



iNPIPE PRODUCTS

www.inpipeproducts.com

ICE PIGGING

The future of pipeline maintenance

Introduction

International Pipeline Products Limited

iNPIPE PRODUCTS™ -

A global leader in the supply of pipeline maintenance and isolation equipment to the Oil, Gas, Petro-Chemical, Food, Water and Sewerage industries

Established 32 years ago

Based North East of England

80 Employees

Turnover £7.5m

Operating throughout 6 continents



Technology Overview

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The inspiration came from nature!

- Glaciers forcibly shape landscapes a clever semi solid that cleans valley floors carrying vast amounts of sediment then disappears
- Using an ice slurry we can recreate this phenomenon inside a closed system
- Ice pigs are not constrained by topology or geometry (within reason) result: a pig that cleans the parts other pigs cannot reach
- If the ice pig gets stuck... it melts



The Evolution of Ice Pigging



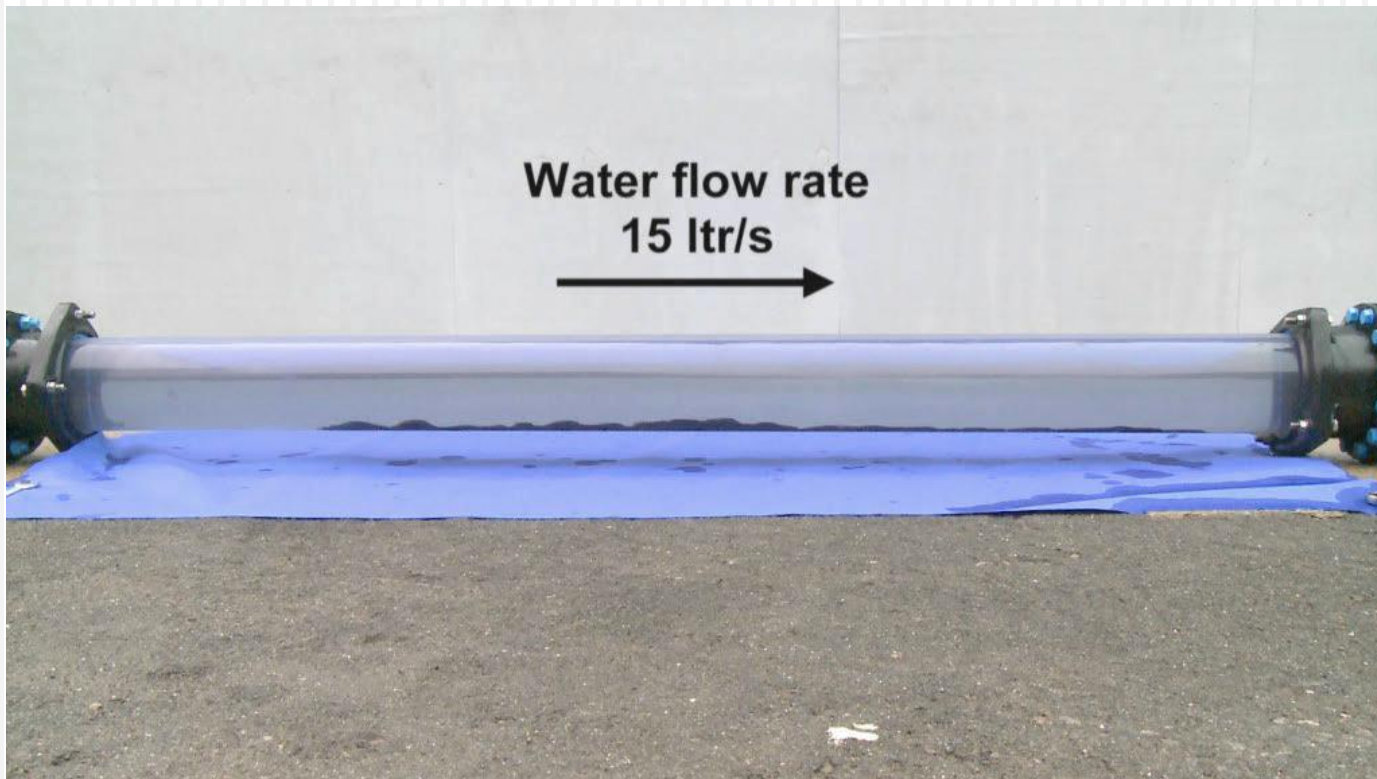
- 2001** – Patent granted to University of Bristol
 - 2005** – Lab tests at University of Bristol
 - 2008** – First live network trials at Bristol Water
 - 2010** – Commercial service launched in UK Water Industry by Suez Aqualogy
 - 2011** – Ice Pigging introduced into Spain, USA, Chile, Japan, Australia, Netherlands
 - 2011** – First contact with Shell
 - 2012** – Sponsored project in Shell GameChanger program
 - 2014** – Full Patent purchased by Suez Aqualogy
 - 2015** – Successful wax removal tests and demonstrations for Shell
 - 2016** – iNPIPE Agreement to partner deploy technology in Oil and Gas sector
- 1st commercial deployment ?**

