LNG INCIDENT IDENTIFICATION — UPDATED COMPILATION AND ANALYSIS BY THE INTERNATIONAL GROUP OF LNG IMPORTERS (GIIGNL)

On behalf of GIIGNL by:

Anthony Acton, ActOn LNG Consulting,
Deborah Brown, GL Noble Denton
Pierre Langry, Dunkerque LNG

KEYWORDS: GIIGNL, LNG safety, LNG incidents, hazardous release, near miss, earthquake, tsunami

ABSTRACT

Safety has been of utmost importance to the LNG industry since its inception. GIIGNL studied incidents within the global LNG industry in 1992 and updated the work in 2001. A second update reported here adds recent incidents mainly concerning import terminals. This work was done by a Study Group from GIIGNL member companies in the Americas, Europe and Asia based on data sought from all GIIGNL members. The goals of the study are:

- To identify actual incidents of hydrocarbon release and other incidents of concern for possible inclusion in the hazard analysis of new, modified or existing facilities.

- To advise on the severity of the incidents to assist evaluation of their importance and potential consequences.

- To provide information on the circumstances under which the incidents occur (and their frequency where possible) to assist understanding of their relevance to particular LNG facilities.

Incidents and near-misses are categorized by type, function being performed, and severity. Trends have been identified.

The overall trend for a decrease in the number of events with significant hydrocarbon release continues, indicating continual improvement in mitigation measures and procedures.

GIIGNL has decided in future to collect incident data on a more-frequent basis and has developed a new data collection system for this purpose.

There have been no reports of injury to the public or offsite damage from an incident at an operational LNG import facility since trade started in the mid-1960’s. This demonstrates the industry’s commitment to safety, the adequacy of design and operating procedures and the suitability of applicable codes and regulations.

1. INTRODUCTION

GIIGNL has an ongoing programme for collecting and analysing safety incidents at its members’ LNG facilities and maintains awareness of incidents worldwide in order to maintain and enhance the excellent safety record of the global LNG industry. The scope includes all LNG incidents with the potential to cause damage to equipment or injury to personnel.

This task is assigned to the Permanent Technical Study Group of GIIGNL, whose participants come from many LNG companies that are members of this international organisation which promotes good practices in the LNG Industry. Currently, the Technical Study Group comprises the following:

GDF Suez (Chair and Secretary, France), BG (USA), BP (UK), Chinese Petroleum (Taiwan), DEPA (Greece), Dragon LNG (UK), Dunkerque LNG (France), ELENGY (France), ENAGAS (Spain), E.ON Ruhrgas (Germany), FLUXYS LNG (Belgium), GAIL (India), Gasunie (The Netherlands), Gate terminal (The Netherlands), GDF Suez Energy NA (USA), GNL Italia (Italy), Kansai Electric Power (Japan), Kogas (South Korea), National Grid Grain LNG (UK), Osaka Gas (Japan), Petronet LNG (India), REN Atlantico (Portugal),
Sempra LNG (USA), Shell Global Solutions (The Netherlands), Southern LNG (USA), STATOIL, STREAM Repsol Gas Natural LNG (Spain), Tokyo Electric Power (Japan), Tokyo Gas (Japan), Total (France) and Vopak LNG (The Netherlands).

This paper updates a previous publication on GIIGNL’s study of LNG incidents of all types which now average less than 0.25 per site year since the start of the commercial LNG industry. A new review of the effects of recent earthquakes and Tsunamis on LNG facilities is included. Historically, incident data has been collected by questionnaire in an anonymous manner because of its commercial sensitivity. Recently, an electronic web-based system has been developed to facilitate data collection and analysis whilst maintaining the anonymity of specific incident data.

The authors of this paper are recent past and present members of the Technical Study Group. We are most grateful to all in the group who have contributed to the study over the years and, in particular, for the help and support of the current Chairman, B. Weiss and the current Secretary, H. Malvos.

2. THE GIIGNL SURVEY

Information on incidents was first collected from previous GIIGNL studies and also on recent incidents known to the Technical Study Group Members that had not featured in those studies. This was used to initiate the work but it was immediately recognised that more details were required for any useful analysis of results to be performed. Reports of events considered to be routine operational incidents were disregarded. Information was also reviewed for a number of incidents in the public domain that were technically outside the scope of this study because the plants concerned did not belong to GIIGNL members.

