Andhra Pradesh State Government investigation reveals LG's reckless manufacturing, disregard for safety and extensive pollution

Liability should extend to the parent company
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Key findings

The Andhra Pradesh State Government created a High Power Committee (HPC) to investigate the May 2020 LG tragedy. The HPC released a final 4,000-page report on 6 July 2020. This summary primarily focuses on the actions and recommendations related to LG in the 329-page principal report which included the following findings:

- The LG tragedy released approximately 800 tons of styrene – one of the largest releases in the world – into a residential community located 200 meters from the factory.
- The HPC raised the possibility of a double standard between LG operations in South Korea and India noting that, *"less stringent standards may have been applied to the Indian facility, due to negligence, leading eventually to the disaster."*
- LG's styrene release resulted in significant water and soil pollution. The least contaminated water sample from a dug well in the community contained styrene levels 87 times higher than the WHO guideline. The least contaminated sample from the Narava Kota Reservoir violated Canadian standards for agricultural land by more than 1000-fold.
- The tank that released styrene (M6) was more than 50 years old and designed to store molasses, not a toxic chemical. The HPC noted that *"The M6 tank is inferior in design in all respects for storing styrene."*
- LG admitted to modifying the M6 tank in December 2019 without obtaining government approval, increasing the likelihood of a release and in the view of the Committee, *"sowed the seeds of disaster."*
- LG manually operated the critical styrene tank cooling system only from 8 am – 5 pm. The HPC criticized this practice calling it *"unscientific, human error oriented and unacceptable in terms of process safety."*
- The HPC condemned LG's disregard for safety, stating that, *"LG Polymers does not have any process safety management system."* The Committee concluded that the *"handling of emergency response by LG Polymers was inept."*
- The company not only failed to alert the community of the deadly release but also did not perform any rescue and evacuation operations. *"Any reasonable person of ordinary prudence would have blown the Emergency Siren to save the life of residents in the neighborhood."*
- The HPC noted that LG appeared to be on a cost-cutting push, *"and not recruiting qualified and technical people."* The HPC put it bluntly: *"There was a dearth of knowledge talent among the top, middle and shift management in LG Polymers."*
- The HPC noted that LG "*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."*
- Key actions that should result from the HPC investigation include: 1) Liability for the tragedy should include the parent company, LG Chemical; 2) Comprehensive health surveillance and compensation should be applied; and 3) Rigorous environmental monitoring and cleanup should be performed.

Introduction

On 7 May 2020, in the early hours of the morning in Visakhapatnam, India, LG Polymers, a polystyrene manufacturing plant owned by South Korea's LG Chemical[1], released large amounts of toxic styrene gas into the nearby residential area, killing 12, sending hundreds to the hospital, and causing the anxious evacuation of approximately 20,000 people. Government officials warned residents not to use groundwater or eat perishable foods from the area due to contamination concerns.

https://www.nytimes.com/2020/05/07/world/asia/india-lg-gas.html

CCTV footage showed thick clouds of gas and people collapsing as they tried to escape. Grim video footage and photos captured casualties and frantic scenes of evacuation.

On 8 May 2020, the State Government of Andhra Pradesh convened a nine-member High Power Committee (HPC) to investigate the LG tragedy. The State assigned the following terms of reference to the HPC:

- Reasons for the leakage, including verifying if the company had adhered to all safety protocols;
- Study if there are 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 vapor leak incident in Visakhapatnam;
- Suggest measures to be taken by industry 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.

This summary does not cover the entire HPC report but instead focuses of four key areas related directly to LG: 1) Reckless manufacturing practices; 2) Irresponsible management; 3) Inept emergency response; and 4) Regulatory violations and liability.

Google map from the HPC report showing the proximity of the LG factory location to the residential community and deceased victims of the styrene release in red.

[1] LG Chemical is one of 70 subsidiaries of LG Group. In 2019, LG Group had 250,000 employees and sales of US$137.2 billion.

