

A Safety Assurance Assessment Model for an Liquefied Natural Gas (LNG) Tanker Fleet

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ABSTRACT: With the world's attention on future energy needs focused on LNG; the unprecedented growth phase and globalization era of LNG Shipping activities are inevitable. Along with that the acute shortage of qualified /experienced LNG Sea Officers to manage, operate and maintain the existing and upcoming LNG Tankers is a crucial issue to LNG Shipping Industry as they are the onsite guardian that safeguard and set the standards for the onboard HSSE Assurance. Hence the write-up is an attempt to recommend a recently developed (tailor-made), tested/proven, practical and cost effective solution i.e a Survey Questionnaire based rapid Safety Assurance Assessment Model to safeguard, sustain and further improve any LNG Tanker's Safety Assurance. The Assessment Model was crafted out after an in depth and width study/research into existing and potential future Safety Regimes applicable to an LNG Tanker (including its current Management Approach (Internal Control) – challenges ahead, needs to reform, etc.). The Assessment Model has also taken into consideration the foreseen challenges from the “humans on-site” with reference to already seen and proven historical perspective and impact of human behaviors onto an LNG Tanker's Safety Assurance.

1 INTRODUCTION

With global primary energy demand forecasted to grow at about 1.7%/year from 2002–2030 [1], the world LNG demand is expected to grow at approximately 7%/Year [2].

By 2020 LNG trading via sea set to look much more global [3]. Hence even in current global economic downturn all activities connected with LNG shipping industry are at its Unprecedented Growth Phase [4-7] and is slowly inching into its globalization era [8].

2 STATEMENT OF PROBLEM

In the past LNG shipping industry has leveraged upon its properly trained and experienced LNG Sea Officers to sustain its business success backed by strong HSSE Assurance. Today the utmost concern in LNG shipping industry is the acute shortage of experienced LNG Sea Officers [9] to man the multimillion dollar F1s at sea (LNG Tankers) without jeopardizing its Safety Assurance [10-12].

3 LNG MANPOWER DEMAND

As of 1st April 2009, the global LNG Fleet is forecasted to hit a total of 396 LNG Tankers by year 2012 [13,14]. Hence by 2012, there shall be (at least) a total of about 8700 active/serving LNG Sea Officers to man all the LNG Tankers afloat.

4 LNG MANPOWER ISSUES & ITS POSSIBLE IMPACT ONTO AN LNG TANKER'S SAFETY ASSURANCE.

The above highlighted matters has brought about increased competition and many new challenges to LNG Tankers owners /operators. Following are some Safety Assurance related “concerns” that arise in their attempt to maintain current competitive LNG market position, ventures and commitments:

- Experienced LNG Sea Officers from existing LNG elite group are “poached” using “economic enticements” [15,16]
- “Wrong kind of” unchecked Sea Officers are brought into the industry at higher rank [17].

- LNG Sea Officers might be frequently rotated among various types/class of LNG Tankers [18], leading to LNG Sea Officers/crews (strangers) cobbled together with little time to develop mutual trust [19].
- Crewing instability can lead to serious deterioration of the relationship between LNG Sea Officers onboard and management ashore within any LNG Tankers operators [20].
- Globally younger generation of Sea Officers (“Y Generation”) are withdrawing from the industry prematurely [21].

In conclusion worldwide shortage of LNG experienced Sea Officers can lead to poor decline in Safety Assurance [17,18].

5 CURRENT STATUS AND PROPOSAL

Many LNG Fleet owning /operating companies already feeling the pinch of “concerns” highlighted above. Moving forward, to safeguard, sustain and further improve LNG shipping industry’s trademark i.e excellent Safety Assurance track record [22]; **customized, rapid, practical and cost effective solutions are desired.**

However before describing one of such (proposed) solution, let’s revisit the typical /existing Safety Assurance regimes of a globally trading LNG Tanker.

6 LNG TANKERS – EXISTING/TYPICAL HSSE REGIMES

6.1 *During Building And At The Point Of Delivery*

Today during construction stage, each LNG Tanker is closely supervised by owner’s representatives and appointed Classification Society’s surveyors.

