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Marine Institute

Oil Based Mud Cuttings Treatment Solutions for Ireland

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1.0 EXECUTIVE SUMMARY

The management of oil based mud contaminated (OBM) cuttings generated by offshore hydrocarbon exploration in Ireland involves transfrontier shipment (TFS) of the cuttings to the UK for treatment. Some companies find that the process is logistically complicated. Furthermore there is an increasing reluctance on behalf of the Scottish Environmental Agency to accept imported OBM contaminated waste from other countries for treatment in response to the Landfill Directive. There is a need for oil exploration companies operating in Ireland to find alternative solutions to TFS. This study was commissioned by the Irish Shelf Petroleum Studies Group to examine the options and makes recommendations.

Through a process of literature search, interviews with stakeholders, attendance at conferences, and a fact finding workshop the situation was examined, options identified and recommendations made. In summary the options available are cuttings re-injection, thermal desorption offshore, thermal desorption onshore and skip and ship to the UK or mainland Europe. The current level of drilling activity offshore Ireland (5 to 10 wells over the next 3 years) is insufficient to make an onshore thermal desorption unit commercial even when other oil waste streams are considered. The only proven, economic and regulatory compliant option is skip and ship with TFS which is likely to become more restricted in the future.

The alternative solutions include finding a re-use for the hazardous waste cuttings residue from thermal desorption; licence hazardous landfill in Ireland; adopt the OSPAR regulation that allows disposal at sea of 1% oil on cuttings; provide financial support to a waste management company to establish an onshore thermal desorption facility; use only water based muds for drilling operations in Ireland.

A number of recommendations arise from the findings of the study. The regulations concerning the treatment of OBM cuttings need to be clarified. The waste management implications of using oil based mud instead of water based mud systems should be factored into any decision on mud systems made by the oil exploration companies operating in Ireland. The IOOA should develop common procedures and guidelines for more efficient skip and ship and TFS of OBM associated cuttings for its members to follow. Furthermore oil exploration companies operating in Ireland are encouraged to continue research into new solutions for OBM associated cuttings treatment.

2.0 INTRODUCTION

Historically, levels of oil and gas activities offshore Ireland have been relatively low, in comparison to many other European countries. However, oil and gas exploration off the coast of Ireland is likely to be sustained within exploration blocks where a number of companies have license commitments to drill. The waste streams associated with drilling and possible production operations can include oil based mud contaminated drilling cuttings, slops, non oil-based drill cuttings, oily water, waste water, various organic and inorganic chemical waste, possible low level radioactive wastes, oil rags and general non-hazardous house-hold type wastes. Many of these wastes require treatment prior to disposal. Previously much of this waste has been shipped to the UK for treatment and disposal due to the lack of suitable facilities in Ireland to manage such wastes. The tightening of trans-boundary shipment of waste to the UK and EU legislation on waste has made it increasingly difficult for oil exploration companies to export the oil based mud contaminated waste generated by offshore drilling of exploration wells. Furthermore the level of activity is considered too low to warrant substantial investment in building Best Available Technology (BAT) facilities onshore to handle such wastes. However the level of oil based mud contaminated cuttings generated offshore is too high to be ignored.

In May 2009 the Irish Shelf Petroleum Studies Group commissioned a study to define how this potential problem can be addressed.

3.0 METHODS OF INVESTIGATION

Onshore and offshore waste treatment technologies were investigated by literature search, attendance at international offshore drilling conferences (e.g. International Association of Drilling Contractors, IADC 2009 World Drilling Conference and Exhibition) and interviews with technology providers, waste management companies and drilling operators

Existing and future oil based mud waste streams were estimated by interviews with drilling engineers involved in recent oil exploration activities offshore Ireland and with exploration specialists in the Petroleum Affairs Division (PAD) of the Department of Communications, Energy and Natural Resources (DCENR). The scenarios and assumptions for future exploration activity presented in the Irish Offshore Strategic Environmental Assessments (IOSEA1, 2 & 3) were also used to establish oil base mud waste streams. These are now considered optimistic projections as discussed under Section 4.2.

The National Hazardous Waste Management Plan 2008 – 2012 published by the Environmental Protection Agency (EPA) was consulted to obtain key statistics in relation to the generation and management of additional waste oil and oily sludges generated by Irish industry and society and projections for future oily waste generation.

The investigation of international best practice and planned legislation was based on a literature search, a review of European Directives and Conventions; existing Irish legislation and interviews with the competent authorities in Ireland.

The long term options for oil based mud contaminated cuttings waste treatment in Ireland was developed from the outcome of a workshop hosted by the Marine Institute in Dublin attended by the main oil and gas exploration companies operating in Ireland, Irish waste management companies, representatives from the relevant Irish government authorities, and technology providers in oil based mud cuttings treatment. The workshop included presentations form each of the representative groups on the current status of the situation followed by a round table discussion on future options.

4.0 RESULTS & FINDINGS

The project plan contained four distinctive work packages with a logical framework of deliverables as described below:-

WP1 Identify Onshore and Offshore Waste Treatment Technologies
WP2 Identify Existing and Future Oil Based waste Streams
WP3 Investigate International Best Practice & Planned Legislation
WP4 Investigate Long Term Options for Oil Contaminated Waste Disposal in Ireland

4.1 Onshore & Offshore Waste Treatment Technologies for OBM Cuttings

Oil based mud (OBM) is routinely used worldwide in hydrocarbon exploration drilling for a number of engineering, formation evaluation and cost reasons. Because OBM is less reactive with rock formations, such as shale and halite, the well bore is smooth and less susceptible to caving. This results in faster drilling times, less stuck pipe and reaming, more efficient casing and cementing jobs and better quality for most wireline logs. Reactive shale and, in some areas, halite are a feature of Irish offshore hydrocarbon exploration. For this reason wells drilled offshore Ireland sometimes use OBM as the drilling fluid.

OBM contains low aromatic and paraffinic oils. According to the OSPAR Convention the discharge to sea of drilled cuttings is prohibited unless the concentration of residual oil is less than 1% by weight. Treatment technologies are available to clean contaminated cuttings to better than 1% by weight of residual oil on cuttings. The recovered oil is normally reused as base oil for drilling operations. The residual treated cuttings can be disposed of onshore in landfill or discharged into the sea without significant impact on the environment.

A number of companies provide OBM cuttings treatment facilities onshore and offshore worldwide. There are a number of technologies on the market providing treatment of OBM contaminated cuttings that comply with the OSPAR Convention definition of best available technique (BAT) and best environmental practice (BEP). Each of the options is examined and its suitability for Irish drilling operations assessed below.

4.1.1 Cuttings Re-Injection (CRI) Onshore & Offshore

CRI means the disposal of drilled cuttings as slurry which is injected into a subsurface formation in a redundant well (see Figure 1). The drilled cuttings are transported from the rig's solids control equipment to a slurrification package where they are mixed with water (and chemicals if required). With a combination of mix-tank agitators and grinding pumps, the cuttings are made into pumpable slurry of known particle size for transfer to batch-holding tanks or directly to the injection pump. The slurry is injected at a predetermined rate and pressure via the casing annulus into the injection zone. CRI can be performed offshore as well as onshore.

CRI can be performed simultaneously with drilling or production operations using one of the well annuli. In a producing field a dedicated injector well is used for waste disposal. Experience indicates that up to 1 million barrels of slurry can be pumped into a single injector well under ideal conditions. CRI avoids material transportation and reduces risks, costs and gas emissions. The critical factors in CRI are slurry containment, slurry rheology, particle size and the surface injection system. In the North Sea, approximately 30% of rigs and platforms use CRI to dispose of oil-base-mud cuttings. A permit is required under the Waste Framework Strategy Directive.

