THE STRUCTURAL SAFETY IMPROVEMENT FOR FPSO HULLS

ColdShield Installation Process

JPh COURT & José ALCORTA

SAMPE – MONTARGIS – 17th of November 2016
ColdPad General Principle

Presentation Agenda

- COLD PAD Generic Principle Introduction
- ColdShield Project Presentation
- Installation Process
  - Laboratory stage
  - Pre-industrial stage
  - Industrial stage
- Example of product performances
FPSO – Floating Production Storage Offloading

Main information

- Floating Factory: Similar to Super-tankers
- Production on station
- Typical production capacity: 100kB/D
- Typical production trade value: 35M€/W
- Storage Capacity: Up to 2 Million barrels
- About 300 Operating Units today
All offshore steel structures are subject to: CRACKS and CORROSION.

Hulls = Oil Storage ➔ particularly sensitive

Conventional Repair

Flammable or explosive environment

Compromise on safety or Production

POTENTIAL IMPACT ON PRODUCTION

http://www.cold-pad.com | contact@cold-pad.com

SAMPE – MONTARGIS – 17th of November 2016
Current Challenges

——— Hot Work Incidence

International rules applicable to Supertankers & FPSOs

Tank capacity impacted

Production endanger

Hull repair required

Unwanted Hot Work

Demand for COLD alternatives

Rising Interest for Bonded Composite Reinforcements

Ref: ISGOTT (International Safety Guide for Oil Tankers and Terminals)
Cold Structural Repair

Classical composite Reinforcement

STRONG POINTS: RELIABLE AND USED IN OTHER INDUSTRIES

Cold Technology extensively used in aerospace & civil industries for the past 40y

Reliable, Proven & Certified – Installed in controlled atmosphere

http://www.cold-pad.com | contact@cold-pad.com

SAMPE – MONTARGIS – 17th of November 2016
Cold Structural Repair

Sensitive to Marine Environment

**OBSTACLE TO OFFSHORE UTILIZATION: NOT ADAPTED TO MARINE ENVIRONMENT**

Critical: INSTALLATION must be done in a CONTROLLED ATMOSPHERE (T° & Humidity)

Polymers are subject to DEGRADATION when EXPOSED to MARINE ENVIRONMENT

MARINE ENVIRONMENT = OBSTACLE for Bonded Composite reinforcement Development in Offshore Industry

WHERE COLD PAD PROVIDES THE SOLUTION

Courbes contrainte - déformation de l’adhésif époxy à différents temps de vieillissement en eau déionisée à 20°C
ColdPad General Principle

- **Base Material** (existing)
- **Target Area for Connection**
- **Peripheral Seal**
- **Rigid Plate** (New)
- **Vacuum Attraction Forces**
- **Seal Compression Polymer**
- **Polymer Hardening UNDER VACUUM**
- **Control of internal atmospheric Parameters**
- **Vacuum-Injection Structural Polymer**

Permanent Seal Compression = Permanent Polymer Protection

Experimental Parameters: **Internal Volume Isolated**

Sealing inlet/outlet holes

SAMPE – MONTARGIS – 17th of November 2016
First Industrial Development

**ColdShield**

**Functions:**
- Restore Initial Structural Capacity
- Protect Against Further Corrosion

**Target Application:**
Locally Corroded Plating of FPSO Hulls

**Artistic View**

**Standard shape**
0.5 to 5 m²

**ENVELOPPE**
Compressed Seal
Protection Plate

**REINFORCEMENT**
Resin
Composite

**Damaged Steel Plate** e.g. Corroded FPSO Hull

SAMPE – MONTARGIS – 17th of November 2016
1st Product Industrial Development

Technical & Financial Partnership

Technical
- Technical Partner for
  - Expertise
  - Seal performance tests
  - Large scale tests
- Head Office: TEC/STR & TEC/COR
  - Total R&D
  - Total E&P Angola

Financial
- Overall R&D till Industrialisation

Elaborated with 4 French laboratories incl. RESCOLL

http://www.cold-pad.com | contact@cold-pad.com

SAMPE – MONTARGIS – 17th of November 2016
ColdShield Qualification – Installation Process

Laboratory stage @ RESCOLL

- **Resin Selection – specification:**
  - Working thicknesses range
  - Injection temperature range
  - Service temperature range
  - Open time: 1 hour
  - Low viscosity (infusion type)
  - High Tg
  - High mechanical performances (Strength, Strain, Adhesion)

- **Commercial References Selection:**
  - 20 references screened (mainly epoxies)
  - 12 references tested mechanically
  - 6 references tested for injection trial

- **Resin Selection – preliminary trial:**
  - On dummy resin (cellulosic blend)
  - On the “short list” selected resin (6 ref)
ColdShield Qualification – Installation Process

Laboratory stage @ RESCOLL

Essais de mise en œuvre

Mélange eau + cellulose + fluorescéine / 1 plis de tissu PE
ColdShield Qualification – Installation Process

Laboratory stage @ RESCOLL

Essais de mise en œuvre

- Sikadur 52 / 10 plis de mat de verre 600g/m²
ColdShield Qualification – Installation Process

Laboratory stage @ RESCOLL

Essais de mise en œuvre

- Sikadur 52 / 4 plis de mat de verre 600g/m²

Infusion OK en 15 minutes à -0,6 bars
ColdShield Qualification – Installation Process

Laboratory stage @ RESCOLL

Essais de mise en œuvre

- Sikadur 52 / 1 pli de tissu PE

Infusion OK en 3 minutes à -0,3 bars
Le manque est due à un manque matière à l’origine
ColdShield Qualification – Installation Process

Laboratory stage @ RESCOLL
ColdShield Qualification – Installation Process

Laboratory stage @ RESCOLL
ColdShield Qualification – Installation Process

Pre-industrial stage @ DOPAG with RESCOLL

• Vacuum assisted injection procedure
• Industrial tool for installation (test machine)
ColdShield Qualification – Installation Process

Pre-industrial stage

- Satisfactory Tests Result with the industrial tool
ColdShield Qualification – 4Pt Bending Test Setup

Full Scale Test – Bench Design
ColdShield Qualification – 4Pt Bending Test Setup

Full Scale Test Bench
Commercial Stage

Privileged Business Model

Organization centred onto our core business

ColdPad SAS

Subcontracted Activities:
Low Added Value or Highly Capitalistic

Pads Prefabrication
Aerospace manufacturers

Logistics
Offshore Maintenance contractors (e.g. coating)

Surface Preparation

http://www.cold-pad.com | contact@cold-pad.com

SAMPE – MONTARGIS – 17th of November 2016
Subcontractors profile – Pads Prefabrication

Pads manufacturer

- Qualification process ➔ highest industry standards for composites
  - Aerospace manufacturers
Subcontractors profile – Logistic & surface prep.

Installation Subcontractors

- Abrasive surface preparation to the Oil & Gas Standards
  - To Total Specification: GS-COR-450 (painting maintenance on site)
- Vessel Support & Logistics
ColdShield Qualification - Outcomes

**Innovative Performances**

- Installation Process ➔ Repeatability ➔ Reliability ➔ Safety
- Unique Encapsulation System ➔ Ultra High Durability in Offshore Environment
- Structural Performances ➔ Remarkable Mechanical Contribution & Resistance

**TECHNOLOGICAL BREAKTHROUGH**

- 3 Patents
- DESIGN techniques using latest numerical development
- Industrial Installation Tool Especially developed
- Certifications

New Technology Available

Technological Breakthrough + Enhanced Reliability =

SAMPE – MONTARGIS – 17th of November 2016