Detailed information on incidents was then obtained by a questionnaire that was developed by the Technical Study Group and then circulated by the regional co-ordinators to all of the GIIGNL companies in their regions. Incidents were divided into three categories based on definitions developed for the study, as follows:

Category 1 - Releases of Hazardous Material

Any release of LNG, LPG, NGL, Liquid Nitrogen or related hydrocarbon gases leading to, or with the potential to lead to, injury to personnel or damage to equipment or buildings either on or off site.

Category 2 - Near Misses

Any incident involving a hazardous material system where there was no actual release of hazardous material but which had the potential to lead to a release of hazardous material as described in Category 1.

Category 3 - Other Incidents of Concern

Any incident, not involving a hazardous material system in the LNG plant, but, for example, with the potential to escalate to Category 1 release.

Companies were asked to report the Immediate and Primary Causes of the incident in order to distinguish between the precipitating event and its basic cause. Companies were also asked to provide a summary of the key points of the incident.

It was recognised that a definition of the Immediate and Primary Causes of incidents can be a subjective view so this was supported by detailed reviews of each incident by the Study Group and a final consistency check between similar types of incident by a sub-group of European TSG Members.

One of the most important points in the incident reports was an estimate of the total quantity released. This had proved difficult to specify in the past and so three quantity bands were defined:

A: Less than 100 kg
B: Greater than 100 kg but less than 1 000 kg
C: Greater than 1 000 kg
Extra information such as date and time of the incident, sequence of events, extent of consequences, details of any casualties, effect on plant production, size of vapour cloud or liquid pool and actions taken to prevent it from happening again, were all obtained where historical records were accurate enough for it to be provided.

The study has already completed three phases, initially covering the period from almost immediately after the start of LNG importation to Q1, 1994 and subsequently from Q2, 1994 to Q2, 2000 and from Q3, 2000 to Q4, 2007.

3. INCIDENT DATA AND ANALYSIS

The incident database currently contains 144 incidents for the period from the start of 1965 to Q1, 1994 (referred to subsequently as pre-'95), 102 incidents from Q2, 1994 to Q2, 2000 (referred to subsequently as ‘95-'00) and 82 ‘new’ incidents from the period Q2, 2000 to Q4, 2007 (referred to subsequently as ‘01-'07) making an ‘All’ incident total of 328.

3.1 Analysis by Function

The following groupings were used for the definition of equipment functions:

- **Unloading:** LNG Ship, Jetty & Unloading Facilities.
- **Storage:** LNG Tanks, In-Tank Pumps & BOG Facilities.
- **Send-out:** Pumps, Vaporisers & Send-out Facilities (including LPG equipment)
- **External:** Equipment outside the control of the terminal, other than the LNG ship.
- **Other:** Utility equipment & any other equipment not included above.

The breakdown of incidents by function and collection period is shown in Figure 1 below.
The proportion of incidents occurring in Storage has increased in the latest collection period and this is the area where most incidents have occurred. A possible reason is that this may be due to the difficulty in carrying out routine maintenance on the storage tanks. Over all the data sets, the greatest number of incidents have occurred in the send-out system.

The major functions, namely Unloading, Storage and Sendout, account for the majority of the incidents. However, (ship) Unloading is a discontinuous function at conventional import terminals so the frequency of incidents as a function of operational time for this function is the most significant of the three, see Section 3.4.

### 3.2 Analysis by Category

The three Incident categories are:

- **Category 1**: Releases of Hazardous Material
- **Category 2**: Near Misses
- **Category 3**: Other Incidents of Concern

The breakdown of incidents by category and collection period is shown in Figure 2 below. There is a significant increase in the relative number of category 2 incidents in the '01-'07 period. However, this is offset by the number of incidents resulting in actual release of hydrocarbon (Category 1) which have reduced suggesting improved safety practices. Note that only significant near misses have been captured, following the study guidelines, hence the percentage relating to near miss is less than that of actual release.

![Incident Data Analysis by Category](image-url)

**Figure 2. Incident Analysis by Category**
3.3 Analysis by Function and Category

The breakdown of incidents by function, category and collection period is shown in Figure 3 below. In the latest collection period ('01-'07) the functions of Storage and Sendout are the largest contributors to category 1 incidents (hazardous releases). The number of unloading hydrocarbon releases have decreased. For the incidents assigned to the ‘Other’ function category, the most significant numbers are associated with LNG truck loading (37%) which may be attributed to an increase in trucking activities. These activities may often be outside the control of the terminal. This is a change from previous collection periods when incidents related to electrical/control equipment were most significant.