However stable, long term containment of the slurry must be assured. The properties of the target geological formation, into which the slurry will be injected, must be well understood. There must be sufficient caprock to prevent migration of slurry to the surface and the ability of the formation to absorb the slurry by hydraulic fracturing must be assessed. It follows that CRI is more suited to production drilling operations than exploration drilling. In a producing field there are years of drilling experience and a well established 3D geological model to allow a suitable target geological formation to be selected for cuttings disposal. Exploration drilling, on the other hand, depends on limited geological knowledge based on seismic interpretation and a small number of offset wells. The geological and engineering information available is insufficient to identify target geological formations for injection of slurry. Therefore CRI is unlikely to be an option for OBM contaminated cuttings disposal in the short to medium term offshore Ireland. Most future drilling operations offshore Ireland within the next few years will be for exploration.

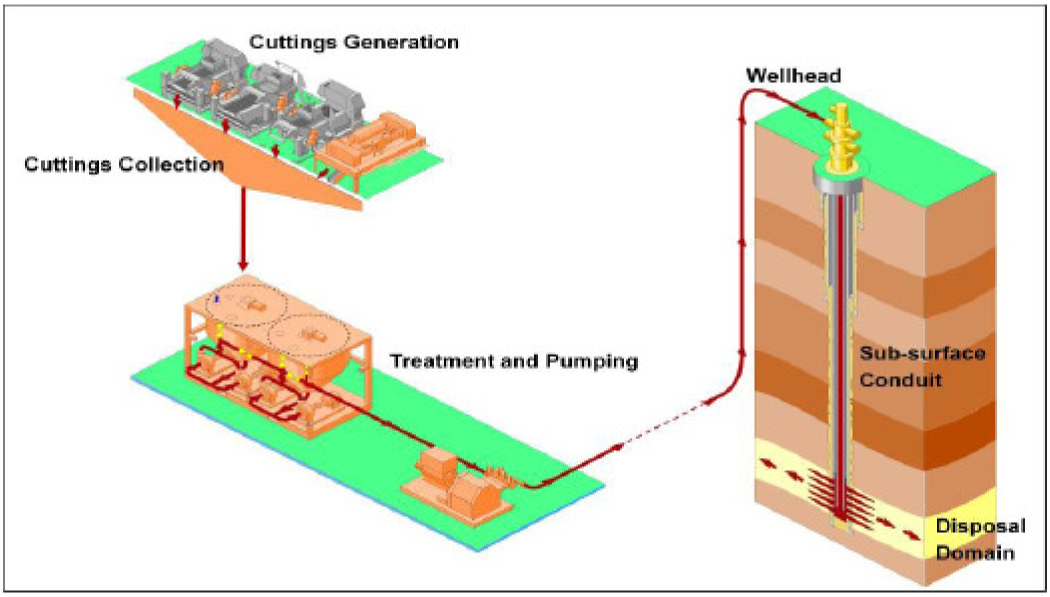

Figure 1 Cuttings Re-Injection

The pumping of untreated drill cuttings into an exploration well during the abandonment process is not technically feasible because the drill cuttings would take an unacceptably long time to settle out in the mud column remaining in the well bore[1]. However an abandoned exploration borehole could be used as a disposal well for some of the oil based mud contaminated cuttings if slurrification equipment was available offshore[2]. Slurrification of cuttings increases the volume to be disposed but allows the slurry to be pumped into the hole and cemented off during the abandonment process. The volume of cuttings that could be disposed of in this way would be dependent on the well design and total depth. Some drill cuttings will still have to be treated in the conventional manner.

An extensive survey of literature on CRI did not find reference to injection of cuttings that had not been slurrified. In all cases pretreatment of cuttings was required and the volumes of cuttings to be injected required fracturing and injection into known weak formations.

CRI Case Study UKCS[3]

The operator was to drill a number of wells for reservoir development within the Clair Field in the UK North Sea sector during 2004 and 2005. Drilling of these wells could generate up to an estimated 75,000 bbl of waste for permanent disposal. High environmental standards in the North Sea sector require safe and environmentally acceptable technology to handle the waste management program.

Waste injection was the immediate program of choice due to high cost logistics of ship-to-shore and other disposal methods. However no dedicated disposal well was available at the initial stage of the development and the choice was made by the operator to look at utilizing the initial production well B annulus as an injection option until a dedicated well option could become available.

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[1] Pers com Feb 2010 Dennis Krahn, Drilling Superintendent, IADC representative.

[2] Case History: Cuttings Reinjection on the Murdoch Development Project in the Southern Sector of the North Sea P.R. Schuh, Conoco UK Ltd.; B.W. Secoy, Eric Sorrie, Thule Rigtech Offshore Europe, 7-10 September 1993, Aberdeen, United Kingdom

[3] Waste Injection Technology Allows Drillers to Fully Satisfy the Most Challenging Worldwide Waste Management Requirements Julio Ronderos, Adriana Ovalle, Gary Woolsey, Steve Simmons, M-I SWACO, IADC World Drilling 2009 Conference & Exhibition, 17-18 June 2009 in Dublin, Ireland.

The injection point lay within a Cretaceous mudstone was overlaid with undifferentiated sands and the client recognized that the risks associated with this were high. A massive architectural fault lay close to the injection zone that could result in surface breaching; in addition, there was no prior extensive waste injection in the area to validate the disposal well option.
When the waste injection program became more critical to the drilling and environmental success of the project, the operator made it a priority and raised the drilling waste management team's level of awareness to the critical path. This led to the operator employing a real-time injection service and monitoring team that could not only carry out the site-specific waste injection management program on surface but could also maintain a injection monitoring program of pressure analysis and provide specific daily and weekly recommendations that would allow the waste injection program to continue operating.
As a result of the surface equipment operation and monitoring services, and successful cooperation with all of the drilling waste management team, a total of 45,564 bbl of drilling waste was injected into the B annulus. Achieving zero discharge with a successful drilling program was a critical key factor to the future success of the field development and this was achieved with Waste Injection.

4.1.2 Thermal Desorption: Hammermill Onshore & Offshore

Figure 2 Offshore Hammer Mill Unit

The Hammermill desorption process is based on direct mechanical heating through the use of a pounding action on the cuttings. The combination of high mechanical shear and in-situ heat generation creates an environment that promotes flash evaporation of water and hydrocarbons. There is no ignition source in this type of desorption process. This technology eliminates the need for large surfaces and complex systems for warming and maintaining a heat-transfer medium, such as hot oil, steam or exhaust gas that require the highest safety and explosion-proofing standards. Hammermill technology utilises friction to generate heat within the cuttings and separates the base oil without damaging its molecular structure.

Hammermill units are fast, clean and efficient to run. The processing capacity is based on the oil/water content. A typical unit can process 3 tons of drilled cuttings per hour assuming 70/15/15 solids/water/oil ratio by weight using a main motor/engine of approx. 700kW. If the water content is lower, the capacity of the same unit can be as high as eight tons per hour. They can be designed as compact units suitable for offshore use. The drilled cuttings are screened for larger objects by a shaker screen on top of the feed hopper. Double piston pumps send the material to the process mill. The crushing of the solids results in significant amounts of ultra-fine particles following the oil and water vapour from the process chamber. These particles are efficiently removed by a cyclone and a special dust separator prior to the vapours moving through the condensers. This technique has been considered by one operator for offshore Ireland.

