

**Sherpa's Response to Advisian Peer Review of *Quantitative Risk Analysis Report Bulk Storage Facilities, Lyttelton Port* (doc ref 21026-RP-002 Rev 0 September 2016**

Rev	Date	Description	Prepared	Checked	Approved	Method of issue
FINAL	28-Nov-16	Issued as Final	J Polich	G Peach	G Peach	Email PDF

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**Peer Review Reference:**

Advisian, *Peer Review of Quantitative Risk Analysis Report Bulk Storage Facilities, Lyttelton Port November 2016*, doc ref: 170396-RPT-X0001-R1.

**Scope:**

It is not clear from the structure or format of the peer review which specific comments Advisian considers a response is required for. Therefore Sherpa has prepared a tabular summary of responses (which includes cross reference to the peer review sections) by taking the following approach:

- Responses to points raised in peer review Executive Summary are provided.
- Responses to technical queries or clarifications raised in the body of peer review where highlighted in blue boxes in the peer review are provided.
- Responses to comments that appear to be incorrect as they do not reflect the content of the QRA report are noted as an incorrect interpretation and potentially misleading comment, with the reference to the relevant section of the QRA provided.
- Responses to generalised statements made without supporting examples, statements regarding typical industry practices, or speculation as what may or may not be in place at particular sites are not provided.
- A number of the peer review comments relate to matters outside the scope of the QRA report (for example site specific safeguarding details, updates when future population data is available) so these items where applicable are noted as out of scope of the study.

The summary of responses is contained in Table 1.

**Use:**

It is intended that this response be included as an addendum to the Sherpa Lyttelton Port QRA report and Advisian peer review when the QRA report is released publicly.

As agreed with the Steering Group, the QRA report will not be reissued to address any matters raised in the Peer Review or other items such as minor typing errors.

**Conclusion:**

The peer review Executive Summary states: *“The cumulative QRA report was prepared as per good industry practice and was based on the agreed database, information and assumptions”*. As per the responses in the attached table, in Sherpa’s view there are no matters raised in the peer review that materially affect the results of the QRA.

**Table 1: Summary of Responses to Peer Review**

Response Number	Advisian Item	Item	Sherpa Response (NOTE: QRA report cross references refer to Sherpa's report <i>Quantitative Risk Analysis Report Bulk Storage Facilities, Lyttelton Port</i> doc ref 21026-RP-002 Rev 0 September 2016)	Sherpa assessment of impact on QRA results
1	Exec Summary page iv 1 <sup>st</sup> bullet pt	<ul style="list-style-type: none"> <li>The cumulative QRA report was prepared as per good industry practice and was based on the agreed database, information and assumptions. However, the calculated risk was seen to be on a caution side due to the assumptions and selected database.</li> </ul>	<p>As no specific assumptions or databases are referred to here, Sherpa is not able to respond to the comment that the calculated risk was "seen to be on a caution side". Comments that imply conservatism are addressed in subsequent sections of this response.</p> <p>In Sherpa's view, QRAs for use in land use planning should be based on conservative assumptions, hence a precautionary approach with stated assumptions has been presented.</p>	None
2	Exec Summary page iv 2 <sup>nd</sup> bullet pt	<ul style="list-style-type: none"> <li>Flash fire event should have been considered for a delayed ignition for pumps and process piping and associated fittings, flanges and etc.</li> </ul>	<p>Incorrect interpretation and potentially misleading comment.</p> <p>Delayed ignition resulting in flashfire events have already been included for pressurised releases of flammables such as gasoline, methanol and LPG for small hole sizes such as fitting leaks, pump seal leaks as per QRA report Appendix D, Table D.2 event tree and example consequence results in Table D.7 of the QRA report.</p> <p>In some cases the model does not predict formation of an LFL hence there are no results for some combinations of hole size, receptor height etc</p>	None
3	Exec Summary page iv 3 <sup>rd</sup> bullet pt	<ul style="list-style-type: none"> <li>It is unclear what input was used in determining the fatality probability for toxicity assessment. Modelling Parameters stated that an averaging time of 10 minutes was used and referenced to TNO yellow book; however a 30 minutes exposure using AEGL 3 concentration was also referenced. A confirmation is required on the actual information used in the QRA.</li> </ul>	<p>An averaging time of 10 mins for toxics has been used as per QRA report Appendix C Table C.3.</p> <p>AEGL3 values for 10 mins and 30mins for ethyl mercaptan are the same (ie 450ppm for both 10 min and 30 min AEGL3).</p> <p>Methanol has no AEGL3 10 min value so 30 min value was used for AEGL3 to predict onset of fatality effects. This may be slightly conservative as ideally the dose response and averaging times to predict peak concentration at a location used to calculate the toxic dose should be consistent, however in this QRA toxic events have small effect zones and no significant impact on the risk contours.</p>	None
4	Exec Summary page iv 4 <sup>th</sup> bullet point	<ul style="list-style-type: none"> <li>The escalation between sites criterion used in the QRA is aligned with the HIPAP 4. This is acceptable in this QRA context as the Christchurch City Council has yet to define acceptable risk criteria.</li> </ul>	Noted	None
5	Exec Summary page iv 5 <sup>th</sup> bullet pt	<ul style="list-style-type: none"> <li>It was noted that the receptor height for flash fires in Table C.3 and the downwind distance to LFL receptor height presented in Table D.6 and D.7 were inconsistent. It is recommended that the receptor height that was used be confirmed and report updated.</li> </ul>	<p>Typing error – as agreed with Steering Group QRA report will not be updated.</p> <p>Receptor height used is 1 m for LFL / flashfire effects as per QRA report Appendix C Table C.3.</p> <p>Sherpa notes a typing error in the flash fire results table headings in QRA report Appendix D, Table D.6 and D.7 (which say 1.5 m instead of 1 m).</p> <p>Receptor height 1.5m for toxic and radiant heat impacts as per QRA report Appendix C Table C.3 and various results tables in Appendix D.</p>	None

