Working in Confined Space
-- the Marine Scenario
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Defining the scope
the measuring tape, putting something in the spot light

- Work (working) : definition in maritime law of Hong Kong – cargo handling, shiprepairing, shipbuilding, shipbreaking, marine construction

- Confined space : enclosed space, hatched cargo hold, compartment, ballast tanks, void space, tanks, double bottom, “gas safe space”;
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• The information provided are not for practical use and users must verify themselves for their accuracy, etc.

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Confined Space Design Guidance Documents:


Confined Space Regulations:


Confined Space Standards:

- **ANSI Z117.1-2003, Safety Requirements for Confined Spaces** - This revised standard provides minimum safety requirements to be followed while entering, exiting, and working in confined spaces at normal atmospheric pressure.

General Confined Space References:

- SOLAS Chapter II-1, Part A-1 Structure of Ships Regulation 3-6
- Access to and within spaces in the cargo area of oil tankers and bulk carriers (2002 rev.)
- **Confined Space Safe Practice Rec. No 72**, International Association of Classification Societies (IACS).
- Human Factors Conference, London, 27 - 29 September 2000, Royal Institution of Naval Architects - Human factors in ship design and operation provides an opportunity to reduce cost, improve safety, increase effectiveness and improve conditions on board ships. Details of papers presented at this conference are available at [http://www.rina.org.uk/](http://www.rina.org.uk/)
- International Maritime Organization (IMO) [www.imo.org](http://www.imo.org) - Safety of Life at Sea (SOLAS)
- International Maritime Organization (IMO) [www.imo.org] - Safety of Life at Sea (SOLAS) rule for merchant oil tankers and bulk carriers requiring permanent means of access (PMA) or alternate means of access to the cargo and fuel storage areas.
- Naval Sea System Command (NAVSEA), Carderock Division - website describes the use of tank level indicators on Navy ships.
- NAVSEA, Capital Investment for Labor - website describes the use of Navy tank monitoring system aboard Navy ships.
  http://www.navsea.navy.mil/
- NAVSEA, Corrosion Control Division, Beau Brinckerhoff’s presentation at the 2002 DoD Maintenance Symposium, describes Navy innovative, cost savings projects for Navy Shipboard Corrosion Maintenance.
- NAVSEA, Corrosion Control Division, E. Dail Thomas II’s presentation describes Navy innovative cost savings projects for Navy Shipboard Corrosion Maintenance.
  http://www.usashipbuilding.com/
- Naval Safety Center website presentation describes the dangers, procedures, and equipment used for confined space entry of Coast Guard boarding team.
- NIOSH/NSRP Project - Ergonomic Interventions in the Building, Repair, and Dismantling of Ships, 2000, Stephen D. Hudek, Ph.D., CSP
  http://www.cdc.gov/niosh/ergship/ergship.html
- NIOSH Shipyard Ergonomics Project New Orleans, 2002
  www.nsrp.org/projects/deliverables/ase_912002.pdf
- OSHA Ship Repair website e-tool, "Confined or Enclosed Spaces and Other Dangerous Atmospheres"
  http://www.osha.gov/
- Safety and Health in Confined Spaces, Neil McManus, copyright 1999 Lewis Publishers - comprehensive review of all aspects of confined space entry including hazard assessment,
Enclosed Spaces – Cap415C(2)

- "enclosed spaces" (圍蔽艙位) means all those spaces, other than excluded spaces, which are bounded by the ship's hull, by fixed or portable partitions or bulkheads, or by decks or coverings other than permanent or moveable awnings. No break in a deck, nor any opening in the ship's hull, in a deck or in a covering of a space, or in the partitions or bulkheads of a space, nor the absence of a partition or bulkhead, shall preclude a space from being included in the enclosed spaces; and for the purposes of this definition "excluded spaces" (免除艙位) means any of the following spaces-

- (a) that part of an enclosed space within an erection opposite an end opening and extending from the opening to an athwartship line at a fore and aft distance from the opening equal to half the breadth of the deck at the line of the opening. Such end opening shall have a breadth equal to or greater than 90 per cent of the breadth of the deck at the line of the opening and shall extend from deck to deck or to a curtain plate of a depth not exceeding by more than 25 millimetres the depth of the adjacent deck beams, as specified in figure 1 of Schedule 2 hereto:

- Provided that-
  - (i) where at any point the width of the enclosed space, because of any arrangement except convergence of the outside plating, as specified in figure 3 of Schedule 2 hereto, becomes less than 90 per cent of the breadth of the deck at the line of the opening, the excluded space shall extend only to an athwartship line intersecting that point, as specified in figures 2 and 4 of Schedule 2 hereto;
  - (ii) where the opposite ends of 2 enclosed spaces are separated by a gap, which is completely open except for bulwarks or open rails and of fore and aft length less than half the least breadth of the deck at the gap, then no part of the enclosed spaces shall be excluded, as specified in figures 5 and 6 of Schedule 2 hereto;

- (b) a space under an overhead deck covering open to the sea and weather, having no other connection on the exposed sides with the body of the ship than the stanchions necessary for its support. In such a space, open rails or a bulwark and curtain plate may be fitted or stanchions fitted at the ship's side, provided that the distance between the top of the rails or the bulwark and the curtain plate is not less than 0.75 metres or one-third of the height of the space, whichever is the greater, as specified in figure 7 of Schedule 2 hereto;

- (c) a space in a side-to-side erection between opposite side openings not less in height than 0.75 metres or one-third of the height of the erection, whichever is the greater. If the opening in such an erection is provided on one side only, the space to be excluded from the volume of enclosed spaces shall be limited inboard from the opening to a maximum of one half of the breadth of the deck in way of the opening, as specified in figure 8 of Schedule 2 hereto;

- (d) a space in an erection immediately below an uncovered opening in the deck overhead, provided that such an opening is exposed to the weather and the space excluded from enclosed spaces is limited to the area of the opening, as specified in figure 9 of Schedule 2 hereto;

- (e) a recess in the boundary bulkhead of an erection which is exposed to the weather and the opening of which extends from deck to deck without means of closing, provided that the interior width is not greater than the width at the entrance and its extension into the erection is not greater than twice the width of its entrance, as specified in figure 10 of Schedule 2 hereto;

- (f) notwithstanding the provisions of paragraphs (a) to (e) inclusive, any space listed in those paragraphs which fulfills at least one of the following conditions shall be treated as an enclosed space-

- (i) the space is fitted with shelves or other means for securing cargo or stores;
- (ii) the openings are fitted with any means of closure;
- (iii) the construction provides any possibility of such openings being closed;
Scientific Method

• Karl Popper: further proof
• Objective: identify hazards to human in c.s.
• Review of literatures: docs, rules & regs
• Tests: examine the bulk & corners
• Conclusions: the threads & threats
• Discussion: open floor
Ship Design & Operation

- Classification societies: rules for design
- Certificate of construction etc.
- Merchant Shipping Ord/Reg: flag of quality, laissez-faire attitude, lack cohesiveness in maritime prowess
- International Health Regulations (2005): Port Health Office of DoH/HKSAR (MDN99/07: SSCC & SSCEC replaced DC & DEC as ship hygiene documents wef 15.6.07)
- Disinfection/fumigation: methyl bromide, for example
- Gas free certificate: entry, hot work/cold work (asphyxiation, injurious fumes or explosions)
SKETCH B

NOT TO SCALE

主尺度

船长: 49.98m
垂线间长: 47.20m
型宽: 15.80m
型深: 6.00m
设计吃水: 3.60m
排水量: 2436t
装载集装箱: 120TEU/空箱180TEU
主机功率: 350Kw*2
设计航速: 8Km
船员: 10人
Local Vessels

- Dumb steel lighters, oil/water barges (tankers), pontoons, yachts, fishing boats, flat top barges, containerised waste carrier, tug boats
- river trade vessels, sand barges, near coastal vessels, coastal vessels
- (see pictures: ship_types)
“Confined Space/Enclosed Space”

- Safe atmosphere – hot work not in an atmosphere containing flammable vapours, flammable gases or explosive dusts. (Cap 548, s42)
- Breathable air in BA (EN132) – dry O2 23.14%v, N2 75.52%v, CO2 0.05%v, Ar, H2, Ne, He, Kr, Xn. No odour of oil, threshold 0.3mg/m3, Water content < 50mg/m3 for 200bar, 30 mg/m3 for 300bar
- Wearer : 40 l/m consumption rate
# International Breathing Air Standards

