backside of the rule as one of the conversions) and the 100% dispersion on **scale 12** which gives the lifetime of spill on **scale 14** ($\pm$ 40 h).

When one wants to know whether a certain sensitive area or part of the coast is in danger of oil pollution, this danger can be estimated by means of this slide rule as follows. At a certain or supposed winddirection and windspeed, by means of the transport-scale the drifttime can be determined. If within this drifttime and at the earlier used windspeed 100% dispersion does not take place, the area is in danger of oil pollution and combat action will be necessary to prevent this.

Emulsification

Emulsification is the process of suspension of drops of water in oil. Because of this the mass that looks like oil but in fact is an oil-water mixture increases. Because the mass-balance is mainly meant to acquire an indication of how much 'oil' must be cleared away, this uptake of water is taken into consideration. The fact is that the whole looks like oil. In practice it often will be evident whether dispersion or emulsification will take place; hardly ever both processes take place at the same time.

For emulsification of drops of water in oil to take place, four conditions should be satisfied:
- thick oil-layer during several hours (first four hours more than 0,75 mm);
- asphaltene-content larger than 0,75 (Volume %) or (V %);
- waxcontent larger than 1 (Volume %) or (V %);
- there must be a certain energy level in the water surface (waves, swell, etc.).

If one of these conditions is not satisfied, an instable emulsion may be formed and dispersion will dominate.

As an example: A spill of 5.000 m³ of Kuwait crude contains after 10 hours 40% water which can be found by selecting on **scale 14** the time and on **scale 15** the watercontent can be read off.

In case this slick (the residual oil after evaporation) floats at the seasurface with a windspeed of 8 m/sec. ($H^{1/3} = 1,2$ m) then $\pm$ 37% has been evaporated in 10 hours and $\pm$ 13% has been dispersed which means that the original oil volume has been decreased by $\pm$ 46% (37% + 13% of 63%), with the density of 870 kg/m³, the residual volume of oil $\pm$ 2700 m³ (54%) contains 40% emulsified water which means that after 10 hours the amount of recoverable water-in-oil emulsion is $\pm$ 4500 m³ (2700 m³ = 60%).

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oil spill slide rule manual

Oil spill slide rule manual

1 2   3 4   5 6   7 8   9 10

11 12

13   14   15
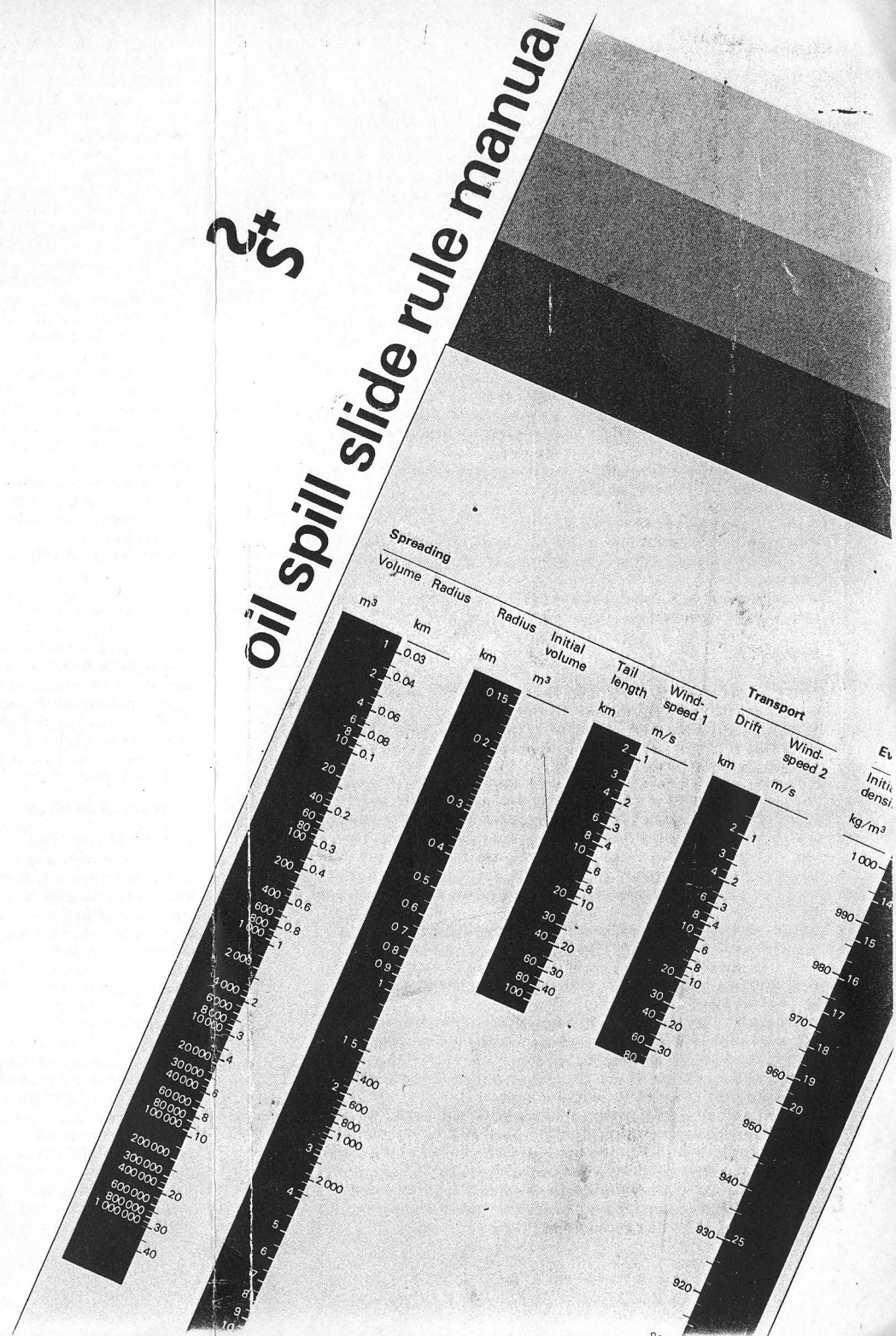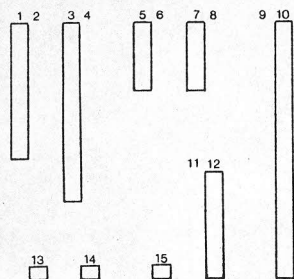
*Front of the Oil Spill Slide Rule
(with scale numbers)*

