The McPIPE ™ Extended Cooldown System
one week (and more) of safe cooldown

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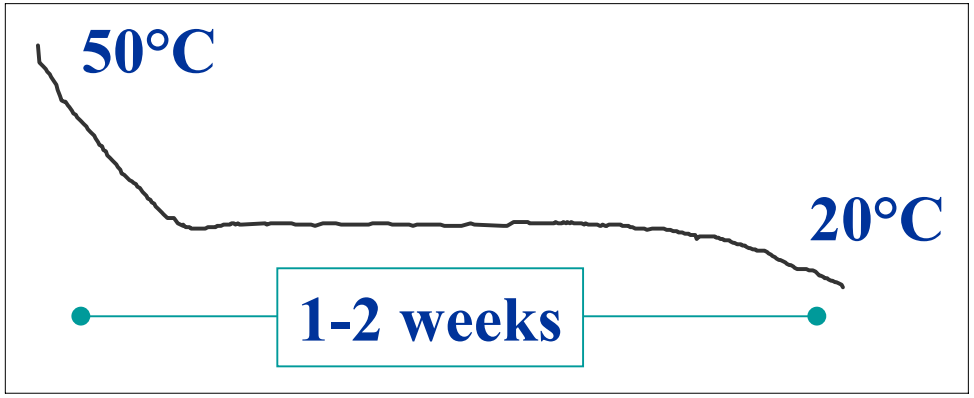
Agenda

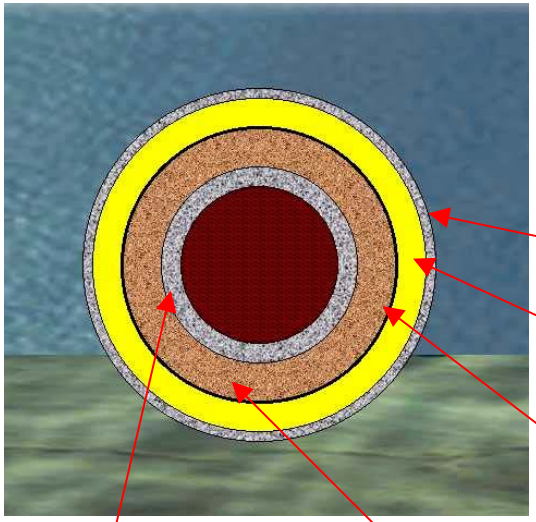
- System definition and principle of the McPIPE system
- In-house thermal analysis to date
- Thermal performance of the system
- Unique thermal solutions and applications
- Mechanical performance
- Construction and Installation
- Unique operability solutions

System Definition

- Patented development from McDermott & ITP
- Passive system = safe, long lasting service
- Field proven design and construction technology (TFE Tchibéli Project, Shell Bonga Project, JIPs at ChevTex's Humble (TX) facility for BP, ChevronTexaco, Exxon, Marathon, Philips, TFE, Shell