Figure 3 Rotary Kiln Onshore Unit

4.1.3 Thermal desorption Rotary Kiln

Rotary Kiln Technology recovers water and oil from contaminated drilled cuttings using a rotating, inclined cylinder. The material is indirectly heated, increasing the temperature and resulting in desorption of the oil and water. The oil and water vapours are removed from the kiln and quickly condensed for oil and water separation and recovery. The oil-free treated solids are then cooled and re-hydrated in an enclosed discharge auger and conveyed away from the unit for disposal onsite or offsite. The process is based on an indirect fired method in which all heat being transferred to the processed material is conducted to, and radiated through, the kiln shell.

The indirect thermal desorption system is designed to treat oil based drill cuttings by applying heat indirectly to the cuttings, which are slowly tumbled in an oxygen-starved environment. The heat from gas or diesel fired burners is transferred through a special stainless steel drum into the cuttings. As the temperature rises, the water and oil in the cuttings vaporises, leaving the dry cuttings as residue. The vapor is then removed from the drum and condensed into oil and water. These two liquids are separated and cooled. The oil is recycled, and the water is used to cool the clean solids as they exit the unit. A basic unit is designed to treat up to 12 tons of drill cuttings per hour. The system achieves less than 1% oil on cuttings.

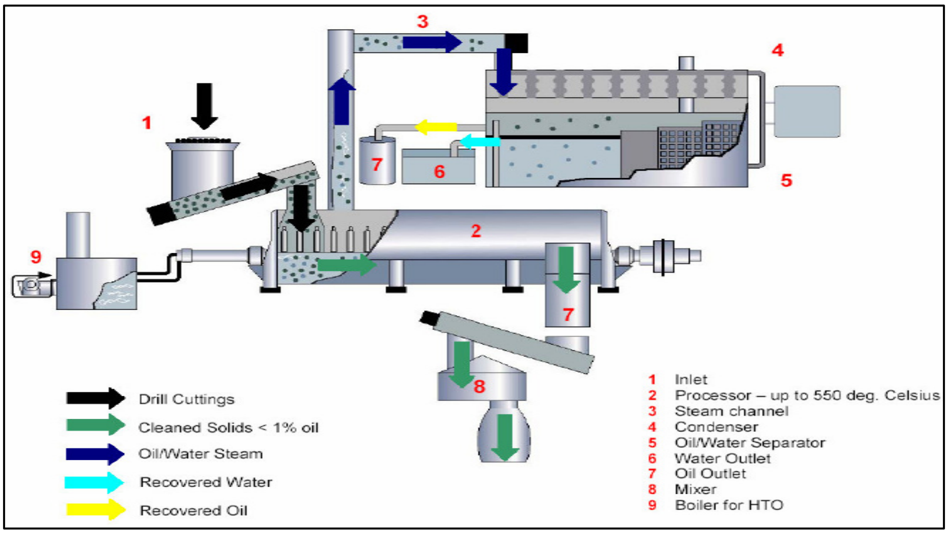

Figure 4 Thermal Oil Recovery System

Recent developments include an onshore/offshore pilot plant for OBM contaminated cuttings cleaning that uses a vacuum principle. The process is claimed to be faster and more efficient that existing systems. The product is expected to be available commercially in the near future.

While these technologies are available onshore and offshore UK there is no existing onshore processing facility in Ireland and to date none of the drilling rigs operating offshore Ireland had offshore OBM contaminated drilled cuttings processing equipment on board. However an offshore processing unit was considered for a recent drilling operation and some operators are seriously considering the use of offshore processing units on future operations in Ireland.

A thermal desorption case study is presented in Appendix C.

4.1.4 Other Techniques

There are a number of other experimental techniques for treatment of oil contaminated cuttings that may become available in the medium term. Three of these are described below.

Surfactant-Enhanced Treatment of Oil-Contaminated Soils and Oil-Based Drill Cuttings

Ultra-centrifugation can lower the oil content to close to 8%. Experiments show that detergency mechanisms using surfactants and electrolytes can further reduce the oil on cuttings to 3%[4].

Magnetic Filtration

Experiments have demonstrated that magnetic extractants in combination with magnetic filtration are capable of removing hydrocarbons from water and in breaking oil in water emulsions[5].

[4] Surfactant –Enhanced Treatment of Oil Contaminated Soils and Oil based Drill Cuttings, Sabitini et al, 2001

Supercritical carbon dioxide
Results of studies using supercritical carbon dioxide to remove the base oil from drilling waste show extraction efficiencies as high as 98%. The hydrocarbons are unchanged by the extraction process and that they may be recovered and potentially reused[6].

Microwave treatment of OBM cuttings
The University of Nottingham, supported by BP and BG, has developed a microwave based, energy-efficient, alternative to thermal and rotomill processing, which can be used for offshore OBM cuttings treatment. Other advantages besides energy efficiency are the low footprint and deck loading, and ease of start-up and shut-down. They are currently negotiating a licensing arrangement with a major oil field service company, who will develop the technology for offshore use within the next year or two[7].

4.2 Existing & Future OBM Waste Streams

The current procedure for processing and treatment of OBM contaminated cuttings generated by exploration and production drilling offshore Ireland is to skip and ship the cuttings to the UK for processing. The OBM contaminated cuttings are sent to a treatment facility certified to deal with OBM waste, where the oil is removed and recovered as far as possible, and the cuttings and mud residue either re-used or sent to landfill. The skip and ship procedure involves some pre-treatment (on the shale shakers to recover drilling fluid) and storage of oil based mud contaminated drilled cuttings in sealed skips on the drilling rig for periodic transport onshore by supply boat. In the case of Irish drilling operations the skips are often stored onshore and transported by truck to the UK at the end of the drilling operation as one shipment, if possible[8]. Drilling slops, generated from setting cement plugs for instance, can be processed in Ireland. There are a number of onshore processing units in the UK where cuttings from Irish operations are processed including a 10,000 bbl capacity storage and processing unit at Pocra Quay in Aberdeen Port and another processing facility at Peterhead.

The ship and skip program has logistical problems associated with handling the volume of cuttings generated during fast drilling which can increase the risk of downtime and introduce safety concerns.

Skip and Ship Case Study North Sea[9]
The Shell operated Shearwater gas-condensate field is estimated to produce 1300 tonnes of cuttings per well, fifty per cent of which are produced over a period of three days in the 16” hole section. For I,000 tonnes of cuttings 250 skips are required. There are at least 15 crane lifts per skip during transport to the rig, on board the rig and return by ship to the dock. This amounts to 3,750 crane lifts.

Offshore Ireland weather, even in the summer months, may prevent supply vessels from operating, and the weight and footprint limitations of the deck restrict containment operations. Furthermore trans-frontier shipment (TFS) of hazardous waste from Ireland to the UK or mainland Europe must follow rigorous procedures involving a significant number of national and local authorities.

The choice between using water based muds and oil based muds is a balance of cost issue. Water based muds have less associated environmental and regulatory restrictions and disposal

5 Novel Materials for Facile Separation of Petroleum Products from Aqueous Mixtures via Magnetic Filtration, Apblett, 2001

6 Treatment of Oil-Based Drilling Waste Using Supercritical Carbon Dioxide, Street et al, Journal of Canadian Petroleum Technology, 2009

7 Microwave Treatment of Oil Contaminated Drill Cuttings – Towards a Commercial Scale System, Robinson et al, SPE 2010.

8 Pers. Com. Fergus Roe, Providence Resources and Margot Cronin, Marine Institute, March 2010

9 Drilling Mud Discharge Reduction in the Shearwater HP/HT Gas Condensate Field, Darke et al, SPE 1999

is cheaper than for oil based muds. However water based muds are not as effective in controlling reactive formations and hole cleaning as are oil based muds. The use of water based muds can result in reduced rates of penetration and lost time due to reaming, stuck pipe and casing hang up. Oil based muds on the other hand usually prevent washouts, result in more stable hole conditions and provide better quality formation evaluation. However OBM restricts resistivity logging to induction-based tools which, by their nature, are less accurate at higher resistivities and consequently hydrocarbon saturation calculations may be uncertain. These advantages offset the additional disposal costs. Drilling offshore Ireland can involve salt horizons and reactive clays in the Jurassic, amongst other drilling challenges for which oil based muds have proven effective.

