



SAFETY OVERVIEW OF LNG TERMINAL OPERATION INCLUDING LNG CARRIER UNLOADING

Presented By

Man Mohan ahuja

SR. Vice President (Technical), Petronet LNG Limited

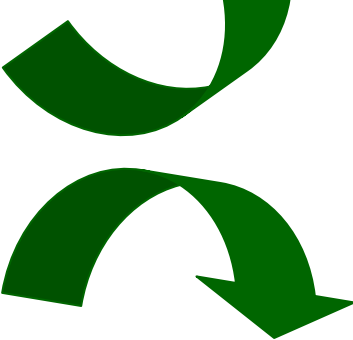
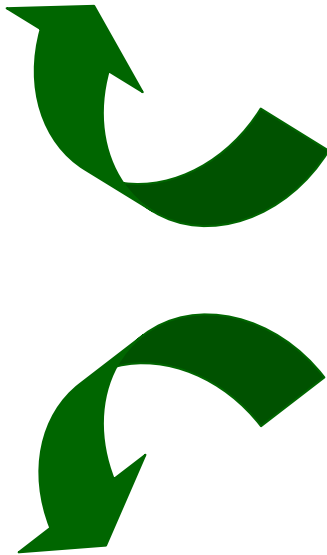
E-mail: ahujamm@petronetlng.com

SAFETY & ENVIRONMENT PROTECTION IN OIL & GAS INDUSTRY

A strong concern since the beginning as Oil&gas are considered as hazardous products. Nevertheless major accidents have occurred: Mexico (LPG), Lyon (France, Refinery), Sea pollution after various Oil Tankers accidents, IOC Storage Terminal Fire (Jaipur)

International regulations: OMI, SIGTTO, etc...

National regulations:
(like OISD in India)



Oil & Gas companies policies

Insurance requirements

SAFETY REQUIREMENTS IN LNG INDUSTRY

Since accident in Cleveland (USA) in 1942, LNG has been considered as Hazardous product, various regulations have been developed:

Transport by sea: IMO rules, SIGTTO recommendations, OCIMF rules, Classification, Insurances requirements.

Plants & Storages:
NFPA 59 A (USA)
49 CFR part 193 (USA)
EN 1473 (Europe)
J G A Rules



National regulations, safety and regulatory bodies, Environment protection bodies & Associations.

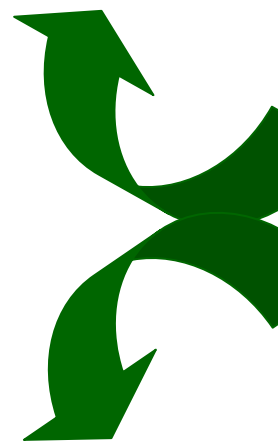
Companies
Policies, Engg.
Standards

SAFETY REQUIREMENTS IN LNG INDUSTRY

Safety and environment protection are considered since preliminary design studies. Codes and regulations mainly provide:

Design criterias: Seismic design, impounding systems, etc...

Minimum safety distances: considering accident scenarios and consequences: vapour clouds, fire radiation, Cold explosion, etc,...



Hazardous areas classification: fire-proof equipment, Electric & instrumentation equipment classification

Design & construction rules: Min. safety systems, Min. protection, Fabrication, construction and control stds.

SAFETY REQUIREMENTS IN LNG INDUSTRY

What is LNG ?

Physical properties

- **Liquefied Natural gas:**
- **Colourless liquid,**
- **Mainly CH₄ (>80%),**
- **Cold: temperature $\approx -160^{\circ}\text{C}$,**
- **Density at 1 bar $\approx 450 \text{ kg/m}^3$**
- **Vapour of LNG:**
- **Odourless and colourless,**
- **Density at 1 bar and $20^{\circ}\text{C} \approx 0.8 \text{ kg/m}^3$**
- **Flamability limits LFL: 5%, UFL:15%**
- **Vapourization of LNG**
- **1 m³ LNG \Leftrightarrow 600 m³ of gas at 20°C**



Properties of LNG

- Properties of LNG that have safety implications include auto-ignition temperature, Low temperature, heat of vaporization, flammability limits, heat transfer rate of boiling liquid and specific gravity
- The average auto-ignition temperature for pure methane at atmospheric pressure is 537°C, which is quite high
- The lower and upper flammability limit of methane in air is 5% & 15% by volume respectively.
- In a closed tank, the percentage of methane is 100%, thus it cannot ignite.
- Methane leaking from a tank in a well – ventilated area is likely to rapidly dissipate to less than 5% , thus it is relatively safer as compared to other fuels

Properties of LNG

- The most of Hazardous properties of LNG are due to extreme low temperatures
- The only danger from skin contact with LNG is freezing; there are no poisonous or toxic effects.
- Tissue damage from extreme cold is similar to damage from extreme heat.
- Unlike heat burns, a cryogenic burn victim will not feel pain until the injured part has begun to thaw.
- If the skin has surface moisture on it, contact with cold objects will result in freezing of the skin to the objects. Flesh will be torn when the victim tries to remove the affected area from cold surface

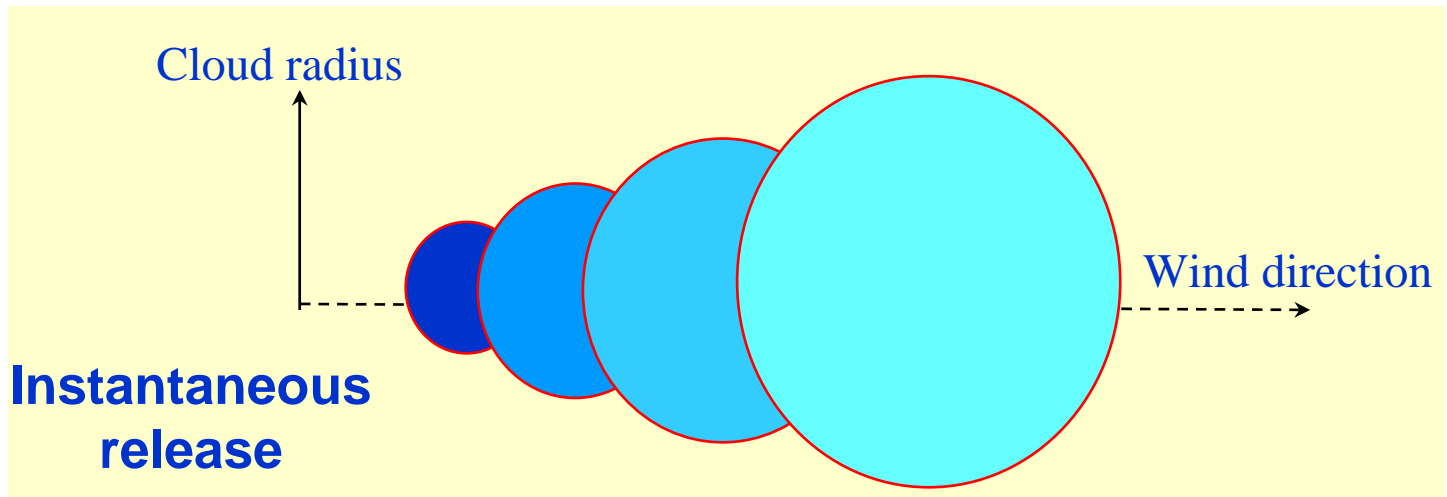
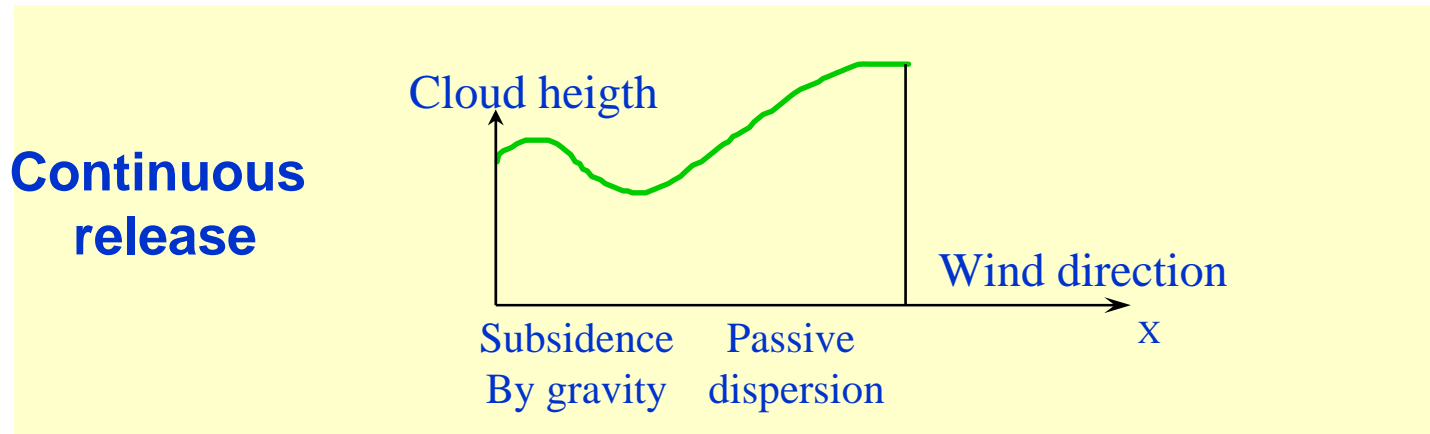
PROPERTIES OF LNG – REACTION ON WATER

Un like other liquid petroleum products LNG reacts vigorously with water and vapourizes very fast (leaving nothing behind) posing minimum risk for the marine life