These people are entrusted to ensure that a New Building strictly complies (at least) with 17 latest Maritime Rules and Regulations required by Flag State, International Maritime Organization (IMO – Load Line, Tonnage, SOLAS , STCW, ISPS Code, IGC Code, ISM Code, International Convention for Prevention of COLREGs, MARPOL, GMDSS), US Code of Federal Regulations (33 CFR, 46 CFR), US Port and Tanker Safety Act, Suez Canal Authority (SCA), ILO Codes and other Rules & Regulations as decided by owner.

6.2 *In Service*

Upon delivery, during in service for globally trading LNG Shipping Company (hence its LNG Tankers) are expected to complied with Safety Regimes i.e Inspection and Vetting related to or required by ISM,

Terminal, SIRE, CDI , Class, Port State Control (PSC) Inspection, Change Of Status, Structural Review, Investigation, Performances and Benchmarking.

7 AN LNG TANKER’S EXISTING HSSE ASSURANCE REGIMES MANAGEMENT

7.1 *Internal Control (IC) Management Concept*

Today onboard LNG Tankers almost all the above listed Safety Assurance regimes are managed by its LNG Sea Officers using “Internal Control” (IC) Management Concept which concentrates on the Obligations, Systems, Interfaces and Procedures [23,24]. Generally IC Management Concept has a “richness” which is difficult to communicate.

7.2 *IC Management Concept – Challenges Ahead*

The implementation of Safety regimes using IC Management Concept within any industry tends to be “mechanical”, with focus on meeting minimal requirements. The approach hence leads to initial improvements in Safety performance that tends to “plateau” after some time [25].

With reference to previously discussed “concerns”, LNG Tanker owners/operators need to do more than just “mechanical implementation” of onboard Safety regime.

The implementation shall be elevated to a level where everyone understand, internalize, adapt, adopt, practice, agree and promote on the values of positive Safety behaviors.

7.3 *IC Management Concept – How to Reform?*

To harness “hard to communicate” IC Management Concept richness, its implementation method (model) needs to be fine tuned. The model shall encourage “scientific objectivity” i.e *exposing risk evaluations and decisions to intelligent debate, critics and amendment by people affected by the risk* [26-29].

8 AN LNG TANKER HSSE ASSURANCE

8.1 *Historical Perspective & Future*

Since the beginning of LNG shipping business (in early 1960’s), there has been efforts and progress in reducing and keeping the industry’s Safety risks to As Low As Reasonably Practicable (ALARP). First generation of LNG ships (about 1960’s – 1980’s) benefited from its “design” by sustaining its intrinsic “engineering safety”. Second generation of LNG ships (about 1980’s – 2000’s) benefited further

through improvement in Safety Management Systems. Today taking note the matters discussed in previous sections; current and future generation (post 2000's) LNG ships' Safety Assurance can only be safeguarded by the integration of and changes to existing organizational culture, personal behavior management and management attitudes [30].

8.2 Impact Of Onsite Human Behavior

Ultimately onboard any LNG Tanker its Sea Officers' "behaviors" that ensures onsite Safety Assurance and status [22]. Research findings by UK P & I Club and SHELL on "human behaviour" [31-33] further elaborate the above statement.

- 1 The plan that people make in their mind centers around "questions" related to the expected action's –
 - outcome,
 - perceived gap (present Vs ideal) and
 - own ability
- 2 Individuals' reaction to above questions depend on their beliefs, perceptions, management methods and working environment.
- 3 Making known the Safety Management Systems' key elements/requirements is crucial for its effective implementation.
- 4 Verifying whether the person "responsible" understands the above key elements/ requirements is important.
- 5 Personal proactive intervention through the application of "Hearts and Mind" is crucial

The research concluded that continuous improvement in Safety Assurance requires a deeper education/ embedding of the Health, Safety, Security & Environment Management Systems (HSSE MS). People shall be motivated to operate the elements of the HSSE MS, because they believe in it ("want to"), rather than that they are being forced ("have to").

