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**INTERNATIONAL COUNCIL FOR
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**FULL SCALE TESTS ON THE INTERACTION BETWEEN BOTTOM FISHING GEAR AND
AN 18-INCH MARINE GAS PIPELINE IN THE NORTH SEA.**

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Abstract

The paper describes the fishery side of experiments carried out by a research team of various governmental departments and the oil and gas industry on the effects of the impacts of commercial bottom fishing gear at a partially - or unburied pipeline in operational use. The experiments were held early 1984 on the NAM K7/K8 18-inch gas pipeline situated on The Netherlands Continental Shelf. It was confirmed that pipelines with the new type of coatings can endure the impacts of fishing gear without ill effects to operation or safety. The forces encountered by the fishing gear, especially the beam trawl can be considerably reduced by special designed adaptations of the trawl head (trawl shoes) on the lines as those developed to avoid the hooking of marine telephone cables. The forces measured in the warps are of the same order of magnitude as measured when the gear strikes boulders or is running into sand dunes.

Introduction

The interaction between fishing gear and marine pipelines was discussed at the 65th Statutory Meeting of ICES (1977) (MCINTYRE & DE GROOT, 1980). Insight into this relationship was mainly obtained through the extensive research program carried out between 1974-1979 at the River and Harbour Laboratory, Trondheim (VHL), now part of the Norwegian Hydrodynamic Laboratories. The research was supported financially and technologically by the industry and authorities of The Netherlands, Norway and the United Kingdom and gave rise to several publications which have greatly increased our knowledge (DE GROOT, 1982).

Fishing gear, beam-, otter trawl, various trawl boards (oval, rectangular, V-shaped) was tested on sections of 16 and 36-inch pipelines on bottom.

Recommendations were put forward to reduce the heavy damage caused by the trawl heads of the beam trawl and the trawl boards to the concrete coating of non-buried or semi-buried pipelines and telephone cables (DE GROOT, 1979).

These recommendations were partially taken up, in fact only to lessen the damage to marine telephone cables (ANON. DE BRUIN, 1979; DE GROOT, 1979).

The offshore pipeline industry absorbed the lessons from the experiments and this was translated into reinforcing the concrete coating with various types of weaponing. This was successfully accomplished and pipelines today can withstand without any serious damage the impact of fishing gear.

The better understanding of the problems of pipeline burying, and the interactions with man-made hazards have led in several countries to lessen the regulations on pipeline burial. For The Netherlands this resulted into a reduction of the required 2-meter cover to 20 cm of marine pipelines.

And even there are sufficient grounds to expect that a pipeline may lower itself by natural process into the seabed (scour, erosion (lee-, tunnel)), dispensation is given for a certain amount of time to cover the pipeline, and await the results of this natural process (VAN DONGEN, 1983).

It is also well known today that artificial burying is on some spots often of a relative short duration and adds more hazards to the existence of the pipeline.

The need was felt for a new appraisal of the relation pipeline - fishing gear in the light of the need of burying the pipeline to avoid unacceptable risks for the fishing industry.

A group was formed in The Netherlands on a initiative of the Nederlandse Aardolie Maatschappij (NAM), with the Koninklijke Shell Exploratie en Produktie Laboratorium (KSEPL), Staatstoezicht op de Mijnen (Ministry of Economical Affairs), Rijkswaterstaat Directie Noordzee (Ministry of Publicworks and Transport) and the Rijksinstituut voor Visserijonderzoek (RIVO) (Ministry of Agriculture and Fisheries).

This paper reports in brief the fisheries side of the obtained results. The full report will be made available by NAM in due time, however, at present it is still unaccessible.

Aim of the experiments

The aim of the experiments was two-fold:

1. To show based on earlier calculations and experiments, that unburied pipelines can withstand the impact of bottom fishing gear.
2. To show that unburied pipelines offer no unacceptable risks damage or hindrance to the fisheries.

Materials and methods

The experiments were carried out on the K7-FA-1/K8-FA-1 NAM 18-inch gas pipeline (ICES F338) in the period 30 January - 29 February, 1984, with a 1900 HP Dutch beam trawler "ANNA HENDRIKA" - KW 45. The trawler was equipped with two beam trawls each about 70 kN (7000 kg) in weight. The trawler is a representative vessel of its class, built in 1982. The weight breakdown of the gear is about:

net material	- 12 kN (1200 kg)
trawl heads and beam	- 38 kN (3800 kg)
chains and ticklers	- 20 kN (2000 kg)

For the duration of the experiments the trawler was also equipped with a bottom trawl with rectangular trawl boards of 11 kN (1100 kg) each.

A second vessel was used in the experiments, the Survey vessel "Mitra" of the Rijkswaterstaat, Directie Noordzee equipped with a remote controlled underwater vehicle to study the impact of the various trawl hits on the pipeline and the equipment for the Sonar Mapping System (SMS). Both vessels were equipped with the standard navigation apparatus, as well as a hyperfix navigation system with an Autocarta Mark II micro-processor, a left/right indicator, printer and a Houston DP-3 plotter.