The amount of cuttings generated, and volumes of drilling muds discharged, depends on the rock characteristics, the target depth and aspects of the well design, including the bore widths of the different sections. Assuming typical well diameters, Table 1 provides indicative amounts of cuttings and muds that may be discharged, based on drilling data from the UK continental shelf (UKCS). Oil based mud is not normally used in the top hole section of the well. Generally speaking water based muds or seawater is used for drilling top hole. Water based muds and associated cuttings are usually discharged to the sea where the muds disperse and cuttings will disperse and settle as a cuttings pile in the vicinity of the rig. It is estimated that the UKCS produces between 50,000 to 80,000 tonnes wet weight of oily drill cuttings annually[10]. The average number of exploration and appraisal wells drilled each year from 2005 to 2008 is 90[11]. OBM is used in only a percentage of these wells. This would suggest at least 500 to 800 tonnes of drilled cuttings per well.

In recent Irish drilling operations there has been zero discharge of OBM and associated cuttings to the sea. The OBM contaminated cuttings are shipped ashore in sealed skips and transported to the UK or mainland Europe for processing. Figures indicate that a typical 2,000m well drilled offshore Ireland generates between 500 and 800 tonnes of OBM contaminated cuttings and 200 tonnes of OBM contaminated slops[12].

For the purpose of each of the Irish Offshore Strategic Environmental Assessments (IOSEAs), in the Slyne Erris and Donegal Basins (IOSEA1), the Porcupine Basin (IOSEA2) and the Rockall Basin (IOSEA3), the Department of Communications Energy and Natural Resources (DCENR) estimates the levels of future drilling activity in each licensing round area based on experience and the levels of interest actually shown by companies in the rounds. Although the IOSEAs are an assessment of exploration activities only, recognition of the possibility that a proportion of the exploration may ultimately result in development drilling taking place is also made. These activities will take place alongside pre-existing exploration programmes planned as a result of previous licensing rounds. For the purposes of assessment of cumulative impacts, activity levels for these pre-existing programmes have also been forecast by DCENR. The cumulative drilling activity estimates based on the figures published in the three IOSEAs predict an optimistic increased level of activity that would be contingent on exploration success. While these figures should not be confused with actual drilling commitments stemming from licences awarded under licensing rounds the recent discovery of oil in the Slyne Basin suggests grounds for optimism.

The DCENR's current best estimate is five to ten exploration wells, in total, over the next three years[13]. Based on DCENR's current projections, assuming fifty percent of the wells use OBM, drilling could generate from 400 to 1,300 tonnes of OBM contaminated cuttings per annum over the next three years.

[10] Options for the Recycling of Drill Cuttings, Page et al, SPE 2003

[11] https://www.og.decc.gov.uk/information/wells.htm

[12] Pers. Comm. Mitch Flegg, Serica, 2009, Margot Cronin, Marine Institute 2010

[13] Pers. Comm. Ciarán Ó hÓbáin, DCENR, 2009

With respect to oil waste from other sources in Ireland, in the region of 27,500 tonnes of waste oil and 14,000 tonnes of oily sludge is generated per annum[14]. The main source of waste oil is from commercial garages, fleet maintenance, machine maintenance, rail, port, airports, and industry. The oily sludge mainly comes from tank cleaning. The waste oil and oily sludge is pre-treated and recycled to generate re-processed fuel oil. There is an onshore licensed facility in Ireland to treat 35,000 tonnes per annum of waste oil and oily sludges and 1,000 tonnes of oil filters. There is also authorised treatment capacity for 30,000 to 35,000 tonnes per annum of oily sludges and oily wastes by centrifugation and settlement in place. Reprocessed fuel oil that meets quality standards is produced. These facilities are currently operating close to capacity.

According to the EPA waste oils and mineral oil waste is the one waste stream for which Ireland is substantially self-sufficient. Some movement of oil waste to and from Northern Ireland takes place. Very small amounts are shipped outside of the island of Ireland..

Investigations are currently underway into the possibility of treating OBM contaminated cuttings and slops with existing oily sludge waste streams using an onshore thermal processing technology.

4.3 International Best Practice & Planned Legislation

4.3.1 International Best Practice Regulation of Offshore Waste Discharge[15]

The Convention for the Protection of the Marine Environment of the North-East Atlantic (known as the "OSPAR Convention") is the basis for national laws governing the discharge of offshore drilling wastes in the waters of the OSPAR signatory states: Belgium, Denmark (including, for these purposes, the self-governing province of the Faroe Islands), Finland, France, Germany, Iceland, Ireland, the Netherlands, Norway, Portugal, Spain, Sweden and the United Kingdom of Great Britain and Northern Ireland. OSPAR regulations thus cover all the oil-producing coastal states of Western Europe. The European Community is also a signatory, as are Luxembourg and Switzerland.

As a result of these agreements, the oil-producing states of Western Europe in effect work as a single country for the purposes of controlling offshore waste disposal, although the detailed implementation of the OSPAR regulations is still governed by national laws and European Union directives (with the exception of Norway, which is not an EU member but has, in general, stricter environmental regulations).

At present it is legal to discharge drilled cuttings in the offshore waters of the OSPAR signatory countries, provided the oil content is less than 1% by weight and the material has passed tests to show that it will bio-degrade over a specified time and will not bio-accumulate.

Norway
The Norwegian State Pollution Control Authority (SFT) regulates the use of drilling fluids and muds through discharge permits. All oil-based muds are injected or taken to shore for treatment. The offshore discharge of solids containing more than 1% oil, by weight, is forbidden.

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[14] National Hazardous Waste Plan 2008 – 2012, EPA, 2008.

[15] A Survey of Offshore Oilfield Drilling Wastes and Disposal Techniques to Reduce the Ecological Impact of Sea Dumping, Jonathan Wills, M.A., Ph.D., M.Inst.Pet., for Ekologicheskaya Vahkta Sakhalina (Sakhalin Environment Watch); 25th May 2000

Canada

Several Canadian laws govern what can and cannot be discharged into the sea on the Grand Banks of Newfoundland and the Scotia Shelf, the two main areas of offshore oil and gas exploration and production to date. However, the Canadian regulations appear to be much less prescriptive and detailed than in Norway with less stringent enforcement and more self-reporting and self-regulation than in the best-performing OSPAR countries.

The regulatory frameworks applicable to oil and gas activities in each of Canada's offshore areas are broadly the same. In the Newfoundland offshore area, such activities are administered by the CNOPB under the *Canada-Newfoundland Atlantic Accord Implementation Act,* S.C. 1987, c. 3 and the *Canada-Newfoundland Atlantic Accord Implementation (Newfoundland) Act,* R.S.N. 1990, c. C-2. In the Nova Scotia offshore area, oil and gas activities are administered by the CNSOPB under the *Canada-Nova Scotia Offshore Petroleum Resources Accord Implementation Act,* S.C. 1988, c-2 and the *Canada-Nova Scotia Offshore Petroleum Resources Accord Implementation (Nova Scotia) Act,* S.N.S. 1987, c. 3. The NEB is responsible for the regulation of oil and gas operations in the rest of Canada's offshore areas under the *Canada Oil and Gas Operations Act,* R.S.C. 1987, c. O-7. This legislation collectively is referred to as the energy legislation.