8.3 Driving Force

From the above it is a fact that an LNG ship /fleet can improve and sustain its Safety Assurance when its LNG Sea Officers' (i.e its driving force) "hearts and minds" are tactfully addressed. With onboard "educated /reminded" LNG Sea Officers and "checked" /known Safety Assurance status, future "hearts and minds" related initiatives (e.g Behavior Based Safety (BBS), etc) can be easily rolled-out and implemented.

9 PROPOSAL – A RAPID CUSTOMIZED HSSE ASSURANCE ASSESSMENT MODEL FOR AN LNG TANKER

Taking note all the above discussed matters, ideally for educating/assessing Safety Assurance onboard an LNG Tanker, the focus and scope (of key Safety elements) shall expand /cover beyond the typical existing HSSE Regimes.

The above can be practically approached via an "one (1) comprehensive" customized Survey Questionnaires i.e a Rapid Safety Assurance Assessment Model.

The following write up further describe the model.

10 DEVELOPMENT OF CUSTOMIZED RAPID HSSE ASSURANCE ASSESSMENT MODEL FOR LNG TANKER

A "one (1) comprehensive" customized Survey Questionnaires (Rapid Assessment Model) was developed adopting "process approach". The following activities were carried :

- 1 An in depth study of:
 - Latest study/research (e.g reports, papers, articles, statistics, etc) on or related to Safety Assurance management in maritime and various high risk industries.
 - Latest 17 mandatory Regulatory Requirements applicable to globally trading LNG ships.
 - Typical 19 Safety Assurance related Inspections, Vetting and Other Initiatives imposed upon/adopted by globally trading LNG ships.
 - Existing/in use (active) MISC Berhad LNG Fleet's (one of the largest owner /operator of LNG Tankers in the world) Safety Management Systems.
 - MISC Berhad LNG Fleet's Safety Performances and Standards for last two (2) Financial Years (FYs)
 - Nine (9) future (potential) Human Elements and Organizational Factors related to Safety Assurance improvement initiatives that can be adopted by any LNG Fleet.
 - Reflect back 21 years of personal LNG shipping (onboard/on field) and academic experience and exposure.
- 2 In the process of studying the above (item 1), the elements crucial to ensure *effective* Safety Assurance Regimes and Systems Implementation were critically analyzed and summarized.
- 3 Resulting from the above (item 2), seven (7) Elements (variables) were identified as "crucial" for effective implementation of Safety Systems/Assurance onboard any LNG Tanker. The seven (7) Elements are:

- Leadership
- Policies
- Resources Management
- Hazards Management
- Planning
- Execution
- Assurance

The below diagram illustrate the interlink between the above seven (7) elements. (See Figure 1 below)

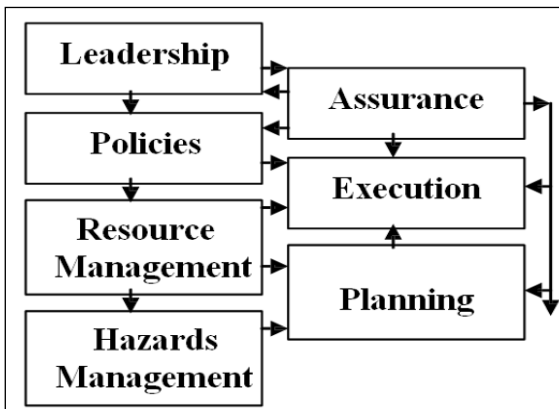


Figure 1. Seven (7) HSSE Assurance Main Elements

To ensure a clear existing status /situational awareness of the research area; a *comparative study* was carried out between the existing typical 36 Safety Regimes for a LNG Tanker against the above seven (7) identified Safety Elements (variables). The comparative study revealed that the existing 36 Safety Regimes address (on average) only 68.6% of the above identified seven (7) Safety Assurance Element.

11 SYNTHESIS OF SURVEY QUESTIONNAIRES

In order to get a fair distribution of data on various Safety Assurance related matters /activities onboard an LNG Tanker all the above detailed seven (7) Element (variables). were treated equally.