- Potential decommissioning application
- Contact for demonstration of technology in Jan 2015

How Ice Pigging Works

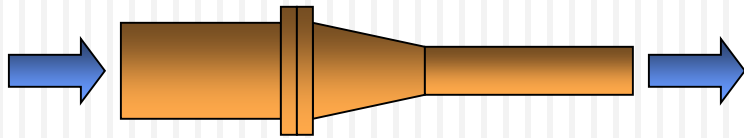
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<https://www.youtube.com/watch?v=DMcoVsyBDp4>

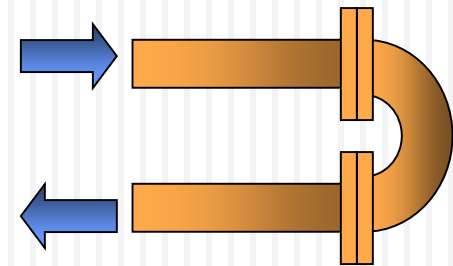


Complexity

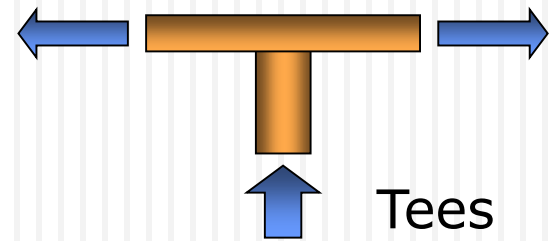
Becomes Trivial



Drastic changes in diameter



Sudden changes of direction



Tees

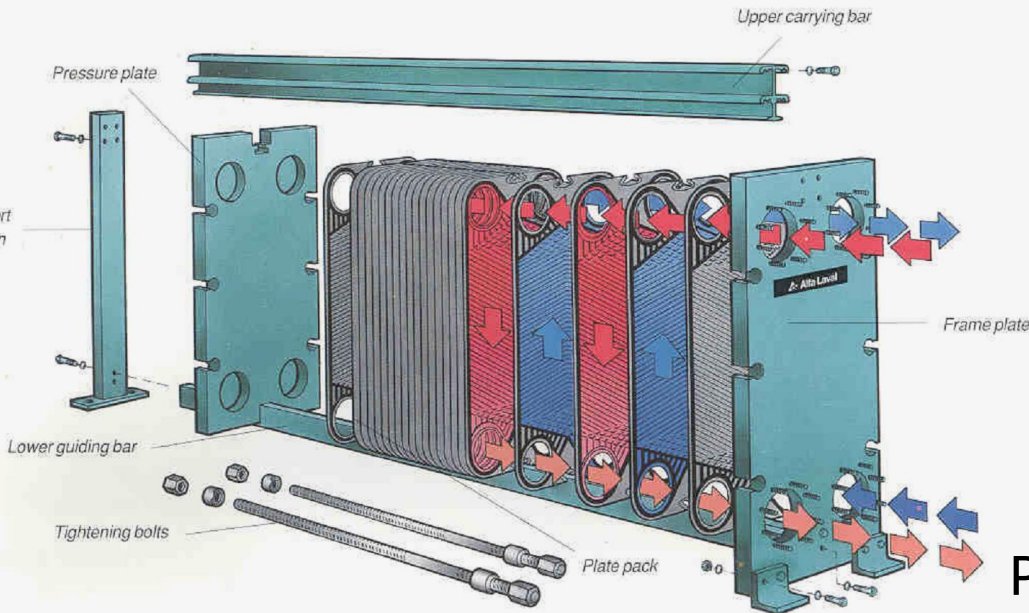


Plate heat exchangers

Preventative Maintenance

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SPHERICAL PIGS & CUP PIGS
DUAL TOOL TESTERS & CUP PIGS
WELD TESTERS



Preventative maintenance in food/beverage industry



Plate heat exchanger

1. Agree design of a test rig to test Proof of Concept
2. Specification of a suitable safe model contaminant
3. Constructing of the test rig
4. The proof of concept
5. Testing
6. Results
7. Conclusions

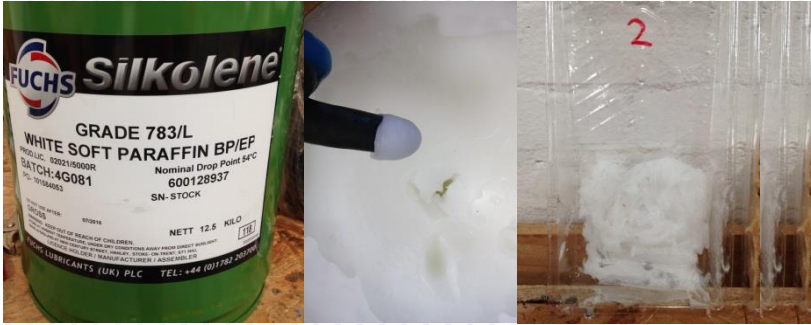
Proof of Concept

SPHERICAL PIGS
SC & CUP PIGS
75 DUAL TOOL TESTERS
SC & CUP PIGS
75 DUAL TOOL TESTERS

- *Proof of Concept*
- To demonstrate that an ice pig can convincingly, repeatably remove 95% of sand and wax at 15% by volume from a 3m test section of 24" diameter pipe



