INJECTION OF OIL SPILL CHEMICALS INTO A BLOWING WELL

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ABSTRACT: *As part of the research program Dispersion of Oil on Sea (DOOS), a subproject has been carried out to develop an all-weather method for oil spill cleanup.*

The aim of the subproject was to evaluate the possibility of injecting oil spill chemicals into a blowing well. Different completion systems were studied as well as different methods for injection of chemicals. The idea behind the method is to improve the oil spill situation by reducing the response time as well as by providing a method usable in all weather conditions. The method will be of special value for wells located near the coast or in other sensitive areas (e.g., arctic regions).

The work concludes that it is possible, and with only a limited need for development of new equipment, to inject chemicals into a blowing well. The injection should be done in the annulus, or through a separate tube. From the annulus the chemical will be inserted into the tubing through a valve.

Norwegian oil spill contingency planning is primarily based upon the use of mechanical equipment for containment and recovery of oil. The operation of this equipment is limited by weather conditions—operational limits are normally set to a sea state with significant wave height less than 2.5–3 m.

Use of chemical dispersants has wide application in oil spill cleanup operations abroad. However, until now Norwegian authorities have been reluctant to use dispersants. Present regulations permit the use of dispersants in the immediate vicinity of offshore installations if needed to reduce the hazard of fire. During the past few months the Norwegian authorities have also stated that dispersants may be used against nearshore spills. However, no efficient chemical oil spill response system exists for offshore locations.[4]

The rate of natural dispersion is a function of many factors, among which oil viscosity and slick thickness are important. The formation of water-in-oil emulsions results in an increase in viscosity and thickness of the oil on the surface. The thicker and more viscous the oil, the slower the natural dispersion.[4] By preventing the formation of stable emulsions, the rate of natural dispersion of oil into the water will increase. One concept for achieving this is to add oil spill chemicals (dispersants or demulsifiers) to the oil at the point of discharge. This will prevent emulsification and improve horizontal spread thus improving natural dispersion of oil into the sea. Direct injection of chemicals will also reduce the amount of chemicals needed due to improved mixing of oil and chemicals. Furthermore, the concept is expected to be weather independent.

Injection of chemicals in a blowing well

The objective of our study was to study and evaluate the technical viability of injecting chemicals directly into a blowing well. This may be done either through the annulus to an injection valve mounted on the casing/tubing, or through an injection valve mounted on the wellhead. The concept is directed toward both exploration and production drilling.

The technical arrangement of an injection scheme is dependent on the well type. It is therefore of particular interest to investigate the problem with the object of finding feasible engineering solutions involving a minimum of interference with normal operations.[2]

The principle of accessing the well bore below the mud-line suspension is well known for a variety of various technical solutions (artificial lift, installation and operation of downhole safety valves, and other specialized applications). Technical solutions to accessing the well, bringing the dispersant to the preferred well depth, and its injection into the wellbore are dependent on factors such as cost, injection rate requirements, specified well bore installation design, and well type.

In this paper we present results from studies of the drilling phase of fixed platforms. In the main project, however, studies of the production phase and of wells where the wellhead is placed on the sea floor (semisubmersibles, jackups, and drill ships) were included. Figures 1 and 2 describe a flow scheme for possible solutions to the injection concept for different types of installations and different phases of the operation.

The following criteria have formed the basis for our study:

- The well system considered is of the Statfjord type: casing sizes of 30, 20, 13⅜, and 9⅝ inches with a 7 inch tubing. The injection system should be operational from the time when the 13⅜ inch casing is run and cemented, throughout the lifetime of the well.
- The injection system must not be exposed to severe stress during normal operation. In addition, it should involve a minimum of new technology and it must not reduce the reliability of the existing well system.

System installation and operation

Four critical phases have been recognized in connection with the supply of chemicals to a blowing well: chemical transport to the wellhead, access through the wellhead, downhole supply through the annulus, and injection into the blowing oil. A possible solution to these problems is discussed below.