The characteristic features of LNG Shipping Safety related matters, challenges, etc. and practicality of conducting an effective Safety Assurance survey (onboard in service/active LNG Tanker) were also well noted during the *synthesis* of the research Survey Questionnaires:

12 CUSTOMIZED RAPID HSSE ASSURANCE

Assessment Model Package Taking note all the above detailed/discussed matters a structured and customized Survey Questionnaires (Rapid

Assessment Model) and its “Supportive Documents” were then detailed out under:

- Seven (7) “Main Elements/Topics”,
- 37 “Sub Elements/Topics” and
- 252 “Survey Questionnaires”.

The below table list down the 37 “Sub Elements/Topics” under the Seven (7) “Main Elements/Topics”. (see Table 1 below)

Table 1. Seven (7) Main Elements/Topics and 37 Sub Elements /Topics

1.0 Leadership
1.1 Management Visibility
1.2 Proactive Targets Setting
1.3 Informed Involvement
2.0 Policies
2.1 Policies Contents & Dissemination
2.2 Strategic Objectives
3.0 Resources Management
3.1 Roles, Responsibilities & Accountabilities
3.2 Advisors or Management Representatives
3.3 Resources
3.4 Competency Assurance
3.5 Training
3.6 Contractors / Third Parties
3.7 Communication
3.8 HSE Committee & Meetings
3.9 Documentation Control
3.10 Checklists & Critical Operation
4.0 Hazards Management
4.1 Hazards & Effects Management – General
4.2 Hazards & Effects Identification
4.3 Hazards and Effects Evaluation
4.4 Records of HSSE Hazards and Effects
4.5 Performance Criteria
4.6 Risks Reduction Measures
5.0 Planning
5.1 Plans & Initiatives – General
5.2 Critical Facilities & Equipment Integrity
5.3 Procedures & Checklists
5.4 Work/Standing Instructions
5.5 Management Of Change (MOC)
5.6 Emergency Response & Planning
6.0 Execution
6.1 Critical Activities & Tasks
6.2 Performance Monitoring
6.3 Records
6.4 Non-Compliance (NCs) & Corrective Actions
6.5 Undesired Events (UDEs) Reporting & Investigation
7.0 Assurance
7.1 Assurance Activities
7.2 Assurance Or Audit Plan & Follow-Up
7.3 Internal & External Auditors’ Competency
7.4 Contractors/Third Party Auditing
7.5 Management Review

**13 RATING SURVEYED ITEMS
(PERCENTAGE (%) OF COMPLIANCE)
(OR RATING METHOD)**

To enable a Survey Respondent to rate i.e to give “opinion on” (points) for a Surveyed Item (Survey Question/Statement); by design for each of the surveyed item either one or both of the following were made available:

- 1 Compare the “current status” against “minimum requirement”
- 2 Verify a surveyed item against onboard /onsite “objective evidences”.

**14 RATING OPTIONS (FIVE (5) POINTS
LIKERT MEASUREMENT SCALE)**

A adopting the Likert Rating Scale [34] for each surveyed item (Survey technique; Question/Statement) five (5) options were made available for a Survey Respondent. (see Table 2 below)

Table 2. The Surveyed Items - Rating Scale

Point(s)	Survey Respondent’s “Opinion”
5	Excellent (E)
4	Good (G)
3	Satisfactory (S)
2	Poor (P)
1	Very Poor (VP)

Hence a Survey Respondent is required to award only one (record his/her feedback or opinion) of the “points”.

Using the above tailor-made “measuring instrument”, the status of each surveyed items is recorded in a quantitative manner.

15 METHOD OF DATA ANALYSIS

Adopting the above mentioned “Likert Scale”; the tailor-made rapid Safety Assurance Assessment Model was ensured to be compatible with the “Statistical Package For Social Scientist” (SPSS Statistics 17.0) software, leading to various meaningful results on surveyed items can be obtained.