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6	Exec Summary page iv 6 <sup>th</sup> bullet point	<ul style="list-style-type: none"> <li>Consideration of natural hazards as initiating events increasing both the likelihood of damage and extent of probable damage is generalised. The second sensitivity in the QRA doubles the ignition probability to account for an earthquake initiated major loss of containment. Note that, that the occurrence of an earthquake leading to loss of containment is in the frequency of 0.001 to 0.002 per year and only a fraction of equipment will likely experience loss of containment in the event.</li> </ul>	<p>Sherpa agrees that only some equipment may experience a loss of containment in an earthquake. Also that only worst case events would substantially affect the QRA results.</p> <p>The peer review states the consideration has been 'generalised' but provides no additional consideration or context the comment.</p> <p>As explained in QRA report Appendix F, only RS3 scale scenarios (catastrophic damage, Risk State 3 level) to tanks and associated bunds are included in the QRA as additional scenarios for each major storage area to account for earthquake risk. Lesser damage levels (RS1 and RS2) are not relevant to the QRA as explained in Appendix F.</p> <p>As per Section F1.3 the doubling of ignition probability applies only to the RS3 level earthquake initiated scenarios, not all other scenarios in the QRA which remain at their base frequencies.</p>	None
7	Section 2.3 page 3	When future use recreation areas that will have population density concentrated around them have their likely locations more specifically defined, consideration of updated modelling may be warranted.	Any future sensitivities or future refinements are outside the scope of the present QRA report.	Not in scope
8	Section 3.2 page 4	It is advisable to consider and define the transition point at which spray releases change to liquid releases in the methodology.	There is no fixed point where spray releases transition to liquid releases. This is dependent on the specific inputs for a scenarios that affect the materials ability to flash, and the PHAST consequence software defines the type of release (spray, liquid gas, two phase) based on the selected material, its physical properties and process conditions as well as the hole size.	None
9	Section 3.2 page 4	A confirmation is required on availability of the ignition control such as whether the electrical equipment and instrumentations located at the tank storage area are rated as per the hazardous area classification.	<p>Hazardous area classification is in place at all terminals.</p> <p>Hazardous area auditing, or installation verification / inspection for electrical or instrumentation equipment located in hazardous areas is not part of the QRA</p>	Not in scope
10	Section 3.2 page 4	Flash fire event should be considered for a delayed ignition for pumps, process piping and associated fittings, flanges and etc.	As per Response Number 2	None
11	Section 3.2 page 5	A confirmation is required on the actual toxicity information used in the QRA.	As per Response Number 3	None