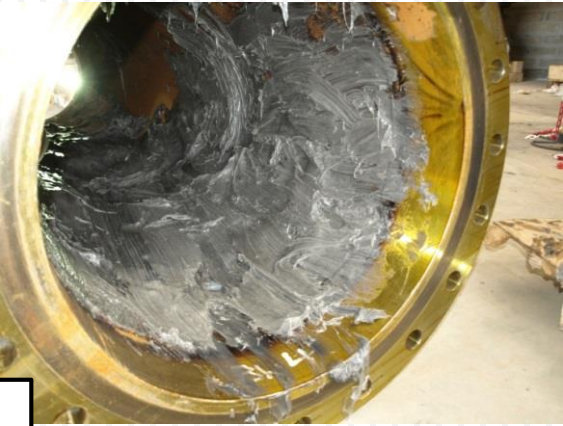
The contaminants



TEST 1: Soft Paraffin wax selected as an analogous contaminant

TEST 1: Soft Paraffin wax mixed with black dye

TEST 1: Wax Smear
evenly around circumference of test spool



107kg

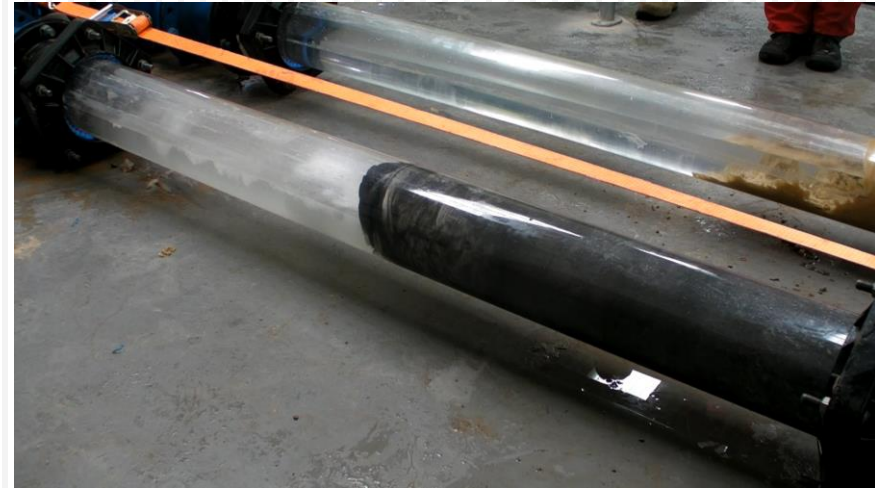


TEST 2: sharp sand in bottom of test spool

250kg

Small scale testing

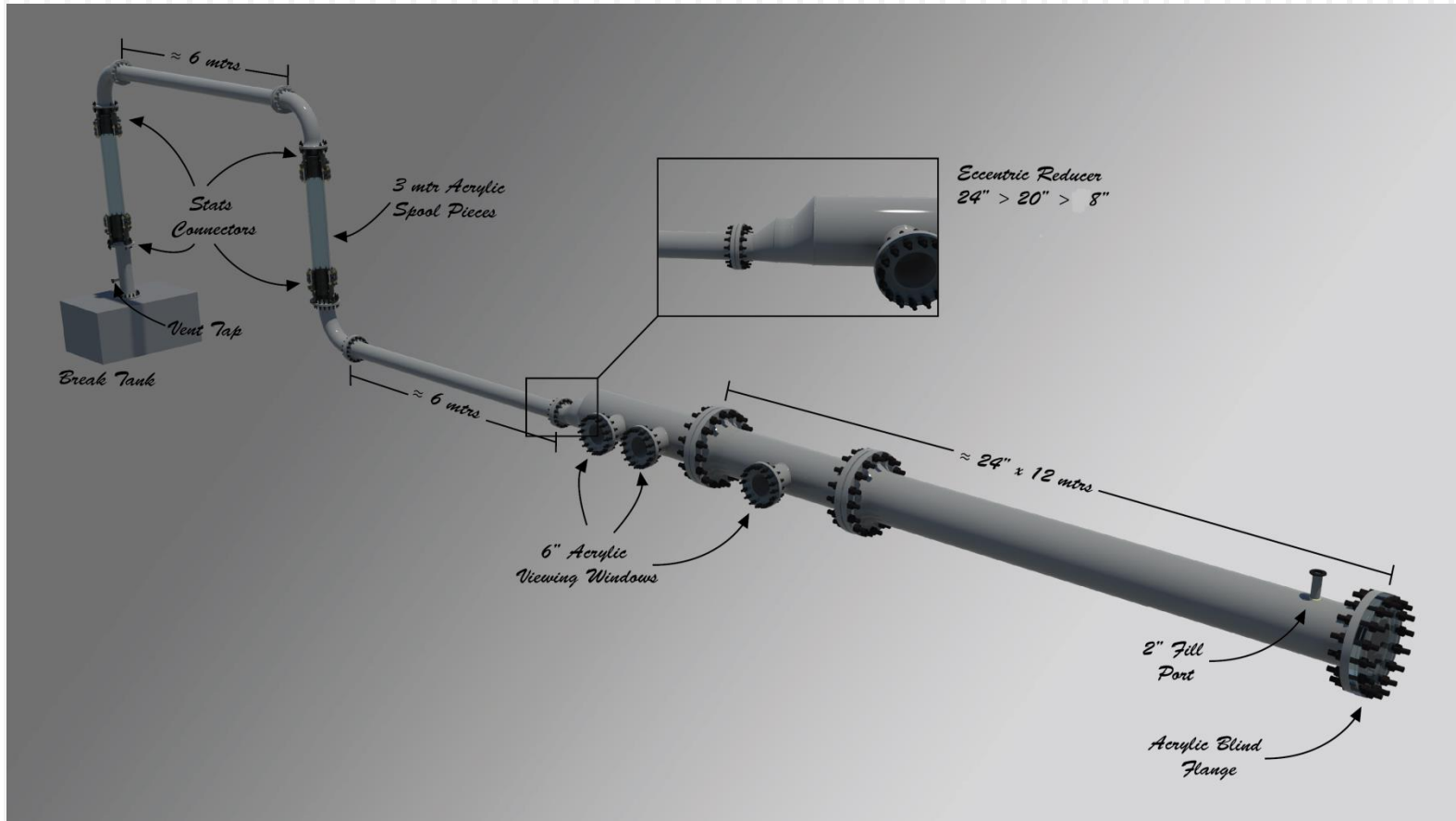
