Pre-commissioning the World's Largest & Most Challenging Offshore Gas Pipelines

Pipe Tech World Summit – 6 June 2011

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Baker Hughes Process & Pipeline Services

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AGENDA

- Introduction (BJ / Baker Hughes)
- Future projects
- Pre-commissioning video
- Lead time required for engineering and procurement
- Impact of local environmental conditions and regulations
- Optimising the selection of equipment for pre-commissioning
- Project management teams – size, roles and locations
- Engineering & control software
- Fuel requirements
- Reducing the time required for pre-commissioning operations

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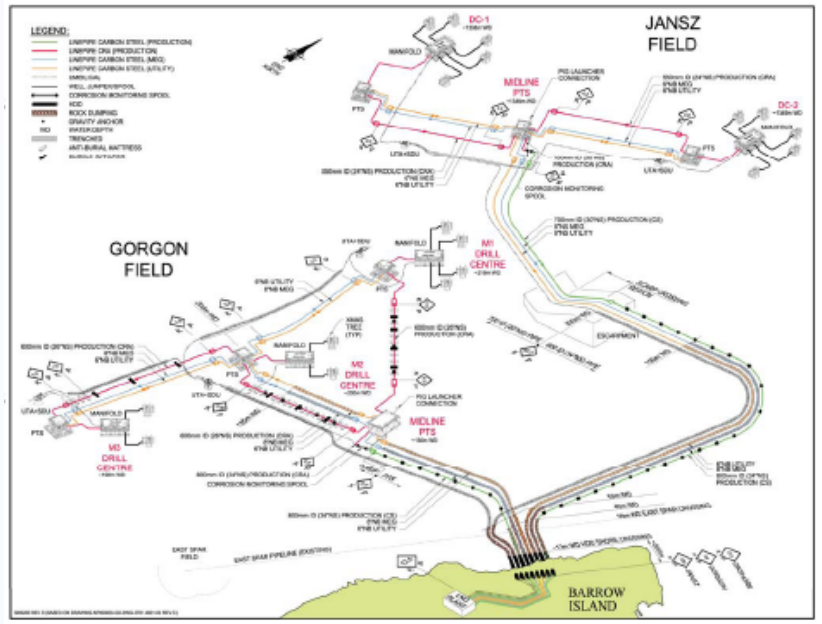
INTRODUCTION

As submarine gas pipelines get longer, deeper and more remote so the challenge of pre-commissioning them becomes greater. Once a task performed by the pipeline installation contractor, pre-commissioning has now become a recognized discipline that is critical to the successful delivery of any subsea pipeline project.

Nord Stream - Twin 48” x 1,220km



Gorgon – 30” x 34” to 1,350m WD

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FUTURE PROJECTS – HOW WILL WE RESOURCE?

The Nord Stream project required CAPEX of $20M. The Gorgon project will require $25M. To resource the Galsi AS line from scratch will require over $50M.

Project	Length - KM	Size - In	Max. WD	FID Year	Completion Date
Nord Stream Line 1	1,220	48	215	2009	2011
Nord Stream Line 2	1,220	48	215	2009	2012
Gumusut Export	170	18	1,350	2009	2012
Jansz Export Line	130	30 x 34	1,350	2009	2013
Liwan Deepwater Gas Field	75	22	1,500	2010	2013
PNG LNG	400	32/34		2009	2014
Galsi AS	285	26	2,824	2011	2014
Galsi SI	280	32	878	2011	2014
Wheatstone and Iago Gas Fields	220	34	200	2010	2014
IGI Gas Pipeline (Poseidon)	225	?	1,370	2012?	2015
South Stream Gas Pipeline Project	900	?	2,000	2012	2015
Shtokman Line 1	550	36	350	2012	2016
Shtokman Line 2	550	36	350	2012	2016
Inpex Icthys Export	840	42	250	2011	2016
Trans Adriatic Pipeline (TAP)	115	?	1,000	2012?	2016
White Stream Gas Pipeline	900	24/26	2,000	2013	2016
Gehem / Gendalo	130	?	1,615	2012	2016
Browse Upstream Development	315	42	100	2011	2017

Significant CAPEX will still be required to pre-commission the above

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PRE-COMMISSIONING – WHAT DO WE MEAN?

Flood, clean, gauge and test

Optional caliper survey / OOS survey

Dewater & swab line to remove bulk water – run desal slug

Dry line to an agreed “dewpoint” using dry air or vacuum

Purge & pack the line with nitrogen gas

Line ready for commissioning / lay up

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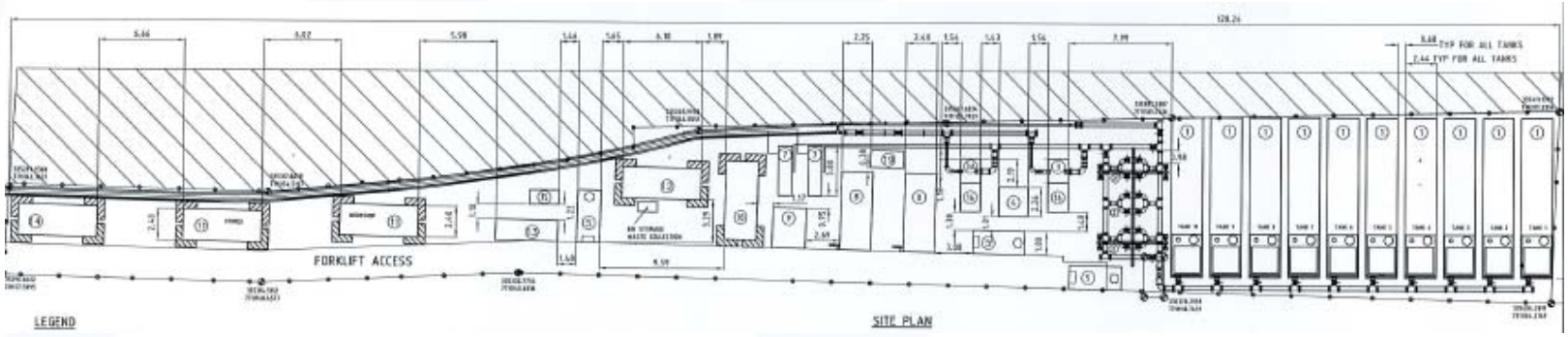
LEAD TIME FOR ENGINEERING & PROCUREMENT