Chemical transport to the wellhead. During drilling of production wells, a temporary supply hose of 4 to 8 inch inner diameter must connect a pumping unit on the fixed platform to the wellhead located on the cellar deck (Figure 3). The hose must have the same degree of fire resistance as the applied wellhead.

As the drilling operation continues and the 9⅝ inch casing has been cemented, the supply tube connection is switched from the 13⅜ inch to a 9⅝ inch annular valve (Figure 4). The tube is permanently connected to the injection manifold established as the wells are put on production.

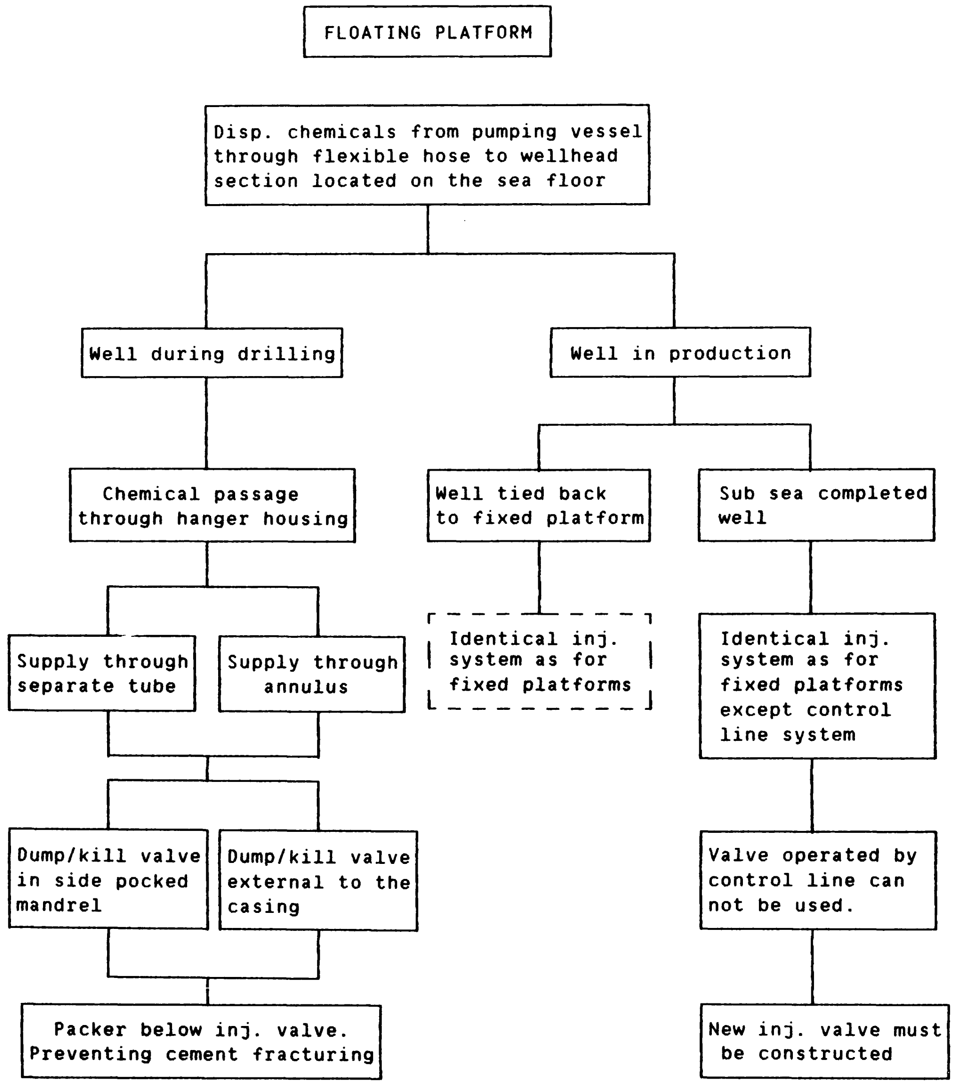

Figure 1. Flow scheme for possible solutions to injection of oil spill chemicals on floating platforms

The manifold valves must be hydraulically operated from at least two consoles, of which one is located close to the BOP (blowout preventer) control console. Supply of chemicals to the injection manifold must exist through two supply tubes which terminate on opposite sides of the platform, and allow connection with a pumping vessel without any use of personnel on the fixed platform (Figure 3).

