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MELTING OF *NORM* – CONTAMINATED EQUIPMENT OF AN OFFSHORE OIL PLATFORM

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1. Introduction
Approx. 6,000 offshore plants all around the world are presently extracting crude oil and natural gas from the sea bottom. 640 of these platforms are located in the North Sea and the north-eastern regions of the Atlantic Ocean. Depending on type and size, their total weight adds up to several 10,000 tons, incl. the steel structures of production and accommodation decks (1).

Fig. 1: Oil platform Kotter

The issue of disposal of these large constructions after shutdown is being thoroughly investigated into, following the heated public discussion of the „Brent Spar" case. According to the moratorium of the June 1995 North Sea Conference and its follow-up conference in Portugal in 1998, platforms may no longer be sunk within its area of jurisdiction. From now on, decommissioning projects for this type of equipment will have to include the two steps: dismantling offshore, disposal onshore. This does not cause any problems in the case of reusable components and steel parts without contamination, whereas contaminated components require special attention. To pre-vent the release of toxic materials which have accumulated in tubes, plant components and on the various decks, into the sea, these have to be removed prior to dismantling resp. the contaminated components have to be disposed of properly on-shore.

Apart from the typical deposits of the materials exploited/extracted, these toxic materials mainly include heavy metals such as mercury, and radioactive materials of natural origin, so-called NORM.

These materials are extracted with oil and gas and, during operation of the plant, form scale in pipes and other plant components. NORM tends to concentrate to such an extent that these components may be disposed of or recycled only by authorized specialized companies. These naturally occurring radioactive materials belong to the natural decay chains of Th232 and U238, in most cases with physical separation of uranium and thorium isotopes so that these do not or only rarely occur in the scale. Concentration of NORM and mercury varies considerably in the individual oil reservoirs and have to be determined separately for each platform.

2. Map indicating the positions of CONOCO platforms

In September 1984, Conoco started crude oil extraction with the Kotter platform (Fig. 1); one year later, Logger platform was taken into operation. Up to 1997, both platforms operated successfully in blocks K18, approx. 50 km, resp. L16, approx. 30 km west of Den Helder (Fig. 2)

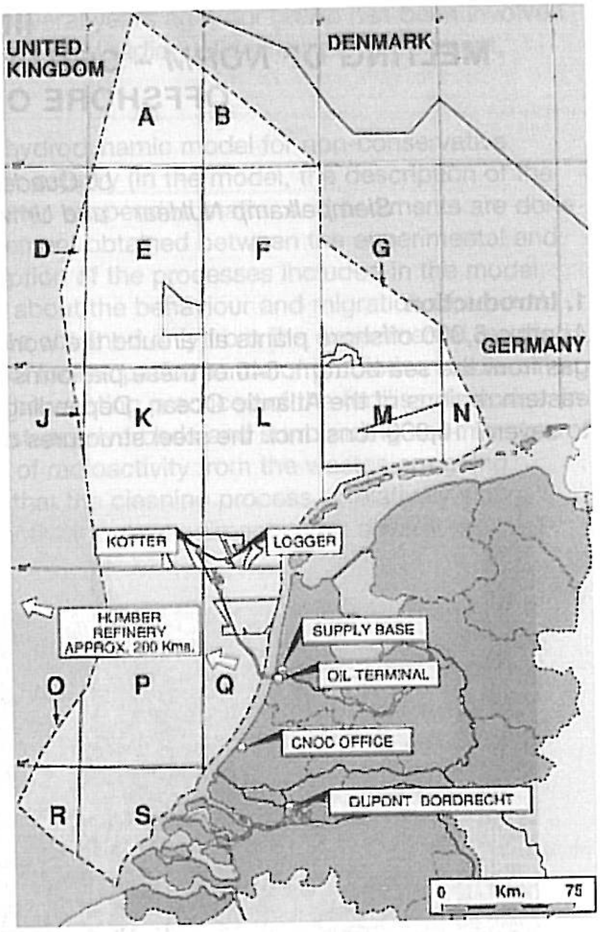

Fig.2 : Conoco Map

Both platforms are of the same type, differing only in size. Table 1 gives the main technical data:

Table 1: **Technical data of Kotter and Logger platforms**

	Kotter platforms	Logger platforms
position	block K 18	block L 16
water depth	27 m	33 m
platform	6 leg drilling platform 8 leg production / accommodation platform	4 leg drilling platform 4 leg production / accommodation platform
drilling jacket	weight : 1150 t dimensions: 32 m x 26 m x 36 m	weight : 673 t dimensions: 24 m x 24 m x 40 m
production jacket	weight : 1250 t dimensions: 42 m x 26 m x 36 m	weight: 617 t dimensions: 24 m x 24 m x 40 m
drilling deck	weight : 1430 t dimensions: 24 m x 35 m x 8 m	weight : 992 t dimensions: 26 m x 22 m x 6 m
production deck	weight : 3800 t dimensions: 55 m x 26 m x 39 m	weight : 1181 t dimensions: 25 m x 25 m x 6 m
living quarters	weight : 1,000 t dimensions: 23 m x 25 m x 15 m	weight : 450 t dimensions: 29 m x 10 m x 11 m
staff	50	28

In 1997, Conoco decided to give up oil extraction in the North Sea and transferred its platforms to an other company. This, however, required dismantling and disposal of contaminated plant components. Particularly disposal of NORM-contaminated components turned out to be highly problematic.

