# CHAPTER 9
# PRIMARY AND ROOT CAUSES

Immediate and system causes were analyzed using the evidence compiled. The evidence was broken down into discrete building blocks of events or conditions from which the Critical (Causal) Factors were identified. Critical Factors are those events or conditions that, if removed, might eliminate or reduce the possibility of the event occurring, or reduce the severity of it. For each Critical Factor, Possible Immediate Causes and Possible Management System Causes (Root Causes) were identified

## 9.1 CRITICAL FACTORS

1. Loss of primary containment

2. Loss of secondary containment

3. Inadequate mitigation measures

4. Shortcomings in design and engineering specifications of facilities and equipment

5. Defunct Vital emergency shutdown system

6. Absence of Operating Personnel in Vital area (Control Room, Field)

7. Absence of On-site and Off-site Emergency Measures immediately on loss of containment

The observations given below are primarily based on the information and feedback gathered during the course of investigation from the Terminal

and Marketing Operation of Indian Oil Corporation Ltd. Their applicability to other areas may need to be verified by a separate study.

## 9.2 CRITICAL FACTOR CASUAL ANALYSIS

| **Critical Factors** | **Immediate Cause** | **Root Cause** (Management System Cause) | **Policy Issues** |
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| **1.**Uncontrolled Loss of Primary Containment in the form of a jet of gasoline | - Wrong Operation of valves by operator<br><br>- Improper Equipment (Hammer Blind valve)<br><br>- Absence of Second Operator<br><br>- Lack of supervision | - Ineffective Training<br><br>- Poor design Awareness<br><br>- Indiscipline<br><br>- Poor leadership at supervisory level<br><br>- Ineffective internal safety audit<br><br>- No external safety audit in 6 | - Safety not given adequate priority<br><br>- Lack of enforcement of discipline<br><br>- Leadership development program not effective<br><br>-Safety function not independent/autonomous<br><br>- No ESA conducted in last 6 years |

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| | | years | |
| 2. Operating personnel incapacitated | - All operating crew overcome by leaking gasoline liquid and vapour<br><br>-Second operator attempting rescue also entered the affected area and was overcome<br><br>- No PPE was used | - Lack of - operational skill and poor mental alertness<br><br>- Lack of training in emergency management<br><br>- Non-availability/lack of awareness on PPE use | - Lack of Risk awareness<br><br>- Lack of Training program |
| **3**.Loss of Secondary Containment | **-** Open dyke Valve in Tank 401A dyke | **-** Poor operating Discipline<br><br>- Lack of Supervision | - Leadership development not effective<br><br>- Independence of safety functions lacking |

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| | | - Position .not monitored in control room | - Risk awareness |
| **4.**Inadequate Mitigation measures | - MOV closure from control room made defunct<br><br>- Non availability of self controlled breathing apparatus (SCBA)<br><br>- No emergency plan for the scenario<br><br>- No emergency responder | -No "Management of Change Procedure"<br><br>- Improper PPE (Personnel Protective Equipment) Policy<br><br>- Quantitative Risk Assessment not done<br><br>- Absence of Training in Emergency Management<br><br>- Inadequate Leadership | - Safety not given adequate priority<br><br>- Risk perception<br><br>- Risk awareness<br><br>-Emergency awareness<br>-<br><br>- Leadership development not effective<br><br>- Independence of safety functions lacking |

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| | - Absence of command and control during emergency | - Ineffective internal safety audit<br><br>- No external audit in 6 years | |
| **5**.Shortcomings in design and engineering | - Selected device for positive isolation is potentially hazardous<br><br>- Operating area was inside dyke<br><br>- MOV operation was from inside dyke<br><br>- Operating area access/escape unsatisfactory | - Old practice not reviewed<br><br>- No Hazard Analysis<br><br>- Improper HAZOP<br><br>- No Hazard Analysis<br><br>- Improper HAZOP | Acceptance of status quo<br><br>No formal structure to scan latest industry development /best practices etc. and picking up best industry practice<br><br>-<br><br>- |

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| | - MOV was used for tank isolation as well as for Hammer Blind isolation. No fall back provision. | | |
| **6.** Absence from site of one operator | - Poor operating discipline<br><br>- Lack of Supervisory Control | - Lack of Supervision and monitoring through surprise checks<br><br>- Laxity in strict enforcement of Conduct & Discipline Rules<br><br>-Incompetency at Supervisory Level | - Inadequate monitoring by senior management<br><br>- Leadership development not effective |

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| 7. Absence of Immediate Response to On-site and Off-site Emergency | - Poor emergency awareness<br><br>- No emergency responders<br><br>- Unavailability of PPE | - Lack of understanding of Hazard potential<br><br>- Absence of Training in Emergency Management<br><br>- Lack of PPE Policy | - Risk Awareness<br><br>- Safety not given adequate priority<br><br>- Lack of risk perception |