System Definition



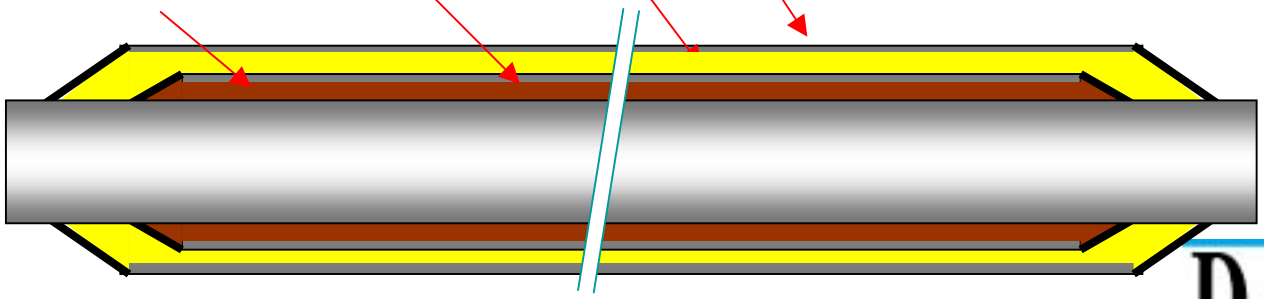
Outer pipe

Izoflex

Liner pipe

PCM

Inner pipe

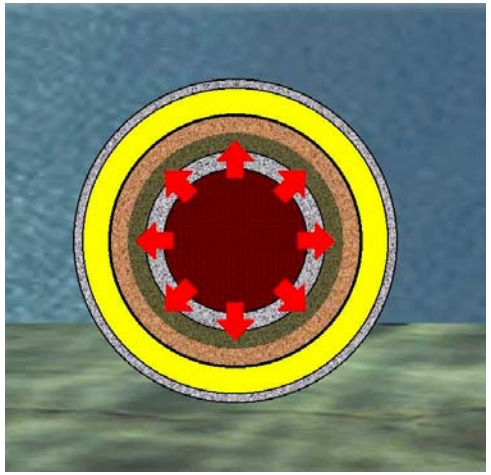


System Definition

- Combines a PCM (Phase Change Material) and high performance insulation to achieve:
  - U=0.5 W/(m^2.K)-0.09 BTU/(hr.ft^2.°F)
  - Extended cooldown time (up to 2 wks)
- Highly efficient Izoflex microporous insulation material and thermal energy storage with a PCM (Phase Change Material)

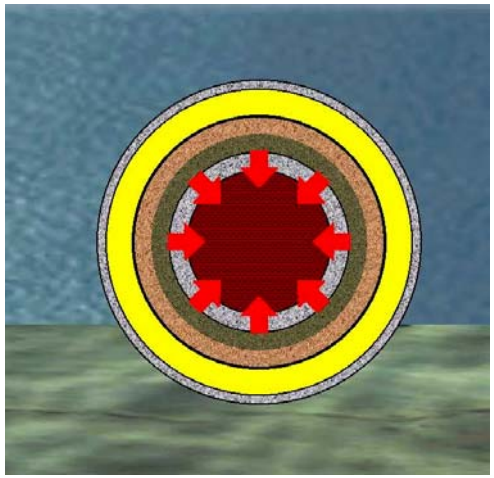
System Thermal Principle

In flow condition



Heat from the hydrocarbon melts the PCM

In shutdown condition



The crystallization of the PCM restores heat to the hydrocarbon

Insulation: Izoflex – 7mW/(m.k)
PCMs: up to 175 °F hydrated salts at 98 Wh/l
above 175 °F hydrocarbons at 60 Wh/l