3. Planning and preparation of the disposal of NORM-contaminated equipment at Conoco company

Decommissioning and partial dismantling of the platforms was authorized and accompanied by the relevant authorities in The Netherlands. Handling and disposal of the NORM contaminated components required a special authorization. To obtain this, numerous samples were taken from the plants in question and analysed at ECN Petten. The result found was the typical nuclide spectrum with Ra226, Pb210, Ra228 and Th228 as main nuclides with Ra226 dominating. As the nuclide specific values varied strongly, next step had to be the definition of a measuring procedure putting the impulse rates measured on site in relation to nuclide specific activities and total activity. As is usual in The Netherlands, short-lived daughter nuclides were also considered in the determination of the total activity; furthermore, the limit of 100 Bq/g scale for free handling applicable in The Netherlands was taken as basis.
These were the conditions on which dismantling of the contaminated plant components started. The original plan was to clean the components on site by hydro-blasting and, after final control, take them ashore for recycling as common scrap. However, as it turned out, this procedure was not applicable for all components, resp. was too time-consuming or costly. Conoco therefore started looking for alternatives and found Siempelkamp as competent partner.

Working with Siempelkamp in this field did, however, require an extension of the license, as NORM-contaminated equipment was to be imported into The Netherlands and then transported into an other EU-member state. During project preparation, several issues emerged which might have caused problems due to different legal provisions in both countries. Table 2 gives a summary of these issues:

Table 2: **Comparison of the relevant limits and calculation methods in The Netherlands and Germany**

	Germany (4)	The Netherlands (3)	Effect
limit for free handling of NORM	500 Bq/g	100 Bq/g	unclarified situation concerning import and export license
calculation of total NORM activity	only long-lived daughters in equilibrium	also short-lived daughters in equilibrium	if values are close to the limits of 100 Bq/g or 70 Bq/g (transport), application of relevant national regulations may be changed at the border
classification of transport as ADR / normal	70 Bq/g, average value of total freight „NORM-contaminated scrap"	70 Bq/g, referred only to the contamination „NORM-Scale"	increased number of ADR-transports

To deal with this unclarified situation (2) with respect to definition of origin (domestic/abroad), classification (waste/resource) and the actual degree of contamination, a procedure was defined that might serve as example for similar projects.
The entire transport of the contaminated scrap from the drilling platform to Krefeld was handled as transfer. This means that upon unloading from the ship, the material was taken over by

Siempelkamp, represented by a qualified German shipping agent, without intermediate storage in The Netherlands. As requested by Conoco, all transports were carried out in accordance with ADR-regulations, irrespective of the actual degree of contamination. All measurements taken on site showed values clearly below the 70 Bq/g of scrap limit, considering even the short-lived decay products.

The material did not require import licenses by the German authorities, as the limits for free handling of NORM - 500 Bq/g - were clearly kept.

On site, the material was cut to pieces of 0.5 to 3 m length and packed in authorized 20'-containers. Documentation of each container included:

- net weight of scrap
- description of the material such as tube, plates, valves, etc.
- type of material (for instance steel)
- adhesions such as gum, oil, etc., incl. quantities (< 5 weight %)
- specific total activity of the material
- gross weight of container

The total activity of the material delivered was determined by the following measuring and calculation procedure:

1. main nuclides : Ra 226, Ra 228
2. measuring equipment : Rados Microcont Contamat
3. factors
   - sensitivity coefficient : 10 %
   - geometry factor (surface detector / total surface) : 0,026 / 72,5
   - gamma-adsorption factor (estimate) : 0,45
4. background : 10 cps
5. calculation

   A: total CPS = measured CPS * 1 / sensitivity coefficient * 1 / geometry factor * 1 / absorption factor

   B: total activity = sum (standardized nuclide activity * offspring factor) * total CPS

nuclide distribution	- acc. to ECN / RTD report	
nuclide activity	Ra 226	= 0,342
offspring factor	Ra 226	= 6
nuclide activity	Pb 210	= 0,0314
offspring factor	Pb 210	= 3
nuclide activity	Ra 228	= 0,364
offspring factor	Ra 228	= 2
nuclide activity	Th 228	= 0,205
offspring factor	Th 228	= 7

This documentation served as basis for the shipping documents.