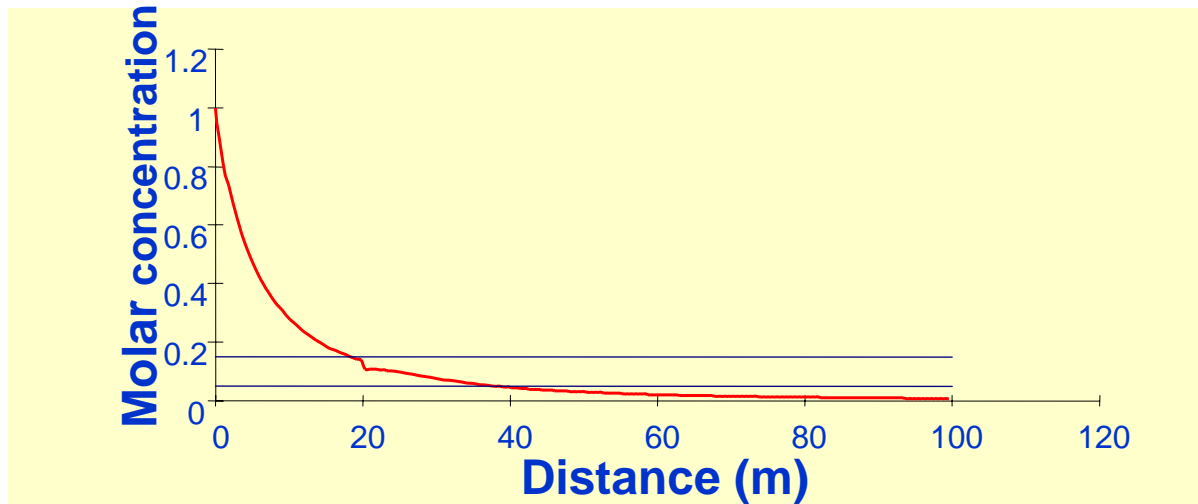
LNG PROPERTIES

- LNG VAPOUR CLOUD DISPERSION



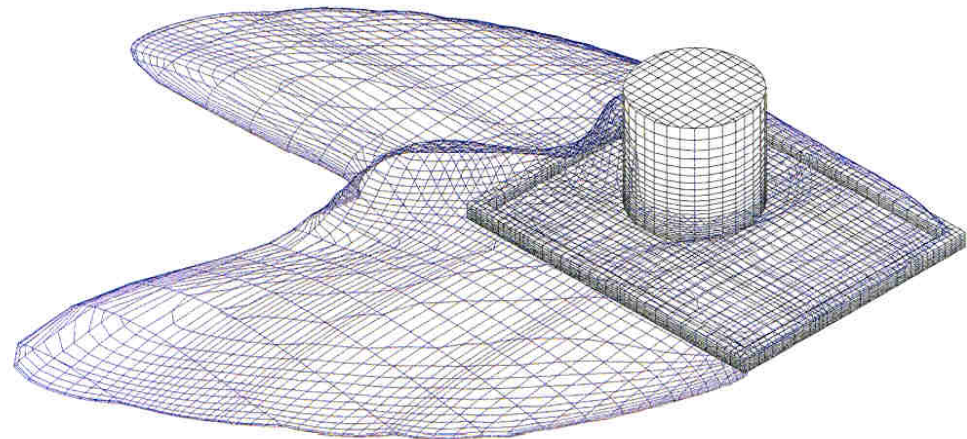
LNG PROPERTIES

- **HEAVY GAS CLOUD DISPERSION FC TANKS**



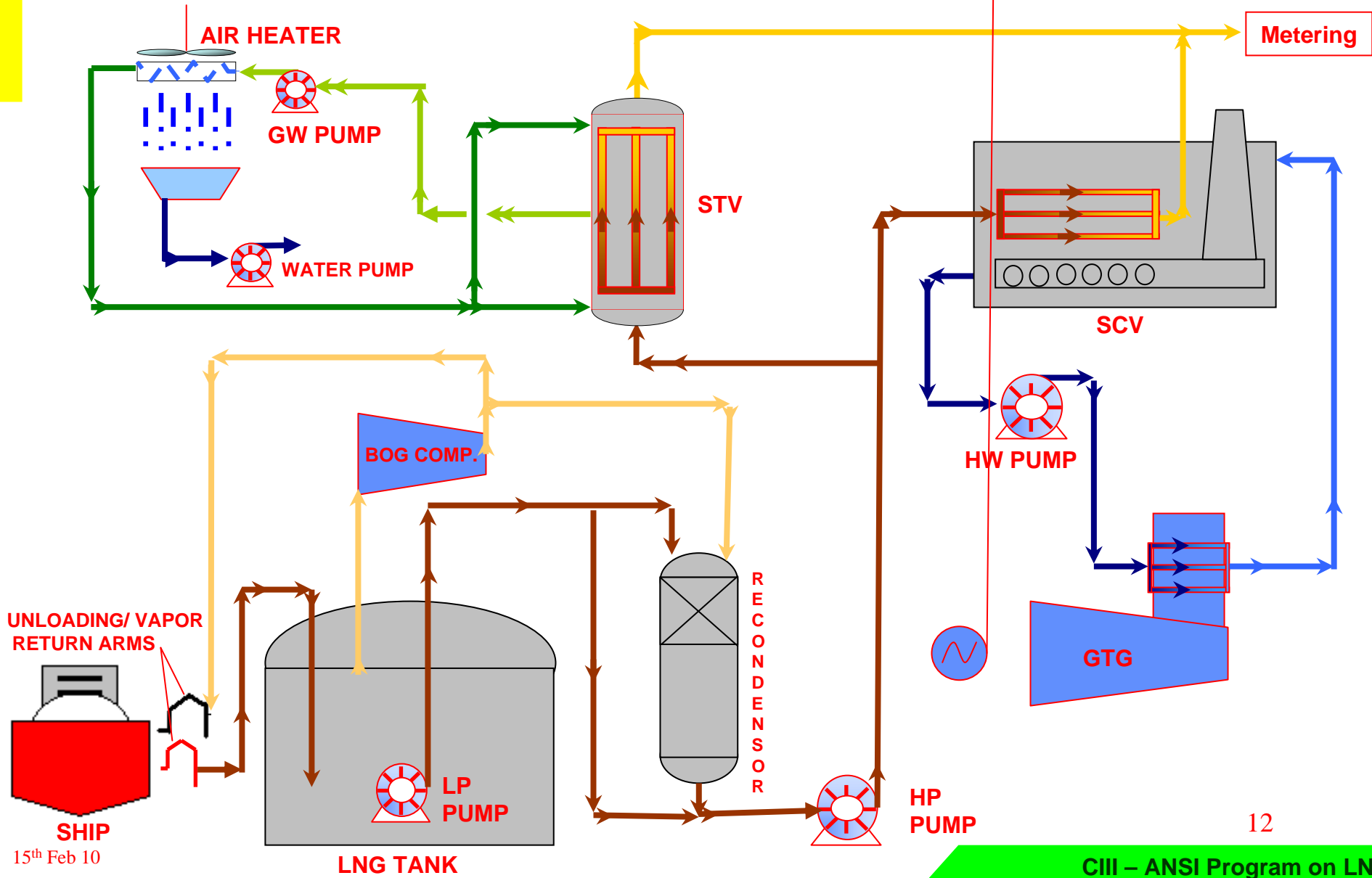
Calculation tools :

- Integral Model : EVANUM
- 3D: MERCURE HEAVY GAS



LNG RECEIVING TERMINAL

LNG TERMINAL DAHEJ



DESIGN HELP - SPECIAL CODES & STANDARDS

A SAFE & SMOOTHLY OPERATING FACILITY CAN BE GENERALLY ENSURED, IF THE APPLICABLE CODES & STANDARDS ARE FOLLOWED IN TRUE SENSE. Some of the special codes followed for LNG terminals are

- **National Fire Protection Association (NFPA-59 A)**
- **British Standard (BS 7777)**
- **European Committee for Standardization (EN 1473) :**
- **OCIMF (Oil Companies International Marine Forum):**
- **SIGTTO (Society International Gas Tanker & Terminal Operators):**
- **OISD STDS 116, 118 & 194**

ISO ACCREDITATION

Certified by DNV on 21st Jan-05

ISO 9001: 2001 QMS

ISO 14001: 1996 EMS

OSHAS 18001: 1999



DET NORSKE VERITAS
MANAGEMENT SYSTEM CERTIFICATE

Certificate No. 01594-2005-AQ-BOM-UKAS

This is to certify that

**PETRONET LNG LIMITED
DAHEJ**

at
GIDC Industrial Estate, Plot No. 7/A, Dahej, Taluka Vagra, Bharuch - 392 130, Gujarat, INDIA

has been found to conform to the Management System Standard:
ISO 9001:2000

This Certificate is valid for the following product or service ranges:

**PORT OPERATION, RECEIPT OF LNG, STORAGE,
REGASIFICATION AND DESPATCH OF RLNG**

Initial Certification date:
2005-01-21

Place and date:
Chennai, 2005-01-24

This Certificate is valid until:
2008-01-21



for the Accredited Unit:
DNV CERTIFICATION B.V.,
THE NETHERLANDS

B. Chatterjee

B. Chatterjee
Lead Auditor

Krishna Kumar N.R.
Management Representative

Lack of fulfillment of conditions as set out in the Appendix may render this Certificate invalid.



DET NORSKE VERITAS
MANAGEMENT SYSTEM CERTIFICATE

Certificate No. 00247-2005-AE-BOM-UKAS

This is to certify that

**PETRONET LNG LIMITED
DAHEJ**

at
GIDC Industrial Estate, Plot No. 7/A, Dahej, Taluka Vagra, Bharuch - 392 130, Gujarat, INDIA

has been found to conform to the Management System Standard:
ISO 14001:1996

This Certificate is valid for the following product or service ranges:

**PORT OPERATION, RECEIPT OF LNG, STORAGE,
REGASIFICATION AND DESPATCH OF RLNG**

Initial Certification date:
2005-01-21

Place and date:
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Management Representative

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DNV CERTIFICATION B.V., Haastrechtstraat 7, 3079 DC Rotterdam, The Netherlands TEL:INT: +31 10 2922 688. FAX: +31 10 4796 768



DET NORSKE VERITAS
MANAGEMENT SYSTEM CERTIFICATE

Certificate No. 00044-2005-AS-BOM

*This is to certify that
the Occupational Health and Safety Management System
of*

**PETRONET LNG LIMITED
DAHEJ**

at
GIDC Industrial Estate, Plot No. 7/A, Dahej, Taluka Vagra, Bharuch - 392 130, Gujarat, INDIA

has been found to conform to the Occupational Health and Safety Management System Standard:
OHSAS 18001:1999

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for the Certification Unit:
DNV CERTIFICATION SERVICES,
REGION INDIA

B. Chatterjee

B. Chatterjee
Lead Auditor

Krishnakumar N.R.
Country Manager
Region India, Sri Lanka, Bangladesh & Nepal

Compliance to the Standard in respect to the indicated is
verified by the DNV approved registered Team Leader.

Lack of fulfillment of conditions as set out in the Appendix may render this Certificate invalid.

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DAHEJ MARINE FACILITIES

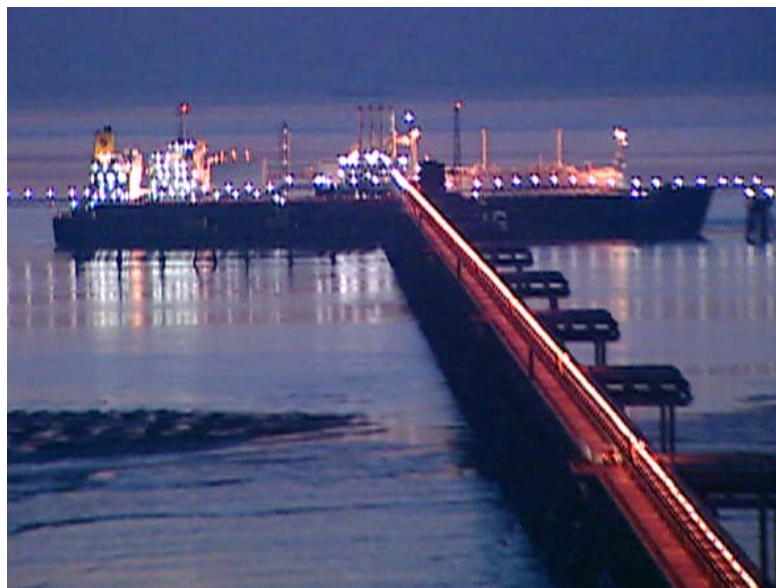


FACILITIES : JETTY



2.4 K.M Long; 536 Steel piles average depth 50 m; Water depth max 16 m from chart datum; Tidal variation 10.4 m; segregation of hydrocarbon & non-hydrocarbon pipelines

FACILITIES : SECTION OF JETTY DESIGN



11 expansion loops for the unloading lines 4 passing bays for Vehicle

Passing bays for safety of vehiculat traffic & Exp loops for thermal expansion

Port Control Room with Latest equipment for safe operation



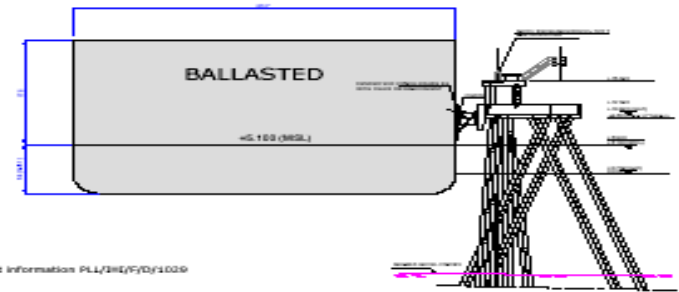
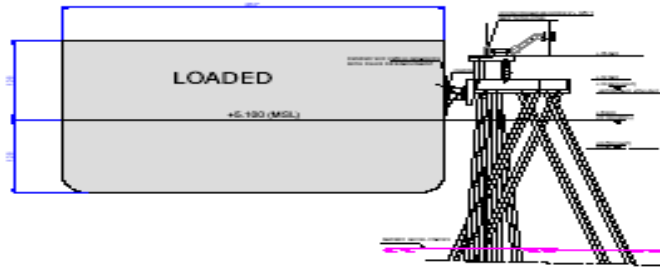
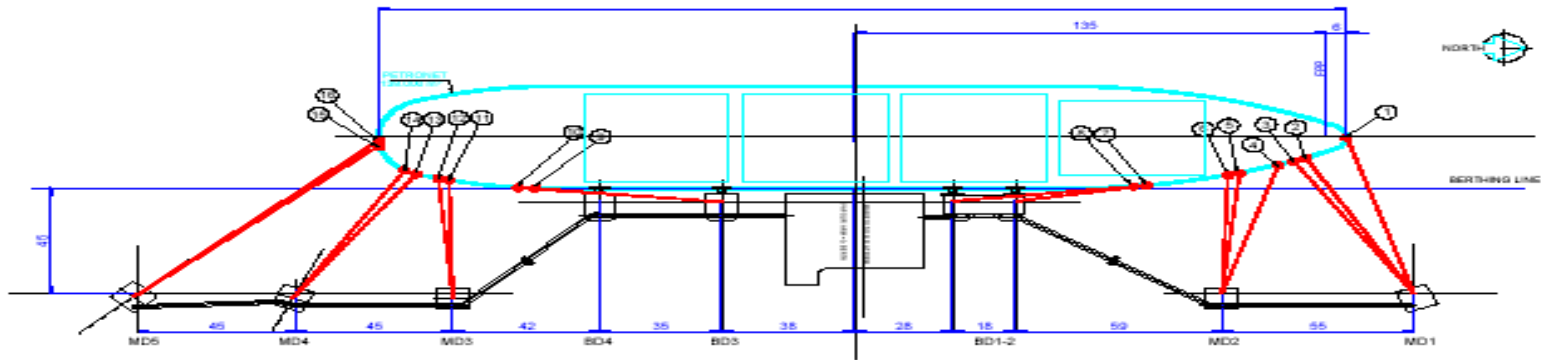
MARINE HAZARDS /RISKS