Reckless manufacturing practices

The HPC investigation revealed that LG had a long list of dangerous practices including outdated equipment, lack of monitoring, incorrect standards, and regulatory violations.

CCTV footage from the HPC report showing styrene vapor escaping at 2:42 am on 7 May 2020.

Old tank: The styrene tank (M6) that leaked was originally designed to store molasses, not a toxic chemical. The tank is more than 50 years-old – beyond its designed lifetime – and has never been assessed for mechanical integrity. The report noted that, *"It is a very risky proposition to store a hazardous chemical in about a 50-year-old tank…"*

Tanks not inspected: LG admitted that its styrene storage tanks were last cleaned in 2015, likely resulting in accumulation of contaminants that can catalyze styrene polymerization and release. In contrast, industry standards recommend cleaning, inspection and application of a coating on storage tanks to prevent polystyrene accumulation every two years. LG admitted that part of the M6 tank had a crack that released styrene vapors which the Committee described as *"extremely worrisome."*

Inferior materials used for tanks: LG's tanks violate industry standards as they are made of mild steel, not lined carbon steel. They are not coated with zinc silicate linings to provide electrical grounding. The HPC report notes that, *"The M6 tank is inferior in design in all respects for storing styrene."*

No styrene vapor collection system: Industry standards for styrene tanks include a collection and containment system so that styrene vapors are not released. LG's tanks did not have these safety systems.

Modifications without government approval: LG admitted to modifying the M6 tank in December 2019 without obtaining government approval. The company claimed that approval was not needed since it was *"only a change in the piping…"* The HPC called this a *"critically wrong assessment"*, noting that the modification undermined effective cooling since it piped in cooled styrene at the bottom of the tank instead of at the top. This increased the likelihood of a styrene release and in the view of the Committee, *"sowed the seeds of disaster."*

Insufficient temperature monitoring: Industry standards call for 4 – 5 temperature probes in different tank locations. In contrast, the M6 tank had only one probe at the bottom of the tank, blinding operators to possible dangerous increases in temperature at the middle and top parts of the tank.

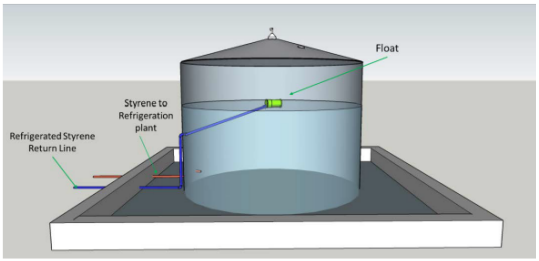

Figure 2.12: Before the Modification in Styrene M6 Tank

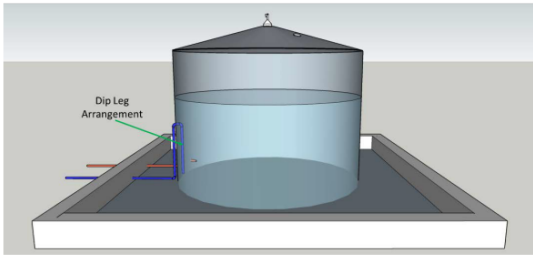

Figure 2.13: After the Modification in Styrene M6 Tank

Diagram from the HPC report showing LG's unapproved tank modification.

Incorrect temperature standard: LG admitted that its standard procedure is to maintain the styrene temperature below 35°C. The HPC noted that this *"is not supported by any literature"* and violates industry guidelines that stipulate a maximum temperature of 25°C due to increased likelihood of styrene release or explosion.

No temperature alarm: The HPC discovered that there is no temperature alarm for the M6 tank which could signal the need for preventive action before a release or explosion.