The pipeline was partly buried by natural process, however, also on bottom or half exposed. The bottom sediment consisted of a silty clay. The gas flow through the line was uninterrupted during the trials. Before and after the experiments the pipeline was surveyed, with the aid of an underwater vehicle, for outward signs of the impact forces.

The tests were carried out with beam trawls - with and without "adapted" trawl heads - with a bottom trawl and with a trawl board lying flat on the bottom. The towing speed, angle of attack and direction were varied. Two towing speeds were selected, one representative for the type of vessel and gear, 7 knots, and a low speed of 4 knots to study the possible effects of e.g. hooking. The angle of attack varied between 90, 60 and 30 degrees.

In all, the test programme consisted of 36 crossings of the pipeline with fishing gear (adapted trawl head - 12; unadapted trawl head - 12 (beam trawl), bottom trawl - 12) and 3 tows with flat lying trawl boards over the pipeline.

Results

Towing speed:

Beam trawl - a high towing speed (7 kn) resulted in a heavier (10 %) impact on the pipeline than a lower towing speed (4 kn). Otter trawl - there were hardly any differences between the impact forces with the two towing speeds.

Angle of attack:

With an angle of 30 degrees and also, however, less, of 60 degrees. The beam trawl will slide more often over larger distances along the pipeline before it will be pulled over. This was also observed for the trawl boards.

Direction:

The direction of the attack was also of importance as due to the main bottom current, sand movement and scour, one side, here SW was more embedded into the seabed than the other side (NE). The more embedded side was far less an obstacle for the passing gear. The non-adapted beam trawl went less smooth over the pipeline, than the adapted one. The adaptations consisted of a hoop welded in front of the trawl head. The pipeline on bottom was an obstacle especially for flat lying trawl boards.

Forces measured in the towing warps (Table I):

The forces in the towing warps were measured with a 50-tons tensionmeter. The obtained data are summarized in table form, both for forces measured during trawling and the actual passage over the pipeline (Table I). The average pull forces during beam trawling are about 100 kN (10 tons). When the trawl is equipped with adapted trawl heads, the forces during the actual passage of the gear over the pipeline increase about 1.5 times. However, the non-adapted beam trawl shows a 2.5 times rise of the pull forces.

The pull forces in the warps of the otter trawl during fishing are about 50 kN (5 tons) and these increase during the passage of the pipeline about 2 times.

Damage to gear (Figure 1):

The beam trawl adaptations, developed in fact to avoid cable hooking, did reasonable well withstand the impact forces. However, chafing along the pipeline caused damage to these constructions. Once a complete beam trawl was lost on the pipeline due to the fact that the connecting shackle of the warp with the trawl broke. The shackle used had a Safe Working Load (S.W.L.) of 60 kN (6 tons), while the one used on the other warp and gear was one of 200 kN (20 tons) SWL. There was no further damage.

Damage to pipeline:

The pipeline was inspected before and after the experiments for signs of any substantial damages. Only markings, scratches in the overgrown coating, the concrete as well as the mastic itself were observed. The field joint protections, used only during the actual laying process of the pipe, were partly torn or moved completely. These protections have no function after the hardening of the somastic/bitumen and erode away in due time. netting material may be damaged by the sharp edges during the short lifespan of these metal moulds.

Discussion

The experiments clearly demonstrate that the pipe on bottom can withstand without ill effects the impact of hitting trawl gear, beam- or otter trawl. The pipeline is not displaced by the hitting gear. A fact well known for small flow lines to occur. Only superficial scratches were observed in the concrete coating and mastic protection of the field joints. These scratches offered in no way a danger or risk to the pipeline.

An adapted beam trawl will cross an unburied, or partially buried pipeline reasonable well. The adaptation of the beam trawl head, originally developed for the avoidance of cable hooking, clearly shows the reduction of the impact forces when the gear strikes the pipeline. This is an other confirmation of earlier findings and recommendations (DE GROOT, 1979, 1982). Further research to establish the optimal form and strength of the adaption is needed. However, this is a straightforward job and will offer no problems.

The fact that a shackle with a SWL of 60 kN (6 tons) cracked and broke during the experiments, considering the forces measured in the warps, is not very surprising. And the observations should be used with caution when the positive or negative effects of the interaction between gear and the pipe on bottom are evaluated. There is no satisfying explanation why two entirely different shackles (port and starboard beam trawl) were used. The safety argument, valid as it is, to chose for a light shackle to give way when forces in the fishing gear exceed certain limits is contradicted by the use of a 200 kN (20 tons) shackle on the other beam trawl as well as to replace the broken one. No further incidents happened with the heavier shackle during the remaining trawl runs.

It can be discussed if the forces on an unadapted beam trawl are acceptable to the fisheries. Still these forces on the gear and vessel do not exceed those encountered during normal fishing operations when the gear hits boulders or gets struck in to sand dunes.

It is evident that the relation between the size of the vessel, towing speed, the weight of a fishing gear, its rigging, is related to its use on a certain type of bottom. This explains why the experiments with a towing speed of 4 knots are in fact not representative for a normal fishing operation with the vessel used on a soft muddy clay bottom. A lighter vessel with a less heavy beam trawl might have fished on this type of ground with this towing speed without any problem.