Some of the examples are:

Post Study One (1) (Pre-Treatment/Intervention)

- 1 Survey Respondents Demographics
- 2 Standard/Descriptive Statistics (Mean, Standard Deviation and Variance)

- 3 Distribution Of Feedback (Very Poor, Poor, Satisfactory, Good and Excellent)
- 4 Normality Of Data Distribution (Skewness and Kurtosis)
- 5 Reliability (Cronbach’s Alpha)
- 6 Safety Assurance Status Summary (Overall Opinion & Conclusion)
- 7 Statistical Data Distribution Tests (Kolmogorov-Smirnov (K-S D) & Shapiro- Wilk (S-W) Tests Of Normality)
- 8 One-Sample T Test (Trial Survey or Pilot Study Vs Actual Study)
- 9 HSSE Concerns (Written and Interview feedback)
- 10 HSSE Recommendations (Written and Interview feedback)
- 11 Survey Findings Reliability (Pearson’s Correlation) and Validity (including a Post Survey – Respondents Feedback).

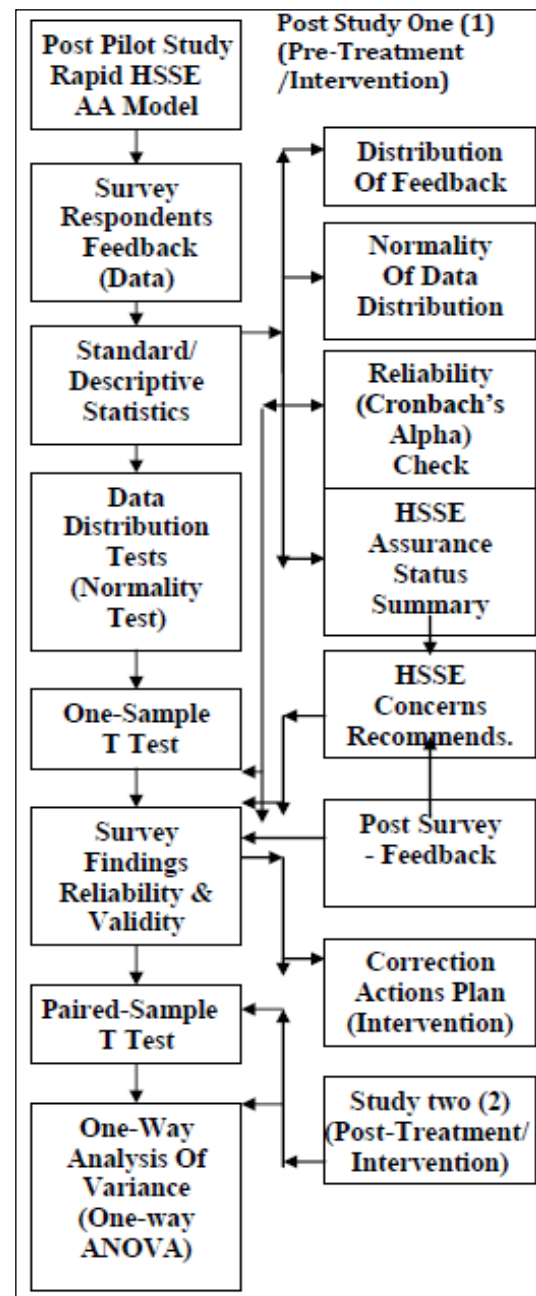


Figure 2. Statistical Analyses/Test

Post Study Two (2), Post-Treatment/Intervention

12 Paired-Sample T Test (Pre-Treatment / Intervention Vs Post-Treatment/Intervention)

13 One-Way Analysis of Variance (One-way ANOVA)

(See Figure 2)

Using the “mean” of Survey Respondents’ “opinions” (feedback) for each surveyed Safety Assurance Sub Elements/Topics; its “status” can be determined. Next by calculating out the “average mean” for a group of Safety Assurance Sub Elements /Topics under a Main Element/Topic; the status of a particular Main Element/Topic can be determined. Subsequently with all the 36 Sub Elements/Topics hence the seven (7) Main Elements/Topics “average mean”, an entire LNG Fleet’s HSSE Assurance status at the point of survey was quantified.