Thermal Assesment

10" steel liner welded to 8" inner pipe

Hole for PCM filling

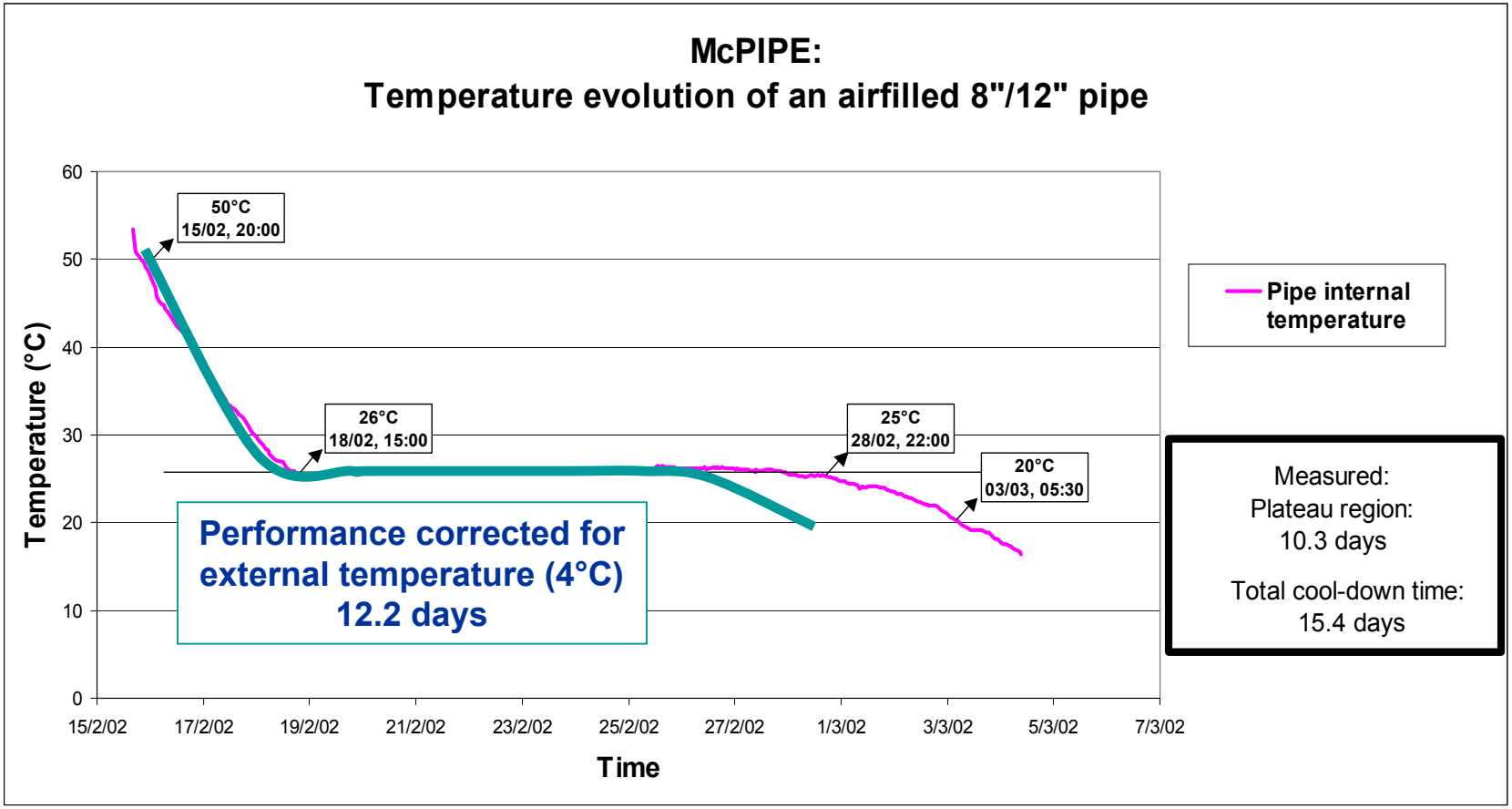
Izoflex

Insertion into the 12" outer pipe

12" outer pipe welded to the 8" inner pipe

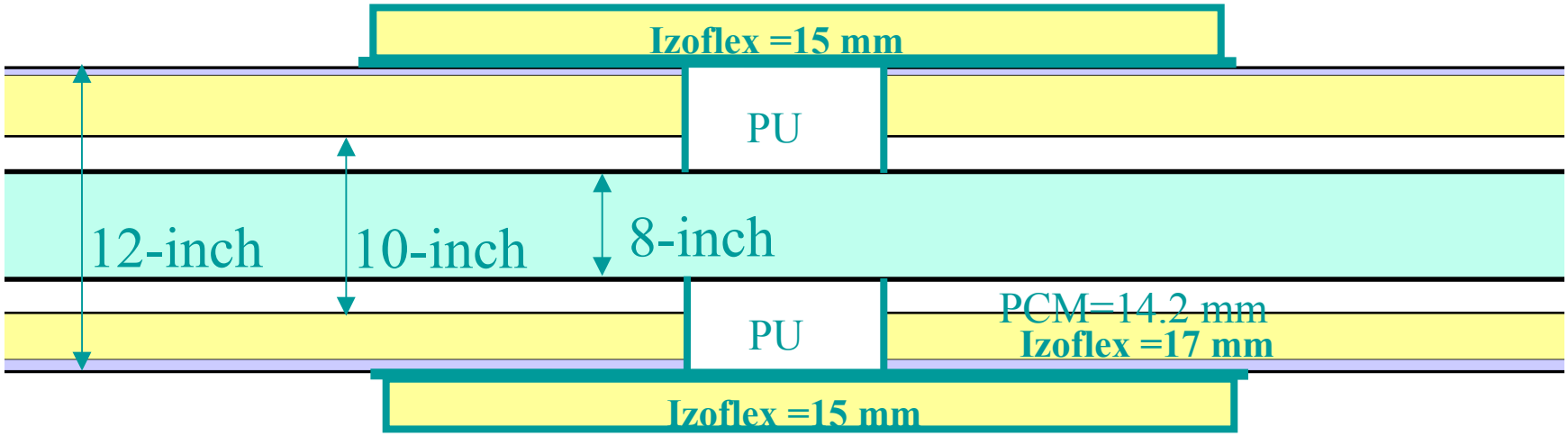
The McPIPE Extended Cooldown System

Results



U=0.37 W/(m².K)

Field Joint Thermal Behavior



- Field Joint is less insulated than mainline,
  - axial conductivities in inner pipe are high
  - radial conductivities are low

Unique Thermal Solution & Applications

Technology step change:
no-touch times are increased from hours (4-8) to weeks

Greenfield developments with
reduced back-up
limited live crude flushing facilities

Brownfield developments with
- **no need for upgrading live crude flushing facilities**