- **Major Causes identified for Marine hazards are**
 - **Striking**
 - **Collision**
 - **Impact & Grounding**
 - **Fire**
 - **Cargo Transfer Failure**
 - **Foundering / Capsizing, Structural Failure**
 - **Domino Accident**

MITIGATION OF MARINE RISKS

- **Traffic Separation scheme in consultation with Port Management**
- **Ship maneuvering to be regulated – (other ships to be disallowed in the vicinity during berthing of LNG ships)**
- **Environmental limits for wind, waves & visibility as per SIGTTO guidelines**
- **Navigational aids such as Docking assistance unit.**
- **Ship/jetty to be fitted with gas / fire detection system**
- **Design of ship with a double hull, and double bottom.**
- **Water curtain system between Jetty and ship**

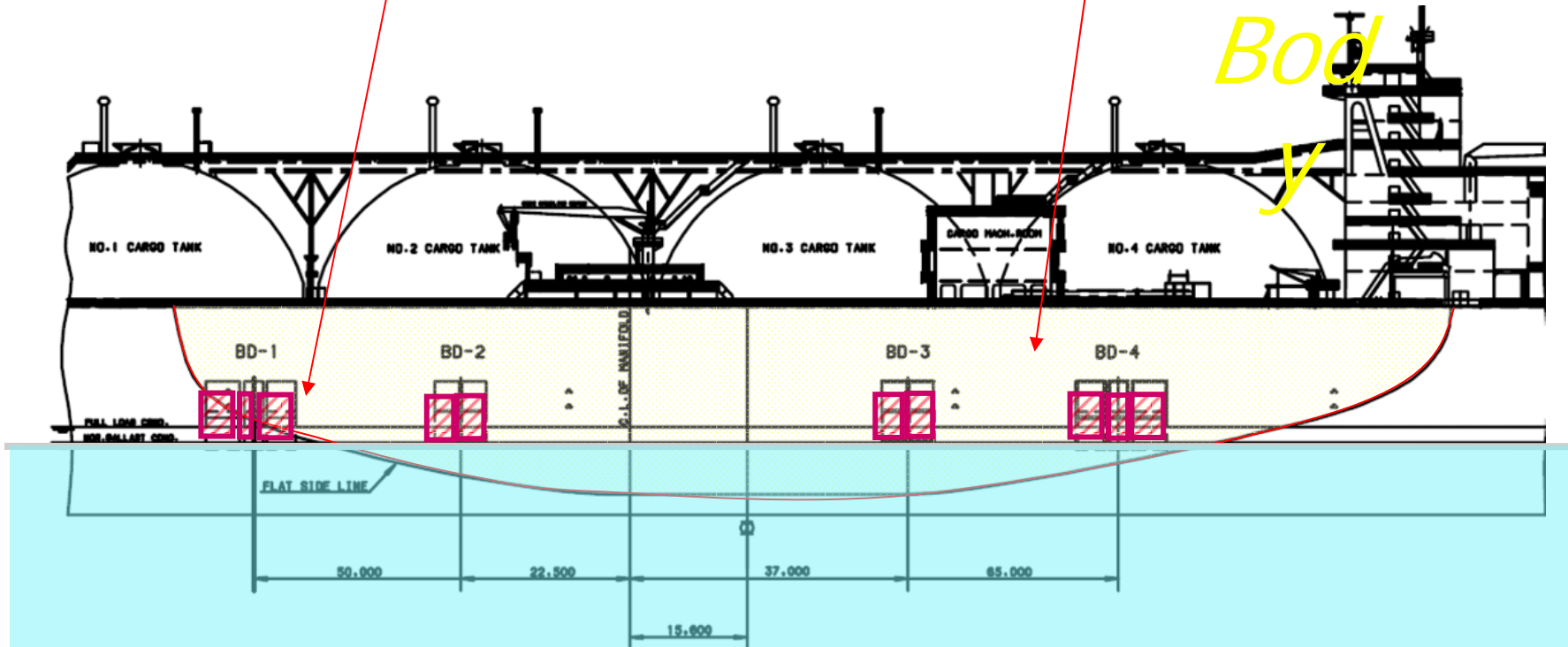
JETTY AND MOORING AT DAHEJ



Fender/Flat Body

Fender contact area

*Flat
Body*

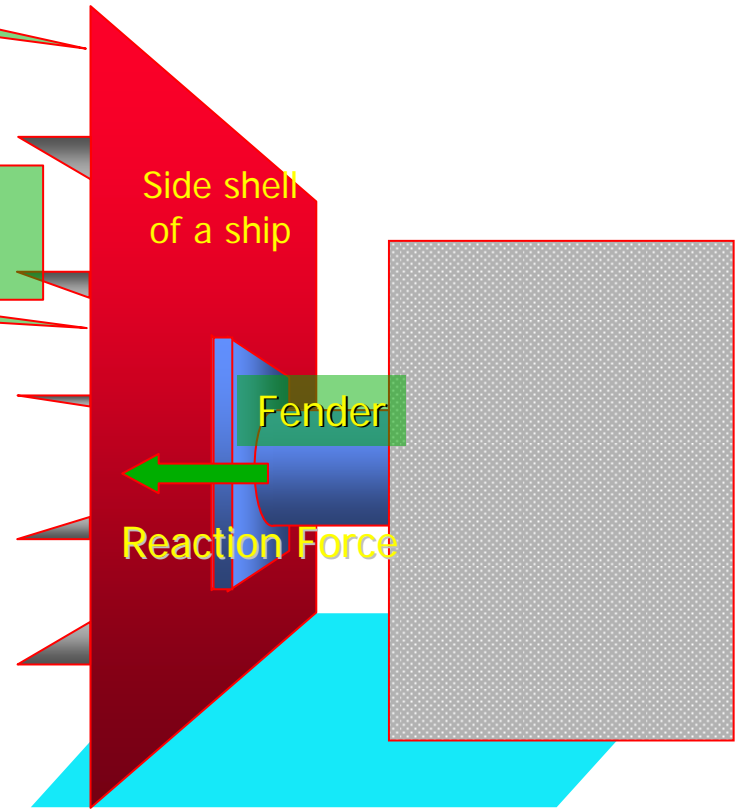
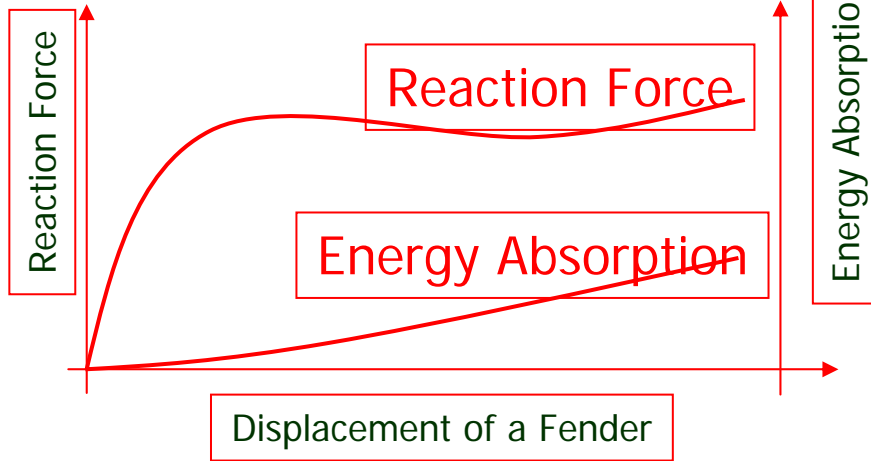