All the above “means” and “average means” can then be directly related to the customized Safety Assurance Element Assurance – Status Summary and Overall Opinion & Conclusion matrix. This enable better appreciation of the research finding’s in term of its “overall opinion” and “conclusion”. (see Table 3, below).

Table 3. Safety Element Assurance – Status Summary (Overall Opinion & Conclusion)

Score (%)	Surveyed HSSE Sub Or Main Element – Status Summary
4.0 – 5.0	EXCELLENT (E) Sustain and still scope for continual improvement
3.0 – 3.9	GOOD (G) Sustain and still scope for further (“specific”) improvement
2.0 – 2.9	SATISFACTORY (S) Cause for serious concern and scope for “overall” improvement
1.0 – 1.9	POOR (P) Cause for serious concern and immediate enforcement.
0.0 – 0.9	VERY POOR (VP) Cause for serious concern and immediate adoption.

16 IDENTIFYING SHORTCOMINGS (OFIS)

Using the above detailed matrix (Table 3) if a particular Sub or Main Element’s/Topic’s “means” or “average means” was < 3.000 the particular Sub or Main Element/Topic can be recorded as “Satisfactory”.

Hence adopting the above described customized method of analyses, shortcomings (OFIs) within any surveyed LNG Tankers’/Fleet’s 36 Sub Elements/Topics hence the seven (7) Main Elements/Topics, crucial for its Safety Assurance can be easily identified/quantified With statistically identified

“shortcomings” (OFIs) a structured post survey Improvements/Intervention Plans can be detailed out.

17 COMPREHENSIVE, WELL DISTRIBUTED AND COMPARABLE DATA COLLECTION

To ensure a comprehensive, well distributed and comparable data collection (hence results) from all level of management onboard any surveyed LNG Tanker, the selected portions of the Survey Questionnaires were carefully distributed to relevant pre-identified LNG Sea Officers (by Rank). The approach also ensured that Survey Questionnaires were answered by the rightful Survey Respondents (focal persons).

CASE STUDY – MISC BERHAD LNG TANKER FLEET

18 PILOT STUDY (PRE-TESTING/FINE-TUNING RAPID ASSESSMENT MODEL)

To test out, fine-tune and further improve the Assessment Model prior actual full scale field/onboard survey, a “Pilot Study” was carried onboard three (3) MISC Berhad’s LNG Tankers. The Pilot Study statistical results were analyzed using the Statistical Analyses package – *SPSS Statistics 17.0*. Upon completion of the Pilot Study the Rapid Assessment Model was further fine-tuned, improved and finalized.

19 FULL SCALE FIELD/ONBOARD SURVEY FIRST STUDY OR ACTUAL STUDY ONE (1) (PRE-TREATMENT/INTERVENTION)

The finalized Survey Questionnaires (rapid Assessment Model pack) were then sent to ALL 28 MISC Berhad’s active/in-service LNG Tankers worldwide.

20 TESTED ASSESSMENT MODEL

A total of 252 active/serving LNG Sea Officers from 28 MISC Berhad’s LNG Tankers responded to full scale study.

The Survey Results were analyzed using the latest Statistical Analyses package – *SPSS Statistics 17.0* (as detailed in section 15.0)

The results were then presented to MISC Berhad Top Management. The survey findings were

accepted as valid. Relevant “Corrective Actions” were commenced.

After a substantial time lapse (1 year) same survey (**Study Two (2) – (Post-Treatment /Intervention)**) were carried out on the same population.

21 CONCLUSION

With reference to LNG shipping industry’s foreseen challenges; the way, the existing Safety Regimes onboard LNG Tankers being managed shall be reviewed and tactfully addressed.

It is also important to acknowledge the fact that any proposed recommendations to manage the foreseen “challenges” shall take note of the already seen/proven historical perspective and impact of human behaviors onto an LNG Tanker’s Safety Assurance.

Taking note all the above a rapid, practical and cost effective solution to safeguard, sustain and further improve an LNG Tanker’s Safety Assurance was crafted adopting a research based “process approach”.

The model has been tested by one of the largest owner/operator of LNG Fleet in the world (MISC Berhad) and proven reliable.

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