

TECHNICAL REPORT

KYSTVERKET NORWEGIAN COASTAL ADMINISTRATION

**SALVAGE OF U-864 - SUPPLEMENTARY STUDIES -
DISPOSAL**

REPORT No. 23916-6

REVISION No. 01

DET NORSKE VERITAS



TECHNICAL REPORT

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Summary:

In September 2007 The Norwegian Coastal Administration (NCA) awarded Det Norske Veritas (DNV) the contract to further investigate different alternatives for the salvaging of the mercury, cargo and the wreck of the sunken German WWII submarine U-864. This report deals with supplementary study number 6: "Disposal".

The task of the study is to investigate the environmental, safety and health consequences from taking up mercury and mercury-contaminated sediments. Further the possible storage locations and costs for the disposal of hazardous waste are included in the study. Finally the study has looked at future demands and legislations and the future market for recycled/disposal of mercury/mercury waste in European Union (EU).

DNV's main conclusion is: Disposal cost (handling of mercury and other material) is estimated to be in the range of 11-39 MNOK depending on the disposal solution. At the moment it is uncertain how the final disposal of the mercury from U-864 will be due to more restrictive EU and Norwegian legislation for mercury. Other material can be recycled, treated and/or sent to an approved disposal facility

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The German submarine U-864 was torpedoed by the British submarine *Venturer* on February 9 1945 and sunk approximately two nautical miles west of the island Fedje in Hordaland. U-864 was carrying about 67 metric tonnes of metallic mercury that implies a threat to the marine environment.

In September 2007 The Norwegian Coastal Administration commissioned Det Norske Veritas to further investigate different alternatives to salvage the wreck and remove the mercury from the seabed.

1 SUMMARY

This report is *Supplementary Study No. 6: Disposal*, one of twelve supplementary studies supporting the overall report regarding U-864 (Det Norske Veritas Report No. 23916) prepared by Det Norske Veritas (DNV).

The task of the study is to investigate the environmental, safety and health consequences from taking up mercury and mercury-contaminated sediments. Further the possible storage locations and costs for the disposal of hazardous waste are included in the study. Finally the study has looked at future demands and legislations and the future market for recycling/disposal of mercury and mercury waste in European Union (EU).

DNV's overall conclusion is:

Disposal cost (handling of mercury and other material) is estimated to be in the range of 11-39 MNOK depending on the disposal solution. At the moment it is uncertain how the final disposal of the mercury from U-864 will be due to more restrictive EU and Norwegian legislation for mercury. Other material can be recycled, treated and/or sent to an approved disposal facility.

Table 1-1 Summary of the estimated amount mercury (Hg) and other material which most likely has to be disposed of from U-864

Material	Amount (metric tons)	Comment
Mercury (elemental)	67	Based on that U-864 had 1 857 mercury canisters which each contained 36 kg mercury as in the canister that was salvaged.
Hydrocarbons	442	U-864 had a fuel capacity (diesel) of 442 metric tons. It is assumed that it had almost full tank when it was hit. In addition there is lubricants and grease estimated to be a couple of hundred kilos.
Scrap metal	1 800	The submarine (type IX D2) weighed 1 616 metric tons, with some safety margin DNV has estimated the weight to be 900 metric tons for each of the two wreck parts /3/.
Batteries	100 - 140	Based on information that the batteries in submarine type VII weighed 50-70 metric tons. The type IX D2 (U-864) had the double amount of batteries.
Transformers and cables	-	No data has been available to estimate the amount. It is assumed there was insulation and transformers containing PCB and asbestos.

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Material	Amount (metric tons)	Comment
Contaminated sediments outside the wreck	22 500	Based on an acceptance criteria of 0.6 mg Hg/kg sediments, NIVA estimates that 15 000 m ³ (22 500 metric tons) has to be removed.
Contaminated sediments inside the wreck	15	Assumed that 10 m ³ (15 metric tons) are inside the wreck parts. These sediments are probably significantly more contaminated than the sediments outside the wreck.
Others	-	Torpedoes with electric batteries or compressed air for propulsion will be demounted by the Norwegian EOD Command (Explosives Ordnance Disposal) and handled by them. The hull was painted; probably the paint contained red lead (Pb ₃ O ₄).

Table 1-2 Summary of the disposal solutions and costs for mercury and other material from U-864 (Transport is not included in the disposal costs)

Material	Disposal Solution	Unit cost	Cost (range)	Comment
Mercury (elemental)	Recycling	32 000 NOK/metric ton	2 - 7 mill. NOK (in best case even a surplus of 2.5 mill. NOK if it is very pure)	Estimated for 30 - 99 % pure mercury, corresponding to an amount between 220 (mercury waste) and 65 metric ton (pure mercury). If the mercury is very pure (99.999 %) it can be sold for 40 NOK/kg.
	Disposal	50 000 - 100 000 NOK/metric ton	3.5 - 20 mill. NOK	Estimated for 30 - 99 % pure mercury, corresponding to an amount between 220 (mercury waste) and 65 metric ton (pure mercury). Cost estimated for stabilising elemental mercury at NOAH (SAKAB method). (Establishment of a disposal in a deep-rock cavern for elemental mercury has in Sweden (2003) been estimated to 210 000 – 550 000 NOK/metric ton).
Hydrocarbons	Incineration	2 000 -3 000 NOK/metric ton	0.9 - 1.3 mill. NOK	Based on that only hydrocarbons are found with low heat value.
Scrap metal	Disposal	500 – 1 500 NOK/metric ton	1 - 3 mill. NOK	The alternative to disposal is pre-treatment such as sandblasting, acid cleaning and recycling (reuse of the steel). Cost in the range of 1 500 – 3 000 NOK/metric ton. Added value for recycling is in the range of 500 - 1 000 NOK/metric ton.
Batteries	Recycling	0 – 500 NOK/metric ton	0 - 0.7 mill. NOK	If the batteries can not be recycled they can be delivered as hazardous waste with a cost in the range of 500 - 1 500 NOK/metric ton.
Transformers and cables	Disposal	1 000 – 2 000 NOK/metric ton	-	No data has been available on amounts.
Contaminated sediments outside the wreck	Disposal	300 – 600 NOK/metric ton	7 - 14 mill. NOK	Stabilisation prior to disposal. Assuming that dewatering is not necessary.