Reaction Force of Fenders

Strength of Side shell

Interference between Fittings on the Side and a Fender

The characteristic curve



Mooring Force Calculation

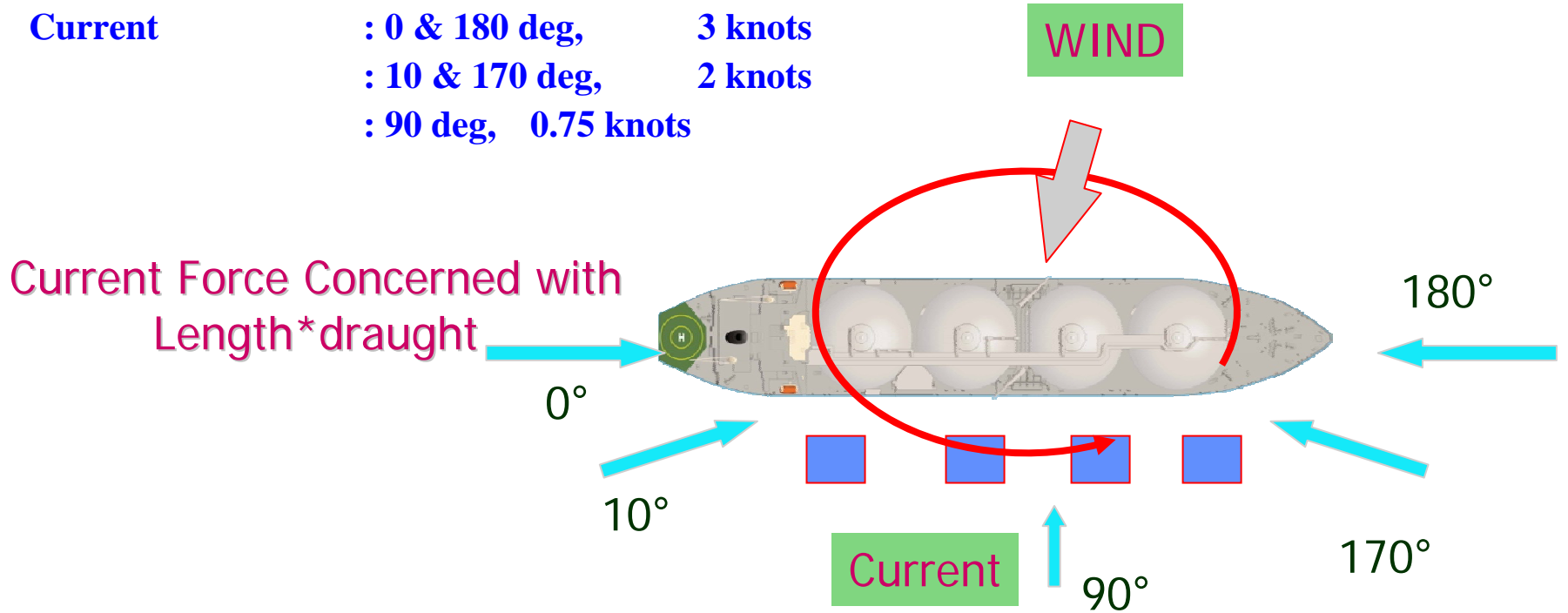
OCIMF recommendation

Current Force + Wind Force

Under the following condition

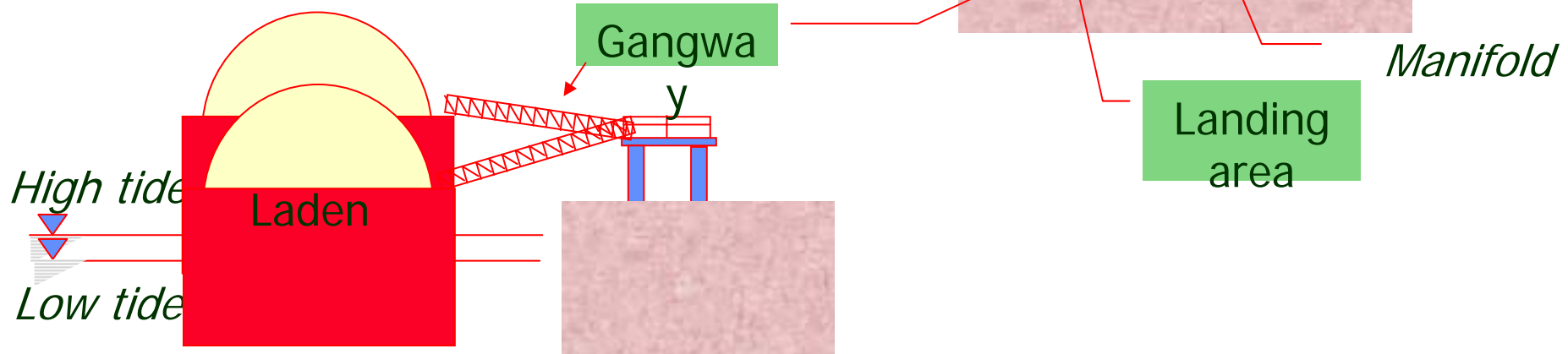
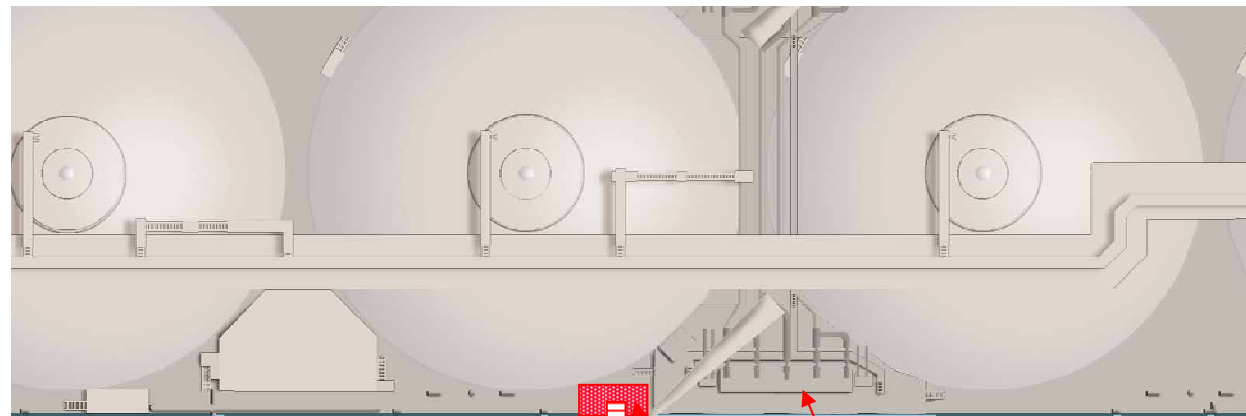
- Wind : All directions, 60 knots
- Current : 0 & 180 deg, 3 knots
- : 10 & 170 deg, 2 knots
- : 90 deg, 0.75 knots

Wind Force Concerned with a projection area above water



Gangway

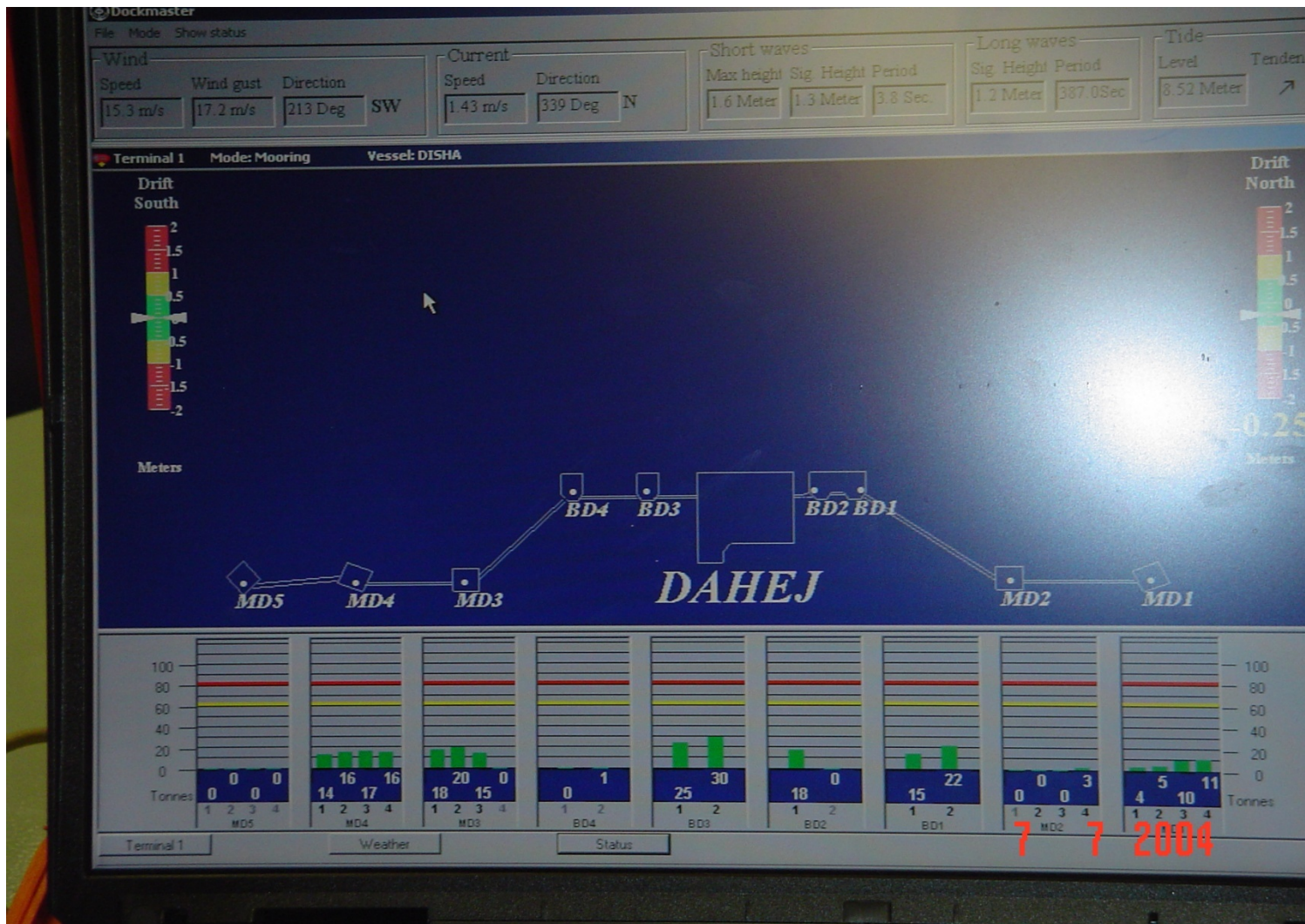
- **Position**
- **Elevation**



FACILITIES FOR SHIP BERTHING

- State of the Art ship mooring system including
 - Electrical Motor winches
 - Mooring Hook stress Measurement
 - Ship Docking assistance Unit Including:
 - Sensors (sea current sensor, Wave & tide sensor, Wind sensor)
 - Radars
 - Display Units
 - Portable Display Units
 - Tension Monitoring arrangement

MOORING TENSION & WEATHER CONDITION MONITORING SYSTEM



QUICK RELEASE MOORING HOOK & LOCAL DISPLAY PANEL



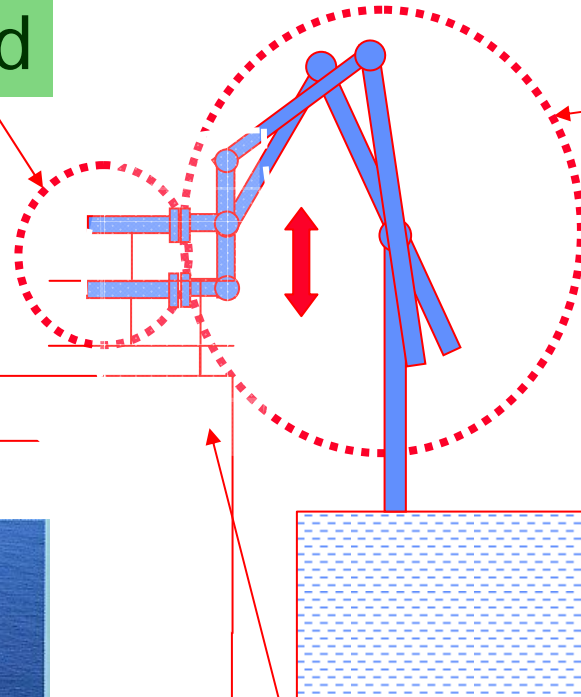
QUICK RELEASE MOORING HOOKS



Loading Arm/Manifold



Manifold



Loading Arm

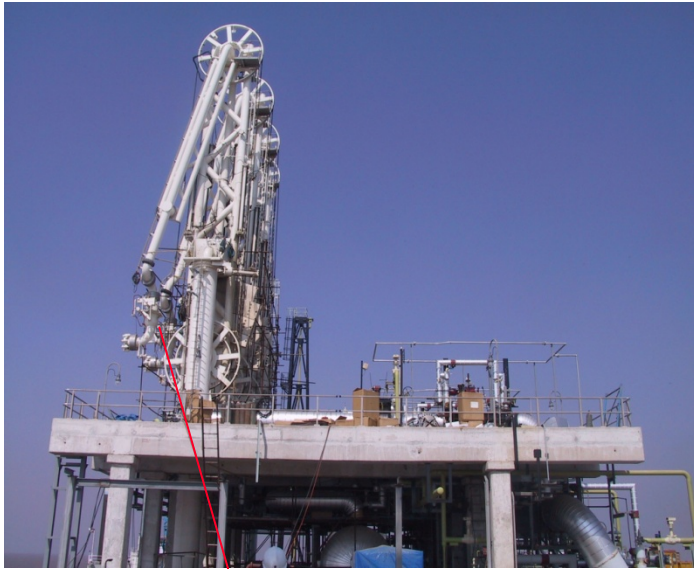


*Loading Arm
Reach Envelope*

FACILITIES : UNLOADING ARMS

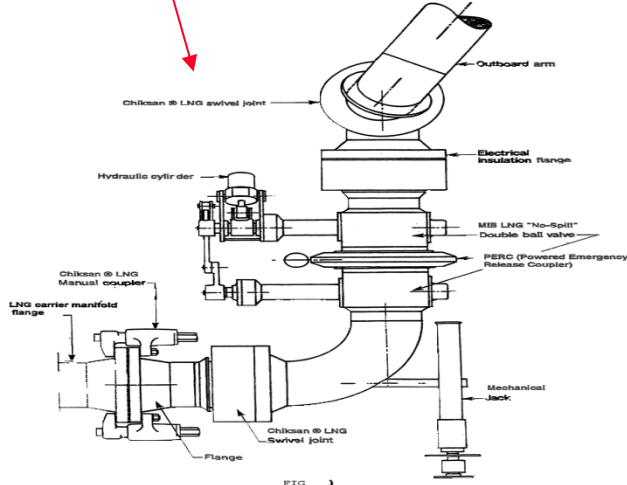
Unloading Arms designed following OCIMF guidelines, which ensures compatibility with most of the ships & safe operation

One of the significant feature is installation of PERC



FMC

Style 80 (Terminal) swivel joint equipped with an MIB LNG Emergency Release System (ERS)