Regulations governing drilling and production operations have been promulgated under each Act which contain requirements related to the protection of the environment. The three Boards have also issued the Offshore Waste Treatment Guidelines, 1996.

The selection of chemicals for Canadian offshore petroleum activities currently does not have specific regulatory requirements under the energy legislation or regulations. The Production and Conservation Regulations require that an operator include in its Environmental Protection Plan, a summary of chemical substances intended for use in the operation and maintenance of a production installation. There are no similar requirements for other petroleum related activities.

There are other regulatory requirements of general application in Canada that provide some restrictions on the transportation, handling and use of chemicals; however, these provide limited direction on the discharge of chemicals into the marine environment. Some of these acts include the Fisheries Act, and the Canadian Environmental Protection Act (CEPA). Canada has signed or ratified a number of international marine conventions, agreements and guidelines and the present Offshore Chemical Selection Guidelines have been prepared within the context and with the recognition of the obligations set forth by this international framework.

The emphasis offshore Canada is on partnership between government and industry, rather than confrontation between regulators and regulated. This voluntary approach seems to work, when both parties are sincere in their commitment to environmental responsibility. There is some evidence that this is so in the Newfoundland sector of Canada's continental shelf. No conventional OBM has been used there since the mid-1980s, when about 10 exploration wells were drilled with it. By agreement, the drilling mud used offshore Newfoundland is based on low-toxicity, synthetic isoparaffin. Also, the Hibernia Oilfield, has converted to cuttings re-injection after successful trials proved good receiving formations.

United States

The Canadian system of regulation contrasts markedly with the situation in the US, where there is frequent confrontation between industry, regulators such as the Environmental Protection Agency (EPA), and pressure groups. In theory, zero discharges are universal in US waters. As in Europe, operators require a licence to discharge any wastes but, once granted, such a licence makes legal what could otherwise be an illegal practice. With the exception of Alaska, the EPA does ban all discharges of drilling fluids and drill cuttings - whether water based, synthetic or oil based mud - within three miles of the shores of the United States, following a decision in Louisiana in the 1980s, after local authorities and citizens' environmental groups had voiced concern at acute and chronic pollution of river deltas, bayous and near shore waters. In Alaska the EPA regulations require zero discharge of OBM contaminated cuttings.

4.3.2 Current Regulation in Europe and Ireland

There are several layers of legislation applying to waste management of drill cuttings. The relevant legislation at EU level includes:

- the Waste Framework Directive 2008/98/EC;
- Transfrontier Shipment Regulations No. 1013/2006;
- Marine Strategy Framework Directive 2008/56/EC;
- Hazardous Waste Directive 91/689/EC;
- The Water Framework Directive – 2000/60/EC.

At National level regulations include:

- the Irish Waste Management Acts 1996 – 2008,
- the Waste Management Regulations 2007 & 2008,
- the Sea Pollution Act 1991 and
- The Dumping at Sea Act 1996.

There are also regional conventions that apply such as the OSPAR Convention on the Protection of the Marine Environment of the Northeast Atlantic. The OSPAR Convention is the regulation most directly associated to discharge of cuttings and other environmental issues relating to offshore oil and gas industry.

The Waste Framework Directive may apply, depending on the classification of cuttings as waste or by-product. The Waste Framework Directive defines “waste” as “any substance or object which the holder discards or intends or is required to discard” The directive requires four “proofs” for a product residue to be classed as a by-product rather than a waste:

1. Certainty of re-use without further processing;
2. Financial advantage;
3. No special environmental precautions required;
4. It is used in a manner equivalent to the material it’s replacing or appropriate for the purpose proposed.

Article 5 of the OSPAR Convention requires contracting parties to take all possible steps to prevent and eliminate pollution from Offshore Sources, as provided for in Annex III, which prohibits any dumping of wastes from offshore installations, except discharges or emissions from offshore sources, and carbon dioxide streams from carbon dioxide capture processes for storage, provided they meet all other requirements. The OSPAR Convention of 1992 is implemented in Ireland by the Dumping at Sea Act, 1996. The OSPAR Decision 2000/3 allows discharge to sea of OBM cuttings meeting requirements of less than 1% of oil on cuttings. The method for measuring oil on cuttings, retort or mass balance or other method, will vary between the National Authorities.
The treated OBM cuttings are classed as hazardous waste according to the European Waste Catalogue and Hazardous waste list (Code 01 05 05). The presence of residual chlorides makes the cuttings unsuitable for recycling and disposal in non hazardous waste landfill. The cuttings can be disposed of only in landfill licensed for hazardous waste. There are no such hazardous waste landfills currently operating in Ireland; therefore trans-frontier shipment of drilled cuttings is most commonly utilised.

Various authorisations are issued by the Minister for Communications, Energy and Natural Resources under the Petroleum and Other Minerals Development Act, 1960. Exploration Licences are issued under Section 8 (1) of the 1960 Act. Terms and conditions, including environmental provisions, are attached to the above mentioned authorisations. These licensing terms are set out in the Departments Licensing Terms for Offshore Oil and Gas Exploration, Development & Production 2007 which provide the operational framework for oil and gas exploration and production. They are the terms on which the Minister is prepared to issue the various authorisations. The DCENR Rules and Procedures for Offshore Petroleum Exploration Operations (PAD 2007) apply to all petroleum exploration and development operations in the internal waters of the State, the territorial waters or in the designated areas of the continental shelf under Irish jurisdiction.

The routine discharge of untreated cuttings contaminated with oil base muds is not permitted in Irish waters. The DCENR Rules and Procedures Manual (PAD, 2007) states that such material must be stored for shipment ashore to appropriate treatment and disposal facilities. There are requirements for pre-screening, a mass balance exercise and a daily analysis of the oil content of the cuttings and an inspection process covering the collection, transport and processing of the cuttings. No discharges of OBMs from cuttings or centrifuges are permitted. A 'skip and ship' treatment of the cuttings is the only option permitted under the DCENR Rules and Procedures Manual. If recycling is to be based in Ireland the nearest local authority is the competent authority. If the cuttings are to be transported outside of Ireland, such transhipment is covered by the Basel Convention and a waste management licence is required. If the cuttings are stored onshore pending the completion of the drilling programme, a waste management licence will be required from the Local Authority.

The competent authorities in Ireland in relation to the treatment, transport and disposal of OBM contaminated cuttings are the:

- DCENR www.pad.ie
    - OSPAR (issues re Offshore Industry only)
- EPA www.epa.ie
    - Waste Framework Directive
    - Waste Management Regulations
- Dublin City Council
    - Transfrontier Shipment
- Dept of Environment (most likely candidate)
    - MSDF

4.3.3 Future Developments in UK and European Legislation

Most UK legislation impacting on waste management is now implemented as a result of European Directives. The Waste Strategy for England 2007 includes an objective to increase the amount of waste diverted from landfill in accordance with the EU Landfill Directive. There is an increasing reluctance on behalf of the UK authorities to accept imported OBM contaminated waste from other countries for treatment.

Most Irish OBM contaminated cuttings are exported to the NE of Scotland. The Scottish Environment Protection Agency (SEPA) is the competent authority under the TFS regulations and deals differently with imported waste depending on whether it is being sent for recovery or disposal. Most shipments for disposal are prohibited, and if they are allowed they are subject to notifications controls. Currently SEPA is accepting OBM contaminated cuttings from Ireland as hazardous waste imported for recovery. If there is some element of disposal, for example of cuttings powder residue to landfill, there is likely to be tighter restrictions on imports in the future as pressure on landfill space increases. TFS should only really be used where it is not technically or financially feasible to undertake the recovery or disposal in the country of origin. It is now technically feasible to recover oil from OBM contaminated cuttings in Ireland. If the appropriate licences can be obtained hazardous waste disposal to landfill in Ireland will also be possible. However the lack of a hazardous waste landfill facility in Ireland impedes the disposal of the residue.

