Miljøkonsekvenser ved opptak og deponering av rørledninger

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Introduction

Environmental parameters used for evaluation

The list below identifies important environmental parameters used in the evaluation: Discharges to sea/land; Emissions to air; Energy consumption; Waste management; Aesthetic concerns; Ecological impact to the environment. These environmental parameters are used to evaluate impact to the environment offshore and onshore, and are summarised in Table 3 and 4.

Methods and operations for removal of pipelines

The main activities to be carried out for each pipeline are: pre-recovery survey; deburial; mattress & groutbag recovery; sub-sea cutting of the actual pipeline; recovery by vessels; transit of recovered pipeline to onshore decommissioning site. Examples of removal operations can be implemented by using either of these alternatives: Pipelines coated with concrete are removed by the S-lay method with Lay Barge LB 200; retrieve them by cutting them on the seabed, and then to lift them to the surface in sections by a construction support vessel; flexible pipelines can be removed by using a reel-ship.

Neither of these methods are more environmentally «friendly» than the other, it is just a matter of using the method which is the most applicable for each pipeline at a given situation. All of the above mentioned alternatives will cause re-suspension of the sea-bed, high energy-consumption and emissions to air.

Methods and operations for disposal of pipelines

The following operations are most likely to be used for dismantling and disposal of pipelines: pipeline landing and handling; pipeline decommissioning & cutting; internal and external pipe cleaning operations. To have an environmental friendly operation, the following facilities should be present:

Catchment Pits: The water collected

in the catchment pits, need to be treated and disposed of correctly.

Cut Pipe Storage Area: Any form of secondary containment to the area where cut and bunged pipes will be stored should be present.

Waste disposal: The disposal of environmentally hazardous wastes (e.g. oil, LSA scale, asbestos, anodes, contaminated water) need to be performed by selected specialist waste disposal contractors. Selected wastes will be transferred off-site to selected specific waste disposal sites.

Discharges to sea/land

Discharges of constituents/contaminants from pipelines are represented by various solids and fluids, where the discharges may be: heavy metals from anodes; oils remaining in the pipeline, and from removal operations; radioactive materials remaining in the pipeline (LSA); preservation fluid (biocides) in the pipeline; asbestos in the corrosion coatings; and PAH in corrosion coatings. In Table 1 the main sources and principal chemical components and effects from pipelines are summarised and presented.

Emissions to air

Emissions to air during the removal operations are represented mainly by CO_2, NO_x and SO_x. The emissions analysis calculates the exhaust emissions generated by the marine spread used in the removal operation and the plant required for onshore dismantling activities (where appropriate). The pollutant emissions generated by this plant are generally oxygen (O), nitrogen (N), carbon dioxide (CO_2), carbon monoxide (CO), oxides of Nitrogen (NO_x), oxides of sulphur (SO_x), hydrocarbons (HC) and particulate emissions.

Energy consumption

Energy consumption has been estimated in GJ, calculated from estimated fuel consumption's of the various offshore and onshore operations. These fuel consumption figures are then also used to estimate quantities of CO_2, NO_X, SO_2 and hydrocarbons and particulate emissions. The pipelines to be included in the current study have been divided into groups to be removed in individual operations. In order to calculate energy consumption for removing and recycling the pipelines an estimate of the steel and concrete weight per pipeline has been made.

Several conclusions can be drawn from the estimates:

* From an energy consumption perspective, energy gains are only made when a pipelines have a larger diameter (20-40 inches) and are recovered and recycled based upon the data and assumptions used.
* The emission of CO_2 is generally lower for recovering and recycling the steel than for making new steel.
* The emission of NOx is generally higher for recovering and recycling the steel than for making new steel.

Table 1: Type of discharges to the sea from pipelines. Main sources and principal chemical components. (Source: Dames & Moore 1996b)

TYPE OF R RELEASE	MAIN SOURCES SOURCES	PRIINCIPAL. COMPONENT MATERIALS	EFFECTS
Heavy Metals	Anodes Sediments adhered to pipelines/vessels/ equipment LSA Scale	Al, Zn Fe, Pb, Zn, Cu, Hg, Cd Ba, Sr (Barium and Strontium & Calcium Sulphate & Calcium Carbonate)	Heavy metals may become concentrated within the food-chain. Heavy metals are toxic to marine organisms as well as mammals at high concentrations.
Oils	Pipelines/vessels/ equipment	Sediments, wax, hydraulic oil	May concentrate within the food-chain. Toxic and carcinogenic at high levels. Seabirds may be fouled by oil-slicks and freeze to death
Radioactive Materials	Pipelines	LSA scale (Radium 226, Actinium 238 and progeny i.e. Lead 210 (daughter isotopes of Uranium 238 and Thorium 232)) .	Very low radioactivity. Not expected to have any effect on marine organisms.