4. Disposal of the NORM-contaminated equipment in Siempelkamp's GERTA plant (Large-scale plant for recycling of toxic waste)

Five pcs. 20'-container with a total of approx. 41 t of contaminated equipment were taken to Krefeld, following the procedure described above, and recycled in Siempelkamp's GERTA melting plant, specially built for this process (5).

Some of the tubes were sealed by plastic foils to retain remaining oil.

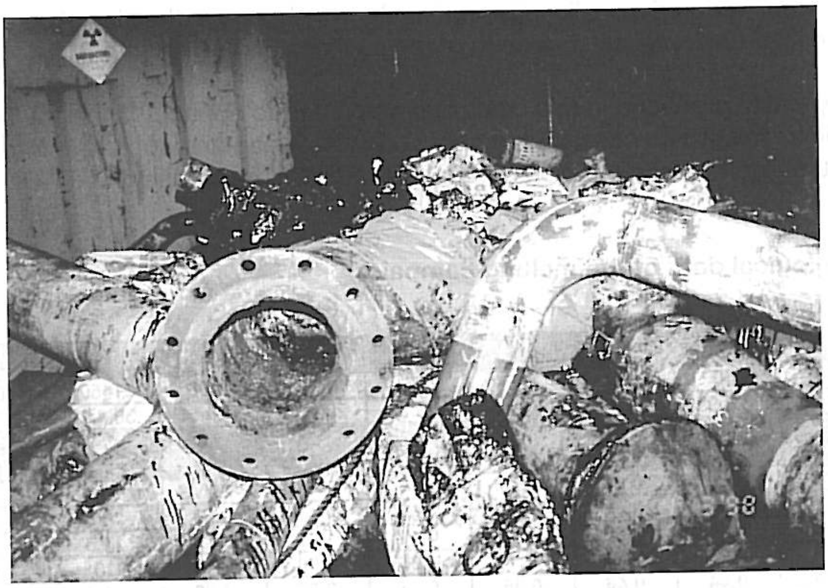

Fig. 3: Scrap delivered to Siempelkamp

GERTA plant is a licensed operating unit of Siempelkamp foundry in accordance with BImSchG (Federal Law on Immission Protection). At present, its annual capacity is limited to 2,000 tons of steel and metal scrap contaminated with mercury and/or NORM. Key element is an 8 ton-net frequency induction-type furnace which is charged via an automatic charging device, completely enclosed to prevent emissions (Fig. 4).

The melting shop is preceded by the cutting area where the materials delivered can be cut to suitable sizes either mechanically by hydraulic shears or thermally in a special housing. Both shops have individual, separately operated ventilation systems.

Off-gas from both systems is cleaned in a filter plant consisting of cyclone, air-cooler, bag filter and activated carbon fixed bed adsorber, and then emitted via a stack (Fig. 5).

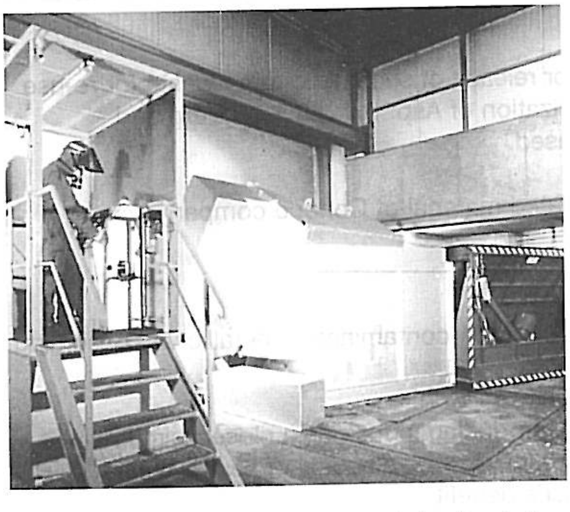

Fig. 4: GERTA furnace with exhaust and charging device

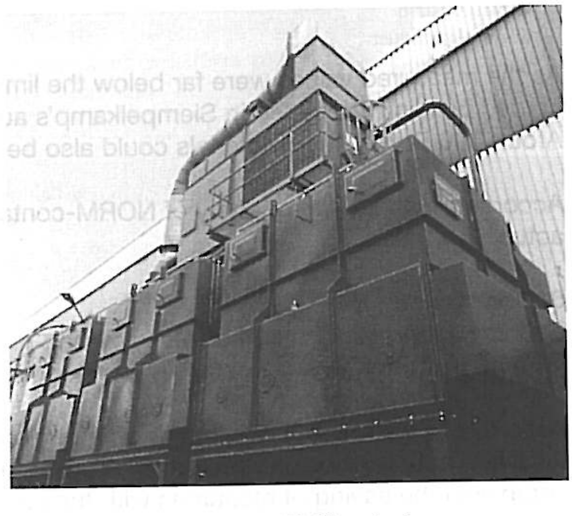

Fig. 5: GERTA filter plant

41 tons of Conoco material were treated in a separate campaign. Secondary wastes such as slag and filter dust were collected, recorded and each lot was analysed radiologically and metallurgically.