The prediction of the fate of an oil spill is one of the most important aspects for an optimal oil combat action. Many computer models have been developed for predicting this fate. These models can result in reliable output if the input information is correct. The result will stand or fall with the input data and this very information is often not available.
The North Sea directorate of the Department of Transport and Public Works of The Netherlands developed this Oil Spill Slide Rule, by which very fast and with very limited input data the necessary predictions can be made.

For its use only the following information is required:
- the quantity of oil released (m³);
- the windspeed;
- the specific gravity of the oil (kg/m³).

With this slide rule it is possible to calculate important data, like spreading, transport and mass-balance, for clean up operations and trials.
The following goes into the subject of the application of the slide rule and the restrictions.

Spreading

This part of the slide rule can be used in different ways. As long as an oil spill is homogeneous, the area of the concentrated part of a slick can be fixed as a function of time. The radius of the concentrated part can be fixed by reading off the radius with a certain time and oil volume.
As an example: a slick with an initial volume of 100 m³ gives a radius of 0,4 km after 6 hours and a radius of 0,6 km after 20 hours. Select on **scale 14** = time, on **scale 4** = initial volume, which gives on **scale 3** = radius. The length of the tail which often appears behind an oil slick can be determined by the time and 2% of the windspeed. On the slide rule, next to the windspeed at a certain time, the length of the narrow tail can be read off.
As an example: at a windspeed of 10 m/sec (5 on the Beaufort scale) the tail is approx. 4,3 km after 6 hours and 14 km after 20 hours. In the example just given the width of the slick is 0,8 km after 6 hours and the length of the total polluted slick area is approx. 5,1 km.
The length of the total oil spill will be the length of the tail plus twice the radius; the width will, for convenience, be twice the radius. Here should be pointed out that with major changes of the winddirection the oil tail disappears after a while and a new tail will appear in the new winddirection.
The bulk contains 95% of the remaining oil; that is why the combat must be concentrated on this part. The mass-balance should also be applied for the thick layer. In course of time the concentrated part will divide itself separate spots. The cummulative area of all these seperate spots can still be determined then, but not the dispersive area in which these separate spots can be found. With this spreading scale also the volume of spilled oil can be determined, if this is unknown. If the time of spillage is known, the volume can simply be read off at the area of the concentrated part.
As an example: It is known that the spill happened 6 hours ago and during air-surveillance the slick width was 0,6 km, which means a radius of 0,3 km (select on **scale 14**: 6 hours and on **scale 3**: 0,3 km, which gives on **scale 4**: 40 m³ as the initial spilled volume).
Often the time of spillage (time = 0) is unknown. In that case there are two possibilities to find out the quantity of oil spilled on the water after all. The simplest method is to determine the time by means of the taillength and the windspeed. With this fixed time and the dimensions of the slick, which can be measured, the volume can easily be determined.
As an example: during an air-surveillance a slick with a length of 1,6 km and a width of 0,2 km has been seen. The windforce is 10 m/sec. The sheen (tail) behind the slick is thus (1,6 km minus 0,2 km) 1,4 km. This means that the slick is 2 hours old (select windspeed on **scale 6** and the taillength on **scale 5**, which gives on **scale 14**: lifetime of the slick). Knowing the lifetime the radius can be found by selecting the time on **scale 4**. The other method is to measure the area of the thick part at two given moments. By 'trial and error' the volume that goes with it can now be determined.
For convenience, determination of the layer thickness is also possible with this slide rule. At a measured, or by slide rule determined radius, the layer thickness can be read off depending on the volume of oil
As an example: With the slide rule it can be found that a spill of 10 m³ of oil has a radius of 150 m after 3 hours. To find the layer thickness select on **scale 2** the radius of the concentrated part and on **scale 1** the (residual) volume which gives on **scale 13** the average layer thickness. In this example if all the oil is still on the water surface the average layer thickness is ± 0,14 mm.
The volume mentioned here is not the original volume described earlier, but the volume after evaporation and dispersion, possibly with emulsification (see mass-balance).
This last scale on the slide rule can for example be useful if one needs a certain layer thickness for a trial. The moment when the right layer thickness will be reached, and also what radius the spill must have at that time, can be determined.