Incorrect operation of the cooling system: LG manually operated the critical styrene tank cooling system from 8 am – 5 pm. The HPC sharply criticized this practice calling it *"unscientific, human error oriented and unacceptable in terms of process safety."* The Committee noted that, *"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."* When the HPC asked LG if this dangerous practice is used in its South Korean manufacturing facilities, the company did not answer. The HPC stated that the lack of an automatic cooling system, *"has permitted the human error and onset of reactive hazard resulting in the release of toxic vapor cloud."*

Photos of the LG refrigeration units from the HPC report

Incorrect inhibitor monitoring procedure: TBC (p-tert-butylcatechol) is added to styrene storage tanks to prevent styrene polymerization and release. Standard industry procedures include monitoring the TBC level at the top and bottom of the tank every day and adjusting the level as needed. In contrast, LG monitored TBC levels only at the bottom of the M6 tank once every four days.

No addition of inhibitor: LG admitted that they do not add TBC to the styrene tanks, claiming that there is no need since styrene comes with TBC already added. HPC criticized the company noting that this practice combined with the operating failures described above made the operation significantly more vulnerable to styrene release.

No stock of inhibitor on hand: TBC is needed in case of runaway tank conditions leading to styrene release, but the investigation showed that on 6 – 7 May, LG had no stocks of TBC at the factory. India's National Disaster Management Authority had to airlift TBC to the factory on 8 May.

No dissolved oxygen monitoring: Oxygen and TBC are both required to inhibit styrene polymerization and possible styrene release or explosion. However, LG has no dissolved oxygen monitoring system in any of its tanks, a practice that the HPC called, *"not acceptable."*

Incorrect polymer content standard: It is critical to ensure that styrene does not polymerize in storage tanks. Under questioning by the Committee, LG admitted that their maximum contaminating limit for polystyrene was 1000 ppm. The company later changed their answer to 500 ppm. However, HPC noted that neither standard is supported by any guideline. More concerning is that LG viewed polymer contamination as a quality measure, not as a safety measure. HPC noted that a limit of 50 ppm would be more appropriate for process safety.

No tank mixing: The HPC noted that LG did not normally perform a mixing procedure on its tanks. This oversight became especially important during the COVID-19 lockdown which interrupted normal manufacturing. The HPC noted that mixing minimizes local heating within the tank and helps maintain uniform cool temperatures.

No adjustment for lockdown conditions: During the COVID-19 lockdown, LG just continued to follow standard operating procedures without considering the impact of idling conditions. HPC called this *"irresponsible."*

In summary, the HPC concluded that the LG tragedy was caused by, *"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."*

Irresponsible management

The government investigation revealed a surprising lack of business management at the Indian LG facility. The HPC put it bluntly: *"There was a dearth of knowledge talent among the top, middle and shift management in LG*

Polymers." For example, despite the chemical engineering focus of the company, most of the supervisors are not qualified engineers. The Committee criticized this practice noting that engineering *"decision-making experience and capability are important in dealing with major upsets during processing hazardous chemicals like styrene."*

LG Polymers submitted a list of employees containing 26 chemical engineers to the Committee. However, the report notes that 17 of them (65%) are trainees *"and hardly have the requisite experience."* Five more engineers only had limited experience in running styrene plants. The HPC asked the technical advisor (listed as an engineer) to submit a statement about the cause of the styrene release and the response was, "*that their investigating team did not find the reasons yet."*

The responsibility for this management lapse ultimately lies with the parent company. LG Chemical is responsible for ensuring that its wholly-owned subsidiary performs in accordance with standard industry practices and regulatory requirements.