ENGINEERING CONSIDERATIONS

- MDR can be over 100 docs inc. logistics, HSE, regulatory compliance
- May involve civil and construction works
- May involve vessel layout drawings and vessel options
- May require contractor & company sign off
- Not just a “cut and paste” from the last project
- Project team will be 10+ at planning stage
- Nord Stream engineering commenced Nov 2009
- Nord Stream operations commenced Mar 2011
- Gorgon engineering commenced Jan 2010 – engineering ongoing
- Gorgon field operations commenced May 2011 – engineering ongoing

12 TO 18 MONTHS ENGINEERING THE NORM FOR MAJOR PROJECTS



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LEAD TIME FOR ENGINEERING & PROCUREMENT

PROCUREMENT CONSIDERATIONS

- Export compliance and product controls
- CE marking for Europe
- DNV 2.71 (& DNV 2.73) offshore lifting regs
- Cash flow during procurement
- Mobilisation windows in pre-com contract
- Local regs (Russia, Australia, Germany)
- Noise levels / soundproofing
- Other projects competing for supplier resources
- Vendor track record and capacity
- Lead time for major items (see next slide)

12 MONTHS MINIMUM NOTICE REQUIRED

Considering the projects shown in slide 4 there will be a huge requirement for pre-commissioning equipment for 2013 onwards. This will require considerable capital investment by pre-commissioning suppliers or 3rd party rental companies. General "plant hire" type equipment will become less viable as projects get larger and deeper.

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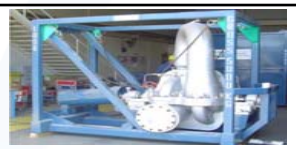
LEAD TIME FOR ENGINEERING & PROCUREMENT

Image	Description	Potential Vendors	Budget per unit	Delivery per unit	Delivery 10+ units
	High flow hydrotest pump	5+	$600,000	5 months	9 months
	High flow flooding pump	3+	$800,000	5 months	9 months
	High flow dual pressure (24 / 34 barg) primary compressors	2+	$400,000	6 months	12 months
	High flow dual pressure (24 / 34 barg) air dryer	3+	$400,000	5 months	8 months
	High flow booster compressors	3+	$1,200,000	8 months	15 months

IMPACT OF LOCAL CONDITIONS & REGULATIONS

Codes & Standards

1. **CE marked equipment for Europe** – much of the older equipment is non compliant
2. **Codes** – crossover between DNV 101 and onshore codes. New DNV recommended practices
3. **Pressure vessel regulations differ between Europe, US and Australia** – complicated the transfer of assets between projects
4. **DNV 2.71 / 2.73 lifting requirements** – fast becoming the norm
5. **Often confusion over zoning requirements** – not all pre-com equipment can be zoned
6. **Fuel storage fire regulations** – projects can require up to 200m3 of storage (2 days)
7. **Tax regulations on who can buy tax free fuel** – big impact if 5,000 tonnes of fuel required
8. **Working hours directives in Europe** – adds cost and travel risk
9. **Customs** – does project come under a PSA? If not who is best placed to manage clearance and importation
10. **Project SoW and Philosophy** - achievable, relevant, may prescribe chemical dosage, dewpoint, cleanliness, water treatment, geometry / metal loss survey

Environmental

1. **Noise levels** – pre-commissioning uses lots of diesel engines. Projects asking for soundproof spreads
2. **Nature reserves** – Gorgon being performed from a class A nature reserve – intensive quarantine costs
3. **Ground preparation and reinstatement** – pre-commissioning spreads need lots of space driving need for better packaged equipment
4. **Importation requirements** – Australian AQIS requirements for example
5. **Bunding and drainage** – pre-commissioning creates oily water and waste

Chemicals

1. **Chemical disposal** – becoming a big issue. Some looking at commodity chemistry, some looking at UV treatment, and most looking for Charm ratings
2. **Limitations** – Sodium hydroxide can freeze and can cause precipitation c/w sodium bisulphate.
3. **Effective period** – some projects looking for wet lay up for 48 months – requires qualification trials