It would be beneficial for both industries, the fisheries as well as the oil and gas industries if all beam trawl fishing gears, were adapted to lessen the effects of hitting pipelines as well as telephone cables according the lines as already proposed since 1977 and only realized to some degree for marine cables, to avoid hooking.

Also an adaptation of the classic rectangular trawl board should on the same grounds be considered.

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TABLE I - Forces measured in the towing warps.

	TRAWLING		PASSAGE	
	Port (t)	Stbd (t)	Port (t)	Stbd (t)
Beam trawl - adapted low towing speed	10.5	8.5	18	13
Beam trawl - adapted high towing speed	12.5	12	16.5	15.5
Beam trawl - non-adapted low towing speed	12	9	29	16.5
Beam trawl - non-adapted high towing speed	12	10.5	31.5	28.5
Trawl board low towing speed	5	3.5	8.5	7.5
Trawl board high towing speed	7	6	11	8

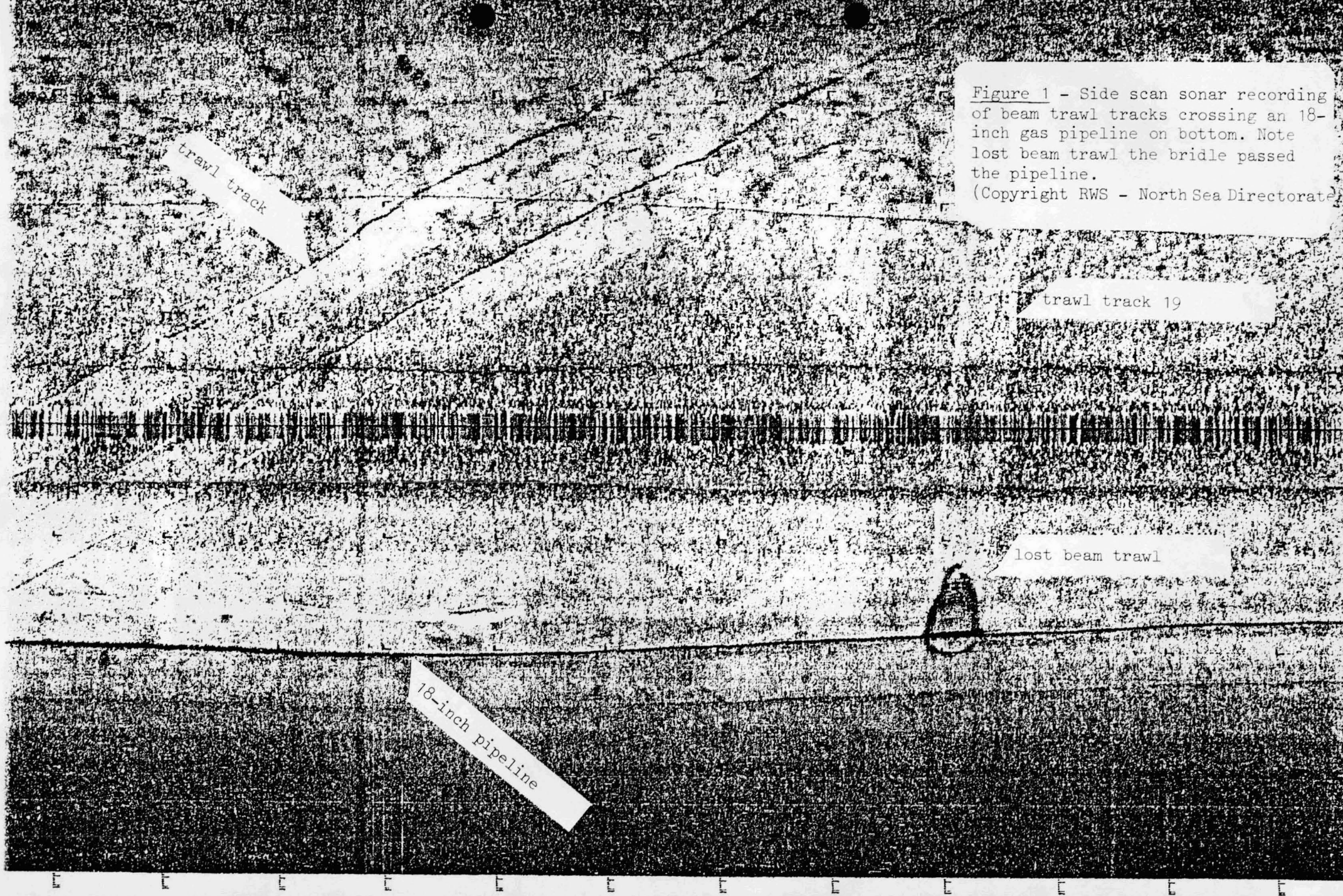


Figure 1 - Side scan sonar recording of beam trawl tracks crossing an 18-inch gas pipeline on bottom. Note lost beam trawl the bridle passed the pipeline.
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