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Material	Disposal Solution	Unit cost	Cost (range)	Comment
Contaminated sediments inside the wreck	Disposal	1 000 - 2 000 NOK/metric ton	<0.1 mill. NOK	Stabilisation prior to disposal is more expensive due to higher mercury content inside the wreck. Average mercury content is assumed to be less than 10 %. If the level of contaminations should be in the range of 10% or more, thermal treatment is probably the only feasible solution (5 000 – 10 000 NOK/metric ton).
Others	-	-	-	Other contaminated waste has to be sent to an approved disposal facility for classification and final treatment/disposal.
		Sum	11 - 39 MNOK	

The market for buying and selling mercury will probably be decreasing due to more restrictive EU legislation. The most probable scenario is that both the demand and supply of mercury in the EU will be reduced gradually. The chlor-alkali industry which is the largest consumer and supplier of mercury is gradually phasing out mercury, but this is expected to take many years, probably at least until 2020. However from 2011 they will have to bring the surplus mercury to a safe disposal if the EU proposal comes into force. This will reduce the mercury supply because they can no longer recycle the mercury.

At the moment it does not look as there are any EU directives which will ban an export of the U-864 mercury inside the EU, provided that the Norwegian authorities will allow such an export. In Norway has elemental mercury until very recently been exported for recycling. The amendment to the Norwegian Product Regulation (Produktforskriften) which came into force 1st of January 2008 forbids the export of mercury in products. At the moment it is very uncertain if elemental mercury will be allowed for export from Norway, it depends on if the authorities will regard the elemental mercury as a product or not.

Depending on how EU defines a “deep water formation” as a permanent storage, it could cause problems finding a suitable location for disposal in Norway. The problem consists in that most storage locations in rock are relatively shallow (<100 m) but may still have stable physical and chemical conditions. The waste industry is working on new technologies for treatment (stabilising) mercury which could simplify a final disposal in Norway.

Other material (hydrocarbons, scrap metal, batteries etc.) can be recycled, treated and/or sent to an approved disposal facility

The rest of *Supplementary Study No. 6: Disposal* details the arguments behind the conclusions.



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Den tyske ubåten U-864 ble torpedert av den britiske ubåten Venturer den 9. februar 1945 og sank omtrent to nautiske mil vest for øya Fedje i Hordaland. U-864 var lastet med omtrent 67 tonn med metallisk kvikksølv som utgjør en fare for det marine miljøet.

I september 2007 tildelte Kystverket Det Norske Veritas oppdraget med å nærmere utrede ulike alternativer for heving av vrak og fjerning av kvikksølv fra havbunnen.

2 SAMMENDRAG

Denne rapporten er *Tilleggsutredning nr. 6: Avhending*, en av tolv tilleggsutredninger som understøtter hovedrapporten vedrørende U-864 (Det Norske Veritas Report No. 23916) utarbeidet av Det Norske Veritas (DNV).

Oppgaven for utredningen er å undersøke konsekvenser for miljø, sikkerhet og helse ved å ta opp kvikksølv og kvikksølvforurensede sedimenter. Videre inngår mulige lagringssteder og kostnader for deponering av det farlige avfallet i utredningen. Til slutt har utredningen sett på fremtidige krav og lovgivning og det fremtidige markedet for gjenvinning/avhending av kvikksølv og kvikksølvavfall i den Europeiska Union (EU).

DNV sin overordnede konklusjon er:

Avhendingskostnader (håndtering av kvikksølv og andre materialer) er estimert å være i størrelsesorden 11-39 MNOK avhengig av avhendingsløsning. På det nåværende tidspunkt er det usikkert hvordan endelig avhending av kvikksølvet fra U-864 kan skje grunnet mer restriktiv lovgivning i EU og Norge knyttet til kvikksølv. Annet avfall kan gjenvinnes, behandles og/eller sendes til at godkjent deponi.

Tabell 2-1 Oppsummering av estimert mengde av kvikksølv (Hg) og andre materialer som mest sannsynlig må avhendes fra U-864

Materiale	Mengde (tonn)	Kommentar
Kvikksølv (elementær)	67	Basert på at U-864 hadde 1 857 kvikksølvbeholdere og at hver beholder inneholdt 36 kg kvikksølv, slik den beholderen gjorde som ble berget.
Hydrokarboner	442	U-864 hadde til sammen tanker for 442 tonn diesel. Det er antatt at den hadde nesten full tank når den ble truffet. I tillegg er det fett og smøreoljer, estimert til et par hundre kilo.
Metallskrap	1 800	Ubåten (type IX D2) veide 1 616 tonn, med litt sikkerhetsmargin har DNV estimert vekten til 900 tonn for hver av de to vrakdelene /3/.
Batterier	100 - 140	Basert på informasjon at batteriene i en ubåt av type VII veide 50 - 70 tonn. Type IX D2 (U-864) hadde det doble antallet batterier.
Transformatorer og kabler	-	Ingen data er funnet for å kunne estimere mengde. Det antas at det fantes isolasjon og transformatorer som inneholdt PCB og asbest.