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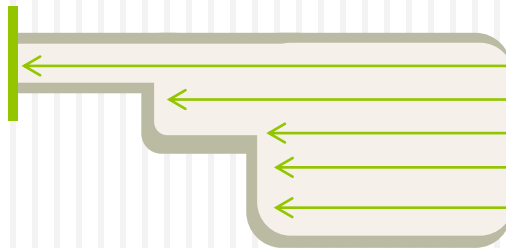
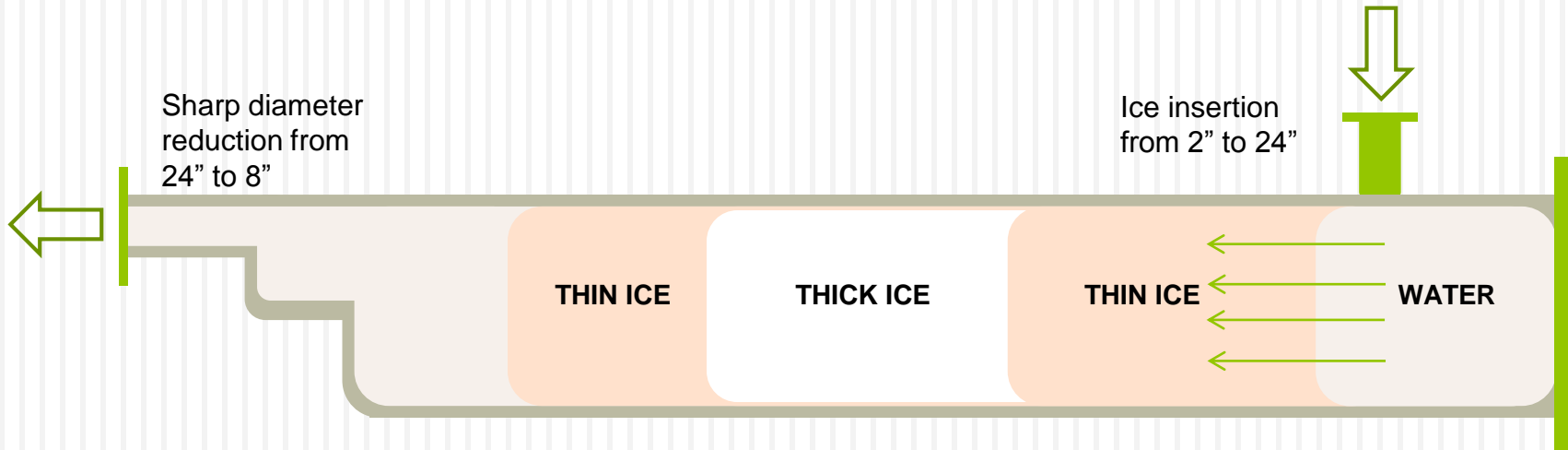
Paraffin wax mixed with black dye and placed in 8" Perspex pipe for scaled down qualification tests.