The root causes are aggregated under the following heads and the indications of:

## 9.3 ROOT CAUSES INDICATORS AND REASONS

| ROOT CAUSE | INDICATED BY | REASONS |
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| Inadequate leadership at Terminal in-charge and state level management | Absence of written Standard Operating Procedures (SOPs) | Inadequate leadership training<br>KRA's too many & diverse |
| | No review of operating practices even after CBI investigation in August 2009 | |
| | Safety rules not enforced | |

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| | Operating discipline very poor | |
| | PLTs carried on after dark, never with manager or senior manager present | |
| Inadequate Safety Priorities | Vital safety devices made non functional since long | Safety Management System not properly implemented |
| | No adequate safety check list | Management of change, safety training ensuring competency of people not adequately done |
| | Risk assessment, Hazop, What If analysis not done | |
| | Communication facilities inadequate | |
| | Vital PPEs like SCBA not readily available and people not trained for emergency use | |
| | Emergency preparedness for major events missing or totally inadequate | |
| | Fire fighting resources (manpower, water) inadequate | |
| | Near-miss reporting system absent | |
| | No safety campaigns or | |

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| | posters visible | |
| | Did not indicate awareness about safety policy, safety policy not displayed | |
| | Security staff and the contractor had no instructions on emergency handling on their own | |
| | Inadequate safety messages displayed through posters, billboards; safety policy not displayed | |
| | No External Safety Audit for last 6 years | |
| | Internal Safety Audit inadequate as it could not point out any deficiency in design or procedures & practices | |
| | Safety performance based on lagging indicators (accident statistics) not on adherence to system and procedures | |
| Inadequate Design and | Push buttons of MOV too | Hazard potential of |

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| | close to each other | |
| | Locations of push buttons difficult to see while standing in front of MOV | |
| | Entire assembly of hammer blind and isolating valve should be outside the dyke area | |
| | Approachability of valves poor, very congested | |
| | One additional valve should have been there on tank body before hammer blind and its isolating valve | hammer blind not realized Deficient design review |
| Construction | Location of fire pumps and tanks poorly conceived though meeting statutory distances | |
| | Bleed valve between hammer blind and MOV not provided even though on P&ID | |
| | Second escape route from installation near pipeline area was blocked by a wall which had been constructed to close the gate | |

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| Quality of supervision inadequate | No checking or guidance from Shift Supervisor when emergency occurred | Focused Supervisor Training and its certification |
| | Poor judgement of Shift Supervisor – taking on too much workload in shift with one operator gone out, 2nd operator working 3rd consecutive day 16 hrs, 3rd operator being emotionally stressed | |
| | Miscommunication between KR Meena & RN Meena | |
| Working in Silos | Marketing and Pipeline Divisions did not display coordinated emergency management | Interface Management Focus |
| | Pipeline Division failed to realize Hazard potential of the loss of containment | |

## 9.4 ESTABLISHING REASONS FOR OPERATOR ACTION

1. The Committee tried to examine the underline reasons that may have led to the experienced operators' making such a

basic mistake in the operation of the valves. Some likely causes which could lead to such an event are listed below:

a) Was it because of human error?

b) Was carelessness the cause?

c) Could it be due to operators' taking a short cut to the procedures?

d) Were the operators misled due to an equipment deficiency such as a passing valve?

e) Was bad practice of the past a reason?

f) Was there any possibility of any ulterior or personal motive?

2. It was also known that Shri RN Meena, the operator who actually operated the Hammer Blind and other valves which resulted in the leak, was somewhat absent-minded and had a withdrawn personality, and also was under some stress due to family problems.
3. Human error, though it can happen any time, seems a little unlikely because the same group of operating personnel had just a few minutes ago carried out an identical operation on another product tank for lining up (SKO). Further, the same group of operators have been carrying out the PLT operation for the last 15 years or so.
4. Carelessness could have been a starting point, especially if we take into account the emotional situation of the concerned operator Shri RN Meena. There is always a likelihood that he might have forgotten to check the position

of the Hammer Blind or the HOV before commencing line up operation.

5. Being misled by a passing valve like the MOV is also a possibility, though such passing of the valve was never reported earlier.
6. Operators taking a short cut is also likely as for example if they were trying to hasten the activity of line pressurizing, even before the tank gauging exercise was completed.
7. Bad practice of the past such as keeping HOV open first seems to have been prevalent but this itself may not be the cause for the incident.
8. As regards ulterior or personal motive the Committee has noted the presence of some unusual circumstances, viz,

i) just prior to tank 401-A lining up operation both the operators had lined up the SKO tank barely 10-15 minutes earlier, when both the operators were present and SKO tank was successfully lined up.

ii) The same procedure was not followed in case of MS. While one operator had gone up the tank, the other operator remained at the valve line up position and was reportedly doing something. Before the crew could come down from top of the tank and be briefed about what he (Shri K R M) had done, for some inexplicable reason he left the work place and was later found having tea in the canteen. This does lead to some doubts and suspicion about what could have compelled him to leave the site.