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Materiale	Mengde (tonn)	Kommentar
Forurensede sedimenter utenfor vraket	22 500	Basert på akseptkriteriet 0.6 mg Hg/kg sediment, estimerer NIVA at 15 000 m ³ (22 500 tonn) må fjernes.
Forurensede sedimenter innenfor vraket	15	Antatt at 10 m ³ (15 tonn) ligger inne i vrakdelene. Disse sedimentene er sannsynligvis betydelig mer forurenset enn sedimentene utenfor.
Annet	-	Torpedoer med batterier eller trykkluft som drivkraft vil bli demontert og håndtert av Forsvarets eksplosivryddingskommando (EOD). Skroget var antagelig malt med farge som inneholdt blymønje (Pb ₃ O ₄)

Tabell 2-2 Oppsummering av avhendingsløsninger og kostnader for kvikksølv og andre materialer fra U-864 (transportkostnader er ikke inkludert i avhendingskostnadene)

Materiale	Avhendings-løsning	Enhets-kostnad	Kostnad (variasjon)	Kommentar
Materiale Kvikksølv (elementær)	Gjenvinning	32 000 NOK/tonn	2 - 7 mill. NOK (i beste fall et overskudd på 2.5 mill. NOK hvis den er meget ren)	Estimert for kvikksølv med 30 - 99 % renhetsgrad, tilsvarende 220 (avfall med kvikksølv) til 65 tonn (rent kvikksølv). Hvis kvikksølvet er meget rent (99.999 %) kan det selges for 40 NOK/kg.
	<i>eller</i> Deponering	50 000 - 100 000 NOK/tonn	3.5 - 20 mill. NOK	Estimert for kvikksølv med 30 - 99 % renhetsgrad, tilsvarende 220 (avfall med kvikksølv) til 65 tonn (rent kvikksølv). Kostnaden er estimert for stabilisering av elementært kvikksølv av NOAH (SAKAB-metoden). (Etablering av et deponi for elementært kvikksølv i et dypt bergrom er i Sverige (2003) estimert til 210 000 - 550 000 NOK/tonn).
Hydrokarboner	Forbrenning	2 000 - 3 000 NOK/tonn	0.9 - 1.3 mill. NOK	Basert på at en bare finner hydrokarboner med lav brennverdi.
Metallskrap	Deponering	500 - 1 500 NOK/tonn	1 - 3 mill. NOK	Alternativet til deponering er en forbehandling som for eksempel sandblåsing, syrevask og gjenvinning (gjenbruk av stål). Kostnad er i området 1 500 - 3 000 NOK/tonn. Gjenbruksverdien av stål er i størrelsesorden 500 - 1 000 NOK/tonn.
Batterier	Gjenvinning	0 - 500 NOK/tonn	0 - 0.7 mill. NOK	Hvis batteriene ikke kan gjenvinnes kan de leveres som farlig avfall med en kostnad som er i størrelsesorden 500 - 1 500 NOK/tonn.
Transformatorer og kabler	Deponering	1 000 - 2 000 NOK/tonn	-	Ingen data er funnet for å kunne estimere mengde.
Forurensede sedimenter utenfor vraket	Deponering	300 - 600 NOK/tonn	7 - 14 mill. NOK	Stabilisering utføres før deponering. Antatt at avvanning ikke er nødvendig.

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Materiale	Avhendings- løsning	Enhets- kostnad	Kostnad (variasjon)	Kommentar
Forurensede sedimenter inne i vraket	Deponering	1 000 - 2 000 NOK/tonn	<0.1 mill. NOK	Stabilisering (nødvendig) i forkant av deponering er mer kostbar på grunn av høyere kvikksølvinnhold inne i vraket. Gjennomsnittlig kvikksølvinnhold er antatt å være mindre enn 10 %. Hvis forurensningsinnholdet er i størrelsesorden 10 % eller mer, er termisk behandling sannsynligvis den eneste mulige løsningen (5 000 – 10 000 NOK/tonn).
Annet	-	-	-	Annet forurenset avfall må sendes til godkjent mottak for klassifisering og endelig behandling/deponering.
		Sum	11 - 39 mill. NOK	

Markedet for kjøp og salg av kvikksølv vil sannsynligvis minke på grunn av at EUs lovgivning blir mer restriktiv. Det mest sannsynlige scenarioet er at både tilbud og etterspørsel på kvikksølv i EU vil bli gradvis redusert. Kloralkali-industrien som er den største forbrukeren og tilbyderen av kvikksølv er ved å gradvis fase ut kvikksølv, men utfasingen forventes å ta mange år, antagelig i hvert fall minst til 2020. Fra 2011 må de imidlertid levere overskudd av kvikksølv til en sikker lagringsløsning hvis EUs forslag trår i kraft. Dette vil redusere tilbudet av kvikksølv fordi kvikksølv ikke lenger kan gjenvinnes.

For tiden ser det ikke ut til at det vil være noen EU-direktiver som vil forby en eksport av kvikksølv fra U-864 innenfor EU, såfremt norske myndigheter vil tillate en slik eksport. I Norge har elementært kvikksølv inntil svært nylig blitt eksportert for gjenvinning. Endringen i den norske produktforskriften som trådte i kraft den 1. januar 2008 forbyr eksport av kvikksølv i produkter. For øyeblikket er det meget usikkert om elementært kvikksølv vil bli tillatt eksportert fra Norge, dette er avhengig av om myndighetene ser på elementært kvikksølv som et produkt eller ikke.

Avhengig av hvordan EU definerer en “deep water formation” som en permanent lagring, kan det gi problemer å finne en egnet lokalitet for lagring i Norge. Problemet består i at de fleste lagringssteder i fjell er relativt grunne (<100 m) men kan fortsatt ha stabile fysiske og kjemiske forhold. Avfallsindustrien arbeider med nye teknologier for behandling (stabilisering) av kvikksølv som kan forenkle en endelig lagring i Norge.

Andre materialer (hydrokarboner, skrapmetall, batterier etc.) avfall kan gjenvinnes, behandles og/eller sendes til at godkjent deponi.

Resten av *Tilleggsutredning nr. 6: Avhending* utdyper argumentene bak konklusjonene.