5. Results of the Conoco melting campaign

The radiological measurements showed that, after melting, the metal did not contain any detectable residual contamination with NORM. The ingots could be released for unlimited re-use in a steelworks.

98 % of the naturally occurring radioactive materials were bound in the slag. Approx. 2 % were detected in the filter dust; mainly consisting of the nuclides Pb 210 and Po 210.

The secondary waste produced in this campaign amounted to approx. 13 weight % of the total material supplied. This waste consisted of approx. 95 % of slag and approx. 5 % of coarse dust. Table 3 gives the results of the radiological analysis of the entire campaign.

***Table 3:* Radiological data of the melting campaign**

waste	dust					slag				melt
mass (kg)	55	60	50	45	65	1700	1000	1450	1000	
date	4.6.98	4.6.98	3.6.98	4.6.98	4.6.98	29.4.98	30.4.98	30.4.98	2.5.98	
activity (Bq/g)										
Ra 224	0,14	0,1	0,11	0,11	0,14	< NWG	< NWG	10,7	4,14	< detec.lim.
Pb 212	0,08	0,04	0,05	0,11	0,08	1,12	0,33	10,8	4,67	< detec.lim.
Bi 212	0,07	0,16	0,07	0,22	0,14	1,02	0,62	11,3	5,97	< detec.lim.
Tl 208	0,11	0,06	0,06	0,1	0,06	1,08	0,45	10	4,57	< detec.lim.
Ra 226	**0,47**	**0,44**	**0,46**	**0,36**	**0,84**	**2,27**	**1,26**	**18,8**	**8,08**	< detec.lim.
Pb 214	0,23	0,13	0,18	0,22	0,28	1,35	0,6	9,7	4,66	< detec.lim.
Bi 214	0,2	0,15	0,11	0,2	0,23	1,19	0,6	9	4,54	< detec.lim.
Pb 210	18,24	24,37	35,69	60,41	102,9	< NWG	< NWG	< NWG	< NWG	< detec.lim.
total	**19,54**	**25,43**	**36,73**	**61,71**	**104,67**	**8,03**	**3,86**	**80,3**	**36,63**	-
Ra 226 ?	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	OK	
total ?	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	OK	
activity (Bq)										
Ra 224	7,54E+03	5,77E+03	5,70E+03	5,04E+03	8,84E+03	-	-	1,55E+07	4,14E+06	-
Pb 212	4,67E+03	2,43E+03	2,33E+03	4,73E+03	5,38E+03	1,90E+06	3,30E+05	1,57E+07	4,67E+06	-
Bi 212	3,92E+03	9,41E+03	3,37E+03	9,70E+03	9,17E+03	1,73E+06	6,20E+05	1,64E+07	5,97E+06	-
Tl 208	6,30E+03	3,42E+03	3,02E+03	4,41E+03	3,97E+03	1,84E+06	4,50E+05	1,45E+07	4,57E+06	-
Ra 226	2,56E+04	2,62E+04	2,31E+04	1,61E+04	5,43E+04	3,86E+06	1,26E+06	2,73E+07	8,08E+06	-
Pb 214	1,26E+04	7,80E+03	8,76E+03	9,85E+03	1,84E+04	2,30E+06	6,00E+05	1,41E+07	4,66E+06	-
Bi 214	1,09E+04	8,87E+03	5,58E+03	9,02E+03	1,48E+04	2,02E+06	6,00E+05	1,31E+07	4,54E+06	-
Pb 210	1,00E+06	1,46E+06	1,78E+06	2,72E+06	6,69E+06	-	-	-	-	-
total	1,07E+06	1,53E+06	1,84E+06	2,78E+06	6,80E+06	1,37E+07	3,86E+06	1,16E+08	3,66E+07	-
m(tot.)	275 kg					5150 kg				41.055 kg
A (spec.)	51 Bq/g					33,10 Bq/g				< detec.lim.

As the measured values were far below the limits for release of such secondary waste for re-use in road building stipulated in Siempelkamp's authorization of Asp. Ra 226 < 65 Bq/g and Atot.< 500 Bq/g, these materials could also be re-used.

Accordingly, the entire quantity of NORM-contaminated material of Conoco company was actually recycled.

6. Conclusion

By this pilot project, an authorized recycling path for NORM-contaminated metallic waste coming from oil platforms was successfully developed.

Accordingly, we are in a position to offer oil and gas producing industries a closed-circuit recycling path onshore, in the frame of our authoritzation, for the disposal of such wastes, combining the saving of resources with the customer's benefit.

7. References

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