Design of Floating Production, Storage, and Offloading (FPSO) Systems for Eastern Canada

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Life Dichotomy

Theory

and

Practice
East Coast Canada Hazards

- Wind, waves
- Possible simultaneous appearance of icebergs
- Focus here is icebergs, with accompanying waves
First major decision

- Type of installation—fixed or floating
- Policy for ice resistance
Dealing with hazards

• FPSO designed to disconnect in presence of icebergs that cannot be removed

• What if an iceberg arrives undetected?
Sea State and Icebergs

- Occurrence of icebergs not directly correlated to sea state
- Detection of icebergs highly dependent on sea state
- Velocity of impact highly dependent on sea state
Monthly Mean $H_s$

Relative Iceberg Frequency
Focus: two aspects

- Design for conditions corresponding to $10^{-4}$ annual exceedance probability to give level of hull ice strengthening (ISO abnormal level design)
- What combination of iceberg size and sea state can be tolerated without having to disconnect? (serviceability)
Monte Carlo simulation
Icebergs Potentially Impacting Installation

- Can’t Detect
  - Impact
  - OK
  - Disconnect
    - OK
    - Impact

- Detect
  - Manage
    - OK
  - Can’t Manage
    - Can’t Disconnect
      - OK
      - Impact
Ice Detection

- Marine Radar
- Satellite Radar
- HF Radar
- Aerial Reconnaissance
- Vessel Reconnaissance

Sensor Integration
Examples of Validated Iceberg Targets

Photographs: C-CORE
RADARSAT Imagery:
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• Physical Management
  – Towing,
  – Water cannon
Monte Carlo simulation
Areal density
Iceberg size and shape
Sea state
Velocity
Avoidance
ALS criteria

- The criteria used in assessing the response of a hull section were first the strain in the structure at the design loads and second the degree of denting of the plate. The value of 5% equivalent plastic strain in the shell plate is used as a reference point.
Serviceability Criteria

• Depth of shell plate denting shall not exceed half of the specified plate thickness
• Localized plastic strain shall not exceed 5%
Pressures on area of 1 m² for side collisions (10% exceedence)
Safe regions
Illustration of iceberg size as viewed from vessel “Maersk Placentia” (vessel length = 72 m, iceberg length = 85m, range = 325 m)
Sea Rose