LG management:

1. *"failed to provide and ensure the information, instruction, training and supervision to ensure health and safety of all workers during start-up operations."*
2. *"failed to provide and maintain the plant and systems to be safe and without risks to the health of the workers."*
3. Did not perform a Pre-Startup Safety Review to catch any potential hazards before starting operation.
4. Failed to implement a company-wide safety training program including emergency procedures.
5. Did not employ a qualified safety officer or medical practitioner.
6. Did not have supervisors certified for styrene handling by the Directorate General Factory Advice Service and Labour Institutes. This violates Section 41-C (b) of the Factories Act.
7. Did not prepare a safety report as required under Rule 10 of the Manufacture, Storage and Import of Hazardous Chemical Rules.
8. Did not have an onsite emergency plan approved by the Directorate of Industrial Safety and Health and the plan it did have ignored the possibility of a styrene release. The Committee noted that LG's 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."*
9. Did not train personnel on the onsite emergency plan *"which has defeated the entire on-site emergency planning process."*
10. Did not submit required risk assessments for the M6 tank before it was installed and converted from a tank storing molasses to one storing styrene.
11. Did not submit required risk assessments for its other major styrene tank, M5.
12. Modified the M6 tank (as described above) in a way that increased the risk of styrene release without getting government authorization and approval.

Photo from the HPC report of the Committee meeting with personnel from LG Polymers

In summary, the HPC concluded that LG violated both the Factories Act and the Andhra Pradesh Factories Rules. Stated simply, the Committee declared that, *"LG Polymers does not have any process safety management system."* This reflects poorly on LG Chemical and illustrates the parent company's disregard for the health and safety of its own workers and the country and community in which it operates.

Inept emergency response

LG's reckless manufacturing practices and irresponsible management had chaotic, lethal consequences. The government investigation concluded that the *"handling of emergency response by LG Polymers was inept."*

Useless emergency plan: LG's emergency plan was useless because it was prepared only for fire emergencies and other accidents, and not a styrene vapor release. As a result, even though there was no fire, company personnel performed a fire emergency response. The HPC criticized LG noting that the company ignored the hazardous nature of styrene in its emergency plan.

No public awareness-raising: LG did not conduct emergency awareness-raising in the community or mock drills to prepare the public in case of an emergency. The result was death, injury, and chaotic evacuation.

Late warning: LG's night duty officer told the Committee that personnel could not get closer than 300 meters from the tank due to the rapidly spreading styrene cloud. Part of the reason for this is that the company set the styrene detector at 2200 ppm – a very high level. The HPC noted that the styrene detector should have been set at 100 ppm so that personnel and the community would have been alerted much sooner.

Personnel chaos: During the massive styrene release, most of the LG staff were panicking and the night duty officer was semi-conscious. LG claimed that management personnel promptly arrived at the plant to deal with the emergency, but the HPC verified with the police that no LG officers arrived at the plant before 5 am – hours after the release began. The investigation showed that, *"runaway polymerization continued for nearly 24 hours as no effective action was taken by the company."*

No alert to the community: The LG factory has five emergency sirens, but the company did not sound any of them to warn the community of the toxic release. An LG manager stated that by the time he arrived at the factory, he saw people trying to escape the toxic cloud and assumed that an emergency had already been declared, so no sounding of the emergency siren was needed. The Committee noted that this lapse violated the law and turned out to be fatal. The Committee bluntly concluded that, *"Any reasonable person of ordinary prudence would have blown the Emergency Siren to save the life of residents in the neighborhood."*

Photos from the HPC report illustrating people affected by LG's styrene release.

Abdicated responsibility to the local government: As their toxic chemical began to poison the nearby community, LG *"shirked-away from their responsibility as part of offsite emergency management"* and left all the responsibility to the local government. In fact, all 15 LG personnel at the factory *"escaped from the accident site without trying to help the affected residents."* The company did not arrange evacuation or transportation of affected people. Instead, volunteers along with local police, fire department, and other government agencies worked on the relief operation to evacuate 20,000 people in the nearby area. Residents were allowed to return on 11 May 2020 after decontamination measures carried out by the government. Government personnel further informed the public about sanitization measures for floors, windows and household items.

Measures to reduce severity not taken: The HPC noted that various measures could have been taken by LG to quickly reduce the styrene release. These included pumping available chemicals that could act as inhibitors into the tank and circulating them using pumps. The Committee noted that LG *"did not use their basic engineering knowledge coupled with widely available specific information on styrene to arrest the radical polymerization with shortstop chemicals."* Since these measures were not performed, the toxic styrene release continued for hours.