Preservation fluid	Pipelines	An organic biocide made up of a blend of glutaraldehyde and forrnaldehyde and also with smaller amounts of methanol and isopropanol.	The biocide will be rapidiy diluted and it is not expected to have a significant impact on marine organisms.
Asbestos	Corrosion coating	Asbestos fibres/felt	Cutting of the pipelines may produce asbestos dust which is carcinogenic if it enters the respiratory system of humans.
Coal-tar(PAH)	Corrosion coating	PAH (e.g. BaP)	Some PAHs in the corrosion coating are carcinogenic to marine organisms and humans.

It should however be noted that the present study is only a high level assessment of the energy and emissions involved in recovering and recycling the pipelines. Several wide ranging assumptions have been made regarding the weight of material recovered, onshore processing methodology and duration. In addition, published figures for energy use in making new steels from ore can vary by ±35% which would considerably alter the benefits of pipeline recovery from an energy consumption viewpoint.

Waste Management offshore & onshore

Waste management offshore

Waste material generated during pipeline removal is limited offshore, since most of it will be taken to shore. Seawater and/or preservation fluid is used inside the pipeline to prevent corrosion and biological growth. It is assumed to be harmless to the environment, and is assumed to be discharged during the removal operation. The components of the preservation fluid is easily diluted when it enters the water column and, except for a local area, it is expected to have a negligible impact on the marine organisms.

During the pipeline removal operation, some parts of the concrete coating may crack and be left on the seabed. These pieces are not considered to be a threat to the marine environment. However, it is likely to believe that the fishermen wants the seabed to be restored back to the way it was before the pipelines were installed. In some cases the debris from pipelines can be snagged by trawlers and other fishing equipment and may cause destruction of the gear.

Problems may appear when the coating is cut and removed from the pipeline, an operation which may create asbestos dust and hence potential exposure to humans through lungs. Pipelines are cut during the removal operation on board, workers may be exposed to asbestos dust if required facilities are not in place. The asbestos represents a group of minerals containing silicate-fibres, especially serpentines. Respiration of asbestos-fibres can give lung-infection; tumour between lungs and chest and lung-cancer. Thus humans should not be subjected to asbestos-dust.

Waste management onshore

Most of the generated waste can be recycled, and should from an environmental perspective not be called waste, but a resource. The following material components in relation to pipelines are: Remnants of oils; Low Specific Activity (LSA); Steel & flexible pipeline; Corrosion & concrete coating; Cathodic protection; Valves, tee pieces and fittings; and Mattresses, grout bags, and other debris. Summary for material, collection method and method of disposal is presented in Table 2.

Table 2: Summary of all waste inventory for all the pipelines, if all material is taken ashore.

Discription of waste	Volume (m^3) or Number	Weight (tonnes)	Collection method	Method of disposal
Low viscosity remains of oils	N/A	N/A	Onshore	Specialist disposal
Low Specific Activity scale	N/A	N/A	Onshore	Specialist disposal
Steel pipeline: Steel	N/A	N/A	LB 200 and	Leave in situ. Re-use, alternative, re-melt or landfill disposal
Flexiblepipeline	N/A	N/A	Northern Explorer	Landfill disposal, eventual recycling and incineration
Corrosion coating	N/A	N/A	Onshore	Specialist disposal. eventual recycle with concrete
Concrete coating	N/A	N/A	Onshore	Recycling or landfill
Zinc anodes Aluminium alloy anodes	N/A	N/A	On board or onshore	Re-melt
Hydrocouples, valves, tee pieces and fittings	N/A	N/A	On board or onshore	Sorted for different somponents R-used, re-melted or landfill disposal
Mattresses, grout bags, and other debris	N/A	N/A	Lifting operations Northern Explorer	Leave in situ, recycling or landfill disposal

Aesthetic concerns offshore & onshore

Negative effects related to removal and disposal

Negative effects to the local community because of dismantling, construction and infrastructure work in the operational phase are important issues to discuss. The removal and disposal operations for the pipelines may have negative effects such as those associated with noise, odour, smoke, dust and other disturbances, such as increase in heavy traffic, and effects on recreational areas. Construction work may take place for some of the disposal options, with increased local road traffic, and activities associated with the presence of the work force.

Positive long-terms effects related to the end use

Positive long-term effects on the society as a result of the end use of the pipelines are another important aspect. Positive societal and public perception effects from re-use/recycling options can be considered. The positive factors worth assessing are; major effects on peoples daily situation; and long-term and short-term enhancement of industrial activities, including employment effects.