The Marine Strategy Framework Directive (MSDF) 2008/56/EC aims to achieve Good Environmental Status for all waters within jurisdiction of EU member states, by 2020, through the establishment of environmental targets and monitoring programmes and programmes of measures (i.e. marine strategies). Ecosystem based marine strategies, developed by member states, will need to be taken into account in future plans for exploration. The Department of the Environment will be the most likely authority to implement the MSDF.

The National Hazardous Waste Plan 2008-2012 recommends that Ireland should strive for greater self-sufficiency in hazardous waste management where this is technically and economically feasible. Economic feasibility means that a project must provide an economic return. Such investments will, for the most part, be funded wholly by the private sector though there may be scope for public private partnerships to be considered for appropriate projects. Certain supports are proposed but these would be relatively minor in the context of total project costs. The one potential exception to this rule is hazardous waste landfill. The National Waste Plan recommends that at least one hazardous waste landfill be developed in Ireland, capable of accepting the wide range of hazardous wastes, including powdered drill cuttings residue, that would otherwise be exported for landfill.

5.0 OPTIONS FOR OBM CUTTINGS TREATMENT IN IRELAND

In the current absence of any onshore processing facility for OBM contaminated cuttings the only option is transfrontier shipment for recycling (and partial disposal) to the UK or mainland Europe. This option can work efficiently if organised and planned well in advance. This option may become redundant in time as the need for landfill disposal of the powdered cuttings hazardous waste may lead to an increasing number of refused imports by SEPA as landfill capacity in the UK declines.

If the offshore zero discharge even after treatment to less than 1% oil on cuttings continues to apply then there will be a requirement for an onshore processing facility and a hazardous waste landfill facility. The National Hazardous Waste Plan 2008-2012 recommends that supports should be available for the commercial development of treatment capacity using new technologies such as thermal desorption. The commercial feasibility of establishing an onshore thermal desorption plant to process OBM contaminated cuttings from Irish offshore hydrocarbon exploration is currently being examined.

6.0 CONCLUSIONS

There are a number of conclusions that can be reached based on the findings of the study.

1. The issue of disposal of OBM cuttings needs to be addressed as it is causing unnecessary confusion for Operators here.

2. Cuttings reinjection, although a well used solution in production wells, is not appropriate for exploration wells.

3. Offshore processing of cuttings and subsequent disposal to sea of the treated cuttings with less than 1% oil on cuttings is probably the most logical and practical solution for rigs with enough space to house the equipment.

4. There is currently no onshore processing facility for OBM contaminated cuttings in Ireland. However there is at least one alliance between an Irish waste management company and a technology company that is actively investigating establishing an onshore processing facility for OBM contaminated cuttings.

5. There is currently no hazardous waste landfill capacity in Ireland to receive the chlorinated residue powder that is a by product of the thermal desorption technique.

6. Transfrontier shipment of hazardous waste from Ireland is a routine activity that is carried out regularly by Irish waste management companies. It is the only method currently used by oil exploration companies to manage OBM contaminated cuttings generated by oil exploration activities offshore Ireland.

7. Transfrontier shipment of OBM contaminated cuttings to the UK may be increasingly subject to refusal by SEPA as pressure on the limited landfill capacity in the UK increases.

7.0 RECOMMENDATIONS

Based on the above conclusions the following recommendations are made:

1. Consideration should be given by the Irish regulatory authorities to adopting the OSPAR Decision 2000/3 on the Use of Organic-Phase Drilling Fluids (OPF) and the Discharge of OPF-Contaminated Cuttings that allows discharge into the sea of cuttings contaminated with OBM at a concentration less than 1% by weight on dry cuttings. This would allow the introduction of offshore processing of OBM contaminated cuttings (using BAT and BEP) and discharge to the sea.

2. The oil exploration companies should hold discussions with the EPA with respect to Section 6.7 of the National Hazard Waste Plan in relation to implementing new technology for OBM contaminated cuttings processing onshore and Section 6.5 of the National Hazard Waste Plan, to facilitate the hazardous waste disposal of chlorinated cuttings powder residue from the thermal desorption process.

3. The IOOA should meet with the IWMA to explore possibilities for joint ventures to deliver mobile thermal desorption units in Ireland during the drilling season and hazardous landfill solutions for the residue.

4. The waste management implications of using oil based mud instead of water based mud systems should be factored into any decision on mud systems made by the oil exploration companies operating in Ireland.

5. IOOA should develop common procedures and guidelines for more efficient skip and ship and TFS of OBM associated cuttings for its members to follow.

6. Oil exploration companies operating in Ireland are encouraged to continue research into new solutions for OBM associated cuttings treatment.

Appendix A Workshop Attendance Sheet

OBM Drill Cuttings Processing & Recovery Project

Workshop Attendance Sheet

Tuesday 18th August 2009

Marine Institute, Dublin

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* Note – '0' omitted after international code ** Land line

APPENDIX B

REFERENCES RELATING TO CUTTINGS RE-INJECTION

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APPENDIX C

Thermal Desorption Case Study Colombia 2005

A thermal desorption process used by BP in Colombia has proven efficient and cost effective in treating oil-based-mud (OBM) drilled cuttings.

Tuboscope subsidiary Brandt, Houston, specifically designed and customized its THOR (thermal oil recovery) system for oil-based-mud drilled cuttings. The system allows for maximum source reduction and minimum waste, recycling, and environmental impact.

BP estimates savings at close to $2 million/well while using thermal desorption. The following items contribute to the cost savings:

Diesel recovered from the cuttings can now be used for new mud makeup (rather than fresh diesel).

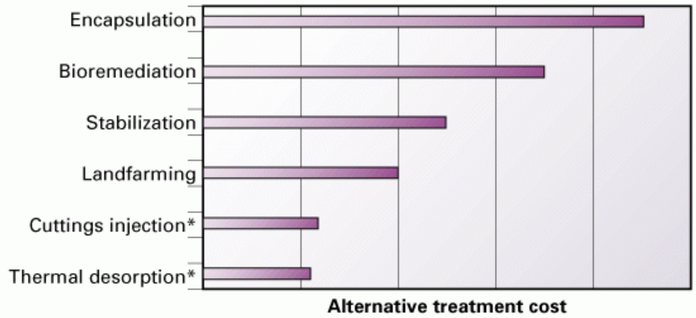
Drilling time is reduced through the use of oil-based mud vs. water-based mud.

Thermal desorption is more economical than other treatment technologies in this particular case.[1]

TREATMENT TECHNOLOGIES

Fig. 1

Technology type	Long-term liability	Waste reduction	Oil recovery or recycling
Encapsulation	√	—	—
Bioremediation	√	—	—
Stabilization	√	—	—
Landfarming	√	—	—
Cuttings injection*	√	—	—
Thermal desorption*	—	√	√



*Cuttings injection is not allowed in many areas of Latin America; comparative analysis was made using US Gulf Coast injection pricing.

Fig. 1 compares other technologies and their associated costs with thermal desorption.

7.1 History

Faced with rapidly tightening environmental regulations, oil companies are finding that the traditional methods of reducing oil on cuttings and some disposal methods for oil-based drilled cuttings are no longer acceptable.

The US Gulf Coast is moving towards zero discharge,[2] and North Sea operators are required to reduce oil on cuttings (OOC) to less than 1 wt % by January 2001.

Land rig operators are finding similar stringent requirements, which lead to increased disposal costs for oily cuttings.