3.4 Frequency Versus Duration for Each Function

For the pre-1995 data, estimates were made based on data from GIIGNL and SIGTTO (Society of International Tanker & Terminal Operators) of the cumulative operating period of the import terminals and peak-shaving sites included in the scope of the study as summarised below.

- 3 060 ‘tank-years’ used for storage analysis.
- 20 250 ship voyages used for unloading analysis
- Total throughput of $868 \times 10^9 \, \text{m}^3(\text{n})$ of natural gas sent out by import terminals used for send-out analysis.

For the latter two collection periods, operational data was collated via a survey of terminals (with the exception of the shipping data) and is shown in Table 1 below. For collection period '95-'00, the shipping data was based on communications with SIGTTO and for '01 to '07 was provided by GIIGL Central office.

---

Figure 3. Incident Analysis by Function and Category (Numbers of Incidents Reported)
Table 1. Cumulative Data for Operating Periods '95-'00 and '01-'07

<table>
<thead>
<tr>
<th></th>
<th>'95-'00</th>
<th>'01 to '07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site-years</td>
<td>208</td>
<td>579</td>
</tr>
<tr>
<td>Tank-years</td>
<td>1,110</td>
<td>1646</td>
</tr>
<tr>
<td>Ship voyages</td>
<td>12,000</td>
<td>21,045</td>
</tr>
<tr>
<td>Total natural gas sent out</td>
<td>$607 \times 10^9 \text{m}^3(n)$</td>
<td>$1081 \times 10^9 \text{m}^3(n)$</td>
</tr>
</tbody>
</table>

For the purpose of analysis, the above operating data has been converted into millions of operating hours for each of the functions. The exception is Sendout which is based on m$^3$ of natural gas sent out. The frequency of incidents within each function was then calculated and the results are shown in Table 2 and Figure 4 below.

Table 2. Incident Frequencies per Function

<table>
<thead>
<tr>
<th>Time period</th>
<th>Storage (per million hours)</th>
<th>Unloading (per million Unloading hours)</th>
<th>Sendout (per $10^9$ m$^3$ (n) of gas)</th>
<th>External (per million hours)</th>
<th>Others (per million hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre '95</td>
<td>1.34</td>
<td>176.95</td>
<td>54.15</td>
<td>1.71</td>
<td>2.14</td>
</tr>
<tr>
<td>95-'00</td>
<td>1.64</td>
<td>166.67</td>
<td>60.96</td>
<td>3.31</td>
<td>10.47</td>
</tr>
<tr>
<td>01-'07</td>
<td>1.66</td>
<td>71.28</td>
<td>20.35</td>
<td>0.79</td>
<td>2.56</td>
</tr>
<tr>
<td>All</td>
<td>1.49</td>
<td>132.91</td>
<td>41.47</td>
<td>1.56</td>
<td>3.63</td>
</tr>
</tbody>
</table>

The analysis shows that events during Unloading functions are the most frequent based on actual operating hours although there is a significant decrease in the latest data set when compared with the previous collection periods. These events are approximately 10 times more likely per operating hour than for any other function. However, it is important to realise that the unloading operation is relatively infrequent at import terminals, typically 16-20 hours per week.
The previous ‘95-'00 collection period had found increases in incident rates for Storage, Sendout, External and Other functions compared to the original data set. The latest collection period, however, indicates a decrease in incident rates for Sendout, External and Other functions with only Storage increasing slightly. Whilst factors such as increased throughput, ageing equipment, and increases due to the introduction of formal reporting procedures could have influenced the trends in ‘95-'00 data, the significant reduction (except storage) in incident rates for ‘01-'07 data may be attributed to a combination of the reliability of relatively new equipment in new terminals, refurbishment of existing terminals, improved maintenance, etc. The increase in the frequency of incidents in the Storage system may be due to the difficulty in routinely maintaining the storage tanks whilst they remain online.

### 3.5 Analysis by Incident Date & Time

**Incident Date.** An incident frequency has been estimated for 5 time periods since the commercial LNG industry began, based on cumulative operation: The historical incident frequencies per site-year are shown in Table 3 below.