Figure 4 shows a recommended injection system for fixed platforms. When the well is put on production, of the three installed injection systems shown only that mounted to the tubing is operational.

Access through the wellhead. During the drilling operation the BOP stack is always mounted on top of the last run casing and wellhead section (Figure 3). During well completion the BOP stack is removed and replaced by a Christmas tree. Assuming that the wellhead, independent of BOP stack and Christmas tree, is still intact when facing a blowout situation, the easiest way of achieving access through the wellhead is through the existing annular valves. The valve bores' inside diameter (ID) is in the range of 1 to 2 inches, and will ensure sufficient flow rate directly into the annulus.

The further transportation of chemicals down the annulus to the injection valve depends on the well operation.

Downhole supply of chemicals. Transportation of chemicals from the wellhead to the injection valve may take place in two different ways: (1) through a thin injection tube strapped to the casing (Figure 5), or (2) through the uncemented annulus (if the upper part of the annulus has been left uncemented, Figure 6).

In the first case, the use of a thin steel tube of ¾–1 inch ID strapped to the casing, and run with the casing string is recommended (Figure 5).

The entrance of the injection tube is located just below the casing hanger and therefore does not allow cementing up to the casing hanger. A leakproof connection between the wellhead and the injection tube, which would call for standard cementing routines, is impossible under these conditions. Because of the large size of the supply tube strapped to the casing, it is not likely that it can be run without extensive alterations being made to the hanger.

If the annulus is chosen as the conduit for the injection fluid, it has to be kept in mind that a sufficient interval of the annulus below the wellhead must remain uncemented (Figure 6). The length of this uncemented section is determined by the required installation depth of the injection valve. A depth of 100 m below the wellhead should ensure a sufficient mixing of the chemicals with the flowing oil in the tubing before it reaches the surface (platform). Slightly below the injection valve, a permanent packer should be installed to prevent fracturing of the cement as a consequence of the high pressure generated during the injection operation.