In summary, the government investigation concluded that, *"there was total breakdown of the Emergency Response Plans."* LG Chemical has responsibility for ensuring that its wholly-owned subsidiary, LG Polymers, has complied with relevant laws and has adequately prepared for any emergency resulting from its operations.

Adverse impacts

LG's massive styrene release impacted human health and the environment in many ways.

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

Figure from the HPC report outlining the details of State Government compensation

Human deaths and illnesses: The LG tragedy caused serious short-term human health impacts including 12 deaths and 585 injuries. The HPC noted that many people were found unconscious or semi-conscious and had breathing difficulties and other health problems. Nearly 20,000 people were evacuated during the tragedy – all under government supervision without assistance from the company. Even though LG should be paying for all costs related to the tragedy, the State of Andhra Pradesh moved forward with compensation to families of the deceased, people requiring medical treatment, affected villagers and people whose animals had died. These payments should be reimbursed by LG Chemical to the State Government of Andhra Pradesh.

Long-term human health impacts: Styrene is a probable human carcinogen, crosses the placenta and has a variety of harmful effects. The HPC notes a plan by the District Collector to conduct health surveillance of the 585 people hospitalized due to the styrene release under the leadership of Andhra Medical College. This surveillance should be paid for by LG Chemical and be extended to the entire community since latent effects may occur after many years, even in people that were not initially hospitalized.

The HPC proposes that the long-term effects of styrene exposure should be studied by the Indian Council for Medical Research (ICMR). However, it would be useful to consider lessons learned from the Bhopal tragedy when selecting an institution for this type of study. Survivors organizations in Bhopal have condemned ICMR for *"not fulfilling its promises of carrying out beneficial medical research."* In 2019, ICMR blocked the publication of a study that found that babies born to women exposed in the 1984 Bhopal Tragedy were more likely to have birth defects. ICMR concluded that the study was poorly designed and inconclusive. However, Bhopal community members noted that the study had been approved at three successive meetings over two years and was conducted by the National Institute for Research in Environmental Health (NIREH), an institution which is one of the permanent institutes of ICMR.

Animal deaths: Other short-term impacts included the death of 34 animals between 7 – 9 May 2020. The government advised farmers to discard milk from surviving animals and not to feed them with anything exposed to styrene. The HPC concluded that long-term impacts need to be assessed in animals.

Ruined crops: The Horticulture Department reported 50% crop damage in a 5 km radius around the LG plant and farmers were advised to destroy their crops and not sell them as they were not safe for consumption.

Water pollution: Due to water contamination concerns, more than 6000 homes were sanitized with mobile water tankers and an alternate source of drinking water was provided to the community after cleaning distribution lines and reservoirs. Government agencies also jointly performed sampling for styrene contamination in nearby water bodies. The results are shown in Table 1.

Table 1. HPC reporting on water sampling near LG Polymers

Sample	Water source	Location	Styrene (ppm or mg/L)	US EPA Maximum Contaminant Level (ppm or mg/L)	WHO Guideline (ppm or mg/L)
1	Reservoir	Meghadri Gedda Reservoir	1.74	0.1	0.02
2	Lake	Narava Kota Reservoir Village Narava	3.76	0.1	0.02
3	Dug well	Dug Well in Premises of LG Polymers	0.723	0.1	0.02
4	Dug well	Near House of G Appa Rao, (V) Venkatpuram	0.181	0.1	0.02
5	Spillage sample	LG Polymers M6 Tank	ND	0.1	0.02

The HPC report suggests that the data are not concerning because it claims that the levels are below 9 mg/L. However, the data indicate significant styrene water pollution. None of the samples met either the US EPA drinking water maximum contaminant level or the WHO guideline. At the Narava Kota Reservoir, styrene levels were 188 times higher than WHO Guideline level. The Meghadri Gedda Reservoir which is located near the LG factory contained styrene at 1.74 ppm or 87 times higher than the WHO guideline. Even the lowest styrene levels which were measured near the house of G Appa Rao were nine-fold higher than the WHO guideline. These results should trigger extensive monitoring and cleanup to rigorous health-protective standards paid for by LG Chemical.

