Challenges for Arctic offshore pipeline developments

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failures / unit time

construction  operation  age of system

external damage

inherent defects

old age

abandonment
Problem areas

ice gouging
wave action
strudel scour
construction
Gouging

initial focus on gouge depth statistics

old idea: pipeline is safe if the ice passes over the top, not safe otherwise

therefore

problem is to determine extreme gouge depth, with some acceptable very low exceedance probability
Gouging

then it was realised that severe deformations occur in the soil under a gouging ice mass

a pipe is bent and distorted even if the ice clears over the top

subgouge deformations extend about another gouge depth below the gouge base, at least in some soils
Gouging

new idea: a pipeline is not necessarily safe if the ice passes over the top

therefore

problem is to determine trenching depth required so that pipe does not rupture, with some acceptable very low exceedance probability
Gouging

rupture allows the content to escape, and is the critical event

yield as such is irrelevant

fortunately, pipeline steels can be very ductile, and a pipe can be distorted a long way before it ruptures

trade-off between ductility and yield stress

weld ductility is the limiting factor
Gouging: outstanding problem areas
prediction of extent of subgouge deformations
influence of soil type
pipeline response
(analogy with landslides: theory and experience in Colombia)
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Strudel scour
Industry Extended Reach Wells Drilled - to April 30th, 1998
Strudel scour

hydrodynamic drag

vortex-excited oscillation

buried pipeline
construction issues

winter construction from ice

is the ice stable? sometimes yes (enclosed bays, lagoons) sometimes clearly no

major uncertainty about ice structural competence: super-brittle material (fracture toughness smaller than glass)
trenching issues

large trenches can be excavated by dredging

smaller trenches can be excavated by ploughing or jetting (or slowly by backhoe or dragline)

contractors cannot commit to develop equipment without some confidence that it will be used
horizontal/extended-reach drilling

• minimal environmental impact
• not weather-sensitive
• avoids shorelines
• as deep as necessary: therefore makes uncertainty about gouging and subgouge deformation irrelevant
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