<table>
<thead>
<tr>
<th>Item</th>
<th>United Kingdom</th>
<th>European-Draft</th>
<th>Germany</th>
<th>Holland</th>
<th>USA</th>
<th>Canada</th>
<th>AUS/NZ</th>
<th>Domestic Hunter Breathing Air Purifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>19.5–23.5%</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
</tr>
<tr>
<td>Oxygen</td>
<td>20–23%</td>
<td>18–24%</td>
<td>21 ± 1%</td>
<td>20–21%</td>
<td>20–21%</td>
<td>approx. 21.5%</td>
<td>19.5–22.5%</td>
<td>19.5–22%</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>500ppm</td>
<td>&lt;500ppm</td>
<td>500ppm</td>
<td>1000ppm</td>
<td>1000ppm</td>
<td>500ppm</td>
<td>&lt;800mg/m³</td>
<td>300ppm</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>5ppm</td>
<td>&lt;5ppm</td>
<td>≤15ppm</td>
<td>30ppm</td>
<td>5ppm</td>
<td>5ppm</td>
<td>5ppm</td>
<td>&lt;5ppm</td>
</tr>
<tr>
<td>Oil Mist</td>
<td>0.5mg/m³</td>
<td>&lt;0.5ppm</td>
<td>0.5ppm</td>
<td>Not Specified</td>
<td>0.1mg/m³</td>
<td>5mg/m³</td>
<td>1mg/m³</td>
<td>0.003mg/m³</td>
</tr>
<tr>
<td>Pressure Dewpoint</td>
<td>5°C below lowest temp.</td>
<td>At least 5°C below minimum temp.</td>
<td>At least 5°C below minimum temp.</td>
<td>-51°C pdp</td>
<td>-51°C pdp</td>
<td>10°F below lowest temp pdp at 5°C below system</td>
<td>100mg/m³</td>
<td>-40°C pdp</td>
</tr>
<tr>
<td>Halogenated Hydrocarbons</td>
<td>&lt;10% OEL</td>
<td>&lt;10% LTEL</td>
<td>&lt;10% LTEL</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>5ppm</td>
<td>Not Specified</td>
</tr>
<tr>
<td>Solid Particles</td>
<td>&lt;10% OEL</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>1mg/m³</td>
<td>Not Specified</td>
</tr>
<tr>
<td>Odours</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Not Specified</td>
<td>No pronounced odour</td>
<td>None</td>
<td>No nauseous odour</td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>&lt;10% OEL</td>
<td>&lt;10% LTEL</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>&lt;10% TLV</td>
<td>Not Specified</td>
<td>&lt;10% LTEL</td>
</tr>
<tr>
<td>Nitrogen Dioxide</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
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</tr>
<tr>
<td>Sulphur Dioxide</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
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</tr>
</tbody>
</table>
SOLAS Convention 1974

• Safety of life at Sea

• Chapter II-2 - Fire protection, fire detection and fire extinction
Includes detailed fire safety provisions for all ships and specific measures for passenger ships, cargo ships and tankers.

They include the following principles: division of the ship into main and vertical zones by thermal and structural boundaries; separation of accommodation spaces from the remainder of the ship by thermal and structural boundaries; restricted use of combustible materials; detection of any fire in the zone of origin; containment and extinction of any fire in the space of origin; protection of the means of escape or of access for fire-fighting purposes; ready availability of fire-extinguishing appliances; minimization of the possibility of ignition of flammable cargo vapour.
Chapter IX - Management for the Safe Operation of Ships

• The Chapter makes mandatory the International Safety Management (ISM) Code, which requires a safety management system to be established by the shipowner or any person who has assumed responsibility for the ship (the "Company").
Seafaring

- Medical examination: hearing, sight, colour vision, general health
- Medical first aid guide prepared by ILO, WHO, IMO
- Standards of Training and Watchkeeping (STCW)
- Working hours: ILO convention 180 Article 5
  - (a) max not exceed (i) 14h in 24h (ii) 72h in any 7-day or
  - (b) min hours of rest not less than (i) 10h in 24h (ii) 77h in 7-day
SH advice: 30 years back

- Personal hygiene & protection: drink sufficient water, salt to avoid heat exhaustion, sensible shoes or boots, non-slip soles and reinforced toecaps, clothes: no loose flaps, head gear, finger rings removed, gloves, well washed hands, avoid infections of cuts
- Changing area of concerns
Ocean-going: technology, global

- Local Vessels (Harbour / port limit) – local legislations with international perspective
- Labour Department (Land) – local legislations with international elements
- ➔ prescriptive to descriptive
- ➔ system approach
- ➔ skills changed, rule changes, knowledge based
- ➔ DoJ (US) attitude: criminalisation of seafarers / workers
MS(LV)(W)Reg, Cap548I

- Shipbuilding and Ship-repairing Safety Guide: Section III Entry into Confined Spaces
- TLV, 8 hr daily exposure
- Toxic vapours: petroleum, benzene, H2S, others
- Lack of O2: CO2 discharge, H2 generation, steam, inert gas, rusting
MERCHANT SHIPPING (SEAFARERS) (ENTRY INTO DANGEROUS SPACES) REGULATION, Cap 478B, s2