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3 INTRODUCTION

3.1 Background

The German submarine U-864 was sunk by the British submarine *Venturer* on 9 February 1945, approximately 2 nautical miles west of the island Fedje in Hordaland (Figure 3-1). The submarine was on its way from Germany via Norway to Japan with war material and according to historical documents; U-864 was carrying about 67 metric ton of metallic (liquid) mercury, stored in steel canisters in the keel. The U-864, which was broken into two main parts as a result of the torpedo hit, was found at 150-175 m depth by the Royal Norwegian Navy in March 2003. The Norwegian Coastal Administration (NCA) has, on behalf of the Ministry of Fisheries and Coastal Affairs, been performing several studies on how the risk that the mercury load constitutes to the environment can be handled. In December 2006 NCA delivered a report to the Ministry where they recommended that the wreck of the submarine should be encapsulated and that the surrounding mercury-contaminated sediments should be capped. In April 2007 the Ministry of Fisheries and Coastal Affairs decided to further investigate the salvaging alternative before a final decision is taken about the mercury load.

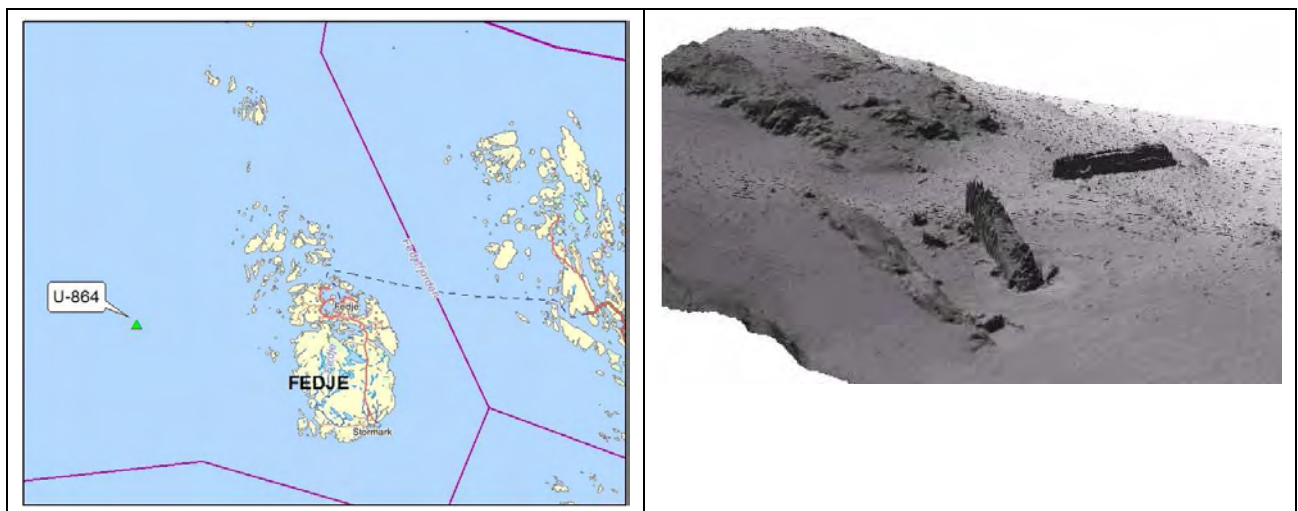


Figure 3-1 Location (left) and a sonar picture of the wreck of U-864 on seabed (right) (from Geoconsult).

3.2 DNV's task

In September 2007 NCA commissioned Det Norske Veritas (DNV) the contract to further investigate the salvaging alternative. The contract includes:

- DNV shall support NCA in announcing a tender competition for innovators which have suggestions for an environmentally safe/acceptable salvage concept or technology. Selected innovators will receive a remuneration to improve and specify their salvage concept or technology.



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- DNV shall support NCA in announcing a tender competition for salvage contractors to perform an environmentally justifiable salvage of U-864.
- DNV shall evaluate the suggested salvage methods and identify the preferred salvage method.
- The preferred salvage method shall be compared with the suggested encapsulation/capping method from 2006. (DNV shall give a recommendation of which measure that should be taken and state the reason for this recommendation.)
- DNV shall perform twelve supplementary studies which will serve as a support when the decision is taken about which measure that should be chosen for removing the environmental threat related to U-864. The twelve studies are:
 1. *Corrosion*. Probability and scenarios for corrosion on steel canisters and the hull of the submarine.
 2. *Explosives*. Probability and consequences of an explosion during salvaging from explosives or compressed air tanks.
 3. *Metal detector*. The possibilities and limitations of using metal detectors for finding mercury canisters.
 4. *The mid ship section*. Study the possibility that the mid section has drifted away.
 5. *Dredging*. Study how the mercury-contaminated seabed can be removed around the wreck with a minimum of spreading and turbidity.
 6. *Disposal*. Consequences for the environment and the health and safety of personnel if mercury and mercury-contaminated sediments are taken up and disposed of.
 7. *Cargo*. Gather the historical information about the cargo in U-864. Assess the location and content of the cargo.
 8. *Relocation and safeguarding*. Analyse which routes that can be used when mercury canisters are relocated to a sheltered location.
 9. *Monitoring*. The effects of the measures that are taken have to be documented over time. An initial programme shall be prepared for monitoring the contamination before, during and after salvaging.
 10. *Risk related to leakage*. Study the consequences if mercury is unintentionally leaked and spreading during a salvage or relocation of U-864.
 11. *Assessment of future spreading of mercury for the capping alternative*. The consequences of spreading of mercury if the area is capped in an eternal perspective.
 12. *Use of divers*. Study the risks related to use of divers during the salvage operation in a safety, health and environmental aspect and compare with use of ROV.



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3.3 Scope of this report

This is *Supplementary Study No. 6: Disposal*. The task of the study is to investigate the environmental, safety and health consequences from taking up mercury and mercury-contaminated sediments. Further the possible storage locations and costs for the disposal of hazardous waste are included in the study.