A drawback of choosing an open annulus as the injection path for

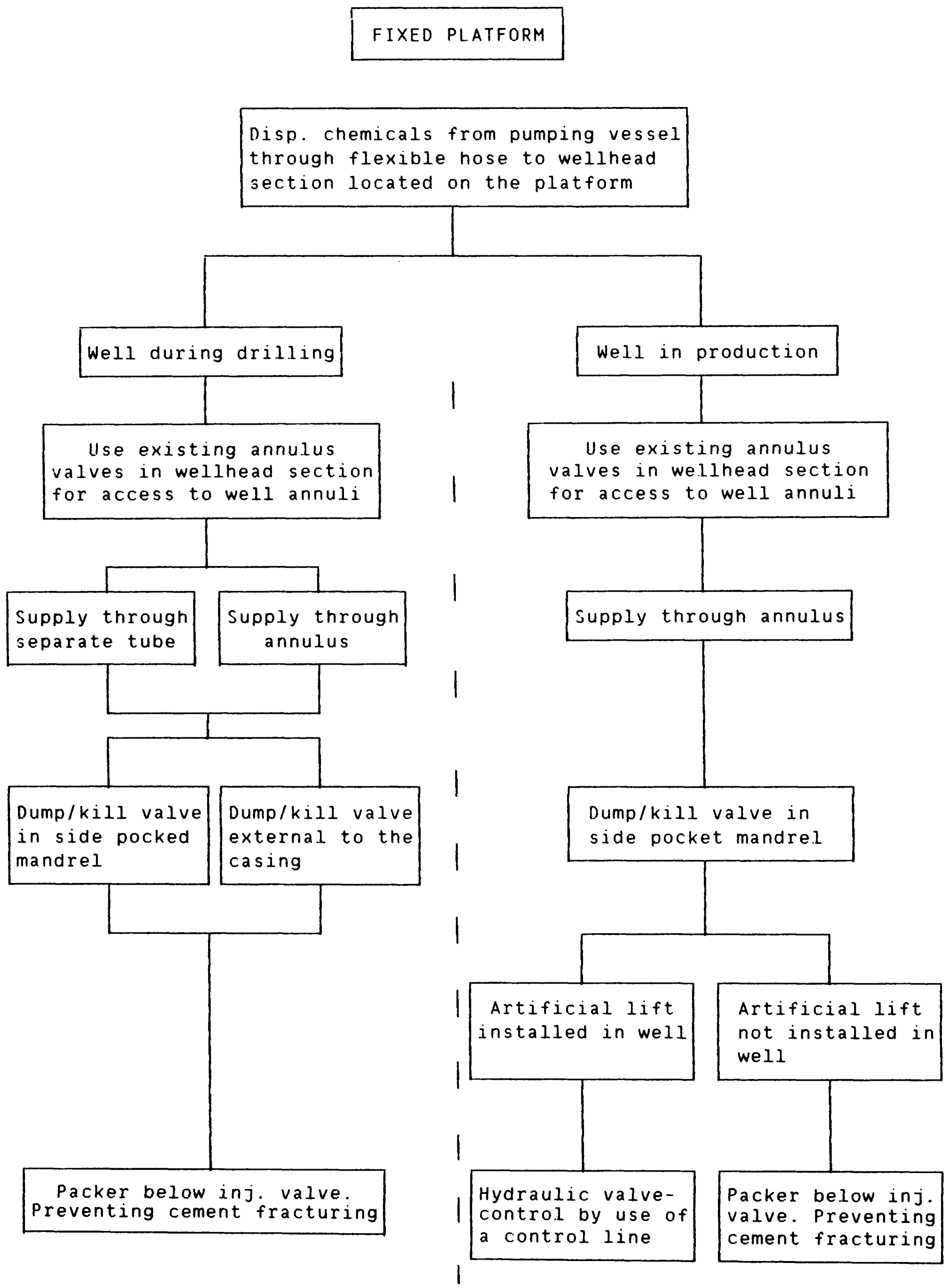

Figure 2. Flow scheme for possible solutions to injection of oil spill chemicals on fixed platforms

the chemicals is, as mentioned, that the casing cannot be cemented all the way up to the ports in the wellhead. This results in a less stable wellhead system and is also in conflict with regulations given by The Norwegian Petroleum Directorate requiring cementing of all casing strings between 30 inches and 13⅜ inches diameter, up to the casing hanger.

On the other hand, an annular solution will minimize the pressure drop in parts of the injection system—i.e., from the wellhead to the injection valve.

The injection valve. The selection of a valve for injection of chemicals into the tubing, 30–300 m below the wellhead, is independent of the chosen conduit of supply. In this study a dump/kill valve is chosen. To ensure the reliability of the valve, it should be located in a side pocket mandrel, modified for use in casing strings. Figure 5 shows a dump/kill valve mounted in a side pocket mandrel. Such a system would allow retrieval of the valve for workover by wireline.

The alternative is to locate the valve exterior to the casing, that is, in the annulus between adjacent casing strings. This solution does not permit workover operations to be performed on the injection valve.

In either case the valves must be sealed to prevent the drill mud from destroying the mechanism when the injection system is inoperative.

Limiting conditions

As part of this study some calculations were carried out to determine the limiting factors such as power requirements vs hose diameter and length. A summary of these results is presented below.

We have chosen an example from a subsea completed well or exploration well (similar conditions) and calculated power requirements from the pumping unit.

Input data	
Released amount of oil	10,000 m^3/d
Dispersant : oil ratio	1 : 25 (4%)
Oil viscosity	30 cp
Distance, pumping vessel-wellhead	1,000 m
Dimension, pumping hose	4 inch ID
injection tube	1 inch ID
Depth, wellhead-injection valve	300 m

From the calculation scheme and according to pressure drop formulae, the needed power from the pumping unit is estimated to be: W = 115 hp which is rather low compared to available pumping capacity on supply vessels and platforms.