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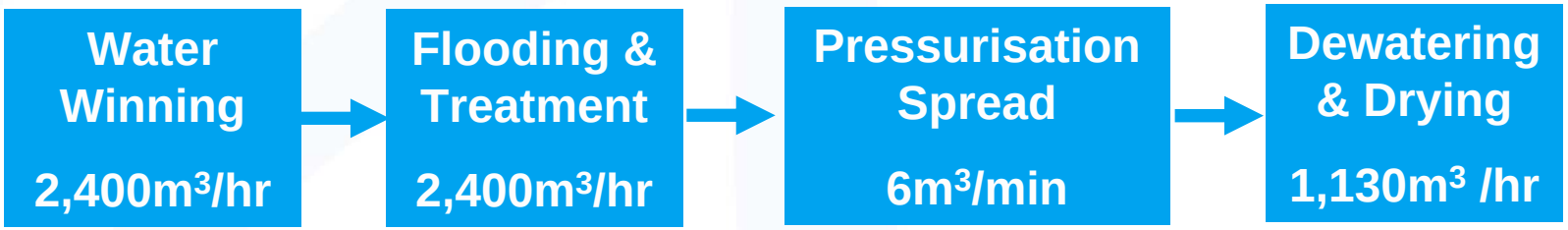
OPTMISED EQUIPMENT FOR PRE-COMMISSIONING

- Historically construction plant equipment was used for pre-commissioning – such equipment was not optimised for shipping, laydown or the job itself.
- The latest equipment purchased by Baker Hughes for projects such as Nord Stream and Gorgon meets the latest standards, requires far less space, and is cheaper to ship
- Here we take a typical but large pre-commissioning spread and compare the space required for it's installation – we have used a regulation football pitch measuring 105m x 68m to illustrate the savings offered by the latest equipment
- The spread has been designed around a 42" x 800KM trunkline and includes:



1,130m3/hr – 40,000cfm

OPTMISED EQUIPMENT FOR PRE-COMMISSIONING

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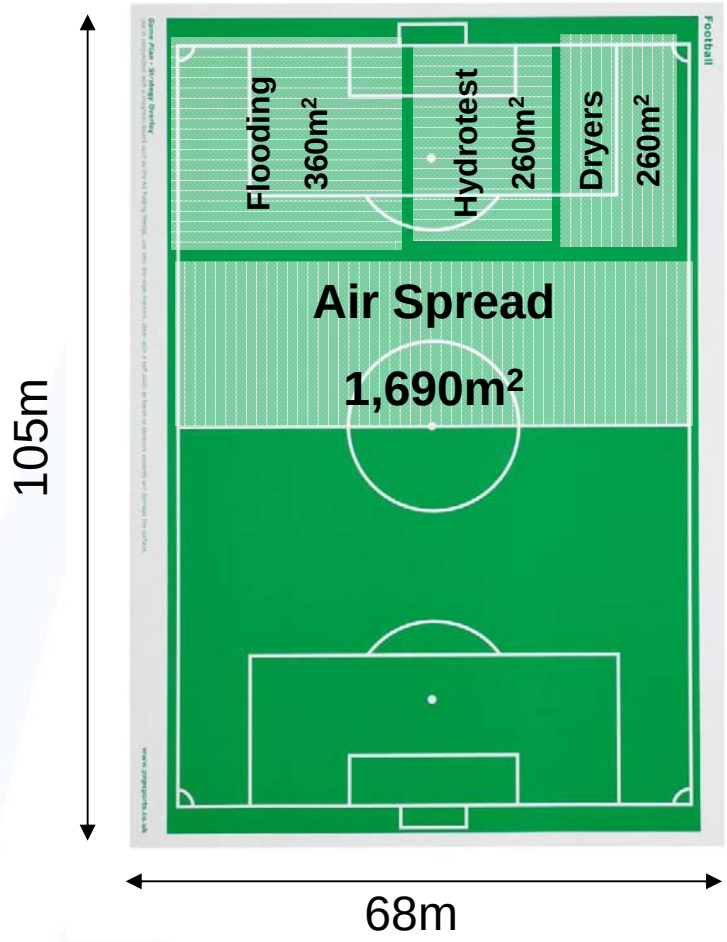

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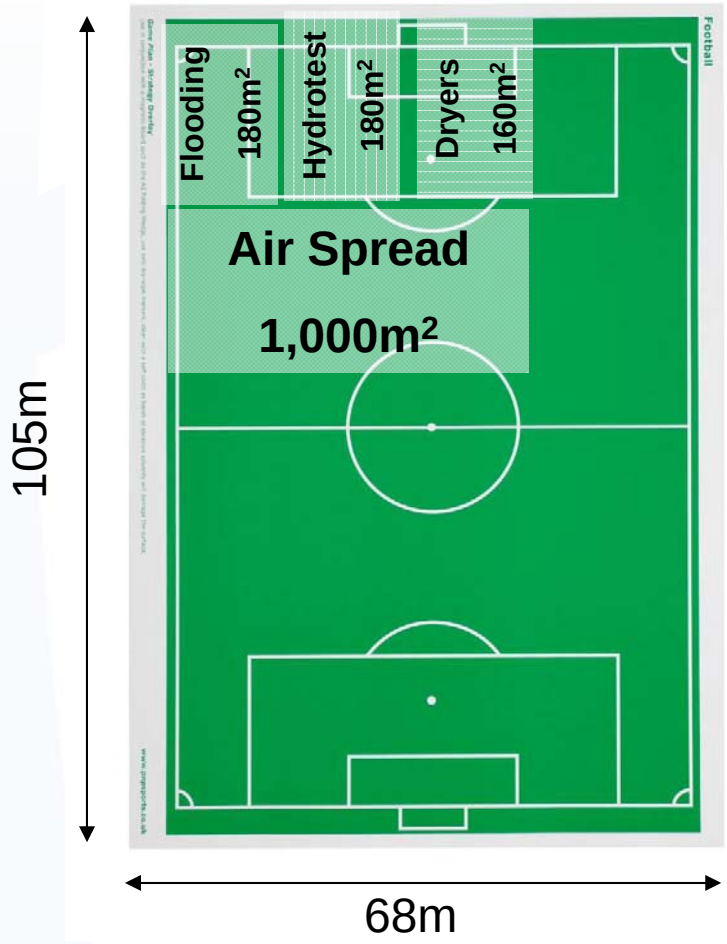