Soil pollution: Government agencies jointly performed sampling for styrene contamination in soil in several locations. The results are shown in Table 2.

Table 2. HPC reporting on soil sampling near LG Polymers

Sample	Location	Styrene (ppm or mg/kg)	CCME* Agriculture Guideline (ppm or mg/kg)	CCME* Industrial Guideline (ppm or mg/kg)
1	Meghadri Gedda Reservoir (surface soil)	318.1	0.1	50
2	Meghadri Gedda Reservoir (deep soil)	444.6	0.1	50
3	Narava Kota Reservoir Village Narava (surface soil)	109.0	0.1	50
4	Narava Kota Reservoir Village Narava (deep soil)	1215.1	0.1	50
5	Opposite to M-6 tank of LG Polymers (surface soil)	342.7	0.1	50
6	Opposite to M-6 tank of LG Polymers (deep soil)	827.6	0.1	50
7	Near House of G Appa Rao, (V) Venkatpuram (surface soil)	731.3	0.1	50
8	Near House of G Appa Rao, (V) Venkatpuram (deep soil)	1427.8	0.1	50
9	Opposite to M-6 tank of LG Polymers (surface soil)	5950.1	0.1	50

*Canada Council of Ministers

The data indicate gross styrene contamination of soil. None of the samples taken near the M6 tank at the plant met the Canadian guidelines. One sample taken near LG's M6 tank exceeded the Canada Council of Ministers guideline for styrene contamination at industrial facilities by 119-fold. The samples taken at the reservoir were higher than the agricultural guideline by 1090 – 12,151-fold. The residential house of G Appa Rao exceeded the agricultural

guideline by 7313 – 14,278-fold. These results should trigger extensive monitoring and cleanup to rigorous health-protective standards paid for by LG Chemical.

Regulatory violations and liability

The Committee reviewed LG's practices before and during the massive styrene release and enumerated a list of 21 company failures – most of which were attributed to management. These included the examples cited above of poor maintenance and design; erratic or missing monitoring procedures; lack of inhibitor on-site; lack of competency among staff; neglecting a spike in polymer content; and failure to alert the community with the siren once the styrene began to be released.

Despite multiple requests, LG did not provide any documentation about standard styrene storage practices at facilities outside of India. The HPC raised the possibility of a double standard between LG operations in South Korea and India noting that, *"less stringent standards may have been applied to the Indian facility, due to negligence, leading eventually to the disaster."*

The HPC also noted that LG appeared to be on a cost-cutting push *"and not recruiting qualified and technical people."* For example, people were designated as engineers even though their training did not justify the title. LG downsized regular staff and most employees were contract workers. The HPC pinned responsibility for this situation directly on the company noting that, *"The responsibility for the absence of competent and qualified employees lies squarely with the management."*

Criminal liability: Police registered a criminal case against LG officials in India and has examined 280 witnesses so far. The HPC recommended that the police promptly take up the investigation and take necessary actions. One day later, police arrested 12 LG personnel in connection with the tragedy: Managing Director and CEO Sunkey Jeong, technical director D S Kim, additional director (operations) P P C Mohan Rao, person in charge of styrene monitoring K Srinivas Kiran Kumar, production team leader Raju Satyanarayana, engineers C Chandra Shekar, K Gowri Shankara Ramu and K Chakrapani, operator M Rajesh, night duty officer (operations) P Balaji, security in person charge S Atchyut and safety person in charge (night shift) K Venkata Narasimha Patnaik. Specific charges included the following: Sections 304 part II (culpable homicide not amounting to murder), 278 (making atmosphere noxious to health), 284 (negligent conduct with respect to poisonous substance), 285 (negligent conduct with respect to fire or combustible), 337 (causing hurt by act endangering life or personal safety), and 338 (causing grievous hurt by act endangering life or personal safety of others).