iii) There has been a case of unusual stock losses in MS sometime in July 2009 which was under internal investigation at the time of the incident. Almost a week prior to the incident a letter had also been written to Senior Terminal Manager by the GM (RSO) regarding these unusual stock losses.

iv) It is also known that there was an incident being investigated by the CBI regarding diesel (HSD) pilferage which happened in June/July 2009.

v) Both the operators were highly experienced and normally not be expected to commit such a mistake of leaving the hammer blind open and opening the MOV.

vi) In the light of what is stated above the Committee feels that motivated actions by the operators for whatsoever reasons cannot be entirely ruled out. In case the delivery line pressurizing is done before the tank is gauged it would distort the tank receipt figures from the pipeline group and reduce the stock loss figure of Marketing Installation.

vii) However, as it was not strictly in the remit of this Committee to collect any concrete evidence or records related to pilferage/mal-intention, the Committee has no means of establishing, with any degree of certainty, that this was indeed a driving motive for the action.

viii) Since both the operator are no more, the committee could not concretely substantiate these issues

## 9.5 POSSIBILITY OF SABOTAGE

There is no concrete evidence of any sabotage as per the extensive field surveys, analysis/equipment conditions.

## 9.6 SUMMARY OF BASIC CAUSES

**Human Factors**

- Operational safety rules, procedures were not being effectively enforced

- Experience level of supervisory staff in installation was considerably diluted as a result of company policy on transfers

- No effort made to assess competency and aptitude of officers and managerial staff and use this for company postings

- Even though plant had some degree of automation, in the tankage operation and pipeline transfer area, considerable human intervention was called for, and therefore human back up should have been carefully assessed.

- One of the shift operators, who was quite experienced and well versed with the Installation and its operation was not at site as he had reportedly gone home for 3-4 hours for some work.

**Technical and Engineering Factors**

- Design of system inadequate – use of Hammer Blind. MOV used for isolating HB. Only one press of a wrong button when HB is open can result in extreme hazard. No fallback in case of leak except remote shutting provision. This can always be defeated but an additional valve on tank cannot be removed that easily. Location of HB and MOV inside dyke is unsafe.

- Construction and equipment – congested area, approachability poor. Push buttons placed inconveniently.

- Drainage system – tank dyke is connected to storm water drain also which is open to atmosphere, Hydrocarbon entering this allows vapor to spread throughout installation.

- Fire water, fire pumps & storage tanks – water adequacy norms not based on major fire explosion. Location of five pumps and FW storage not ideal.

- Restricted VHF communication facility, paging facility for operating staff and no Public Address System.

- Flow meter on product lines from the Installation was not provided.

**Organisational Factors**

- No contingency plans in place for dealing with major incidents. Hazards in operating large installation like Jaipur were not fully understood.

- Safety and loss management systems were inadequate (e.g. Internal Safety Audit, risk reduction strategies etc), No near miss reporting system seems to be in place, there was no evidence of any accident records, even minor ones, absence of safety posters/slogans etc.

- Corporate Safety Group being inadequate, professional training to safety and line managers in quantitative methods and risk assessment techniques etc., was not provided.

- In terms of overall corporate priorities, terminal operations, primarily being a cost center, may be getting less management time and attention than direct revenue earners like sales or production or other external facing departments like retail sales and lubes etc.

- Manpower requirement and quality of personnel not assessed properly.

- Discontinuity in senior management in the Terminal. During the about 14 years of operation since commissioning, the installation had 8 managers (incharges). Result was that systems, procedures and training and follow up suffered greatly.

- Emergency/Contingency plans for dealing with major incidents were inadequate.

- Internal Safety Audits conducted did not point out the non availability of the emergency remote close facility on the critical motor operated valves since several years. External Safety Audit had been conducted about six years ago which had pointed out a deficiency in these valves.

- A growing corporation with bigger sizes of installations and plants and also increasing numbers of such installations needs greater sophistication in both technology and engineering controls as well as in management systems. No evidence seems to be in place of a review mechanism to periodically oversee these aspects.

**Environment**

- The original location about 15 years ago had hardly any industrial establishment around it.

- .Rapidly developing Jaipur city resulted in industries being set up contiguous to the installation.

**Overall Lessons Learnt**

- Management must always ensure that systems to provide realistic feedback to them about the safety and operational readiness and the practices in the field areas, are always in place and a system of checks and balances is maintained.

- Terminals and installations should be subjected to a QRA and treated as a high hazard location

- Combined knowledge and experience of operations maintenance and management personnel must be maintained at a high level

- Senior management both at local and corporate level need to give more attention to monitor installation actual practices

- Greater coordination required between local Land Planning Authorities and major high hazard and other Industries.