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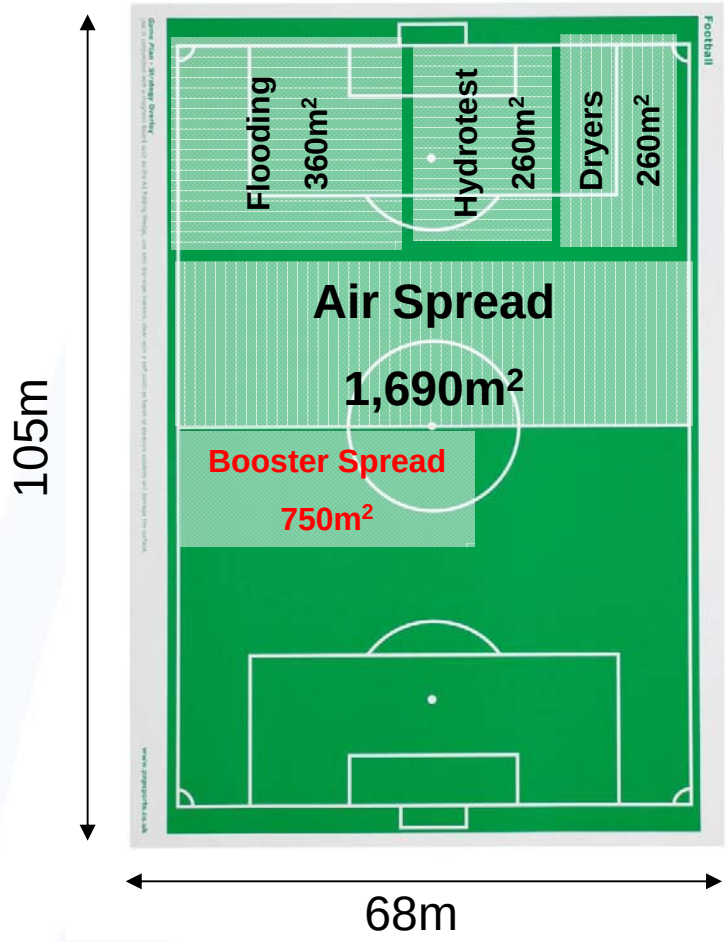
OPTMISED EQUIPMENT FOR PRE-COMMISSIONING

Showing additional 1,130m³/hr booster spread

Yesterday



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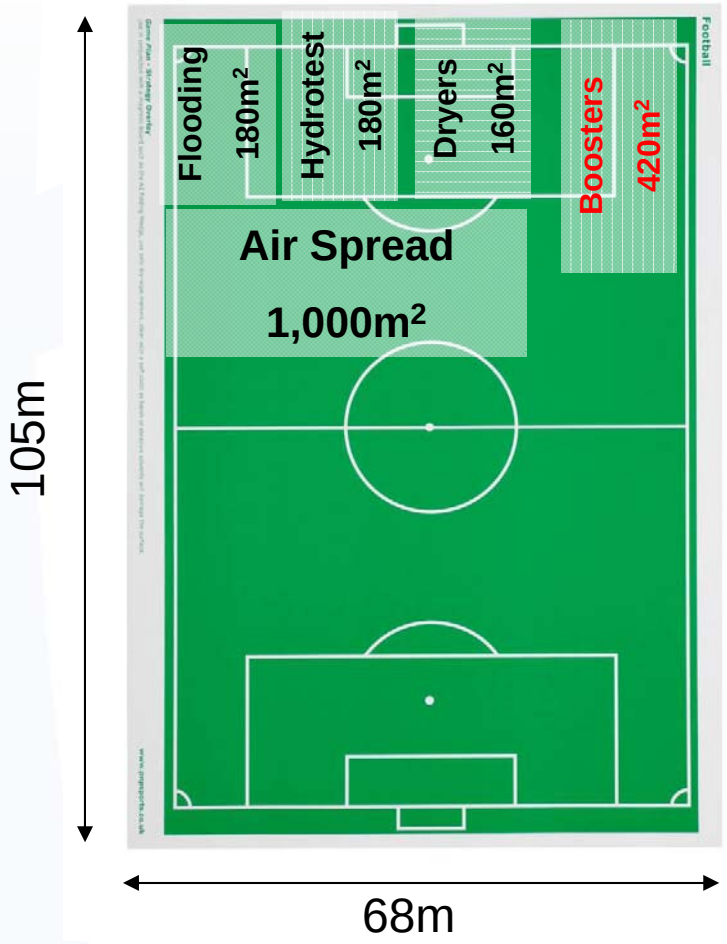

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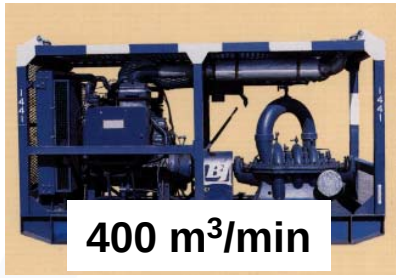
OPTMISED EQUIPMENT FOR PRE-COMMISSIONING