The drift of an oil spill

The drift of an oil spill depends on the windspeed and the speed of the current. The speed of the current is so varied locally that this is not taken into consideration on the slide rule. It is very important however for the transport, because the drift of an oil spill is equal to the speed of the current plus an extra transportation because of the wind. This extra transportation can easily be determined with the slide rule. On the slide rule a windfactor of 3% of the windspeed has been used.
This transport depends however on the layer thickness; thick oil layers will have more and thin layers will have less drift.
This scale is particularly meant for use at sea or large inland waterways. On rivers and canals the transport is mainly determined by the speed of the current.
At sea also the drifttime to shore can be determined with this scale. By means of the distance of the oil spill from the coast in the direction of the wind, and the prevailing windspeed, this drift time can be read off.
As an example: An oil spill floats 2 km from shore. The windspeed is 8 m/sec. perpendicular to the coast.
To find the drifttime to shore select on **scale 8** the windspeed and on **scale 7** the distance in the winddirection to the coast, now the drifttime can be read at **scale 14** (2,25 h).

Mass-balance

By certain processes the quantity of the oil to combat is reduced while other processes make this quantity increase; this is usually called mass-balance. On the slide rule the most important processes for estimating the mass-balance are given, namely:
- the evaporation;
- the dispersion;
- the water-in-oil emulsification.
Other processes such as biodegradation and photo-oxidation play a more longterm part, and since this slide rule is an expedient article during the combat action (short-term), these processes have conveniently been neglected.

Evaporation

Evaporation is a process by which a part of the oil disappears. This process plays a most important short-term part (during the first hours) in mass-balance. To be able to show this process on the slide rule strong simplifications have been applied.
The slide rule offers only the possibility to use three variables of which time is one. These simplifications, like constant temperature (10°C), layer-thickness (2 mm) and windspeed (10 m/sec.), particularly influence the velocity of the evaporation. But because the evaporation process is especially very fast during the first hours and after that rapidly stabilizes, these simplifications are hardly influential in the long run (more than 10 hours after the spillage). The evaporation-scale on the slide rule should mainly be regarded for the evaporable part of crude oil. Oil products behave different, and for these this scale can serve at best as an indicator.
As an example: 100 m³ of Kuwait crude has been spilled in a harbour. To find the amount which has been evaporated after 10 hours, one has to know the specific gravity of the oil in this case 870 kg/m³.
Now select on **scale 9** the initial density (870 kg/m³) and on **scale 14** the time which gives on **scale 10** the evaporated percentage in this case 37%.

Dispersion

The dispersion of oil drops in the water column is also a process by which oil disappears from the water surface; this oil therefore does not have to be combatted. The dispersion process depends on the energy in the water surface (e.g. wave-energy).
The significant wave height $H^{1/3}$ (m) is a standard for this energy and can easily be determined because this itself depends on the windspeed.
By use of the windspeed or the significant wave height the dispersed volume percentage can be read off. This is a percentage of the remaining oil-volume after evaporation. Here also a small error is introduced, because the part that is dispersed cannot take part in the evaporation process and conversely. By first determining the evaporated part and after that the dispersed part, the error will be as small as possible.
It is mainly this dispersion that can have affects on decision making policy. By evaporation, except for some very light oil products, often only a part of the oil disappears, while by the dispersion process **all oil** may disappear from the water surface. This process essentially determines the time an oil spill will stay on the water surface.
As an example: In case of a spill of 100 m³ of Kuwait crude on the seasurface at a windspeed of 13 m/sec. (6 on the Beaufort scale) the lifetime can be found by selecting on **scale 11** the significant wave height ($H^{1/3}$ = 2,5 m) (which can be found on the