So far a total of 25 m³ of mercury contaminated sediments have been dredged around the stern section of the wreck by use of a Scanmudring machine. Purpose built containers were used for environmental safe recovery of the sediments to the deck onboard the DOF Subsea vessel Geoholm. Only 2 mercury canisters have been recovered and both thoroughly inspected. The mercury content, contaminated consumables from the vessels used in 2005 and 2006 and the containerised sediments have been shipped to a hazardous waste storage facility site at Langøya. Disposal of contaminated material is dealt with in DNV's risk assessment report from 2006 where disposal of the mercury is assessed to be the largest factor of uncertainty for the salvage alternative. The costs for disposal were assumed to be very uncertain and could be very large.

This report investigates how wreck parts, mercury canisters and contaminated sediments can be disposed of. The costs and benefits by separating the most contaminated material before disposal are studied to evaluate if a separation can give a major cost reduction for the disposal.

The solutions and costs for disposal of the different waste components are calculated and authorized companies which can receive the waste are indicated. In addition the safety, health and environmental consequences are given.

Assessments of the amount of wreck parts and mercury canisters are based on existing estimates and data of the submarine and cargo. Amount of contaminated sediments (volume) is based on existing estimates of the contaminated area and the thickness of the mercury contamination.

In addition, possible new legislation and regulations which are expected to come from the authorities with respect to handling and disposal are evaluated.

The structure of this report is:

- Estimate of amount of material which has to be disposed of (chapter 4)
- Disposal solutions (chapter 5)
- Separation technologies that could give a major cost reduction for the disposal/treatment (chapter 6)
- Future demands (chapter 7)



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4 ESTIMATE OF AMOUNT OF MATERIAL WHICH HAS TO BE DISPOSED OF

In this chapter the estimated type and amount (volume/weight) of wreck parts, mercury canisters (and free mercury) and contaminated sediments which have to be disposed of is identified.

4.1 Mercury

Available information reports that there were 1857 canisters filled with mercury on board. The canisters found have been made of steel or cast iron. A canister that was salvaged and opened in 2005 contained 36 kg (2.7 litres) metallic mercury /2/. Assuming all canisters contained the same amount; there was approximately 67 metric tons of mercury on board.

In addition some of the instruments on board like thermometers, barometers etc. most likely contained mercury. The amount of mercury in the instruments has not been investigated; it can be assumed that it was a relatively low amount and less than 1 kg.

4.2 Hydrocarbons

U-864 had a fuel capacity of 442 metric tons. When it was hit by the torpedo it had probable almost full tank since it recently had left Bergen. Some diesel tanks were probably destroyed when it was hit by the torpedo; HMS Venturer reported they saw oil on the water surface after U-864 had sunk.

Lubricants and grease was very likely stored in tanks outside the hull, amounts are not quantified. Estimated amount is in the order of a couple of hundred kilos.

4.3 Scrap metal

The submarine (type IX D2) weighed 1616 metric tons. It is divided in two parts and with some safety margin DNV has estimated the weight to be about 900 metric tons for each of the two wreck parts /3/.

4.4 Batteries

Submarines of the type IX D2 contained 248 lead-acid battery cells type 44 MAL 740 (22 600 Ah) for propulsion under water. All batteries for submarines were produced at AFA Battery Works in Hagen, Germany, the sole manufacturer of special batteries for the submarines of the Kriegsmarine between 1905 and 1945 /4/.

The weight of the batteries on U-864 (for propulsion) is probably in the range of 100-140 metric tons (ref. Fritz Köhl/Axel Niestle – Uboottyp VII; the U-boat type VII had 50 - 70 metric tons of batteries which is half the amount of batteries compared to a type IX D2).

In addition the torpedoes on the IX D2 submarines were equipped with batteries or compressed air for propulsion (<http://uboat.net/technical/torpedoes.htm>), see also chapter 4.7.



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4.5 Transformers and cables

It is assumed that there was insulation and transformers containing PCB and asbestos on U-864. No data has been available for estimating the amount.

4.6 Contaminated sediments

There is 30 000 m² seafloor which is contaminated, NIVA estimates that at least 0.5 m has to be removed, equivalent to 15 000 m³ (approximately 22 500 metric tons) if the acceptance criteria is set to 0.6 mg Hg¹/kg sediment.

The amount of sediments inside the wreck parts is assumed to be 10 m³ (approximately 15 metric tons). These sediments are assumed to be significantly more contaminated with mercury than the sediments on the seafloor outside the wreck parts.

4.7 Others

Torpedoes (electric batteries or compressed air for propulsion) will be demounted by the Norwegian EOD Command (Explosives Ordnance Disposal) and handled by them.

The hull was painted; probably the paint contained red lead. In past red lead (lead tetraoxide, Pb₃O₄) was used in combination with linseed oil as a thick, long-protecting anticorrosive paint. Due to its toxicity its use is now being very limited.

¹ Hg = Mercury



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5 DISPOSAL SOLUTIONS

In this chapter disposal solutions for the different waste components are presented. When companies which can receive the waste components are known they are presented as well as disposal/treatment costs and information on existing permits. Safety, health and environment (SHE) consequences are discussed and if the solution has any special benefits.

The demolition of the U-864 is not discussed in this chapter. The costs which are indicated in this chapter do not include the transport to the disposal/treatment facilities.

5.1 Mercury

5.1.1 Background information on mercury

Mercury is a silvery metal, which is liquid at or near room temperature and pressure. The melting point of mercury is $-38.8\text{ }^{\circ}\text{C}$ and the boiling point is $356.7\text{ }^{\circ}\text{C}$. The density is 13.5 g/cm^3 .