Flooding – 2,400m³/min

Yesterday



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Today

- **BHP PER UNIT = 500**
- **Q MAX PER UNIT = 400 m³/hr**
- **P MAX PER UNIT = 25 barg**
- **UNIT SPACING = 2M**
- **AREA 2,500M3MIN = 360m²**
- **TRUCKS PER 2,400M3/MIN = 8**
- **CE MARKED = UNLIKELY**
- **SHIP AS CSC 20' = UNLIKELY**

- **BHP PER UNIT = 1,800**
- **Q MAX PER UNIT = 800 m3/hr**
- **P MAX PER UNIT = 35 barg**
- **UNIT SPACING = 2M**
- **AREA 2,500M3MIN = 180m²**
- **TRUCKS PER 2,400M3/MIN = 4**
- **CE MARKED = YES**
- **SHIP AS CSC 20' = YES (OPEN TOP)**

Latest split skid flooding pumps custom built for Nord Stream, offer laydown savings of up to 100%, reduce freight costs by up to 100%, comply with all European regulations and can be shipped as CSC containers.

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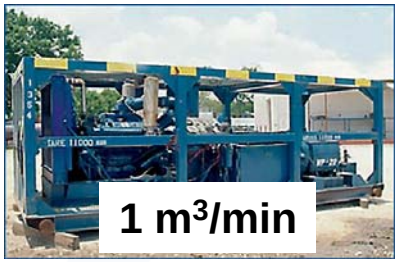
OPTMISED EQUIPMENT FOR PRE-COMMISSIONING

Hydrotesting 6m³/min

Yesterday



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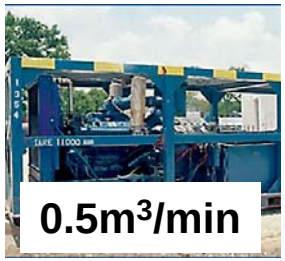

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Today

- **M3/MIN PER TEU = 1**
- **TEU PER 6M3/MIN = 8**
- **UNIT SPACING = 2M**
- **AREA 6M3MIN = 260m²**
- **TRUCKS PER 6M3/MIN = 4**
- **CE MARKED = UNLIKELY**
- **76 dB(A) @ 7m = UNLIKELY**
- **SHIP AS CSC 20' = UNLIKELY**

- **M3/MIN PER TEU = 1.5**
- **TEU PER 6M3/MIN = 4**
- **UNIT SPACING = 2M**
- **AREA 6M3MIN = 180m²**
- **TRUCKS 6M3/MIN = 2**
- **CE MARKED = YES**
- **76 dB(A) @ 7m = YES**
- **SHIP AS CSC 20' = YES**

Latest hydrotest pumps custom built for Nord Stream, offer laydown savings of up to 30%, reduce freight costs by up to 60%, comply with all European regulations and can be shipped as CSC containers.

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OPTMISED EQUIPMENT FOR PRE-COMMISSIONING

Primary Air Compression 1,130m³/hr (40,000cfm)

Yesterday

+

=

Today

- **CFM PER TEU = 900 (25m³/min)**
- **TEU PER 40,000 CFM = 45**
- **UNIT SPACING = 2M**
- **AREA 40,000 CFM = 1,690m²**
- **TRUCKS PER 40,000 CFM = 23**
- **CE MARKED = POSSIBLY**
- **76 dB(A) @ 7m = POSSIBLY**
- **DUAL PRESSURE = NO 24 BAR**
- **SHIP AS CSC 20' = UNLIKELY**

- **CFM PER TEU = 1,525 (43m³/min)**
- **TEU PER 40,000 CFM = 26**
- **UNIT SPACING = 2M**
- **AREA 40,000 CFM = 1,000m²**
- **TRUCKS PER 40,000 CFM = 13**
- **CE MARKED = YES**
- **76 dB(A) @ 7m = YES**
- **DUAL PRESSURE = YES 24 / 34 BAR**
- **SHIP AS CSC 20' = YES**

Latest generation compressors custom built for Nord Stream, offer laydown savings of up to 40%, reduce freight costs by up to 60%, comply with all European regulations and offer dual pressure (34 / 24 bar) capability.

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OPTMISED EQUIPMENT FOR PRE-COMMISSIONING

Air Dryers 1,130m³/hr (40,000cfm)

Yesterday

X 5 =

Today

- CFM PER TEU = 4,000
- TEU PER 40,000 CFM = 10
- UNIT SPACING = 2M
- AREA 40,000 CFM = 285m²
- TRUCKS PER 40,000 CFM = 5
- CE MARKED = POSSIBLY
- SHIP AS CSC 20' = NO
- 76 dB(A) @ 7m = POSSIBLY
- DUAL PRESSURE = NO 24 bar only
- DEWPOINT = - 40°C Max

- CFM PER TEU = 10,000
- TEU PER 40,000 CFM = 4
- UNIT SPACING = 2M
- AREA 40,000 CFM = 157m²
- TRUCKS PER 40,000 CFM = 2
- CE MARKED = YES
- SHIP AS CSC 20' = YES
- 76 dB(A) @ 7m = YES
- DUAL PRESSURE = YES 24 / 34 bar
- DEWPOINT = - 60°C Max

Latest generation air dryers custom built for Nord Stream, offer laydown savings of up to 45%, reduce freight costs by up to 43%, comply with all European regulations and offer dual pressure (34 / 24 bar) capability.