Un-loading Arm – During Testing

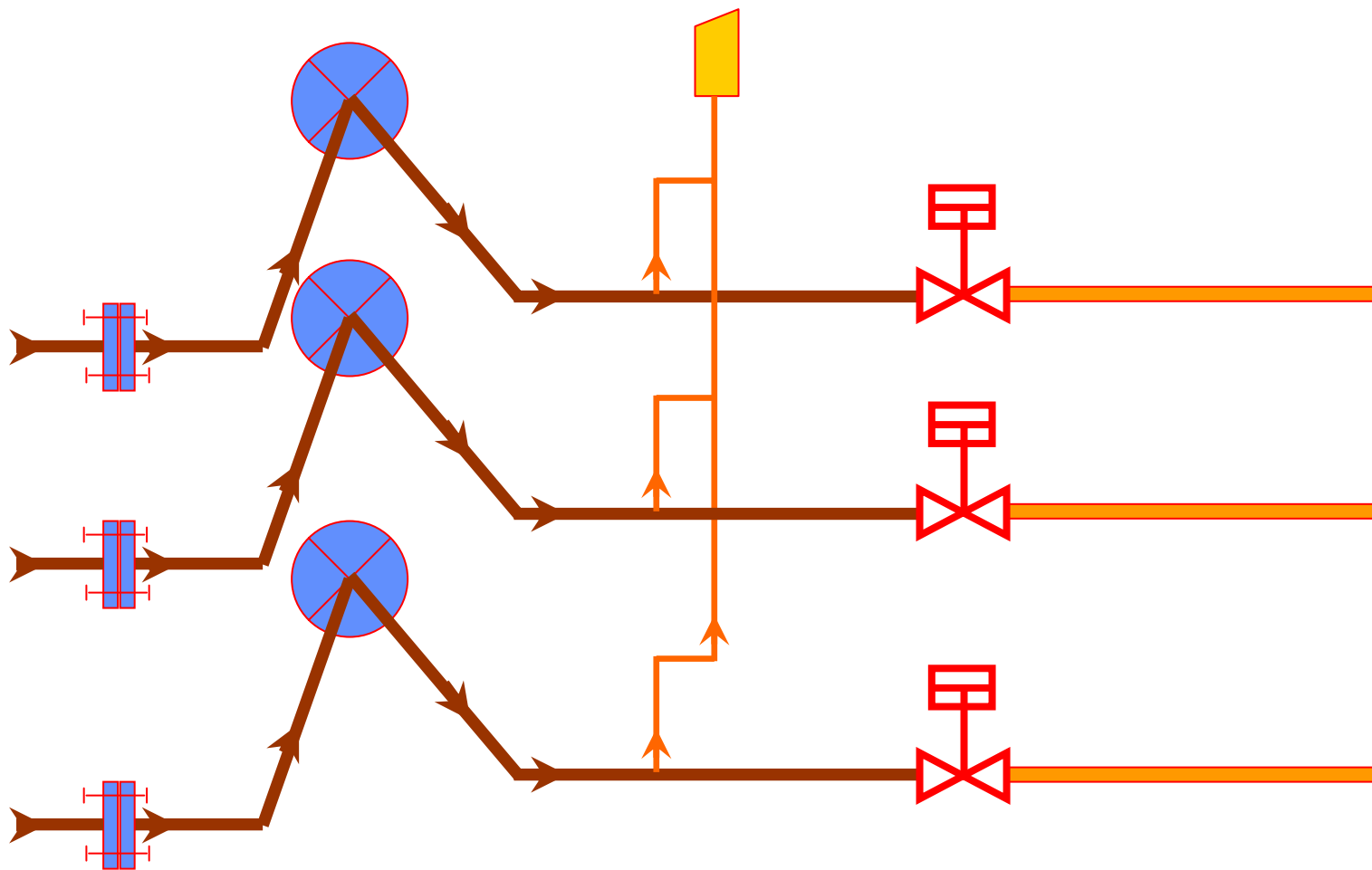


PERC REACTIVATION – DURING TESTING

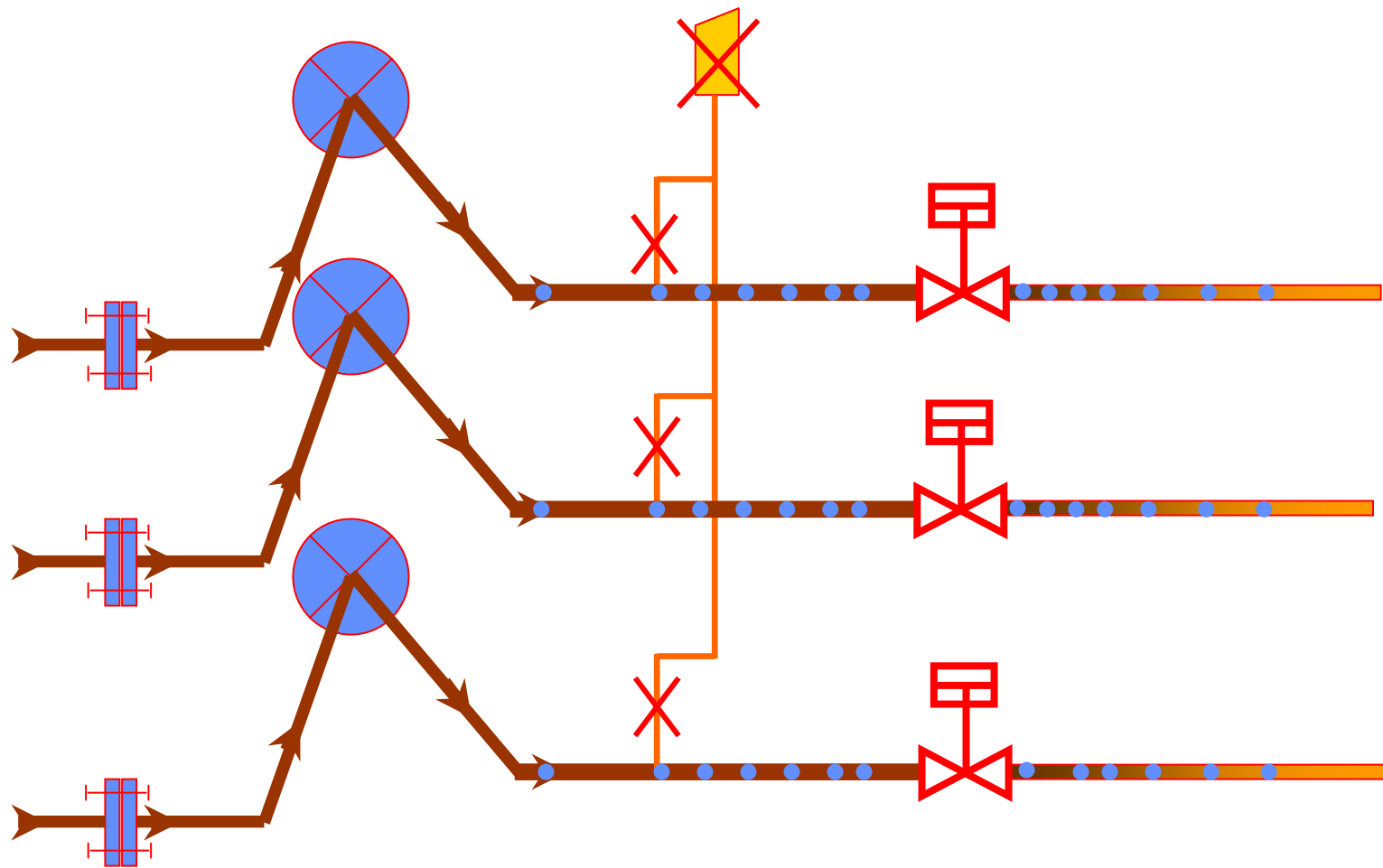


[BACK](#)

Unloading Arms Cool down – Normal scheme for long jetties



Unloading Arms Cool down – Scheme based on site specific risk analysis



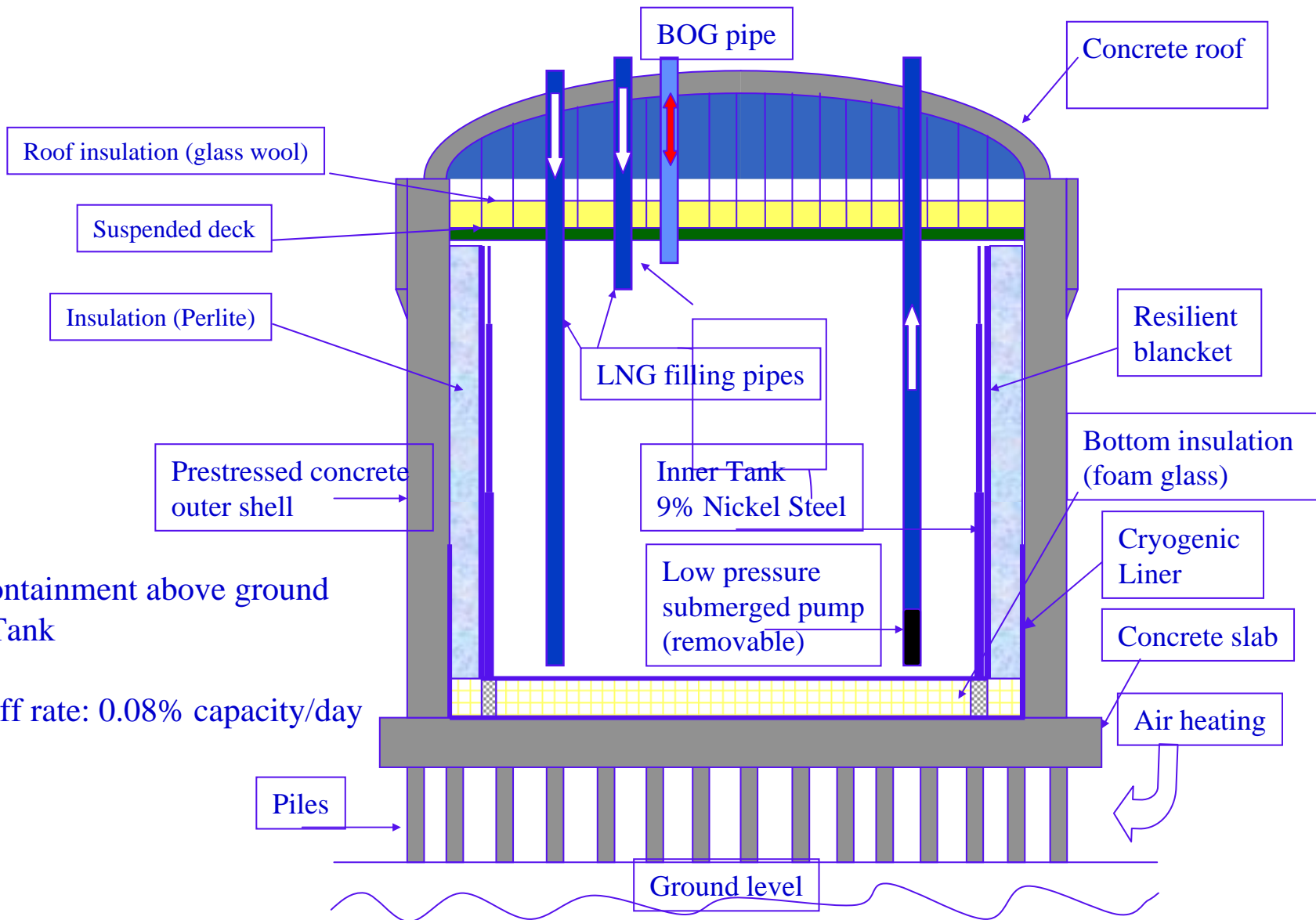
TANK SAFETY

Results of Consequence Modeling

		Containment Type			Remarks
		Single	Double	Full	
Heat flux due to LNG Fire	At Luvara	Acceptable (0.9 Kw/m ²)	Acceptable (nil)	No affect outside plant	NFPA 59 A Criteria is 5 KW/m ²
	At GCPTCL	Acceptable (1.2 Kw/m ²)	Acceptable (0.1 Kw/m ²)	No affect outside plant	Flux causing structural damage estimate is 25 Kw/m ²
	5 Kw/m ² distance	700 m	300 m	77 m	Minimum distance to property line
	3 Kw/m ² distance	1200 m	700 m	88 m	
Hazardous Vapour Cloud	Spread	Unacceptable (2500 m to 5600 m)	Unacceptable (1100 m to 1200 m)	Acceptable (57 m)	LEL not to spread outside battery limit