Mercury occurs in deposits throughout the world and it is harmless in an insoluble form, such as mercury sulphide (cinnabar), but it is poisonous in soluble forms such as mercuric chloride or methyl mercury. Mercury is mostly obtained by reduction from the mineral cinnabar.

Mercury has been used widely in many applications (thermometers, barometers etc.), though concerns about the element's toxicity have led to that mercury is being phased out.

Mercury is still used in some chloride-alkali industries (not in Norway), luminous tubes, low energy light bulbs, amalgam in dentistry (being gradually phased-out in favour of other dental filling materials) and in different scientific and research applications.

In 2005, China was the top producer of mercury with almost two-thirds global share followed by Kyrgyzstan. The global demand for mercury is about 3 400 metric tons per year and the European Union (EU) accounted for 440 metric tons of that in 2005. The mercury deposits of Almadén in Spain account for the largest quantity of liquid mercury metal produced in the world. Approximately 250 000 metric tons of mercury has been produced there in the past 2 000 years. In 2000, the mines closed due to the fall of the price of mercury in the international market. However, Almadén still has one of the world's biggest reservoirs of mercury. The state owned company Mayasa owns the Almadén mines and does still export about 1 000 metric tons of mercury per year that it buys from European companies which are turning away from the use of mercury. In October 2007 Mayasa started a 4.2 million Euro project to solve the problem with finding a safe storage of mercury in Europe.

In Europe the EU works towards a phasing-out of mercury. EU has suggested a ban on exports of mercury to countries outside EU from 2011.



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5.1.2 Recycling Mercury

There is no known company in the Nordic countries which recycle mercury.

In Germany, Netherlands, United Kingdom and France there are companies which recycle mercury from different wastes and sell the recycled mercury.

The recycling is done by distillation of the mercury containing waste and collection of the pure mercury. Elemental mercury from canisters in U-864 would probably also be going through the distillation procedure to minimise the impurities in the mercury. To obtain a good price for the mercury it is very important that the mercury is as pure as possible.

The companies which have been contacted have policies on mercury export and none of them allows any export of mercury for gold production.

Examples of companies which recycle mercury are:

NQR Nordische Quecksilber Rückgewinnung GmbH, Lübeck, Germany

Homepage: <http://www.nqr-online.de>

NQR is a part of the international Remondis group (15 000 employees). NQR has a distillation recycling facility for mercury in Lübeck which normally produces about 40 metric tons Hg per year. Less than 10 % of the produced mercury is sold outside EU.

They would be interested to receive the 65-70 metric tons of mercury and they could also be willing to pay for the mercury.

GMR Gesellschaft für Metallrecycling mbH, Leipzig, Germany

Homepage: <http://www.quecksilber-gmr.de>

GMR was founded in 1991 and has 12 employees. GMR works worldwide and is specialised on recycling of mercury-containing waste. They have a distillation recycling facility for mercury in Leipzig and the facility can treat 500 – 1 000 metric tons of mercury containing waste per year.

GMR would be interested to receive the 65-70 metric tons of mercury, preferably at no cost because of the risk that they maybe need to place some of the mercury in a disposal facility if they can not sell all the mercury (due to possible changes in the laws/regulations for handling mercury).



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BMT Begemann Milieutechniek B.V., Dordrecht, Holland

Homepage: <http://www.bmt-begemann.nl>

BMT was founded in 1991. BMT works worldwide and is specialised in recycling of mercury-containing waste. They have a distillation recycling facility in Delfzijl. The facility has a production capacity of 1 000 metric tons/year (permit up to 5 000 metric tons/year) and a storage capacity of 2500 pallets.

BMT are planning to open a production site in Thailand in 2008. They are ISO 9001 and ISO 14001 certified. Among their customers is Statoil.

Other companies are (not contacted);

Ophram Laboratoire, Saint Fons, France

Homepage: <http://www.ophram.com>

Mercury Recycling LTD

Homepage: <http://www.mercuryrecycling.co.uk>

Cost estimate for recycling mercury

Cost estimate for buying mercury in today's market is 10 - 12 EUR/kg for 99.999 % pure and 0.8 EUR/kg for 99 % pure. Delivering pure mercury from U-864 will not likely give more than a maximum income of 5 EUR/kg (40 NOK/kg). Delivering impure mercury will likely generate costs in the order of 4 EUR/kg (32 NOK/kg) mercury waste. Thus, 65 metric ton of mercury (99.999 % pure mercury) could generate a maximum income of approximately 2.5 million NOK. Assumed that impure mercury contains 30 - 99 % pure mercury, which means between 65 - 220 metric ton mercury contaminated waste, there will be a treatment cost of approximately 2 - 7 million NOK.

At this point it is not known what the quality is of the remaining mercury at the site. So far the recovered mercury, one canister, has been of good quality. The main uncertainty is linked to how much mercury is found within intact canisters and how much has leaked out. It is assumed that some of the mercury which has leaked out can be collected and recycled, but this will be at a relatively high cost as shown above.



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5.1.3 Disposal of mercury

Disposal of elemental mercury

Today there is no disposal of elemental mercury in the EU due to that it is still much better economy to recycle and sell the mercury. The EU has started to look at the possibilities of disposal of elemental mercury to prepare for a total ban on elemental mercury. As a leading country, Sweden has introduced a ban on export of elemental mercury.

In Norway elemental mercury has until very recently been exported for recycling. The amendment to the Norwegian Product Regulation (Produktforskriften) which came into force January 1 2008 forbids the export of mercury in products /5/. At the moment it is very uncertain if elemental mercury will be allowed for export from Norway, it depends on if the authorities will regard the elemental mercury as a product or not.