#### Table 3. Historical Incident Frequencies

<table>
<thead>
<tr>
<th>Period</th>
<th>Incidents</th>
<th>Operating site-years</th>
<th>Frequency (Incidents/Site-year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965 - 1974</td>
<td>15</td>
<td>44</td>
<td>0.34</td>
</tr>
<tr>
<td>1975 - 1984</td>
<td>52</td>
<td>179</td>
<td>0.29</td>
</tr>
<tr>
<td>1985 - 1994</td>
<td>94</td>
<td>327</td>
<td>0.29</td>
</tr>
<tr>
<td>1995 - 2000</td>
<td>85</td>
<td>191</td>
<td>0.45</td>
</tr>
<tr>
<td>2001 - 2007</td>
<td>82</td>
<td>579</td>
<td>0.14</td>
</tr>
<tr>
<td>Total 1965-2007</td>
<td>328</td>
<td>1320</td>
<td>0.24</td>
</tr>
</tbody>
</table>
As noted in the previous section, the increase in incident frequency in the ‘95-‘00 period may be due to factors such as increased throughput and ageing of equipment but is likely to be influenced by improved reporting rates following the introduction of formal reporting procedures. The decrease in incidents in ‘01-‘07 data may be attributed to improved procedures and reliability of new equipment in the newly built and refurbished terminals.

**Incident Time.** Analysis was based on an operational day period from 6:00 a.m. to 10:00 p.m. The results in Figure 5 show that whilst the number of incidents occurring in the night and day time remain the same in the first two data sets, the results for data set ‘01-‘07 show an increase in the percentage of incidents occurring in the night.

![Incident Data Analysis by Time of Day](image)

**Figure 5. Incidents during the Day and Night**

### 3.6 Analysis by Incident Cause

Two levels of incident causality were defined in the study, Major Immediate Cause and Main Primary Cause in order to distinguish between the precipitating and the underlying causes of incidents.

**Major Immediate Cause.** Four Major Immediate Causes were defined as follows:

- Operation (concerning an action, including maintenance)
- Material (concerning equipment, materials or installation)
- External (concerning anything out of the influence of the terminal)
- Unknown (concerning those where the Immediate Cause was never found)

The results are shown in Figure 6 below:
Whilst Pre '95 and '95-'00 data suggest that there are more incidents with a Major Immediate Cause which can be attributed to problems with materials or equipment, the '01-'07 data suggest a higher proportion of incidents are caused by a direct action or operation.

The breakdown of Categories of incidents for each Major Immediate Cause is shown in Figure 7 below:
The results show that incidents with 'Material' as a Major Immediate Cause (i.e. defective equipment, materials or installation) tend to involve releases of hazardous substances, and external causes are less likely to bring about an incident involving a release.

**Main Primary Cause.** Four Primary Causes were defined as follows:

- Design/Construction (D/C),
- Operation/Maintenance (O/M),
- External Cause,
- Unknown,

For these cause groupings, the Design/Construction cause was restricted to those incidents which were caused by a problem with the initial design and installation of the equipment. Any incidents caused by equipment failure during operation, operator error, poor procedures and poor maintenance were grouped together under Operation/Maintenance. In other words, these incidents were caused as a result of the operation of the terminal and could not be attributed to poor design or installation in the first place. The results are shown in Figure 8 below:

![Incident Data Analysis by Main Primary Cause](image)

**Figure 8. Incident Analysis by Main Primary Cause**

It can be seen that Operation/Maintenance continues to be the major Main Primary Cause of incidents followed by Design/Construction.

**Major Immediate Cause versus Main Primary Cause.** Further analysis of the two dominant Major Immediate Causes, Material and Operation, has been carried out with the dominant Main Primary Cause of Operation/Maintenance, split further into Operator Error, Poor Procedures and Poor Maintenance.

**Material.** Design/Construction failure followed by Poor Maintenance continue to be the Main Primary causes for the Material category, accounting for approximately 90% of reported incidents as shown in Figure 9. A
comparative analysis of data sets '95-'00 and '01-'07 suggest an increasing proportion of incidents due to Poor Maintenance while all others show a downward trend.

**Figure 9. Primary Causes for Material as Major Immediate Cause**

**Operation.** Further analysis of incidents with Operation as the major immediate cause as illustrated in Figure 10 below shows that causes that were attributed as due to human actions (Operator Error and Poor Procedures) have decreased in the latest data collection period whereas Poor Maintenance has increased. These suggest an improvement in procedures and training of operators.

