

Hydrogen Safety Management – Essential practices for risk management in Operational facilities

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**LEADERS IN RISK
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AN ISO 9001:2015 CERTIFIED CONSULTING AND
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INTRODUCTION AND CONTEXT SETTING

Hydrogen Demand in India

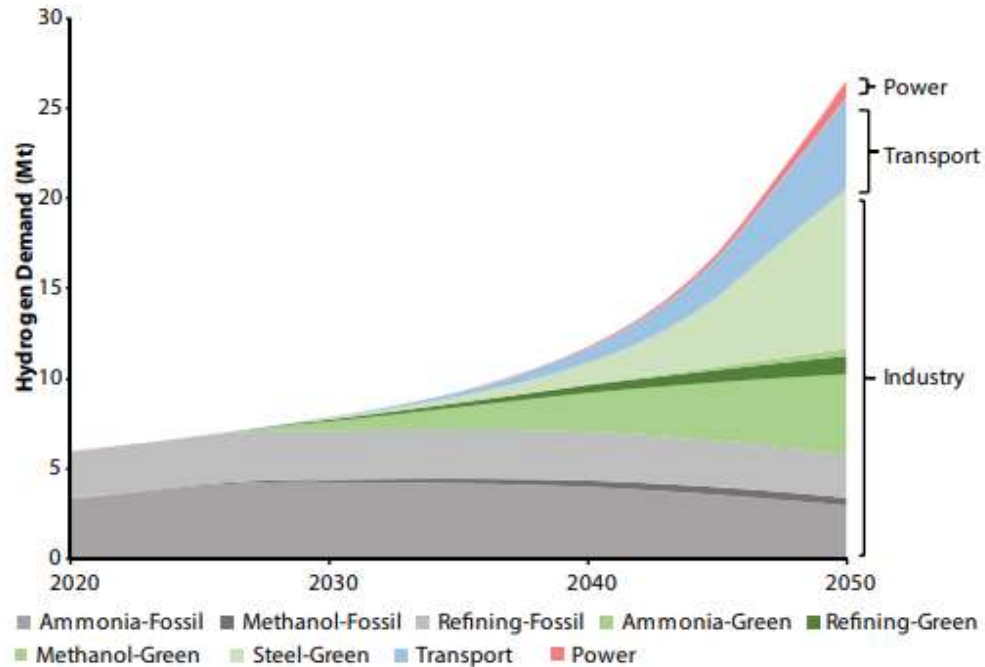


Figure 1: Hydrogen demand projection in the Low-Carbon scenario, 2020-2050

Source: TERI analysis

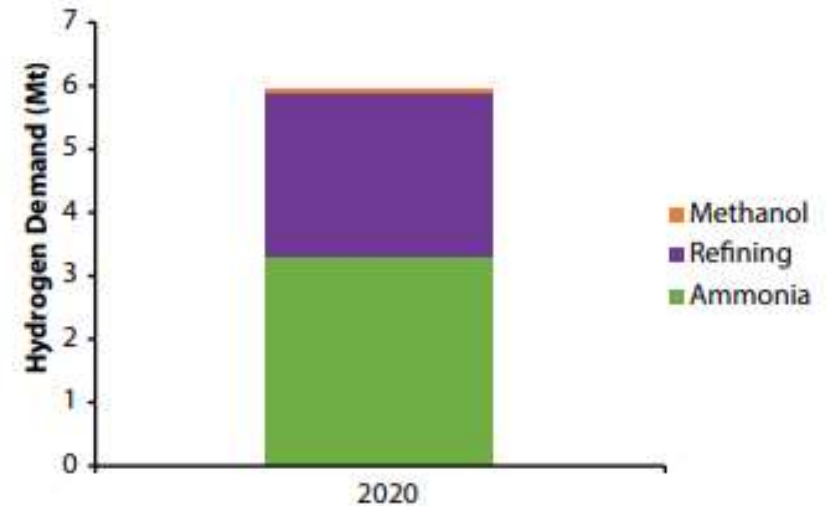


Figure 5: Hydrogen demand by sector, 2020

Source: TERI analysis based on (Ministry of Chemicals and Fertilizers, 2020)