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12	Section 3.2 page 5  Also Section 6, table page 11	Re: Cox , Less and Ang as source of ignition probabilities  <b>This reference was prepared in 1990 and should be replaced with a more rigorous approach.</b>  <b>Justification of using higher immediate ignition probabilities should be provided.</b>  <b>A further refinement of the QRA could be made by conducting a sensitivity analysis with reduction of total ignition probability and lower immediate ignition probability.</b>	Whilst Cox Lees and Ang is a relatively old data source, it is still used for QRA and has been selected as it allows immediate and delayed ignition probabilities to be distinguished for both liquid and gas phase releases. Cox Lees and Ang also generally sets higher ignition probability for scenarios up to around 10kg/s than in the OGP / EI ignition models but they are lower than other sources such as TNO Purple Book. At the higher release rate end (> 100kg/s) the OGP/ EI probabilities are higher.  The biggest differences in ignition probability data between different sources relate to lower leak rates (< 1kg/s) which have limited effect areas when ignited and do not make a significant contribution to offsite risks.  The database chosen (Cox Lees and Ang) is conservative ie predicts higher probability of ignition for smaller leaks (around 1kg/s) compared to OGP/EI ignition prediction models but not always for larger leaks (>10kg/sec). The EI methodology also inherently includes the effect of hazardous area classification and hot work controls and has largely been based on offshore data with modifying factors applied to reflect other types of plant configuration, ie it is not based on specific data for the types on installations covered but an different curves have been developed using factors to reflect likely differences in ignition sources of "typical" facilities. Whilst these ignition control systems are in place to the Lyttelton Port sites, there is very little access control to the site boundaries (which coincide with bund walls), process equipment such as loading bays is very close to public roads and live aboveground pipelines and pipebridges are in public areas and it is Sherpa's view the Cox Lees and Ang is adequate.  Refer to Figure 1 and 2 for a graph showing a comparison of various data sources which shows Cox Lees and Ang generally sits between the TNO and the specific EI ignition model sets that may be relevant to the type of facilities at Lyttelton.  In Sherpa's view a sensitivity study will provide no additional information for offsite land uses planning purposes as the scenarios that dominate the risk (flashfires involving large gasoline overfills, punctures of LPG pipelines, catastrophic tank failures and large bund fires as per Table 6.1 in QRA report all have high ignition probabilities approaching probability of 1 for volatile flammables regardless of the different data sources such as EI, Cox Lees and Ang, CCPS and Purple Book	Some effect on inner (mostly onsite) risk contours, relatively small effect on large offsite contours.
13	Section 3.2 page 5	Re: Site specific safeguards <b>A table of bowtie risk analyses drawn upon would need to be supplied in order to review this aspect of the QRA.</b>	Bowtie diagrams are not part of the QRA scope.  Details of site specific safeguards are outside the scope of the cumulative QRA report and included only in the confidential site specific QRA reports for individual operators  The general approach is described in the QRA report Section 4.4.6 and per APPENDIX E Section E7.	Not in scope
14	Section 3.2 page 6	Re : Earthquakes <b>It was understood that structural assessment has been excluded from this QRA but it is worth considering leaks from all credible releases.</b>	Only worst case loss of containment events caused by an earthquake would substantially affect the QRA results.  As explained in QRA report Appendix F, only RS3 scale scenarios (catastrophic damage, Risk State 3 level) to tanks and associated bunds are included in the QRA as additional scenarios for each major storage area to account for earthquake risk. Lesser damage levels such as damage with no leak, leaks from pipes and flanges (ie RS1 and RS2) are not relevant to the QRA results as explained in Appendix F.	None
15	Section 4.1 page 6	Re: Population <b>An incremental societal risk should be provided due to the changes in manning from permanent to temporary population.</b>	There is no "manning" (assuming this term refers to employees or onsite personnel). As per approach to population in QRA report Appendix A, as is standard in land use planning QRA, populations on the sites generating the risk are set to zero. In this case the populations for all bulk storage facilities and the hazardous substances wharf has been set to zero. There are no permanent populations, all populations are temporary in that the all have different population of presence as per Section A1. The incremental risk between the current population and future population (again all temporary) can be seen in the societal risk curve in QRA report Figure 7.1.	None