18 Violations of the Factories Act, Manufacture, Storage and Import of Hazardous Chemicals Rules and The Chemical Accidents (Emergency Planning, Preparedness and Response) Rules: These violations included failure to provide, maintain and monitor a safe and risk-free work environment; poor tank design; lack of training programs; inadequate knowledge of personnel; non-maintenance of required temperature; improper tank measurement; lack of mixing in the tank; not adding TBC to the M6 tank; no measurement of dissolved oxygen; spike in polymer content; absence of a formal Pre-Start-up Safety Review; no implementation of a Process Safety Management System or a Management of Change system; no buffer tank to transfer styrene in an emergency; no labeling of styrene storage tanks with hazard information; no qualified medical practitioner approved by the Directorate of Industrial Safety and Health; emergency plan did not consider a styrene release scenario; non-compliance with the Offsite Emergency Plan; and non-dissemination of information to those people likely to be affected by a major accident.

Violations of the Environment (Protection) Act: This law says that, *"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."* In addition, the law provides for actions to be taken when there is a discharge of any environmental pollutant in excess of standards. In contrast, LG released massive quantities of styrene, resulting in losses of human and animal life. The HPC urged the Ministry of Environment, Forests and Climate Change to examine LG's violations and take necessary action. The Committee also noted that other regulatory bodies such as the Director of Factories and the Andhra Pradesh Pollution Control Board may also take actions consistent with violations of this law.

Violations of the Air (Prevention and Control of Pollution) Act: According to this law, no one operating a plant shall discharge or permit the discharge of an air pollutant in excess of standards laid down by the State. The HPC noted that LG failed to comply with this law and that the Andhra Pradesh Pollution Control Board *"must examine the failure to comply"* and take necessary actions.

Violations of the Water (Prevention and Control of Pollution) Act: This law prohibits pollution into any stream, well or sewer or on land of any poisonous, noxious or polluting matter in excess of any standards. The HPC noted that LG *"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 Committee urged the Andhra Pradesh Pollution Control Board to take actions on these violations.

Violations of the Andhra Pradesh Fire Service Act: There are three conditions of the No Objection Certificate issued to LG: 1) all employees must be trained to operate fire safety equipment during an emergency; 2) the company should conduct mock drills every 3 months for two years and then at least one every six months thereafter; and 3) raise an alarm if a fire cannot be controlled and evacuate the area completely at once, using the nearest safe exit. The Committee noted that LG did not raise an alarm which it described as a *"serious lapse"*. The Committee urged the Andhra Pradesh State Disaster Response and Fire Services Department to promptly take action on this matter.

Absolute liability should be applied to LG Chemical

Two types of liability principles have emerged in dealing with corporate accidents: strict liability and absolute liability. Strict liability would hold a company responsible and require compensation, but certain loopholes exist. These include an accident caused by strangers or a natural disaster, among others. In contrast, absolute liability places a duty on the company that no harm will be caused to the community. If harm is caused, then no exceptions can be used by the company and the cause of the accident is not required to establish liability. In other words, the company cannot argue that it took all reasonable precautions and therefore should have reduced liability. In 1990, the Indian Supreme Court affirmed the use of absolute liability in the Bhopal disaster-related case of Charan Lal Sahu vs. Union of India. Absolute liability should be fully applied in the LG tragedy to both LG Polymers (India) and LG Chemical (South Korea), including prosecution of executives, compensation, medical expenses, health surveillance, and remediation, among others.