As a result of pressure drop calculations, and the conditions listed, it can be concluded that the supply of chemicals from the annular valve located on the wellhead down to the injection valve should take place through the open annulus. This seems to be the simplest and most reliable chemical transportation path. Under certain conditions, however, there might be problems related to the opening mechanism of the valve, and also a risk of cement fracturing due to the high injection pressure.

Discussion

The injection concept is intended for use as an alternative and in situations where no other action is adequate.[1] The method may be particularly relevant in early stages of a blowout (before mechanical equipment is operative), in situations where mechanical cleanup actions are impossible (bad weather), or in situations where other actions are insufficient (that is, for a combination of mechanical and chemical measures).[6]

The consequences of complete dispersion of the released oil into the sea are expected to be different from present known situations (mechanical clean up or low-effectiveness aerial dispersant spraying). As described by Figure 7, the drift time to the shore for untreated oil may be as low as a few hours for certain nearshore sites.[3] The contingency plan will hardly be activated during this time and the damage may therefore be significant. Dispersed oil will, on the other hand, be carried away by the currents and cause little damage to the shore.[5]

The damage reduction potential for the injection concept is expected to be large. However, the negative effects also may be significant for some periods of the year (e.g., spawning periods, when fish eggs and larvae are present). It is therefore necessary to establish the knowledge of these effects before utilization of the concept will be accepted by the pollution authorities.[7]

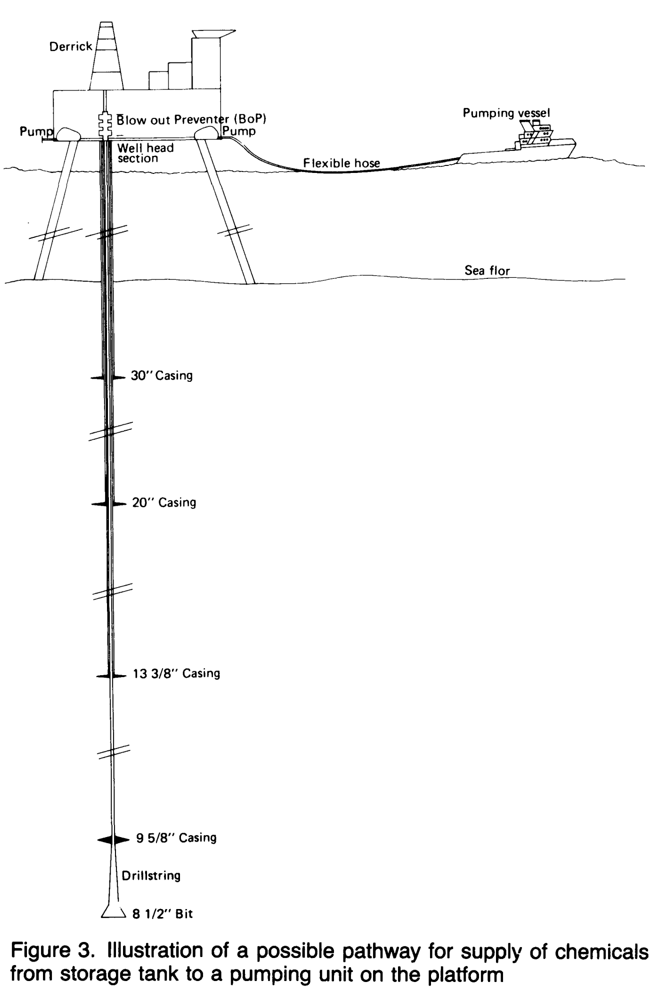

Figure 3. Illustration of a possible pathway for supply of chemicals from storage tank to a pumping unit on the platform