Since the EU Commission announced in 2005 that it intended to phase out all mercury exports by 2011 work has been concentrated on providing safe, indefinite storage of liquid (elemental) mercury as part of a strategy against mercury pollution. In the EU, the long-term aim is to develop safe immobilisation technologies. Immobilisation is still at the research level, but in Sweden, SAKAB is working on a promising technology where elemental mercury is mixed with sulphide and over time a stable mercury-sulphide (HgS - cinnabar) is formed. So far this technology is on the lab scale, but a pilot plant is planned to develop the technology. SAKAB has discussed with NOAH to establish a pilot plant in Norway, utilising the Langøya facility for safe underground storage. This stabilisation/solidification increases the volume of the material with a factor of 3 but the weight remains almost the same (sulphide is much lighter than mercury).

While immobilisation technologies are developed a temporary storage is recommended. Temporary storage could typically be in salt mines (exists today), rock caverns, e.g., preferably in deep bedrock permanent depositories in order to obtain non-oxidative conditions.

Cost estimate for disposal of elemental mercury

Due that there is no disposal of elemental mercury today, there is no experience with costs for disposal. However, the Swedish Environmental Protection Agency has published an official report (report 81-05, 2003) concerning establishment of a disposal in a deep-rock cavern for elemental mercury. The estimated cost in 2003 was 250 000 - 650 000 SEK/metric ton (210 000 - 550 000 NOK/metric ton).

Establishing a future method for stabilising elemental mercury at NOAH (production of cinnabar) is estimated to cost 50 000 - 100 000 NOK/metric ton.

A temporary solution could be storage of elemental mercury in seamless steel flasks (ref. EU type QC 801) above ground or in rock caverns. The price of such disposal could be relatively low given that the environmental authorities approve the solution. The main uncertainty regarding this option are possible future requirements related to EU regulations. This may again imply high future costs.



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Disposal of mercury waste

Hazardous waste containing mercury is disposed of if it is a cheaper and more practical solution than recycling.

Today, disposal of mercury waste with up to 10 % of elemental mercury is possible in Norway. Export of mercury waste from Norway (≤ 10 % Hg) needs permission, but such a permit will almost certainly not be given due to that there are treatment solutions in Norway (ref. Basel Convention). Waste containing > 10 % Hg has probably to be exported for recycling or disposal. If waste containing very high amounts of mercury will be considered to be a product is uncertain, see “Disposal of elemental mercury” on page 16.

In the EU storage (rock caverns, salt mines etc.) or immobilisation would be the two methods for disposal of mercury waste with > 10 % Hg.

In Norway there are at least two facilities which have permits for disposal of mercury waste (≤ 10 % Hg):

NOAH AS, Langøya, Norway

NOAH is Norway’s largest disposal facility for hazardous waste. NOAH has a permit to receive a total of 622 000 metric tons of different types of waste per year, including 322 000 metric tons of inorganic hazardous waste per year. Since the year 2000, NOAH has received approximately 200 000 tons of mercury waste (≤ 10 % Hg). NOAH has developed a stabilisation method in cooperation with the University of Oslo, where mercury is absorbed to gypsum and iron hydroxide. The maximum allowed discharge of mercury to water is 0.0013 kg/day. NOAH is situated on the island Langøya and waste can be transported directly to the island by ship.

Miljøteknikk Terrateam AS, Mo i Rana, Norway

Miljøteknikk Terrateam has a large disposal facility in the rock caverns of the former steel works in Mo i Rana. Miljøteknikk Terrateam has a permit to receive 70 000 metric tons of inorganic hazardous waste per year. The waste has to be stabilised/solidified before placement in the rock cavern. Maximum allowed leaching of waste containing mercury which has been stabilised/ solidified is 0.01 mg Hg/l. The leached amount is determined by using the United States TCLP (Toxicity Characteristic Leaching Procedure) test.

There are also other possible disposal facilities in Norway:

Boliden Odda AS, Odda

Boliden Odda has large rock caverns for disposal of mainly jarosite-bearing sludge from the smelter, but also for mercury sulphide compounds. They have 14 large rock caverns and each is 75 000 m³ – 220 000 m³. The waste is placed in plastic drums and is then cast in concrete in the rock caverns.

There has been no inquiry to the company if they are interested to receive Mercury waste from U-864.



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BIR (Bergen Interkommunale Renholdsverk), Hordaland

BIR has a disposal facility for hazardous waste in a rock cavern in Stendafjellet. Their permit would probably have to be revised to be able to receive the mercury. This is the disposal facility which is closest to the submarine U-864.

There has been no inquiry to the company if they are interested to receive Mercury waste from U-864.

Cost estimate for disposal of mercury waste

Disposal of mercury waste in Norway (allowed for waste with $\leq 10\%$ Hg) will need stabilisation prior to disposal. Binders for stabilisation could be gypsum, cement, sulphur and sulphides. The cost will vary dependent on mercury concentration and use of binder. Stabilisation of mercury waste is estimated to vary in cost from 400 - 1 500 NOK/metric ton.

5.1.4 Health, Safety and Environment (HSE)

When working with mercury, special precautions have to be taken. Health, safety and environment measures should include:

- information meetings with personnel at the site.
- disposable coveralls and other personal protection aids such as respiratory protective equipment, gloves and safety glasses.
- establishing a monitoring program, including regular measurement of mercury concentration in the air around different work processes.
- possible measurement of mercury in the urine of employees who have been in intense contact with mercury contaminated waste.
- establishing restricted areas where handling of mercury is ongoing .
- establishing an emergency plan for spills of mercury including first aid.

If possible, work with mercury should be performed at low temperatures (cold seasons) to avoid evaporation of mercury.

5.2 Hydrocarbons

Diesel can probably be reused if it is intact in the fuel tanks. This was the case for the salvage of U-534. If not able to reuse, the diesel can be sent to an approved disposal/recycling facility for incineration.

The cost for incineration is dependent on the diesel quality. In Norway the incineration of organic waste costs approximately 2 000 - 3 000 NOK/metric ton (with low heat value). Based on experience, incineration is probably slightly cheaper abroad.