**Figure 10. Primary Causes for Operation as Major Immediate Cause**
3.7 Analysis by Release Quantity

Analysis of the Category 1 incidents (the only category that includes actual releases of hazardous material) produced the results shown in Figure 11 below. The trend shows a significant increase in the proportion of incidents leading to a release less than 100kg.

![Figure 11. Incident Analysis by Release Quantity](image)

Further analysis by Send-out, Storage and Unloading functions as shown in Figure 12 below indicates that a high proportion of the largest releases occur in Storage while small releases are most likely in Sendout.

![Figure 12. Release Quantity for Unloading, Storage and Sendout Functions (Numbers of Incidents Reported)](image)
3.8 Incident Analysis by Gravity of Event

Incidents have been classified according to their gravity by cross-referencing the incidents of release of hazardous material (Category 1 Incidents) against the range of consequences reported, i.e. Explosion (E), Fire (F) or Rapid Phase Transition (RPT). It can be seen that there is a decrease in the percentage of incidents where a leak resulted in an explosion, fire or RPT in the last data collection period.

![Incident Data Analysis by Gravity of Event](image)

**Figure 13. Incident Analysis by Gravity of Event**

4. IMPACT OF RECENT TSUNAMIS AND EARTHQUAKES ON LNG TERMINALS

The design of modern LNG terminals includes consideration of earthquakes and, as these facilities are located close to the coastline, the possibility of a Tsunami resulting from an offshore earthquake. Earthquake frequency and magnitude are dependent on global location and the effects also depend on local soil conditions and nearby geological faults. The international design codes for LNG facilities, e.g. NFP 59A and EN1473 include specific procedures for earthquake design and the Japanese design rules have similar requirements.

4.1 Earthquakes

A number of very large and large earthquakes have occurred with epicentres in areas that could potentially affect LNG facilities and are listed in Table 4.
It can be concluded that even very large earthquakes have never caused major incidents at LNG facilities. Current seismic design standards do include adequate safety margins but it is important that the regulations, standards and fitness for service of the seismic design are reviewed every time a large earthquake occurs.
4.2 Tsunamis Resulting from Earthquakes

A few earthquakes have resulted in Tsunamis that could impact LNG facilities and are listed in Table 5.

Table 5. Historical Relevant Tsunamis

<table>
<thead>
<tr>
<th>EARTHQUAKE NAME</th>
<th>TERMINAL</th>
<th>DESCRIPTION</th>
<th>TYPICAL DAMAGE TO FACILITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan 2011</td>
<td>Minato LNG</td>
<td>Approximately 4 m over usual tide level for one hour</td>
<td>Facilities supported by pile foundations were not damaged. On the other hand, facilities such as small size piping unsupported by pile foundation were greatly damaged, but the damage did not cause LNG leakage</td>
</tr>
<tr>
<td>Sumatra 2004</td>
<td>Osaka gas</td>
<td>Approximately 1m over usual tide level</td>
<td>No damage to facilities</td>
</tr>
<tr>
<td>Chile 2012</td>
<td>Mejilones</td>
<td>Approximately 0.5m over usual tide level</td>
<td>No damage to facilities. GNLM took the decision to disconnect and send the ship far away from the terminal</td>
</tr>
</tbody>
</table>

Only the Great East Japan Earthquake on March 11, 2011 resulted in damage to LNG facilities due to Tsunami. Send-out from the Minato (Sendai) LNG Import Terminal was safely suspended immediately after the earthquake but the Tsunami struck an hour later and flooded as far as 4 km inland. The marine LNG unloading facilities and the inground LNG storage tank were undamaged but some low-level pipe supports with shallow foundations and many instruments were affected and a utility building including electrical power supply equipment was washed away. There were no injuries to personnel resulting from the incident. An airtight odorisation building and pipe supports on piles survived.

This recent experience in Japan has confirmed the basic principles of Tsunami design resistance: to ensure that LNG storage, key pipework and power supply / ESD and other safety systems are protected from flooding by being raised above the potential flood level or by a suitable sea wall. The use of piles to support pipe racks was proved effective against flooding by this incident.