The HPC noted these precedent-setting liability cases and clearly stated that, *"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 HPC also bluntly stated how matters should proceed with regards to the company: *"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."*

A 2017 study from the University of Chicago Booth School of Business examined corporate decision-making in pollution and proposed several deterrence mechanisms as solutions. A key lesson applicable to the LG tragedy (and all other chemical industry pollution cases and accidents) is to allocate responsibility to executive managers in the company. In the case of a foreign company, that should include executives from the parent company as well as the national subsidiary. The study notes two precedents for this practice in the US: 1) The financial world in which the Chief Executive Officer and Chief Financial Officer must certify the company's reports; and 2) Under the US Clean Air Act in which the person in charge of submitting information to the regulator is subject to jail time if the information is false.

The 1984 Union Carbide Bhopal disaster also provides an important lesson about holding parent companies liable. Dow Chemical purchased Union Carbide in 1999 but claimed that it did not buy the company's liabilities resulting from the Bhopal disaster. However, Dow's subsidiary, Union Carbide, is wanted in India on criminal charges and US investors have expressed concern that Dow did not disclose potential liabilities in the Bhopal case. Dow Chemical refused to clean up the toxic site and the tragedy still continues. In the recent LG tragedy, LG Polymers is

a subsidiary of LG Chemical – one of the ten largest chemical companies in the world. Liability and criminal prosecution for the accident should include executives at LG Polymers (India) and LG Chemical (South Korea).

Key actions that should result from the HPC investigation

Several key actions should result from the detailed HPC investigation and report:

1. Liability for the tragedy should include the parent company, LG Chemical

   LG Chemical, the parent company, is largely absent from the HPC report. However, one of the key lessons that should be learned from the Bhopal tragedy and applied in this case is the importance of parent company accountability (see above). As the owner of LG Polymers, LG Chemical also bears responsibility for the extensive failures in safety operations, irresponsible management, inept emergency response, regulatory violations, compensation of victims, long-term medical surveillance and care, and restoring the environmental degradation it caused as a result of its record-setting styrene release. In addition, the HPC raised the possibility of a double standard between LG operations in South Korea and India noting that, *"less stringent standards may have been applied to the Indian facility, due to negligence, leading eventually to the disaster."* Liability and criminal prosecution of LG Chemical executives is consistent with established legal principles and necessary for this pattern of bad corporate behavior to change.

2. Comprehensive health surveillance and compensation should be implemented

   Styrene is a probable human carcinogen, crosses the placenta and has a variety of harmful effects. Considering the magnitude of the release and the large number of people exposed, a long-term, robust health surveillance program paid for by LG Chemical should be established due to the long latency of cancers and other health effects. For example, a large epidemiological study of plastics workers exposure to styrene found an increased risk of acute myeloid leukemia with a latency period of approximately 15 years. The HPC proposes that the long-term effects of styrene exposure should be studied by the Indian Council for Medical Research (ICMR). It would be useful to consider lessons learned in the Bhopal tragedy when selecting an institution for this type of study. Finally, criteria for establishing links to the LG tragedy for purposes of compensation should be designed to favor the public. There is already an example of three recent deaths allegedly linked to the tragedy including Kadali Satyanarayan on 8 June (age 58), Yelamanchili Kanaka Raju on 1 June (age 45), and Pala Venkayamma on 29 May (age 73). The families of all three should be compensated. Compensation should also include crop damage and harm to animals, among others. So far, the State of Andhra Pradesh has paid for compensation, but all these costs should be reimbursed to the State Government by LG Chemical.

3. Rigorous environmental monitoring and cleanup should be performed

   The HPC report tends to downplay the severity of water and soil pollution that resulted from LG's massive styrene release. However, even the least contaminated water source in a dug well in the community contained styrene levels 87 times higher than the WHO guideline. Styrene levels in soil samples taken near the M6 tank at LG's factory grossly failed Canadian guidelines for industrial facilities. The least contaminated soil sample from the Narava Kota Reservoir violated Canadian standards for agricultural land by more than 1000-fold. LG has turned the area into a large contaminated site. The strong links between environmental pollution and public health justify extensive environmental monitoring and rigorous cleanup using health-protective standards paid for by LG Chemical.