the recommendation for EC to the MoEF&CC. It shall issue CFE for category A projects, after issue of EC by MoEF&CC.
    iv. It will save facilitate the project proponents to get their clearances in one place.

- To effectively monitor and implement the provisions of the E(P) Act and rules and notifications issued thereunder, it is essential that all the officers of SPCBs are appointed as monitoring and competent officers under Section 4 of E (P) Act for all categories of industries including category A.
- Section 5 of the E(P) Act provides for action for violation. This has been presently delegated to the State Governments. It is essential to delegate this function to the SPCBs, so that they can exercise the monitoring function effectively
- Environment is a matter of concern for both State and Central Governments. “Environment” subject should be included in the Concurrent list of the Constitution.