Thermal desorption has been used in the soil-remediation industry for decades. This process involves heating oil-contaminated solids past the vaporization point of the liquid, removing the liquids (oil and water) in a gaseous state, and either recovering or destroying them.

This process leaves the solids clean and oil-free.

Previous testing of these systems in the oil field has proven less than satisfactory.

Oil-based mud drilled cuttings are inherently abrasive and sticky and require high temperatures of vaporization due to the longer-chain hydrocarbons that can be present. Traditional thermal desorption systems were not designed to handle the high btu content of the oil, nor were the materials of construction adequate to handle the temperatures required.

Oil field operators who may have tried thermal desorption at some point in the past will probably attest to the fact that these systems were uneconomical, could not handle the required throughput, and were frequently out of service due to mechanical failures.

7.2 THOR system

The THOR system processes around 7,500 tonnes/month of OBM cuttings contaminated with 25-30 vol % oil and 25-30 vol % water. The raw influent requires no additional pretreatment before processing.

A water-treatment system is unnecessary because the water produced during the process is used in the desorption process for cooling, rehydration of discharge solids, and dust elimination, thus avoiding any water discharge to the environment.

OIL-BASED MUD DRILLED CUTTINGS RESULTS IN COLOMBIA Table 1

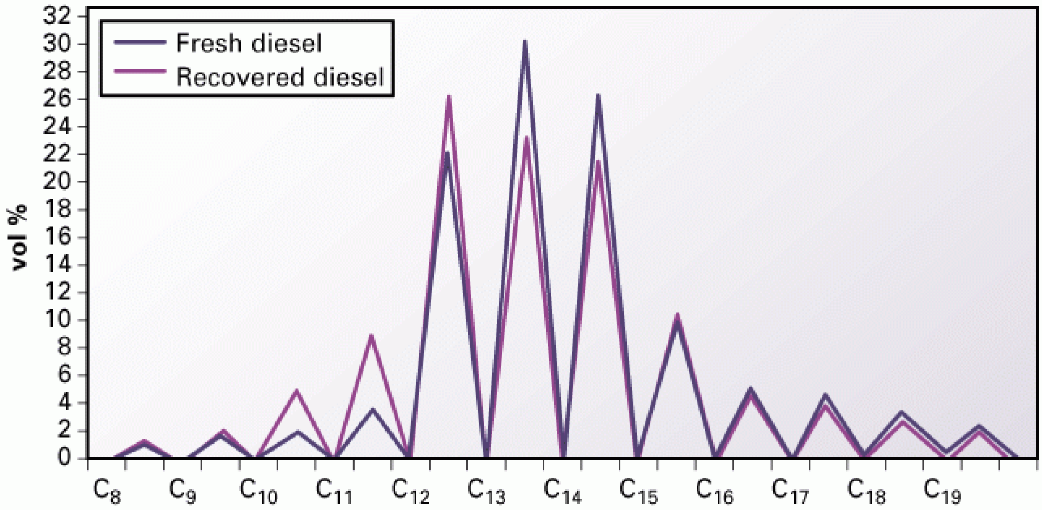
Parameter	Local criteria	Measured
Cuttings oil content (TPH)	—	28 vol %
Feed rate	—	17 tonnes/hr
Feed solids (water content)	—	32 vol %
Weight	—	14.0 ppg
Total petroleum hydrocarbons (TPH) of treated solids	<50 ppm	<10 ppm
Recovered oil - solids content	<1.0%	Nondetect to 0.03% (vol)
Recovered oil - water content	—	Nondetect to 0.08% (vol)

The processed cuttings typically have fewer than 10 ppm of total petroleum hydrocarbons (TPH), and the oil quality far exceeds the results from other technologies. The solids content varies between nondetectable and 0.03% vol % (Table 1).

Laboratory testing has shown that the recovered diesel is remarkably similar in composition to the original diesel in composition and that it may be used in an identical manner.

OIL COMPARISONS*

Fig. 2



*The gas chromatographs show approximate volume percent concentration; composition breakdown by GC/MS, EPA 8270M (direct injection method). Testing shows the oil phase maintaining consistency throughout the thermal process, without significant gradation or formation of new hydrocarbon chains.

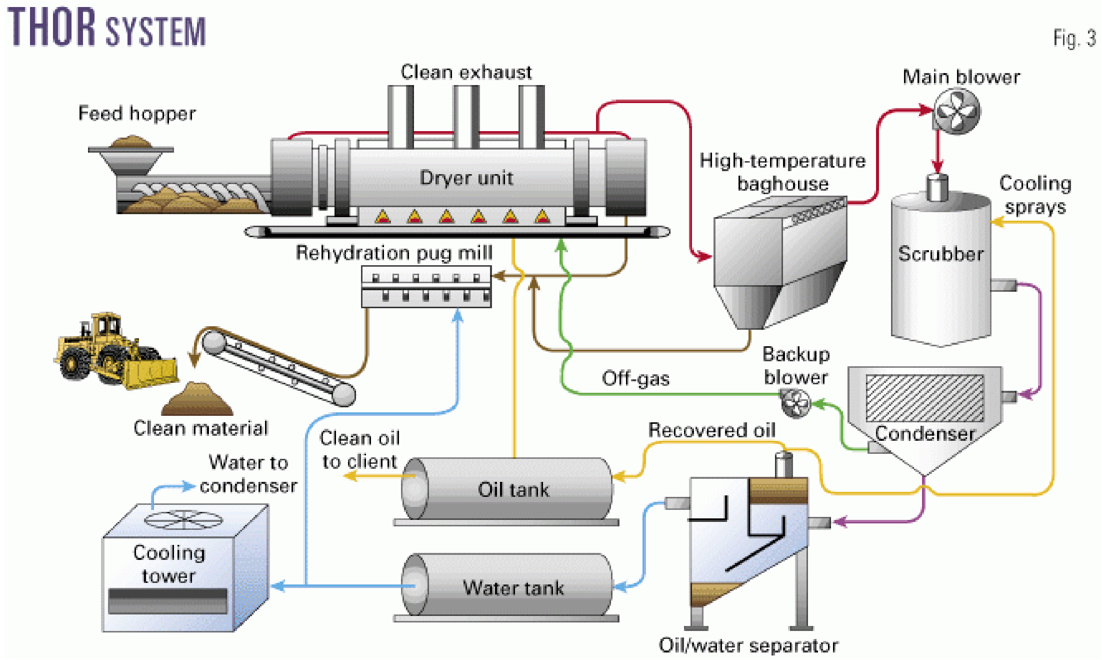
For BP's Colombia application, the THOR system uses approximately 20% of the recovered diesel volume to fuel the thermal process, with the excess returned to BP. The company chooses to use the high-quality recovered diesel to make up new drilling mud (Fig. 2).

7.3 Colombian operation

The OBM drilled cuttings from various drilling locations around the Yopal, Casanare, area are transported in specially designed 12 cu m hermetically sealed dump trucks to the central thermal facility for processing. They are then placed in the steel-lined holding pits, which are used to store material for feeding the THOR unit.

Through a minimum of handling steps, BP ensures maximum logistical efficiency and reduced environmental risk while moving the cuttings from the field.

Once the cuttings are on the THOR processing location, Brandt personnel run a retort analysis and check mud weight to verify the condition of the material and update control documents before proceeding.



Cuttings are then lifted from the holding pit by a trackhoe and placed into the THOR system feed hopper several meters away (Fig. 3).

A variable speed auger in the bottom of the hopper pushes material into the stainless steel dryer at a rate of 15-20 tonnes/hr. The externally heated (indirect) rotary dryer shell rotates within a ceramic insulated refractory firebox designed to withstand internal temperatures of up to 2,200° F.