100 km tiebacks are possible
- **Normal production: flowspeed 1 m/s – 1 day transit time**
- **Degraded mode (turn down): 3 day transit time**
- **Ample margin left for downtime, etc.**

Thermal System Benefits

- Passive energy storage system.
  - No operation is necessary to activate the system
- A unique solution for long tie-backs (→100 km)
- In flow conditions :
  - Excellent U-value - better than 0.6 W/(m².K) (0.1 Btu/ft².hr.°F)
- In shutdown conditions :
  - Extended cooldown time
  - Increased operational flexibility
    - larger time window for decision making and intervention
    - easier planning of shutdown

Operability Assessment

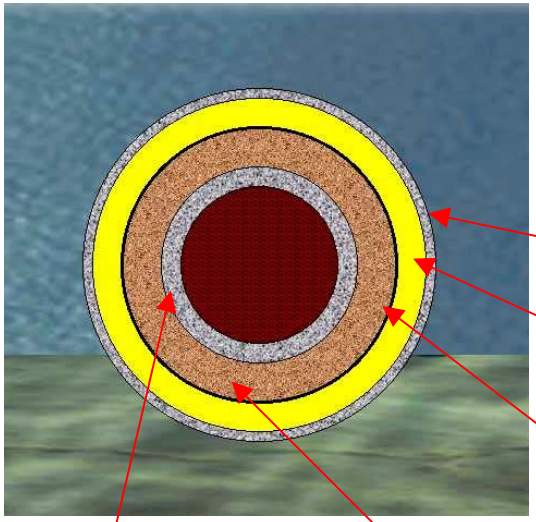
- Mechanical tests and evaluation
- Onshore fabrication
- Installation
  - Expected load behavior during installation
- System Benefits
- Further Applications

Mechanical Performance

At present the system is being evaluated with the participation of a joint industry project. This study includes a mechanical evaluation of:

- Stress distribution along the pipe during operation
- Pipelay analysis
- Effective tension
- Free Span Allowance