*** PLL has selected fully contained tanks to ensure MAXIMUM SAFETY

LNG STORAGES TANK-PLL



Full containment above ground
LNG Tank

Boil Off rate: 0.08% capacity/day

FACILITIES : LNG TANKS



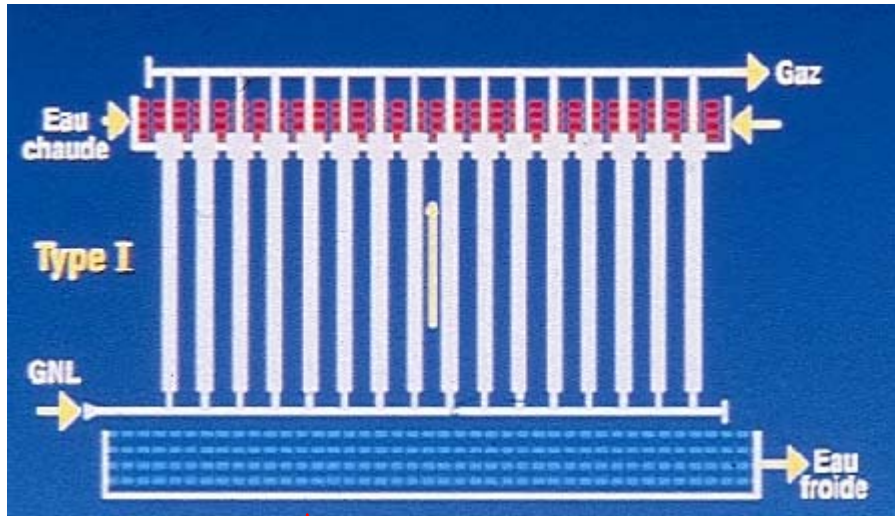
**Two nos. – 160,000 m³
capacity**

Type: Full Containment

**Design codes: BS 7777, API
620, EN 1473, NFPA 59A**

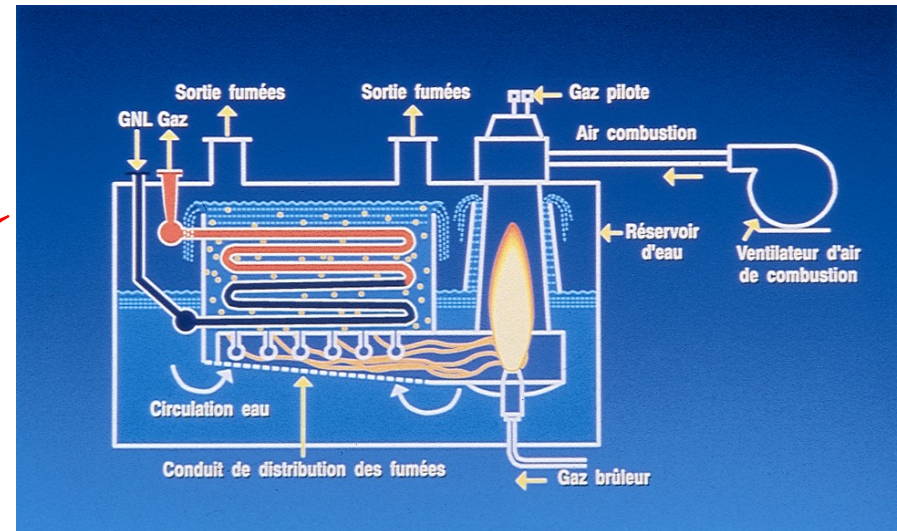
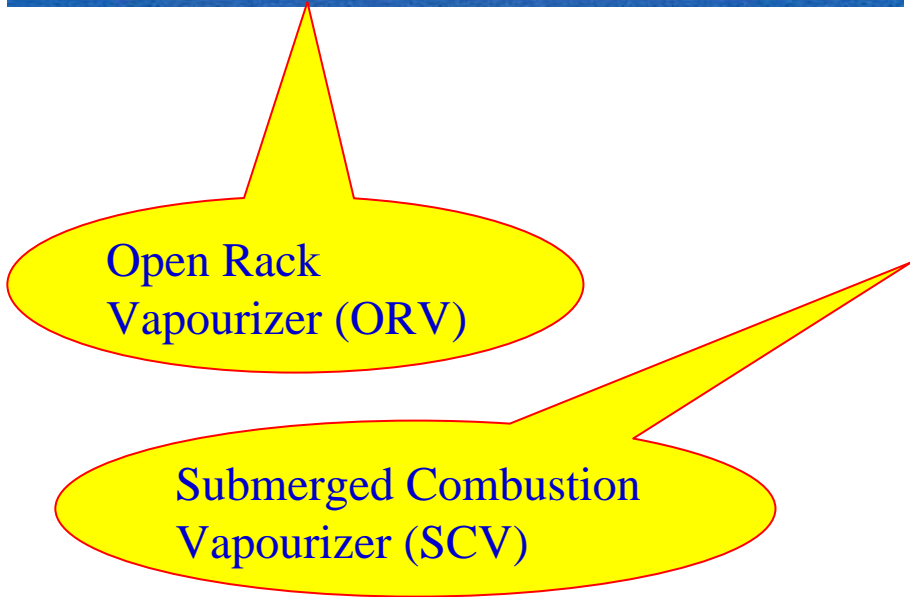
Dia: 81 m; Height – 55 m

LNG Regasification

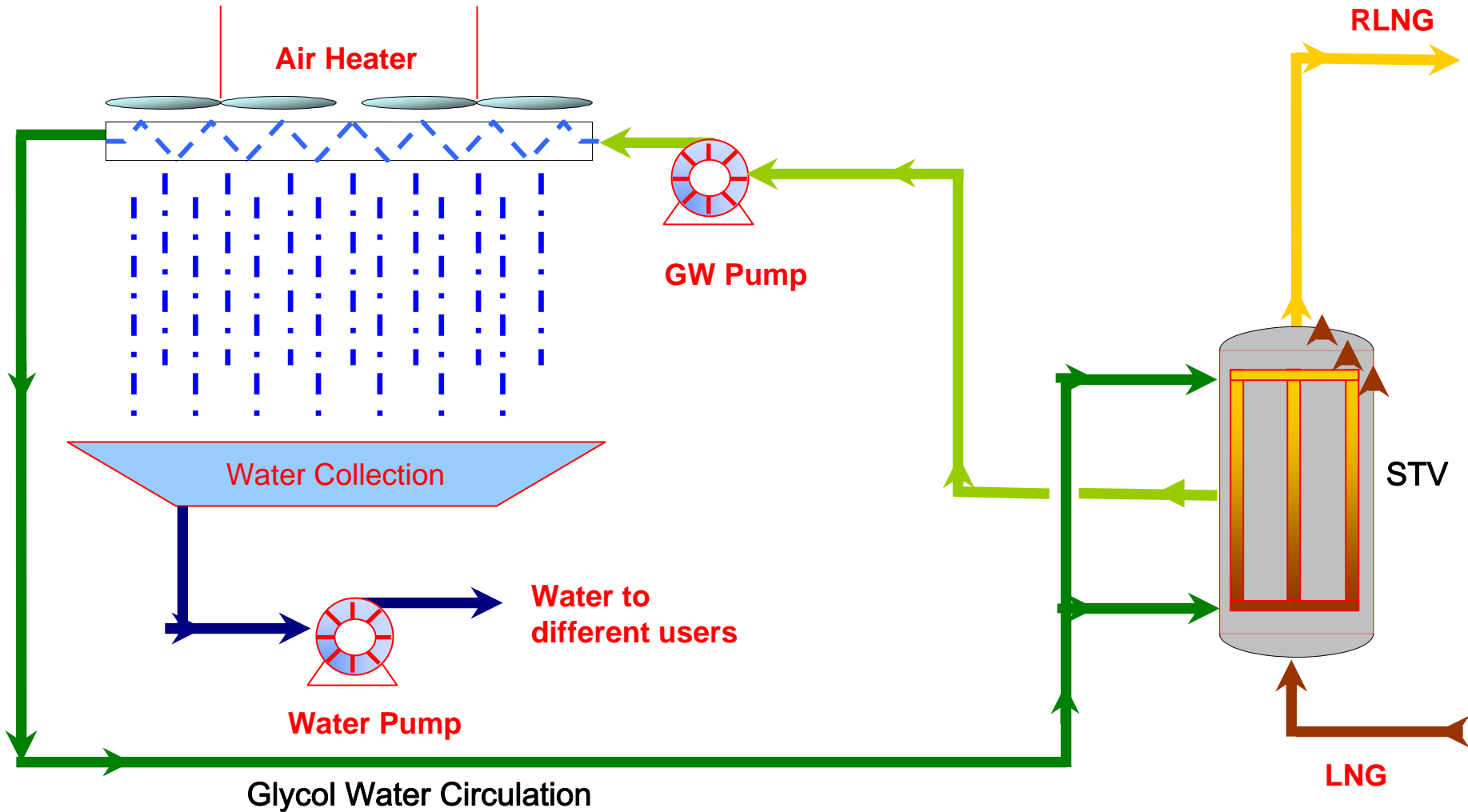


For ORVs Sea water characteristics not acceptable

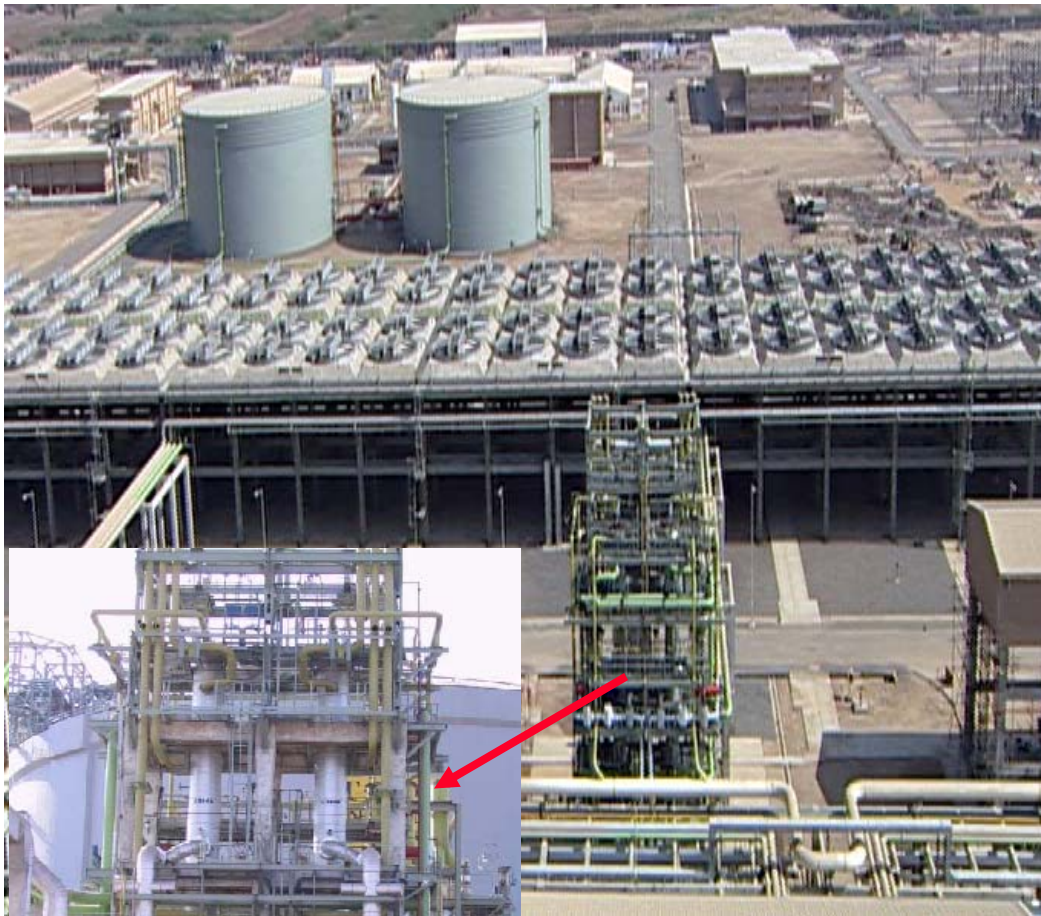
For SCVs high operating cost & high exhaust gas mission



LNG REGASIFICATION



FACILITIES : AIR HEATERS & STVs



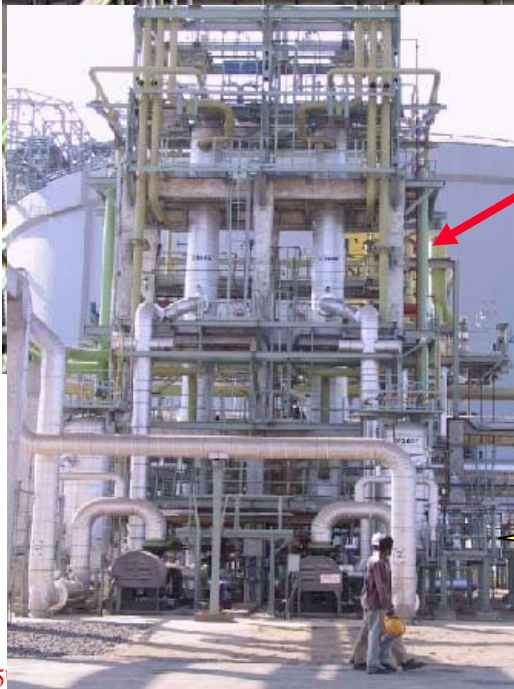
7 STVs / Air Heaters with 112 fans-16.4 MW each