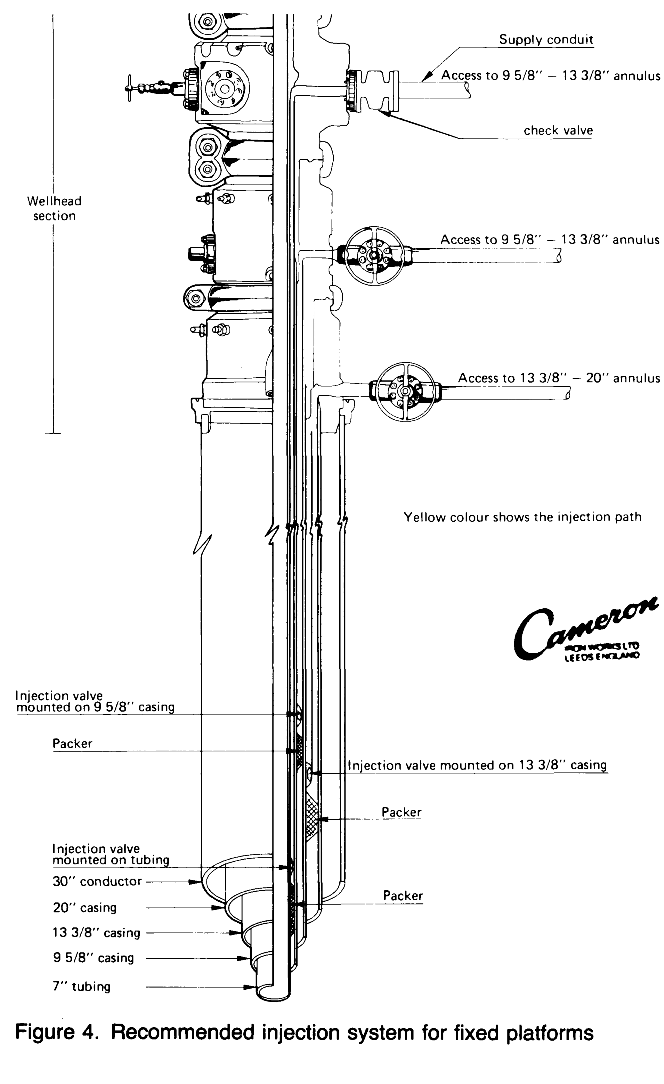

Figure 4. Recommended injection system for fixed platforms

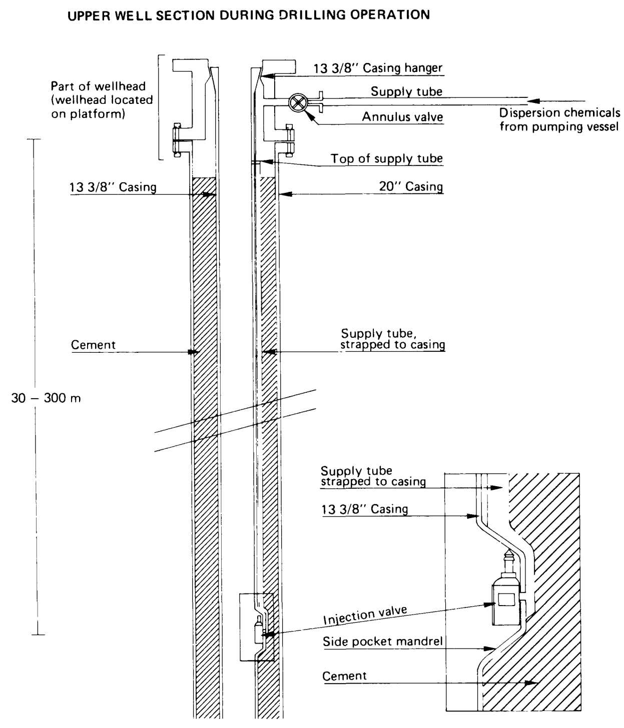

Figure 5. Chemical supply through small diameter tube, strapped to casing

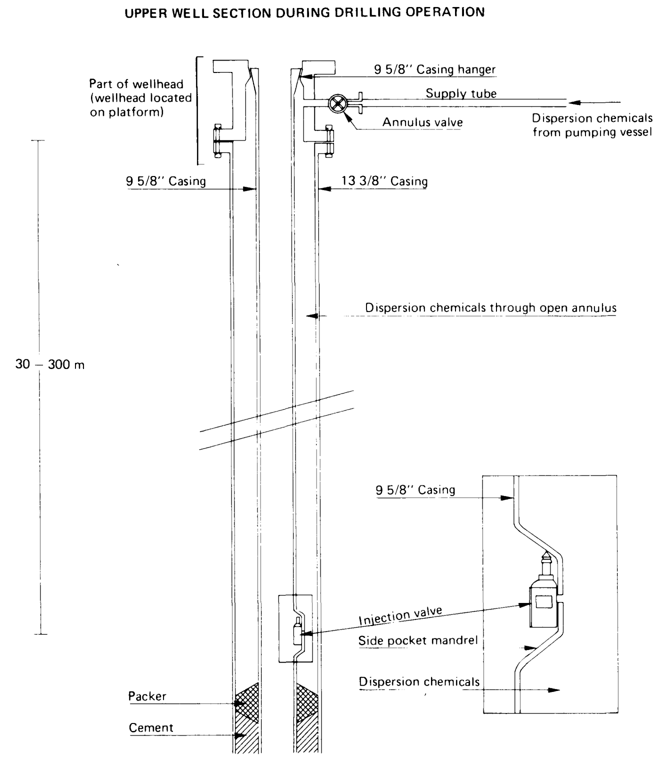

Figure 6. Chemical supply through open annulus