Onshore Fabrication



A single weld for connecting pipe in pipe doublejoint or quadjoint

Outer pipe

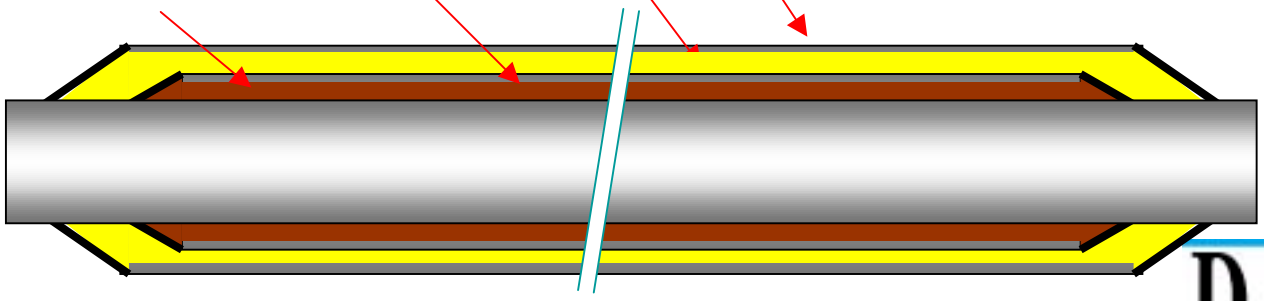
Izoflex

Liner pipe

PCM

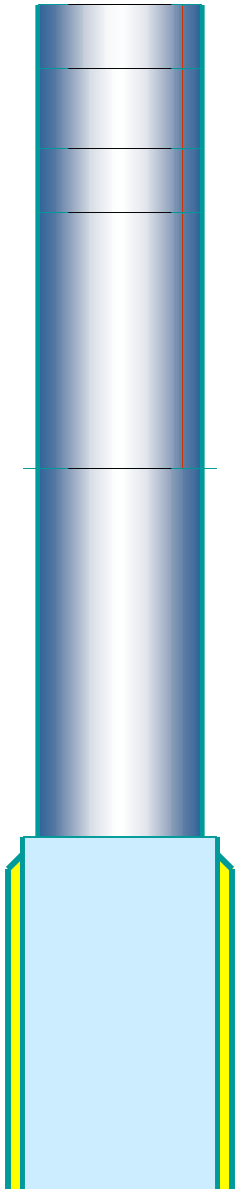
Inner pipe

- In built buckle arrestor
- In built bulkhead
- Simple construction

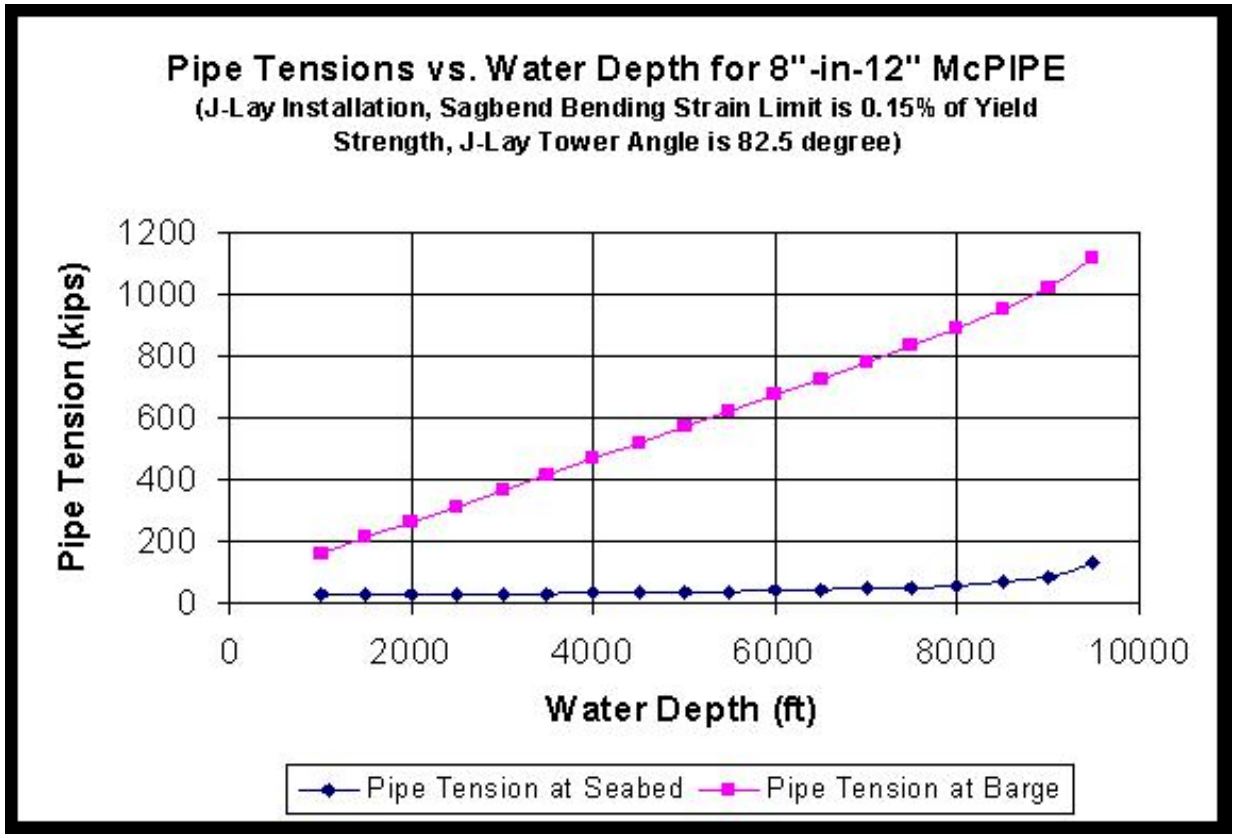


Field Joint

- Good thermal performance
  - insulated sleeve to minimize heat loss
- Short offshore assembly time
  - sleeve injected with fast curing resin
  - 5 mn cycle time for field joint installation
  - only inner pipe weld and UT to perform



System Installation Analysis



Mechanical System Benefits

- No centralizer required
- Minimum offshore cycle time
- Simple fabrication process and handling
- High collapse resistance
- Inherent on-bottom stability
- Simple installation
- Alternate to electrically heated pipe-in-pipe systems
  - No additional topsides equipment
  - No wet electrical connectors/isolation requirements
  - No CO_2 emissions
- Alternate to conventional pipe-in-pipe systems

Further Benefits

- Eliminates the need for host facility
- Suitable for local content in remote areas
- Provide an economic opportunity for the deepwater development of 50 million barrel recoverable fields which does not exist today
- Simplifies hurricane shut down and start up procedures
- Alternate to chemical treatments for wax and hydrate inhibition

Further Applications

- Provide an economically and technically viable solution for single line tie backs.
- Provide insulation on ancillary equipment, i.e. connectors, flanges
- Harsh environmental conditions

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