Close loop system with no exhaust

Only ambient air heat

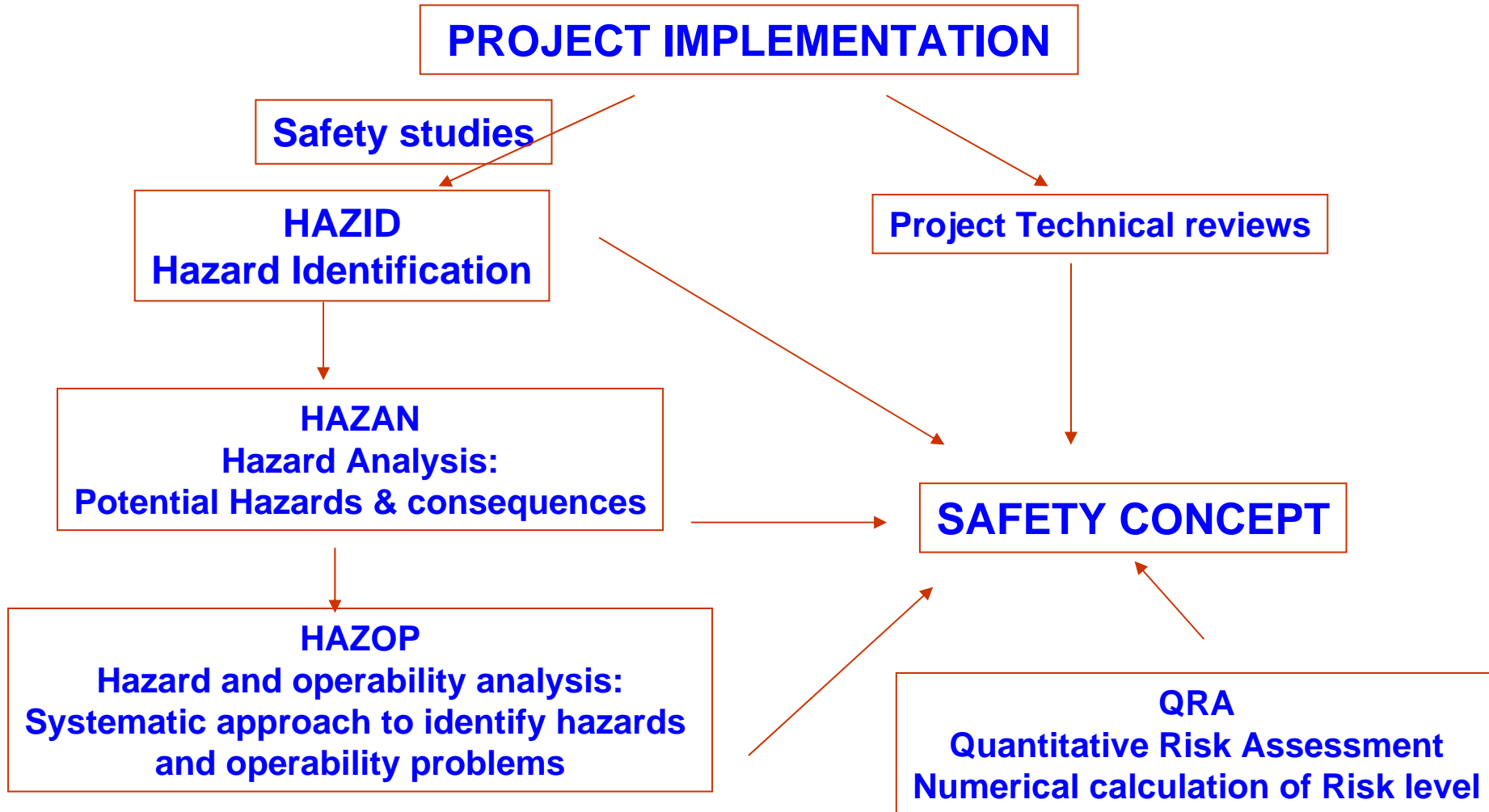
No external firing

Most environment friendly system



STV

SAFETY ISSUES



IDENTIFICATION OF RISKS

- **External Origin**

- **Natural Risks (Earthquakes, flooding, wind, typhoons and lighting)**
- **Non Natural Risks (from other industry, Marine traffic, Aircraft crash)**

- **Internal Origin**

- **Release of LNG**
 - **Release from tanker, Spill from un-loading arms**
 - **Failure of transfer line, Inner / outer tank failure**
 - **Overfilling of storage tanks, Send out pump failure**
- **Release of NG**
 - **Tank safety valves, Vapouriser safety valves, Flare stack**
- **Process upsets like equipment failure, utility failure, roll over are not included as these are covered under ESD system**

RISK / HAZARD CONTROL

- **Measures to avoid the cause of release**
- **Measures to reduce the consequence of a release.**
- **LNG Spill Action Plan**
 - **Prevent spill**
 - **Detect spill, if it happens**
 - **Keep the spill volume minimum**
 - **Control the Vapours**
 - **Detect the fire quickly, if it happens**
 - **Control the fire immediately, if it is detected**
 - **Protect the other facilities**
 - **Extinguish the fire**

MAJOR STUDIES CONDUCTED

- **Rapid Risk Analysis for Tank Type Selection**
- **Marine Risk Analysis for design of marine facilities**
- **Integrated Quantitative Risk Analysis (QRA) for layout selection**
- **Modeling studies for berthing, mooring & navigation for finalization of design for the marine facilities**
- **HAZOP studies for design & operability of the terminal facilities.**
- **Shipping Logistic study for finalizing the tank age requirement**
- **Marine & Terrestrial Environment Impact Assessment studies for studying the impact on environment (as a part of statutory requirement)**
- **Land Survey, soil investigations & seismic analysis for design of civil foundations & structures**

SAFETY MEASURES INCORPORATED IN THE DESIGN

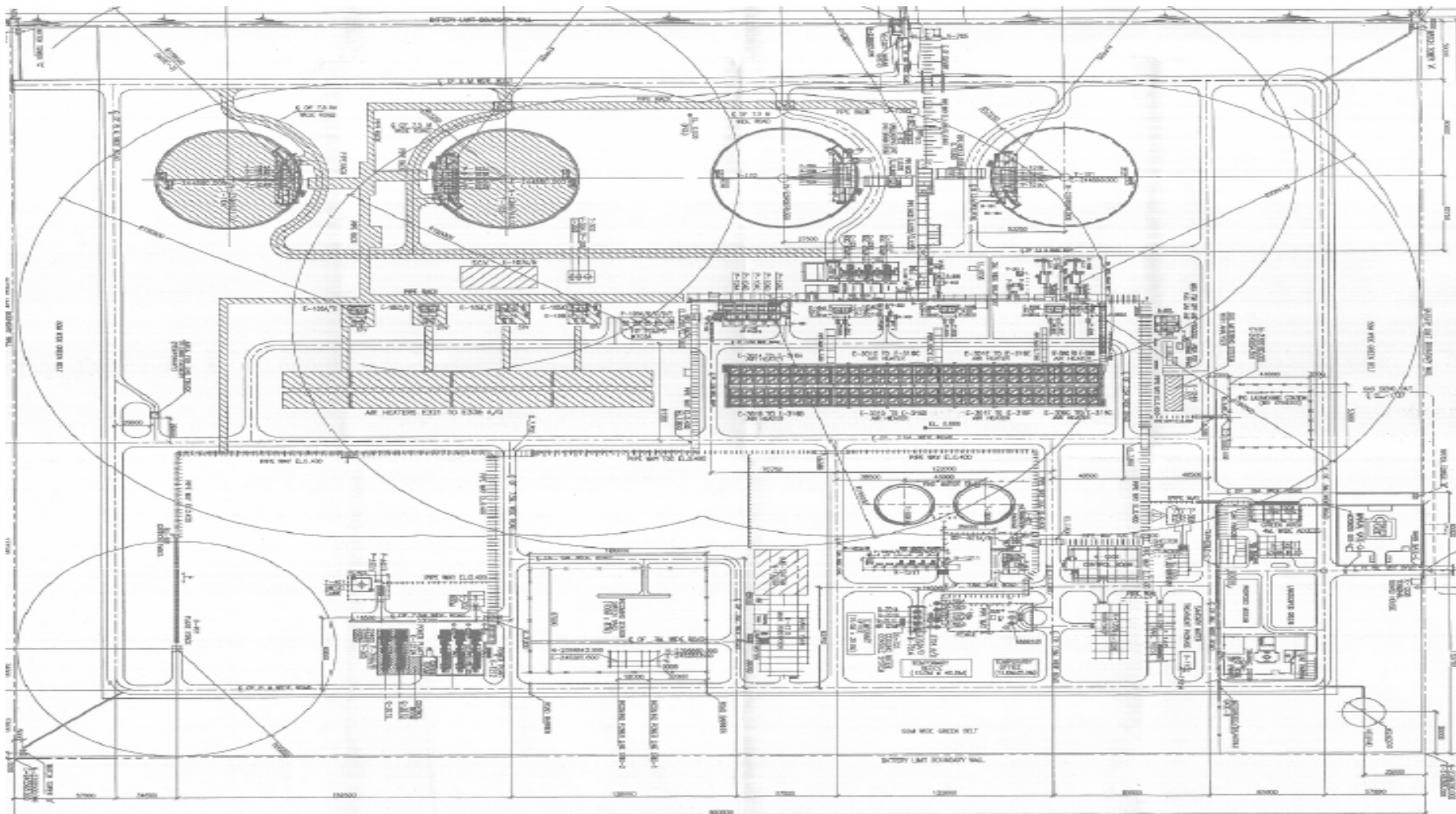
- **State-of-the-Art Technology.**
- **Automatic Safety Shutdown System Have Been included in the Plant Control System.**
- **System for early detection of leakage / spillage of LNG or regasified LNG.**
- **Plant Design and Equipment Layout as per International & Domestic Safety Standards.**
- **Dedicated team to ensure adherence to safety measures.**
- **Safety Audits & Mock Drills**
- **Regular Safety Trainings (Internal & External)**
- **Incident Reporting & Analysis**

EQUIPMENT LAYOUT

REGASIFICATION TERMINAL EQUIPMENT LAYOUT

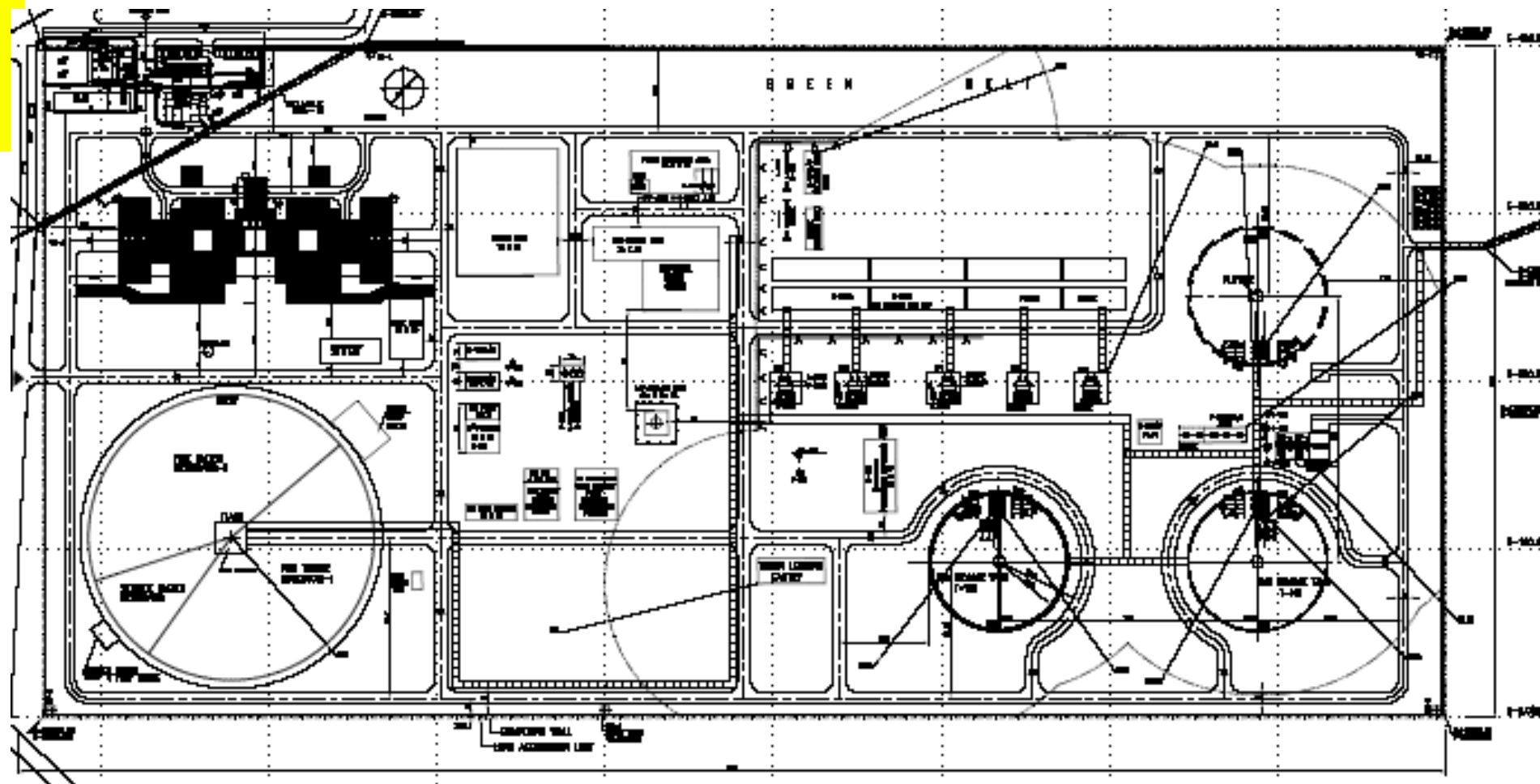
- **EN 1473 & NFPA 59 A provides guideline**
- **Layout to ensure LNG piping is minimized**
- **Layout to ensure risk does not extend beyond the plot**
- **Main Control room to be in non-hazardous area.**
- **Hazardous area classification may be decided based on dispersion calculation from possible spills.**