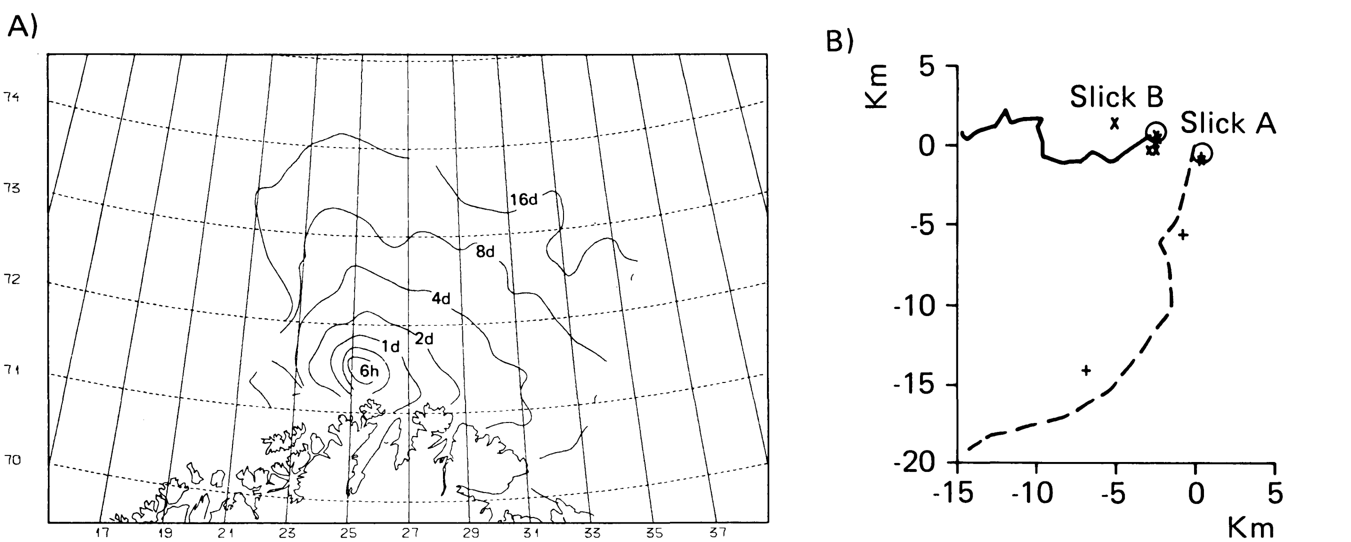

Figure 7. (A) Drift time to shore from untreated oil released on Troms II, Norway; (B) Drift of dispersed oil (slick B, x) and untreated oil (slick A, +) vs drift of drifter with underwater sail (——) and of drifter without sail (– – –).

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