Source: [The Potential Role of Hydrogen in India by The Energy and Resources Institute \(TERI\).](#)

Hydrogen – Few Incidents in India

- ❑ **In March 2023**, private chemical factory in Nagda, a hydrogen gas leak resulted in severe burn injuries to four workers. The incident occurred when there was a violent explosion, injuring the workers, while they were performing maintenance on the hydrogen pipeline at the MC 2 caustic facility. **Ref.** <https://energynews.biz/hydrogen-gas-leakage-in-nagda-chemical-factory-leaves-four-workers-injured/#:~:text=At%20a%20private%20chemical%20factory,sent%20to%20an%20Indore%20hospital.>
- ❑ Hydrogen gas cylinder exploded at Cospower Engineering in Maharashtra's Palghar district on **28 September, 2022**. Three workers died and eight others sustained severe burns. **Ref.** [https://www.industrialunion.org/three-workers-die-eight-injured-after-explosion-in-indian-factory.](https://www.industrialunion.org/three-workers-die-eight-injured-after-explosion-in-indian-factory)
- ❑ There was a massive explosion at the generator-turbine of the 500 megawatt unit (Unit 7) of Anpara D power station on **November 13, 2019**. Unattended hydrogen leak from the generator was identified prima facie as a major trigger. There was a leak in hydrogen from the generator. However it was not attended by shutting the plant and there was anticipation that it can be fixed without shutting the unit. **Ref.** <https://www.google.com/amp/s/www.downtoearth.org.in/news/energy/amp/blast-in-anpara-d-power-station-67746>

Hydrogen – Few Incidents in India

- ❑ A fire broke out aboard *Sindhurakshak* while the vessel was in [Visakhapatnam](https://www.indiatoday.in/india/north/story/indian-navy-submarine-ins-sindhurakshak-fire-explosion-gas-buildup-173752-2013-08-13) in **February 2010**. One sailor was killed and two others were injured. Navy officials reported that the fire had been caused by an explosion in the submarine's battery compartment, which occurred due to a faulty battery valve that leaked hydrogen gas. **Ref.** <https://www.indiatoday.in/india/north/story/indian-navy-submarine-ins-sindhurakshak-fire-explosion-gas-buildup-173752-2013-08-13>
- ❑ Blast at the hydrogen plant at the refinery at Reliance Industries' refinery at Jamnagar in Gujarat on **January 2009**. **Ref.** <https://www.dnaindia.com/india/report-two-killed-in-explosion-at-reliance-s-jamnagar-refinery-1219690>
- ❑ **In 1999**, Seven persons were killed in a cylinder burst at the Panipat Indian Oil refinery in Haryana. A minor leak was observed by operating staff at the discharge of make-up gas compressor which supplied hydrogen to the unit. Explosion with a flash fire occurred. **Ref.** <https://www.tribuneindia.com/1999/99may08/>

Risk Management Themes

Risk Consulting
Services



Analysis to
understand safety
challenges



Essential Safety
Practices for each Risk
Management Theme

Hydrogen
Safety
Management
– Risk
Management
Themes

Assessing the risk

Conduct of Operations

Asset Integrity Practices

Transportation Safety

Fire Detection, Prevention and Protection Practices

ASSESSING THE RISK

Assessing the Risk

Safety Challenges

- QRA & Facility Siting – In the event of leak, the jet fire radiation and overpressure consequences are impacting the adjacent areas (E.g., Control room). The Hydrogen Generator leaks tend to be contributing 30% for the risk to be in intolerable region.
- Location for Hydrogen Cylinders.

Essential Safety Practices

- In case of outdoor units – Avoid enclosure of the process equipment (E.g., Ensuring there is no obstruction above Hydrogen handling equipment).
- In case of indoor units – Blower operation and HVAC are critical. Also, positive isolation (Automatic fire dampers, fire doors etc.) is important.
- Relocation of Hydrogen Cylinder storage to remote areas.

CONDUCT OF OPERATIONS

Safety Challenges

- Integrity Operating Window and Process Operational Window.
- Consequence of Deviation.
- Interlock bypasses and impairments.

Essential Safety Practices

- Establishing IOW and POWs is important.
- Establishing the consequence of deviation and respective actions.
- Establish protocol for taking interlock bypass.