An integrated positive-sealing system on either end of the dryer shell allows for a slightly negative pressure within the system. Conductive heat transfer through the dryer shell heats the cuttings as they pass along the interior of the drum.

Movement of cuttings through the dryer is proportional to the angle of the dryer (+2°) and the speed at which the dryer rotates. Retention time of cuttings within the dryer is controlled based on moisture content and varies between 20 and 35 min.

Mixing flights and a special cleaning system within the dryer ensure a homogenous mixture and eliminate caking that may occur in the heat transition zones within the dryer.

The cuttings are heated to 550-800° F. before exiting the system; these temperatures ensure complete evaporation of the oil phase from the solids.

Hot processed cuttings leave the dryer through an airlock at the discharge plenum; they are rehydrated and cooled with processed recovered water in a soil conditioner (18 in. mixing auger with water sprays).

These processed inert "oil-free" solids are tested and transported approximately 1 km to the designated area for non-hazardous waste disposal.

The gaseous water and oil phase (evaporated from the cuttings in the dryer) passes through a high-temperature baghouse to remove dust and particulate. The particulate is collected on the outside of the filter bags and conveyed into the soil conditioner.

The "clean" gaseous stream is then condensed back into a liquid with a fin-tube condenser and a closed loop water-cooling tower. The oil and water (now in a liquid phase) are pumped by positive displacement pumps to an oil-water separator-coalescer. The recovered water is stored in a tank on location, to be recycled to the process as cooling and rehydration water.

Oil recovered from the process is stored in a 500-bbl "frac tank" that provides fuel for 40-MMbtu primary burners to heat the process. The oil that is not required for the process (more than 80% of the recovered total) is pumped to storage tanks on location for use by BP to make up new drilling mud.

For each tonne of cuttings processed in Colombia, the system recovers approximately 0.61 bbl of diesel fuel valued locally at $53/bbl. At an average 275-tonnes/day process rate, this equals $8,890/day savings to BP.

Recovery of synthetic or mineral oils can yield substantially greater savings.

7.4 Operation

The BP BA-J20 drilling site in the Casanare area of Colombia in February 1999 during initial installation reveals (bottom to top) equipment layout for dryer, baghouse, condensers, oil-water separator, generators, and (right) control room. (Fig. 4; photograph by Douglas M. Odle, courtesy of Brandt)

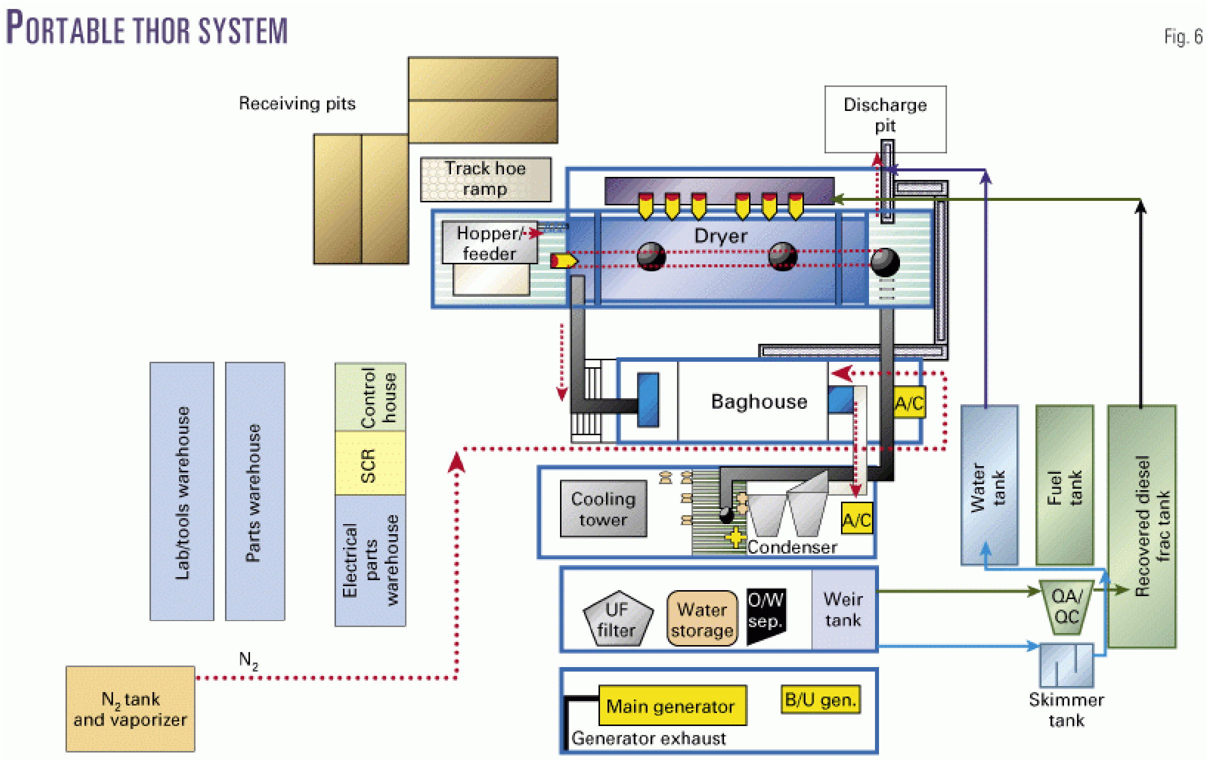
The BP BA-J20 drilling site in the Casanare area of Colombia in February 1999 during initial installation reveals (bottom to top) equipment layout for dryer, baghouse, condensers, oil-water separator, generators, and (right) control room. (Fig. 4; photograph by Douglas M. Odle, courtesy of Brandt)

The THOR system (Fig. 4) has been operating for BP Colombia since early 1999. During its first year of operation, the system successfully processed more than 78,000 tonnes of oil-based mud drilled cuttings (approximately 250,000 bbl), and recovered more than 41,000 bbl (1,722,000 gal) of oil that would have previously been fixated with lime and most likely retreated again later.

Independent stack testing has shown air emissions are well below the standards set forth in the EPA 1990 Clean Air Act and more than 90% less than local Colombian emission standards.

As the oil associated with the cuttings does not come in contact with an open flame, the actual emissions are the byproducts of combustion from the burners only, which are tuned to achieve close to stoichiometric conditions.

Actual system throughput depends on the initial moisture content of the cuttings. Water takes a significantly higher percentage of btus to evaporate than does oil (Fig. 5).



As shown in Fig. 6, the portable THOR system operates 24 hr/day with shutdowns for regularly scheduled maintenance. The footprint of this particular installation is approximately 100 sq ft.

Cleaned cuttings at the BP BA-J20 site (bottom center) are being discharged from the dryer unit through the rehydration auger. The trackhoe bucket (top-right) feeds raw cuttings slurry into the feed hopper (Fig. 7; photograph by Brad Wood, courtesy of Brandt).

Cleaned cuttings at the BP BA-J20 site (bottom center) are being discharged from the dryer unit through the rehydration auger. The trackhoe bucket (top-right) feeds raw cuttings slurry into the feed hopper (Fig. 7; photograph by Brad Wood, courtesy of Brandt).

Not only has the THOR system (Fig. 7) allowed BP Colombia to realize greater economical savings, there are many social and environmental benefits associated with this operation, including:

- Reduction of waste transportation
- Reduction of land requirements

- Shorter treatment time
- Reduction or elimination of long term environmental liability
- Maximization of recycling
- Less pollution to the environment
- Better community relations with the creation of new job opportunities.

7.5 References

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7.6 The authors

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