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16	Section 4.1 page 7	A statement with respect to toxic gas reaching/not reach offsite/public sites is recommended. Note that, Table B2 needs to reflect that Methanol is a toxic substance.	<p>Methanol toxicity effects at the AEGL3 level can extend outside site boundaries for limited areas only and hence makes minimal contribution to offsite fatality risk</p> <p>Typing error – as agreed with Steering Group QRA report will not be updated</p> <p>Table B2 notes that methanol is classed as 6.1 acutely toxic. We note there is a typing error and that the row for Toxic is blank, ie missing the additional text “yes” for methanol.</p>	None
17	Section 4.1 page 7	A confirmation on whether there is a typing error made on the flash fire assessment summary (refer to second bullet point) should be obtained.	<p>Typing error – as agreed with Steering Group QRA report will not be updated to correct this.</p> <p>There is a typing error in Section D6, bullet point 2, the corrected test is highlighted in yellow:</p> <p><i>and pool evaporation (for hole sizes &gt; 22 mm) based on the rule set defined in Table D.2 (Table D.7). (ie not &lt;22mm)</i></p>	None
18	Section 4.1 page 7	A consideration of the online time for piping / pipeline needs to be included in the QRA to account for the inventory within the piping / pipeline under static overhead pressure from the tank which could be above atmospheric condition.	<p>As per QRA Report Appendix E Section E8. an online factor was applied to the leak frequencies adjusted by parts count for each identified equipment item. The online time factor reduces the leak frequency based on the proportion of time that the equipment is used.</p> <p>This factor includes online time for piping from tanks. If the pipe is isolated at the tank shell valve, it is not exposed to the tank inventory or head pressure and the probability that pipe is unisolated is included in the frequency of leaks with pump head as driving force (such as pump suction)</p> <p>Details of site specific online times are outside the scope of the cumulative QRA report and included only in the site specific QRA reports for individual operators</p>	None
19	Section 5.1 page 8	The Future Case 2 should state all export increase via pipeline instead of road tanker.	<p>Typing error – as agreed with Steering Group QRA report will not be updated to correct this.</p> <p>Comment is correct, there is a typing error Future Case 2 does refer to Pipeline export.</p>	None.
29	Section 5.1 page 9	Justification or explanation of risk contributors for Future Case 2 requires elaboration.	<p>Future Case 2 risk contours are shown in the QRA report Figure 6.3 The only noticeable difference is that the <math>100 \times 10^{-6}</math> purple contour around the road tanker bays (as shown on Figure 6.2 in the middle of the overall contours for the road tanker export case) disappears in the Figure 6.3 for the Future Case 2 (all export by pipeline case) as there are far fewer gasoline road tankers being loaded compared to Future Case 1</p>	None
30	Section 6 page 9	Site specific QRA to be made available for review if deemed required by CCC.	<p>The scope set by the Steering Group covered confidentiality of site specific reports and release of this material would need to be agreed between operator and Council.</p>	Not in scope
31	Section 6 page 10	Greater clarity on the influence of natural hazards in magnifying risk is warranted.	<p>Appendix F explains the approach to assessing the potential effects of earthquakes. Only severe damage (RS3 level resulting in tank failure and possible bund damage) is included in the QRA. Appendix G, figure G4 shows the comparison of risk contours without the adjustment for natural hazards. There is not a large difference.</p>	None

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31	Section 6 page 10	The site specific QRA should include risk reduction measures as the risk contributors for the site specific could be narrowed down to the causal factors.	Comment on site specific QRA reports is not in scope	Not in scope
32	Section 6 page 11	Consideration to assess the risk acceptance criteria in the next phase for decision making and communication with affected parties on options evaluation and mitigation measures to reduce the risk to ALARP. This helps CCC in decision making / discussion with regards to future development.	Not within Sherpa's control or scope of QRA report	Not in scope
33	Section 6 page 11, 12	Communication and alignment on forward plan to prioritise <u>mitigation measures</u> implementation and development are required between CCC and all Operators.	Not within Sherpa's control or scope of QRA report	Not in scope

Total Ignition Probability Data Used in QRA:

Cox, Lees, Ang - Gas		Cox, Lees, Ang - Liquid (Class 3)	Cox, Lees, Ang - Liquid (Adjusted for diesel)
Mass Rate (kg/s)	Ign Prob	Ign Prob	Ign Prob
0.1	0.0035	0.005	5.3E-05
10	0.07	0.032	0.00032
100	0.3	0.08	0.0008
Rupture	1	0.08	0.0008

Figure 1: Comparison of Total Ignition Probabilities – Liquid, Various Sources

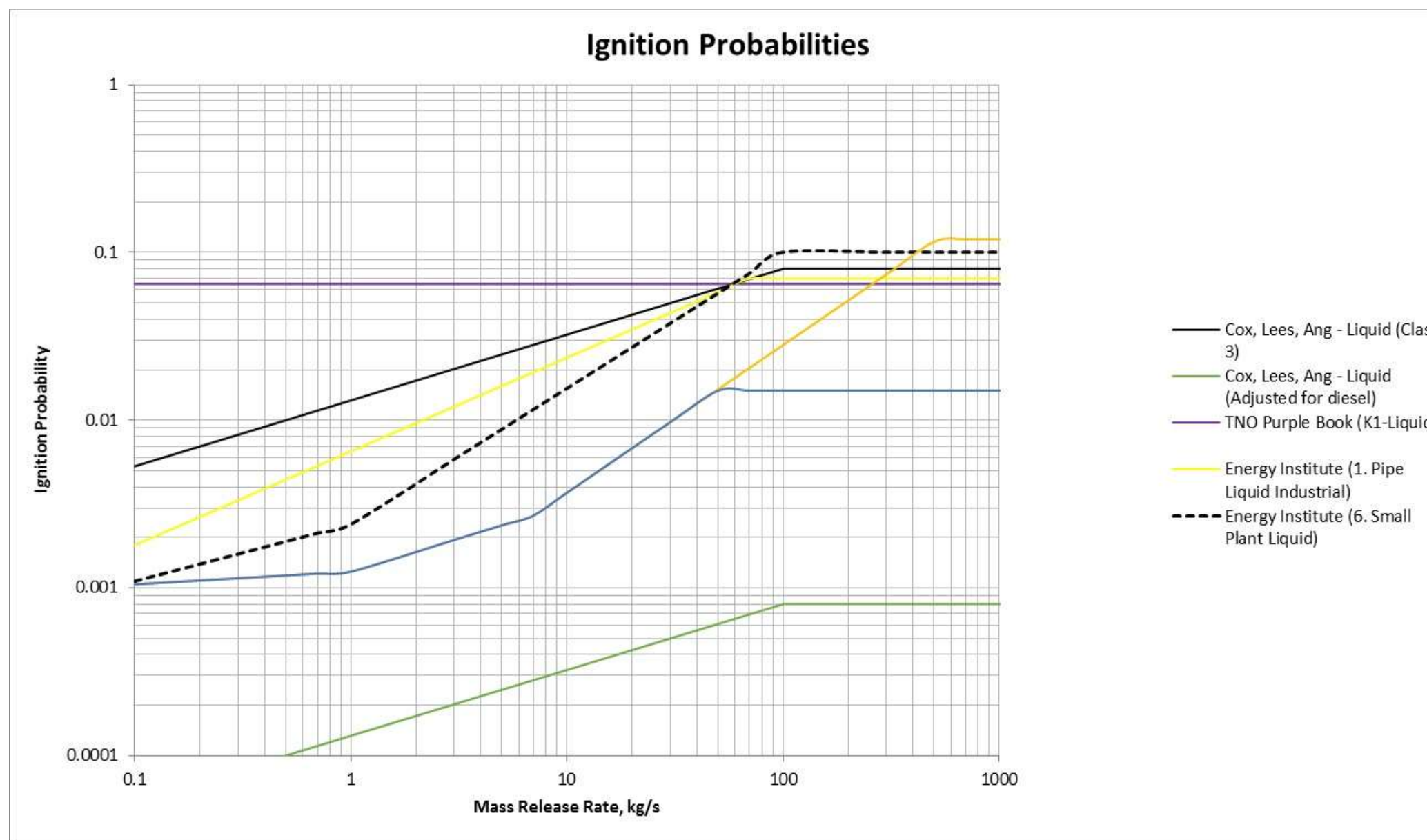




Figure 2: Comparison of Total Ignition Probabilities – Gas / Vapour, Various Sources