Ecological impacts to the marine & onshore environment

Ecological impacts to the marine environment

The effects on the marine organisms are difficult to assess, since many of them are capable of adapting to contaminated components in the water column, and acute effects are not expected in the North Sea. The ecological impact from contaminants may occur as a result of accumulation in the food chain. In relation to the heavy metals, like cadmium and mercury, there may be an impact on fish-eating species like birds and marine mammals, if they consume contaminated fish (AURIS 1995).

Pipelines can be buried, and removal of covering sediments before removal of pipelines may be necessary. The impacts resulting from removal operations are caused by vessel operations, and disturbance of seabed sediments. For example, trenching of pipelines disturbs the fauna in an area of approximately 15 m wide (centred on the pipeline), with 10-20 m3 of sediment disturbed for each metre of pipeline retrieved (Dicks 1982).

The removal of the pipelines in this area might cause re-suspension of these contaminants into the water-column. The contaminants are not expected to have any significant effects on the marine organisms because of the rapid dilution in the water masses.

An important consideration with regard to the discharge of contaminants to the water column is the potential for tainting commercial fish. However, investigations undertaken by Aabel et al., (1997), indicate that there are no evidence of taint in fish close to platforms.

An important aspect in the consideration of leaving pipelines totally/partly in situ is the impact they may have on other users of the sea. The North Sea is an important fishing area, both historically and economically. Pipelines on the seabed has proven to be a problem, especially for trawling activity. Recent studies by Statoil have indicated damages to trawling gear after passing rock dumped pipelines.

Most of the operations during retrieval of the pipelines will have a minor impact to the marine organisms. The impact on plankton and benthic fauna will be limited, and therefore the impact and long term effect of the operations on fisheries, mammals and cetaceans will also be insignificant.

Ecological impacts to onshore environment

The key potential receptors of potential contamination from the dismantling and disposal site may be:

* surface and groundwater at the disposal site from free product and dissolved phase contamination;
* on-site workers from contact and inhalation of soil and/or dust-borne contamination; and
* general public receptors from dust/ particulate contaminants downwind of the site.

If the dismantling site previously has been used for industrial purposes over a long time range, there is a potential for contaminated materials to be present on the site and surrounding area.

Activities related to dismantling, are such as: craneage use, transport, cutting, crushing, loading and unloading, shredding a.s.o.. These activities will naturally have an impact on the surrounding environment. However, the provision of adequate dust suppression measures (e.g. water sprays, ground surfacing) could significantly reduce the potential for dust generation.

Conclusions

Removal of pipelines

* Removal of pipelines will cause resuspension of contaminants into the water-column and may also result in deteriorated concrete coating being deposited on the seabed as the pipelines are recovered. The resuspension and the following settling of sediments cause suffocation in the benthic community. The impact is considered minor and a full recovery of a healthy community is expected after approx. 2 years.
* Recovery and disposal of pipelines involves substantial energy expenditure and emissions to air, whereas leaving them in situ may be a more favourable environmental option. Emissions to the atmosphere effects air quality, contributing to acid rain and greenhouse-effect, there is also a considerable consumption of fuel which is a non-renewable resource.
* The energy consumption during pipeline removal operations are quite high. However, it is possible to achieve energy gains by recycling/re-use of pipelines with larger diameters. The emissions of CO_2 will be generally lower if the

Table 3: Summary, environmental impact of leaving in situ and removal operations

Disposal category/option	*Discharges to sea/land*	*Emissions to air*	*Energy consumption*	*Waste management*	*Aesthetic concerns*	*Impact to the marine environment*	*Potential source of effects*	*Concerns*
Leave in situ	MINOR Physical presence and slow leaching of materials over time	NEGLIGIBLE Emissions only during regular inspections.	NEGLIGIBLE Only low air emissions and energy consumption due to inspection.	NEGLIGIBLE No material brought to shore	NONE	MINOR Unlikely that accumulation in organism may occur Potential problems with debris in the future for fishermen, if not properly stabilised	Physical presence of the pipeline on the seabed. Release of contaminated materials from the pipeline.	Obstruction from debris/pipeline on the seabed and potential risk associated with commercial fishing. Leaching of contaminants into the water column and sediments affecting food chains.
Removal operations	MINOR Preservation fluid or seawater Resuspension of sediments, limited impact Small amounts of remaining oil	MODERATE Emissions to atmosphere effecting air quality. Contributes to acid rain and greenhouse-effect. Negligible impact in the local area	MODERATE Considerable use of fuel which is a non-renewable resource.	MINOR Small production of asbestos dust during cutting	NEGLIGIBLE At the offshore site there will be no impact from noise, smell or visual impacts.	MINOR Smothering of benthos following resuspension of sediments. Debris on the seabed may cause interactions with fishermen (trawlers)	Emissions and discharges from vessels and equipment Accidental loss of debris/lifts during preparation work and operations Accidental emissions and discharges from clean-up of pipelines Accidental damage to transport barges and loss of pipelines	Residual contaminants in the emissions/ discharges effecting habitat and floral and faunal communities. Obstruction from pipeline/debris on the sea-bed Leaching of contaminants into the water column and sediments, effecting benthic communities Local reduction of air quality/water quality.