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OPTMISED EQUIPMENT FOR PRE-COMMISSIONING

Air Booster Compressors 1,130m³/hr (40,000cfm)

Yesterday

+

=

Today

- CFM PER TEU = 2,000
- TEU PER 40,000 CFM = 20
- UNIT SPACING = 2M
- AREA 40,000 CFM = 756m²
- TRUCKS PER 40,000 CFM = 5
- CE MARKED = POSSIBLY
- DNV 2.71 = NO
- SHIP @ CSC = POSSIBLY
- 34 BAR FEED = POSSIBLY

- CFM PER TEU = 4,000
- TEU PER 40,000 CFM = 10
- UNIT SPACING = 2M
- AREA 40,000 CFM = 420m²
- TRUCKS PER 40,000 CFM = 2
- CE MARKED = YES
- DNV 2.71 = YES
- SHIP @ CSC = YES
- 34 BAR FEED = YES

Latest generation booster compressors being custom built for Gorgon, offer laydown savings of up to 100%, reduce freight costs by over 100%, comply with all European regulations and can be shipped as a 20' CSC

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PROJECT MANAGEMENT TEAMS

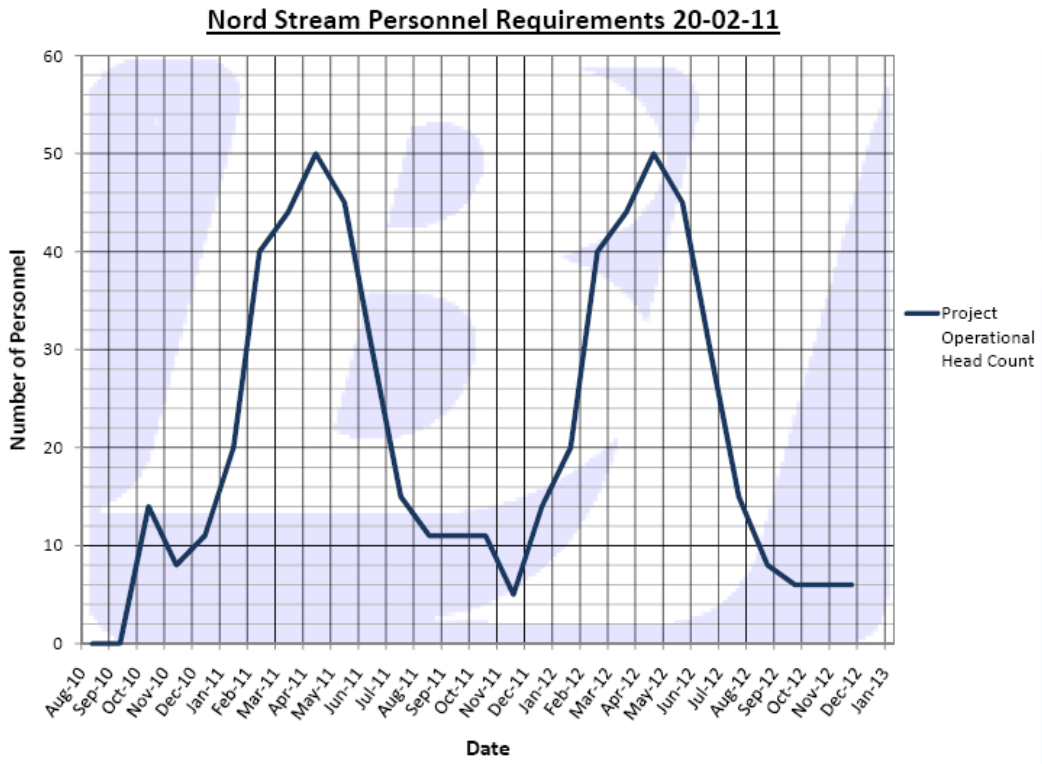
Size, Roles & Locations

Nord Stream Project Team:

QHSE Manager
Office Administrator
Document Control
Controller
Draftsman
Project PM

Nord Stream Operational Team:

- Lead Engineer
- Project Manager
- Site Manager
- Project Coordinator
- Project Engineer
- Project Engineer
- Project Engineer
- Project Engineer
- Supervisor
- Supervisor
- Supervisor
- Supervisor
- Lead Mechanic
- Operator
- Operator

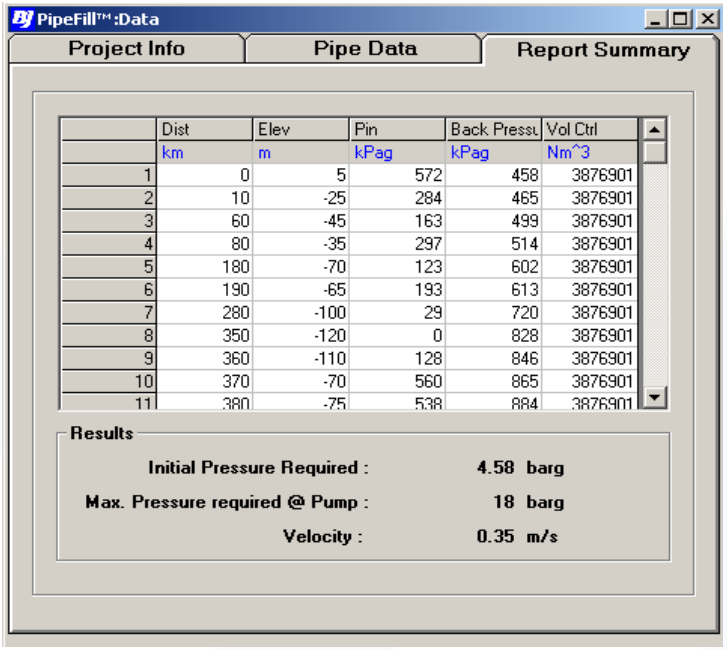


Large projects require large, specialised teams. As we move in to new countries local skills vital for onshore operations. In addition to engineering, logistics and immigration soon become key issues