Safety Distance – Dahej LNG Plant



The required safety distance form leakage point for HP & LP source are 190m and 168m which could be accommodated within the Allocated plot

Safety Distance – Kochi LNG Plant



The required safe distances from leakage point from HP & LP source are 141 & 105 m, which could not be accommodated within the allotted plot. PLL had to use water curtains to resolve this problem

LNG Spill Prevention Methods

- **Release From Un-loading Arms**
 - **Powered Emergency Release Coupling with two step ESD System**
 - **Step 1: - Close the NG / LNG valves**
 - **Step 2: - Disconnect the NG / LNG un-loading Arms**
 - **Failure of both the steps only can cause the LNG spill.**
- **LNG Transfer Lines**
 - **Pipes are protected against corrosion, overpressure, Vehicle crash, equipment fall by design features & mostly being welded pipes**
- **Inner Tank Failure**
 - **Design Features (e.g. metallurgy, welding procedures, earthquake factor, low temperature detectors, no nozzle on side or bottom of tank, provision of VRV etc.) make the failure chance almost rare.**
- **Outer Tank Failure**
 - **Pre-stressed concrete outer tank designed to with stand cold LNG & external aggression due to LNG leak, earthquake, projectile attack etc.**

HANDLING OF LNG LEAKS & SPILLS

- **Elaborate Leak detection system**
 - **Thermal Sensors**
 - **Gas Detectors**
- **procedures to protect personnel from contact with leaking liquid or cold vapor and minimize the chance for vapor contact with potential source of ignition**
- **Equipment such as barricades, Warning signs and combustible gas indicators are available at the plant**
- **Elaborate Emergency Shut Down (ESD) system & System isolation**
 - **ESD1: - Stop Ship Un-loading**
 - **ESD2: - Stop Send out system**
 - **ESD3: - Stop Complete facility**

ACTIVE EMERGENCY / FIRE PROTECTION MEASURES

- **Fire Water System: Ring Main, Hydrants, Tower Monitors, Remote / manual operated spray system, Water Curtain**
- **High Expansion Foam System**
- **Clean Agent (Inergen) system**
- **Potable Fire Extinguisher**
- **Mobile Fire Fighting triple purpose (Water/Foam/DCP) Tender**
- **Personal Protection Gears & Breathing Apparatus**
- **Oil Spill Handling Equipment**

SAFETY - DOCUMENTATION

- **A Comprehensive set of Documentation is in Place for Safe & Reliable Operation:**
 - **Disaster Management Plan**
 - **Oil Spill Contingency Plan.**
 - **Port Administration**
 - **Port Operations**
 - **Health, Safety and Environment (HSE)**
 - **Maintenance of Tugs and Support Craft & Jetty**
 - **Training**
 - **Terminal Information & Regulations & Operation Books**

Concluding Remarks

- **Follow the Codes & Standards leads to safe design & operation**
- **Studies like HAZOP, QRA, SIL, Risk Analysis etc. during the design phase help in ensuring the safety during construction & operation.**
- **For Key to Success remember**
 - **Engineering is easy**
 - **Environmental issues, public safety & public perception are difficult**
 - **Carryout detailed modeling studies to establish compliance with environmental / regulatory requirements in project development process from the very beginning**

REDUCING THE RISKS AT DAHEJ TERMINAL

DESIGN & CONSTRUCTION

Emergency Release Coupling

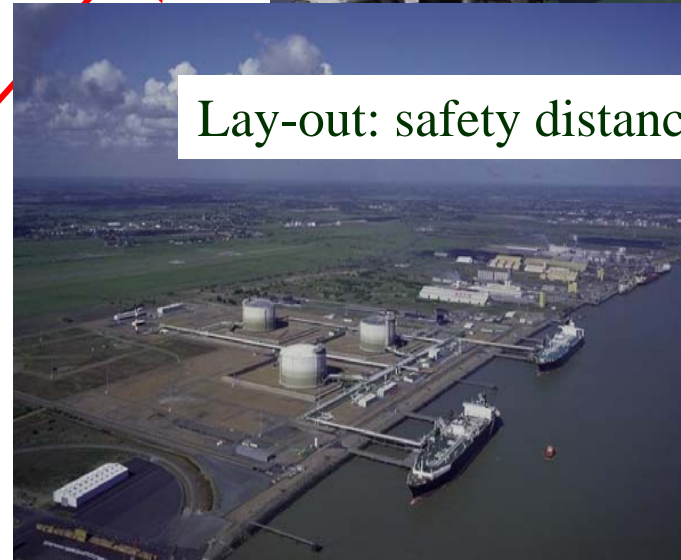
Full containment Storage Tanks



Some examples



Lay-out: safety distances



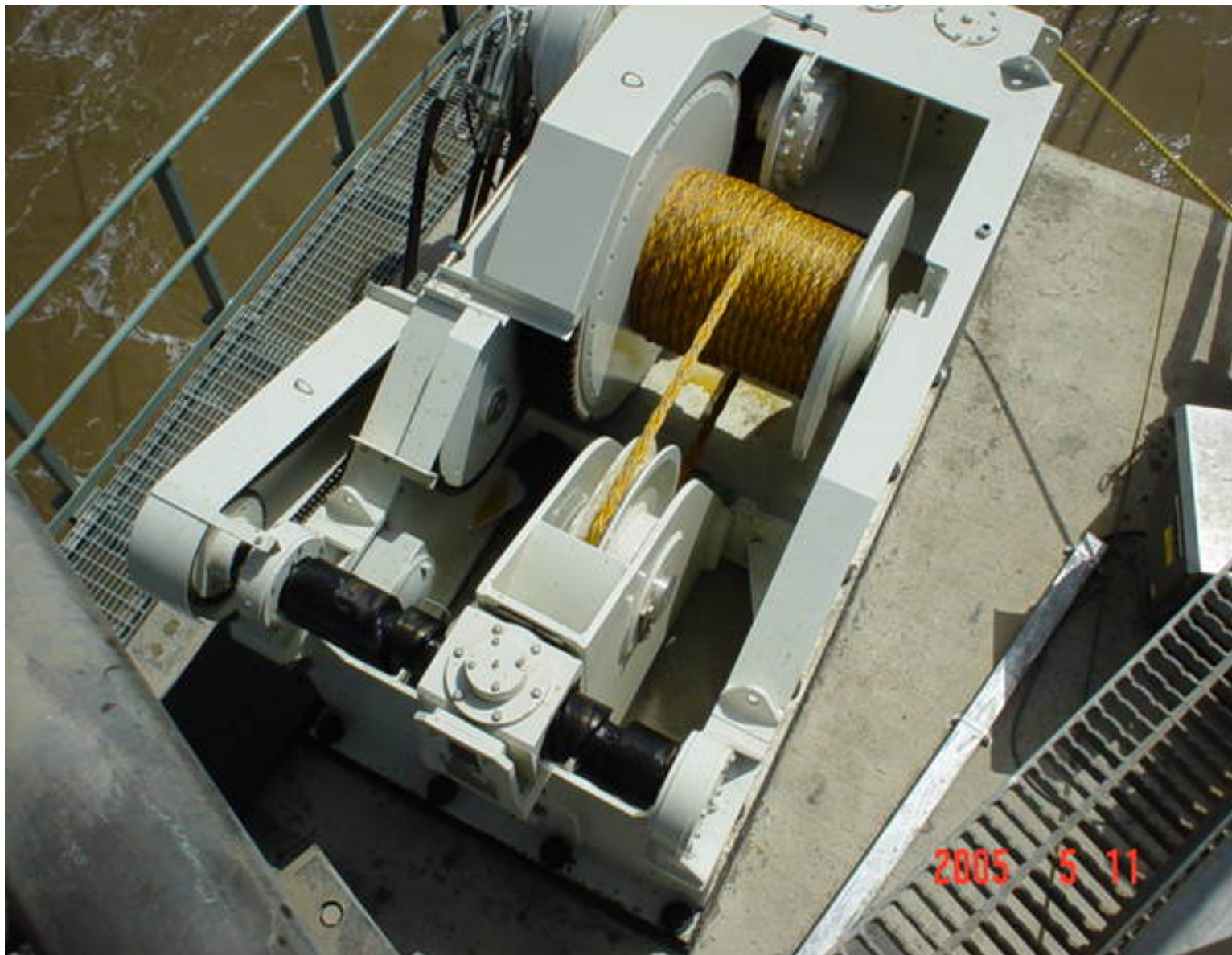
Cold and Gas Detection

**LNG IS A MATURE INDUSTRY
ENJOYING A VERY HIGH LEVEL
SAFETY RECORD WORLDWIDE**

**THANK YOU FOR YOUR
ATTENTION**

160,000 m³ LNG tanks under construction
Petronet LNG Ltd LNG Terminal DAHEJ -Gujarat

Constant Tension Winches

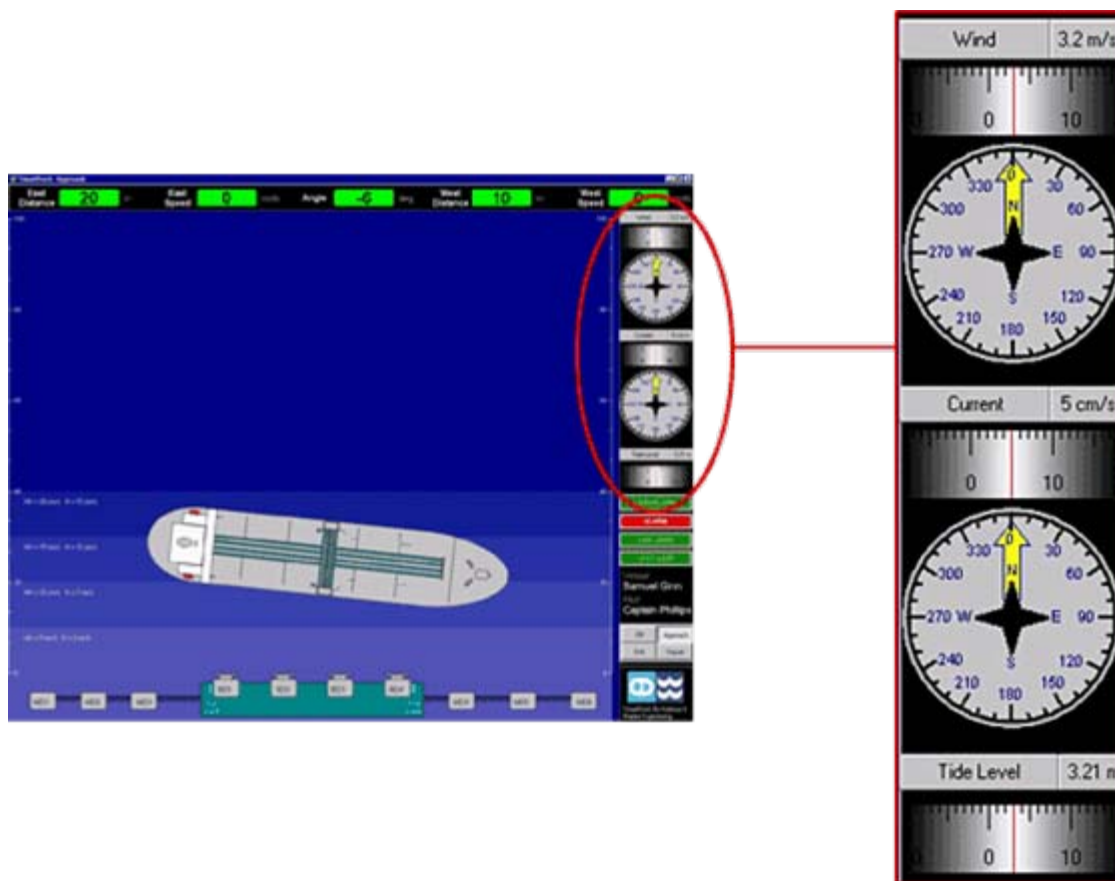


Berthing Aids



Data Monitoring – While Ship at Berth

Using standard interfaces, environmental data can be integrated with load monitoring and docking systems to display all essential mooring information on one screen. This creates a clear understanding of the interaction between wind, current and vessel mooring dynamics



MOORING HOOK TENSION MONITORING