Table 4: Summary of overall environmental impact of dismantling and disposal

Disposal categoryn/ option	*Discharges to land*	*Emissions to air*	*Energy consumption*	*Waste management*	*Aesthetic concerns*	*Impact to the onshore environment*	*Potential source of effects*	*Concerns*
Reuse in petroleum industry or alternative reuse	NEGLIGIBLE If oil remnants, LSA and corrosion coating are disposed of correctly	MINOR Emissions to atmosphere effecting local air quality.	MINOR Less energy use since coatings are not stripped of	POSITIVE Only waste inside pipe, minor volumes of coatings disposal	MODERATE Visual impacts, disturbance of local community, noise and dust/asbestos dust Positive factors long & short-term enhancement of industrial activities & employment effects	MINOR Need to remove, inspect, refurbish and relocate the pipeline	Emissions and discharges along the route Positive effect in terms of recycling most of the material components	Local reduction of air quality/water quality. May need removal from seabed in the future
Recycling	NEGLIGIBLE Same as above	MODERATE Emissions to atmosphere effecting air quality. Contributes to acid rain and greenhouse-effect.	MODERATE Energy gain from recycling pipelines with large diameters Considerable use of fuel which is a non-renewable resource.	POSITIVE Recycle all material, reduces the waste volumes	MODERATE Same as above	MINOR Need to keep material flow separate	Emissions and discharges along the route Positive effect in terms of recycling most of the material components	Local reduction of air quality/water quality. High air emissions, and increased fuel consumption for most pipelines. May not justify removal of any pipeline
Disposal at landfill, specialist disposal or incinerate	MINOR Leaching of materials into surface/ground water, may affect water supply and food chains	MODERATE Same as above	MODERATE Energy can be gained if corrosion coating is incinerated Transport of several tonnes of waste	MODERATE Old coatings removed and disposed properly or incinerated Hugh volumes to handle and dispose off properly	MODERATE Same as above	MINOR Leaching of materials into surface/ground water, may affect water supply and food chains	Physical presence, emissions and discharges during disposal Transport of materials off-site to disposal sites Insecure disposal sites Incineration may not burn all toxic substances properly	Disturbance of local communities. Accidental loss of material during transit Emissions to atmosphere effecting air quality, noise and dust. Reduction of local air quality

pipelines are recycled/reused rather than production of new pipelines. NOx emissions are highest when the pipelines are reused/recycled.

* The environmental impacts associated with removal options could potentially be greater than those associated with leaving the pipelines in place. There exists indication that the pipelines may need to be recovered, because: public and fishermen's perception of leaving pipelines in situ, is not favourable; obstruction from debris/pipeline on the seabed and potential risk associated with commercial fishing, if left in situ.

Disposal of pipelines

* Discharges/leaching of waste materials into surface/ground water, may affect water supply and food chains. Contaminants in the air emissions may affect habitat and floral and faunal communities. However, minor impacts are expected on the water and air quality if waste materials are disposed correctly.
* Onshore dismantling and disposal will also contribute to air emissions and energy use. From an environmental view, reuse and recycling are the most favourable, if the operations do not exceed the use of energy or air emissions when new pipelines are produced with new materials from an ore.
* Once recovered, the pipelines need to be taken ashore, stripped of concrete coating and possibly the coal tar enamel coating as well. The steel pipe and concrete coating can be recycled whereas it is thought that most of the corrosion coating will need to be disposed of as waste.
* During handling and cutting of the pipelines, personnel onboard the LB 200 vessel may be exposed to asbestos and coal-tar. Onshore the handling of these components are regulated by law, while onboard the Norwegian Working Environment law does not apply. However, the handling of asbestos (and coal-tar) presents a health risk and should be properly dealt with.
* Onshore dismantling and disposal may be of an aesthetic concern, both in terms of noise, dust, and disturbance to local communities, including visual impacts. These factors again may be weighted towards the positive impacts like: major effects on peoples daily situation; and long-term and short-term enhancement of industrial activities, including employment effects.

References

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