ENGINEERING SOFTWARE

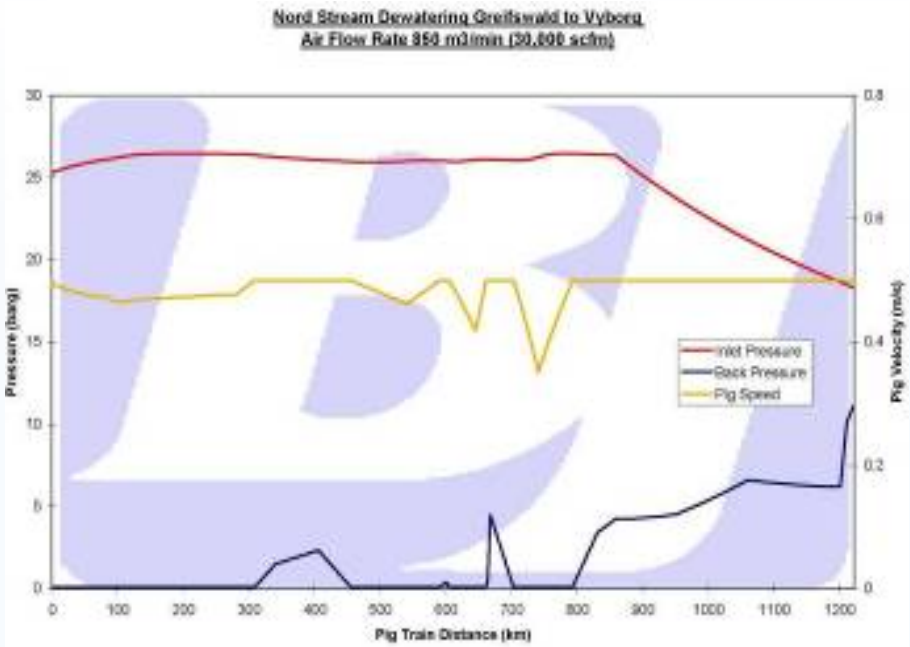
Flooding & Dewatering

PipeFill™ - Flooding



	Dist	Elev	Pin	Back Pressu	Vol Ctrl
	km	m	kPag	kPag	Nm^3
1	0	5	572	458	3876901
2	10	-25	284	465	3876901
3	60	-45	163	499	3876901
4	80	-35	297	514	3876901
5	180	-70	123	602	3876901
6	190	-65	193	613	3876901
7	280	-100	29	720	3876901
8	350	-120	0	828	3876901
9	360	-110	128	846	3876901
10	370	-70	560	865	3876901
11	380	-75	538	884	3876901