Wax Removal Test Rig

SPHERICAL PIGS & CUP PIGS
DUAL TOOL TESTERS
FIELD TESTERS



Testing Methodology



- Thick ice will flow around this restriction
- But hydraulically unusual and creates unusual situations
- Represents a quasi blocking point
- Not representative of real world
- Has caused us problems with very thick ice

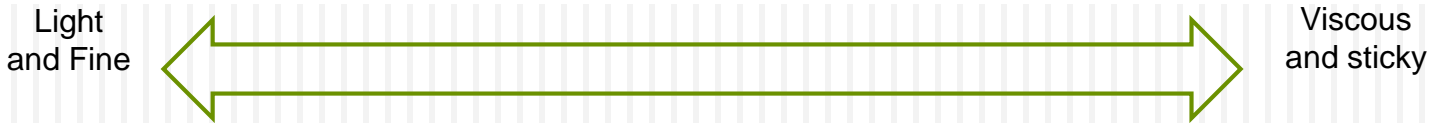
SPHERICAL TESTERS & CUP PIGS
DUAL TOOL TESTERS & CUP PIGS
FIELD TESTERS



<https://www.youtube.com/watch?v=nJ01tqPfZm0>



In Depth Characterisation



Greater liquid content	Contaminant Type									
	Fine Sediment	Sand	Biofilm	Pet food	Shampoo	Paint	Hair conditioner	Mayonnaise	Paraffin Wax	
50 Pa @ 5m ³ /h										
100 Pa	✓	✓								
250 Pa			✓	✓	✓					
350 Pa						✓	✓	✓		
400 Pa									✓	
Greater Solids content										

- Viscous contaminants can only be removed with ice that has a high effective shear rate
- Ice thickness can be measured in relation to head loss (friction) induced in a pipe - Pa
- Loose and light material can be removed with ice with low ice fraction
- We can make and use ice slurries up to a theoretical limit of 2000 Pa

This has necessitated various equipment and technique adaptations

Results Achieved

SPHERICAL PIGS & CUP PIGS
TESTERS & DUAL TOOLS
WELD TESTERS



Before

After



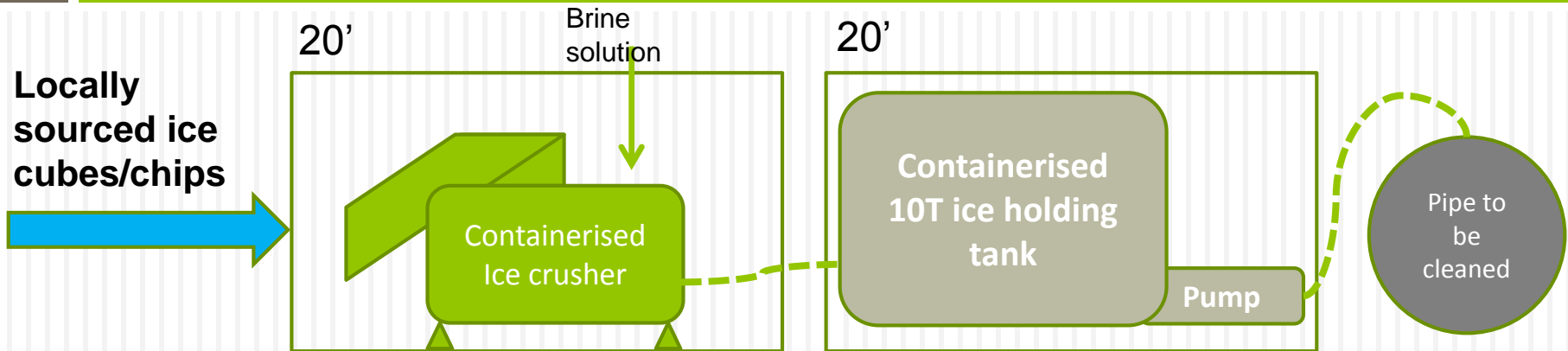
Conclusions

1. Ice Pigging can remove sand and wax from previously 'unpiggable' lines
2. Ice Pigging can restore hydraulic capacity where soft wax has accumulated
3. Ice Pigging will eliminate the risk of a pig getting stuck
4. Ice Pigging would raise the bar for sub-sea decommissioning where water flushing is the currently the only option
5. Ice Pigging has real potential beyond pipelines, such as clearing heat exchangers
6. Technology now described as 'technically credible' by Shell Global Solutions



Proposed Oil Industry Service

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- Only 2 x 20' containers to mobilise anywhere in the world
- Equipment fully designed and tested
- Capable of making 400 Pa ice (for wax removal)
- Continuous flow of ice into pipe to be cleaned – delivery capacity of 10 tonnes of ice per hour
- Potential to marinise for off-shore projects and or deliver from vessel



2. Crushing Method

Add crushed ice to a brine solution and fly mix and grind until the required ice quality is achieved. thick ice in large quantities possible.