• "dangerous space" (危険艙) means any enclosed or confined space in which it is foreseeable that the atmosphere may at some stage contain toxic or flammable gases or vapours, or be deficient in oxygen, to the extent that it may endanger the life or health of any person entering that space;
“Competent Persons”

- Gas free inspectors (marine, 295C, s21): qualification, mentor, examination, fee, revalidation
- Person approved under Cap295B (General): approved person, s108 (container repairs), s120 (hot work to tank wagon), s128 (hot work repair to tanks)
- Competent person under Cap59AE: 2-day training, risk assessment report
- Person trained in using the gas tester
"confined space" (密閉空間) Cap59

- means any place in which, by virtue of its enclosed nature, there arises a reasonably foreseeable specified risk, and without limiting the generality of the foregoing, includes any chamber, tank, vat, pit, well, sewer, tunnel, pipe, flue, boiler, pressure receiver, hatch, caisson, shaft or silo in which such risk arises; (L.N. 17 of 1999)
"specified risk" (指定危険)

- (a) serious injury to any person at work arising from a fire or explosion;
- (b) the loss of consciousness of any person at work arising from an increase in body temperature;
- (c) the loss of consciousness or asphyxiation of any person at work arising from gas, fume, vapour or the lack of oxygen;
- (d) the drowning of any person at work arising from an increase in the level of liquid; or
- (e) the asphyxiation of any person at work arising from a free flowing solid or the inability to reach a respirable environment due to entrapment by a free flowing solid. (L.N. 17 of 1999)
Screen Clips

From OSHC VCD “死亡陷阱”
Accident Cases Investigated

- 8 illustrative cases
- Exhaust gas,
- narrow cargo hold with moving load,
- bulk cargo hold (coal),
- water jet in double bottom,
- Folding hatch cover
- Accumulation of gases
- Using diesel engine in a hold
- Inside a mixer
Control of human behaviour

- Law and regulations (passive, man-made)
- Directions (stop, suspension, corrective)
- Marine Department Notices (instructive)
- Code of Practices
- Guidelines, Guides, Guidance Notes,
- Notices, Information
- Warning letters
- Safety pamphlets, leaflets, posters, Green Cross Articles
- TV / Radio, Newspaper, journals, newsletter
- Internet websites, passive, interactive
- Supervision, peer review, audit (i/e)
- Person in charge, employer, supervisor, worker
History of Health Education 健康教育
<table>
<thead>
<tr>
<th>空气含氧量</th>
<th>21%</th>
<th>18%</th>
<th>16%</th>
<th>12%</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>状态</td>
<td>清醒</td>
<td>不适</td>
<td>晕眩</td>
<td>失觉</td>
<td>死亡</td>
</tr>
</tbody>
</table>

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在氖气系抛柱或密封的船舱工作，必须采取下列安全措施：
1. 在进入船舱前，测量舱内氖气的含氧量。
2. 若有多人一起在船舱内工作，必须在入口处使用通风扇吹送新鲜空气入舱内。
3. 工作中如感觉不适，应立即离开船舱。

海事处：海事工业安全组
查询电话：852 4472
Testing for safe atmosphere

- Gas detector, gas sampler, gas analyzers,
- Sensor poisoning
- Life span of sensor
- Calibration, span gas, (outside the space)
Why take risks?

• Hunch $\rightarrow$ Quick, short time exposure, strength, low concentration, less likelihood,

• Assumptions in the effect of ventilation: point of measurement, Brownian movement, diffusion

• Method of ventilation: air replacement, air changes, uniflow, turbulent flow, circulated flow, crossed flow, stratified flow, air volume, air streams, air speed,

• Time pressure: economy OR
Risk Taking Behaviour

- Tolerable risk, acceptable risk, trivial risk
- Lesson learned
- Specifications for filament wound composite cylinders: life extension
- Failure mode, statistical data, safety factors (factor of ignorance)
Prediction

• Laws & regulations, review or lesson learned is looking back, not forward looking – disadvantage is “after the fact”, not before the happening; rulings tended to restrict, confine, prohibit, design the human out of the system, man-machine interface, human error…

• Risk by design: construction methods

• Think / act before leaping (preparedness)

• Yi-ching (understanding and monitor changes)
  • CONCLUDED
Time is up, open your eyes to the inner and outer spaces
Discussions

• Q & A

• Further explanation