5. MOVING FORWARD

The GIIGNL Technical Study Group decided early in 2011 to develop an on-line questionnaire through a web based application. The specifications were set up and implementation has taken place during 2012. To maintain consistency with the previous data collected, only a few adjustments and simplifications were made to the questionnaire. Particular attention was paid to developing a system that kept the incidents anonymous, whilst still ensuring ease of access and use.

An additional functionality is that the new application also allows the user to obtain statistics or carry out specific searches (file export is also possible).

5.1 New Incident Identification Application: Highlights

The Originators of incident reports (assigned by company members of the GIIGNL) will be located at plant level. Any incident reported by an authorized Originator, will automatically be sent to a Regional Moderator. The Regional Moderator has a key role with responsibility for checking the content of the incident report, and the right to populate the report on the database. Three Regional Moderators have been chosen from all the company members.
Figure 14. Web-based Incident Data Collection System

The incident report will only become visible to GIIGNL users when it has been checked and validated by the Regional Moderator.

Figure 15. Incident Data Management
5.2 Immediate Perspectives

A user test panel, made up of members of the Technical Study Group, found that utilisation of the Database was convenient and quick. Thus a final decision was made that all Incident Identification reporting should now be done on line. Since the ability to share incidents between members is of major interest, it was further agreed that there should be no strict criteria in deciding what must or must not be collected in the database.

The next LNG incident survey will involve collecting incidents from Q1 2008 till now. The learning period for the use of the application will be assisted by on-line support. By the end of Q2 2013, it is intended that the application will have become familiar to all GIIGNL company members, ensuring quick and easy reporting.

6. CONCLUSIONS

- Since the commercial LNG industry began in late 1964, there have been no reports of offsite damage outside the operational peak shaving or receiving LNG facility at which the incident occurred.
- A total of 328 incidents of releases of hazardous material, near misses and other incidents of concern have been reported and analysed in this comprehensive study of GIIGNL members’ facilities covering the 42 year period from 1965 to 2007.
- The frequency of incidents over the entire period is very low at 0.24 incidents per site-year. The most recent data collection period has the lowest reported incident frequency to date, 0.14 per site-year. Assuming that formal reporting has continued unchanged during this period, the reduction in number of incidents could be attributed to an improvement in risk mitigation measures and procedures on site.
- In the current period, incidents involving the actual release of hydrocarbons represent 54% of all those reported. This is a reduction from the average of 69% calculated from the earlier data collection periods.
- There is a decrease in the gravity of events with 7% resulting in a fire, explosion or rapid phase transition compared to 11% previously.
- The majority of actual releases are less than 100 kg. These now account for 75% of incidents where there are releases of LNG compared to the 48% and 64% previously reported for data set Pre 1995 and 1995 - 2000 respectively.
- The main sources of hydrocarbon releases are from Storage and Sendout equipment. Larger releases (>1 000 kg) are most common in the Storage system while smaller releases (<100 kg) are most common in the Send Out system.
- The analysis shows that incidents during unloading of LNG are the most frequent based on operating hours. These events are approximately 10 times more likely per operating hour than any other function. However, they do not contribute excessively to the total number because LNG unloading is a relatively infrequent operation at LNG import facilities.
- There is a significant decrease in incident rates for Unloading, Sendout, External and Other equipment functions which may be attributed to a combination of the reliability of relatively new equipment in new terminals, refurbishment of existing terminals, improved maintenance and procedures.
- There is a slight increase in the frequency of incidents in the Storage system which may be due to the difficulty in routinely maintaining the storage tanks while they remain online.
- There is an increase in the number of LNG truck related incidents. This may be attributed to an increase in trucking activities in the terminals. These activities may often be outside the control of the terminal.
- Fewer incidents still occur in the night but the proportion has increased from 19% in the previous studies to 25% in the current data set.
• Operations are now reported as the most significant Major Immediate Cause of incidents. Previously, a greater proportion of incidents were attributed to Materials. However, incidents with Material as the Major Immediate Cause are still more likely to lead to a release.

• The Main Primary Cause of incidents still remains identified as Operation/Maintenance.

• Earthquakes have had little impact on LNG facilities and in only one case has a Tsunami damaged a terminal but with no release of LNG and no injuries to personnel.

• The LNG Importers Group (GIIGNL) believes that maintaining a comprehensive record of incidents will be useful for the future design and development of safe LNG facilities. GIIGNL is committed both to improving further the report of incidents and to ensuring that its data remains up-to-date for the general good of the LNG industry.