ASSET INTEGRITY PRACTICES

Asset Integrity Practices

Safety Challenges

- Philosophies
- Selection of material
- Behavior of Hydrogen under different process conditions
- Ignition Sources

Essential Safety Practices

- Depressurization, Isolation and Emergency Shutdown Philosophy, Deferral Management System.
- Have an understanding on the material chosen and the inherent hazards involved.
- Establishment of DMRs and preparing ITPM
- Control of ignition sources – HAC and compliance. Earthing and Bonding requirements.
- Preparation of Lessons Learned.

TRANSPORTATION SAFETY

Safety Challenges

- Piping/Pipelines
- Road Transport

Essential Safety Practices

- Corrosion protection and external impact.
- Route Risk Assessment and Journey Risk Management

FIRE DETECTION, PREVENTION AND PROTECTION PRACTICES

Fire Detection, Prevention and Protection Practices

Safety Challenges

- Fire and Gas Detection.

Essential Safety Practices

- Hydrogen gas detectors shall be provided at credible scenarios and shall be integrated to shut down the process.
- Notification of Hydrogen release from the safety relief devices in manned areas.

The background image shows an industrial facility with several large, cylindrical storage tanks. The scene is lit with a warm, golden light, likely from the sun, which creates a prominent starburst flare in the upper right quadrant. The left side of the image is partially obscured by a dark red and blue vertical bar. The overall atmosphere is industrial and dramatic.

CONCLUSION - OPERATIONAL REVIEW - WAY FORWARD

Operational Review

Assessing the risk

- Ensure that all HSE studies (HAZOP, QRA, Facility Siting, Bowtie) are conducted.
- Ensure HSE action items are implemented.
- Develop risk profile.
- Identify the risk receptors. Also, assess the infrastructure being impacted and prepare an action plan.
- Develop procedures for risk reduction.
- Ensure all the PSI is available in as built condition.
- List down the operability issues – Accessibility, Egress, laydown areas, Escape routes.
- Human factor analysis.
- Identifying Confined spaces, Work at Height and prepare rescue plans.
- Utility service to Operations interfaces.
- Inerting Requirements

Conduct of Operations

- Ensure Operating Procedures are available for all stages.
- Establish IOWs and POWs.
- Document deviations from standards.
- Ensure all the changes are reviewed and documented.
- PPE Management.
- Previous Incidents and Lessons Learnt.

Operational Review

Asset Integrity Practices

- Establish Competency requirements.
- Depressurization, Isolation and Emergency Shutdown Philosophy, Deferral Management System.
- Establishment of DMRs and preparing ITPM.
- Equipment Maintenance and Inspection history data.
- Spares Management.
- RAM analysis.
- Corrosion Management.
- Hydrogen Embrittlement Management. High Temperature Hydrogen Attack
- Lifecycle approach – SIFs, Cybersecurity etc.
- Long-term Asset Planning

Transportation Safety

- Defensive Driving Techniques focused on HAZCHEM transportation.
- Transporter selection, vehicle healthiness and no-go parameters.
- Corrosion protection and external impact.
- Route Risk Assessment and Journey Risk Management.
- Transportation Emergency Response Plan.
- Enroute Risk Assessment
- Driver selection, training and counselling using vehicle GPS data.
- Piping/Pipeline route risk management.
- Hydrogen Bank Cascade Transportation plans and checklists.

Fire Detection, Prevention and Protection

- Selection and location of detectors and providing suitable one.
- Requirements of Passive Fire Protection.
- Requirement of Explosion Protection.
- Cooling requirements for adjacent systems.
- Fire detection and protection system for Hydrogen Holdup tanks. To be considered same as storage tank.
- Selection of Fire Extinguishers. CO2 to be avoided.

Decommissioning Review

Decommissioning Review

- Ensure all HSE actions are closed
- Multidisciplinary Decommissioning Review (similar to HAZID)
- Statutory Requirements
- Listing of all modifications carried out
- Data on accidents, incidents, community complaints
- Operations, maintenance and inspection reports
- Selection of Contractor and Execution Plan
- Phase wise decommission plan.



THANK YOU

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