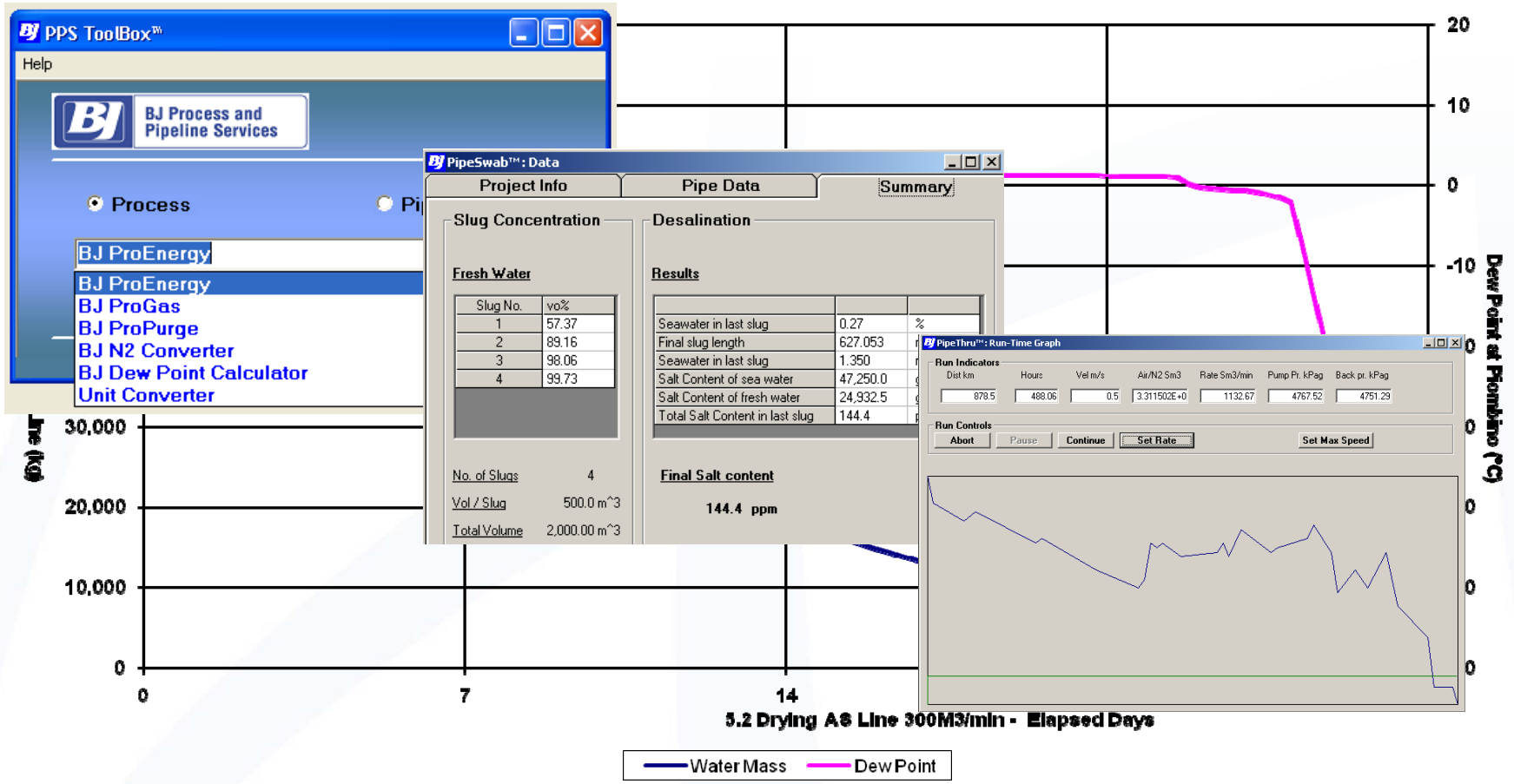
PipeThru™ - Dewatering



- **All consider multiple “nodes” along the length of the line**
- **PipeFill™ models back pressure requirements to prevent pig runaway**
- **PipeSlug™ optimises slug qty and size desalination & MEG conditioning**
- **PipeThru™ considers impact of changing head pressure, friction pressure, pig drive and weight of air column at multiple points**
- **PipeDown™ accurately models air & vacuum drying**

ENGINEERING SOFTWARE

Toolbox™, PipeSwab™ & PipeDown™



Baker Hughes recognised the need for bespoke pre-commissioning software over 10 years ago and has invested heavily in the best modeling software. An excel sheet is no longer adequate

FUEL REQUIREMENTS

Overview

- **Fuel requirements for major pipeline pre-commissioning can be huge, contributing up to 20% of the overall project cost.**
- **The highest fuel demands are for air dewatering and air drying**
- **Where pipelines run between countries the price and availability of fuel may dictate where operations are performed**
- **Duty (tax) free fuel may be available to the project but often only if purchased by the project owner**
- **Passing the fuel supply obligation down the contract tree can add to the number of mark-ups and hence overall cost**
- **A major 1,000km + / 42” + pipeline will require up to 4.5 Million litres for FCGT, dewatering and drying to -30°C+**
- **At a cost of €1.50 per litre = €6,750,000**
- **Such quantities require significant storage capacity – normally for at least 2 days running**
- **For such large projects remote fueling is preferred**

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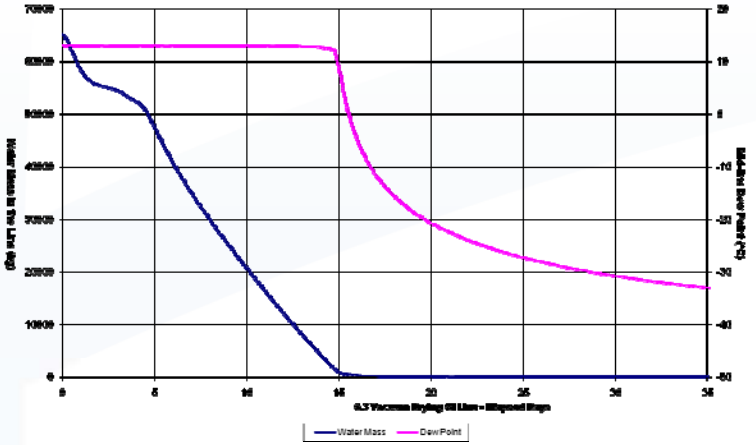
FUEL REQUIREMENTS

Optimising

Choosing vacuum drying over air drying

- Vacuum drying effective to -20°C
- Slow thereafter
- For project size of Galsi would save 80% on fuel for drying
- Allows gas up in to vacuum
- Still widely used
- Generally low noise levels



Consider Gas Dewatering / MEG Conditioning

- Minimal fuel consumption for pumps and nitrogen only
- Requires gas supply near to one end
- Gas pressure can be boosted using gas fuel booster compressors
- Can offer huge schedule savings…
- But can be politically sensitive
- Large quantity of MEG required

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REDUCING THE TIME REQUIRED FOR PRE-COMMISSIONING OPERATIONS

1. **Beware of setting the minimum technical requirements just to get 3 tenders**
2. **FCGT work normally sits best contracted via the installation contractor**
3. **Where gauging to a subsea head consider using a Smart Gauge Tool to remove the need for a head recovery between flooding and testing**
4. **For any vessel based work the vessel cost will be higher than the pre-com spread rate. Therefore always opt for as much contingency as possible**
5. **Dewatering and drying may sit better under the pipeline owner**
6. **Use the highest flooding / pressurisation / dewatering rate possible within the pressure range of commercially available equipment**
7. **Dewatering and drying specifications should always be based on pipeline commissioning / start up philosophy (dry or MEG condition?)**
8. **Remember internal coating benefits all phases of pre-commissioning**
9. **Always consider the fuel requirements – this may dictate other matters**
10. **Always use bespoke software to model and control critical activities such as dewatering and drying**
11. **Be aware of the latest equipment capabilities – as shown earlier the latest units offer twice the performance per m2 of laydown space**

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QUESTIONS?