Examples of companies in Norway that may handle the diesel are; Renor, Norsk Spesialolje, Franzefoss Gjenvinning AS, Veolia Miljø AS and NOAH AS (export).



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Lubricants and grease were also used on board, no exact figures of the amounts exists. Estimated amount is in the order of a couple of hundred kilos. Costs are in the same range as diesel, and the same companies as above can handle these substances. Special attention has to be shown if there is risk that the diesel and/or organic waste is contaminated with mercury, due to emission of mercury in case of incineration.

5.3 Scrap metal

Steel fractions that are contaminated have to be analysed for impurities and categorised before disposal/recycling.

Possible treatment methods of contaminated steel are:

- Pre-treatment such as sandblasting, acid cleaning and recycling (reuse of the steel). Cost in the range of 1 500 - 3 000 NOK/metric ton. Added value for recycling is in the range of 500 - 1 000 NOK/metric ton.
- Disposal at an approved disposal facility. Cost in the range of 500 - 1 500 NOK/metric ton.

Examples of companies in Norway that may handle the scrap metal are; Stena Jern og Metall, Hellik Teigen Group, NOAH AS, Veolia Miljø Metall AS and Franzefoss Gjenvinning AS.

Sandblasting of contaminated steel should be evaluated especially with respect to Health, Safety and Environment (HSE).

5.4 Batteries

The batteries are old and detailed specifications are missing. Batteries could still be intact, when the submarine U-534 was salvaged in 1993 in Kattegat batteries were reported to still be intact. <http://uboat.net/technical/batteries.htm>

The possibility for recycling of batteries from U-864 is uncertain. In general, old batteries can be recycled or disposed as hazardous waste.

In Norway, the recycling of batteries is free of charge for private households, but in this case it has to be assumed that a certain cost for delivering the batteries. Companies in Norway which import batteries established in 1993 the company AS Batteriretur to take care of the collection and recycling of batteries containing hazardous waste.

- Examples of companies that can dispose of batteries as hazardous waste are; Miljøteknikk Terrateam AS and NOAH AS. Delivering the batteries as hazardous waste will cost in the range of 500 - 1 500 NOK/metric ton.
- Examples of companies that recycle batteries are Exide (Exide Sønnak in Norway) and Boliden Bergsöe AB (Landskrona, Sweden). NOAH can receive the batteries, remove the lead and send (export) the lead for recycling. The cost for the extra handling has to be deducted from the value of the lead. The cost for handling the batteries is expected to be in the range between 0 (the recycled lead covers the handling) and 500 NOK/metric ton.



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5.5 Transformers and cables

Transformers and cables have to be analysed for impurities (especially PCB) and categorised before disposal/recycling. Asbestos is assumed to have been used as insulation.

Possible treatment methods of transformers and cables are:

- If there are no impurities, the transformers and cables can be delivered to an authorized waste dealer. In general, delivery of electronic waste in Norway is free of charge for private households, but in this case it has to be assumed that a certain cost will be involved for delivering the transformers and cables. This cost is expected to be in the range between 0 (the value of the metal covers the handling) and 500 NOK/metric ton.
- If the transformers and cables contain PCB, asbestos or other impurities they have to be delivered to an approved disposal facility. Cost in the range of 1000 - 2000 NOK/metric ton.

Examples of companies in Norway that may handle the transformers and cables are; Ragn-Sells AS, Veolia Miljø Metall AS, Hellik Teigen Group, Stena Jern og Metall and Franzefoss Gjenvinning.

5.6 Contaminated sediments

Sediments within U-864 could be severely contaminated with several pollutants like mercury, PCB, diesel, heavy metals, etc. These sediments should be treated separately from the sediments outside U-864. Assumed that parts of the mercury canisters, diesel tanks etc. inside the wreck are destroyed, the level of contaminations can be in the range of 10% or more. In this case thermal treatment is probably the only feasible solution. Such facilities are found in the EU region. Thermal treatment is expected to cost in the range between 5 000 - 10 000 NOK/metric ton.

Assumed that the level of contamination is lower than 10%, stabilisation/solidification should be considered. This can be done in Norway by companies like NOAH AS and Miljøteknikk Terrateam AS. Stabilisation/solidification will cost in the range of 1000 - 2000 NOK/metric ton.

Sediments outside U-864 are less contaminated (mostly much less than 1%) and can be treated with stabilisation/solidification but with less binder (cement/gypsum) than sediments inside U-864. This can be done in Norway by companies like NOAH AS and Miljøteknikk Terrateam AS or by establishing a new disposal facility closer to the wreckage site (permit is needed). Stabilisation/solidification of the less contaminated sediments will cost in the range of 300 - 600 NOK/metric ton.

Independent of the contamination level and treatment method the surplus water in the sediments should be removed to reduce the amount (and cost) of material for treatment as much as possible.

5.7 Others

Other contaminated waste materials could occur. These have to be collected and sent to an approved disposal facility for classification and final treatment/disposal.



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6 SEPARATION TECHNOLOGIES THAT COULD GIVE A MAJOR COST REDUCTION FOR THE DISPOSAL/TREATMENT

In this chapter separation technologies which can give major cost reductions for the disposal/treatment of the (hazardous) waste are described. It is especially volume reduction of the contaminated sediments by dewatering which substantial cost reductions for disposal/treatment.

6.1 Contaminated sediments

If sediments outside the wreck are removed, it will be done with dredging technology. Depending on dredging technology, different amounts of water will follow the sediments. With suction dredging more than 95 % of the dredged material will be water. For such dredging technologies, the separation of water can give a major cost reduction, due that the volume which has to be disposed of can be strongly reduced. One solution could be that the dredged sediments are placed in a barge with a sand filter and a protective geotextile for dewatering. This will demand monitoring of the surplus water which is returned to the sea and accept criteria for the amount of mercury in the water. If the accept criteria are not fulfilled, further water treatment is necessary. A precipitation process using sulphide may be used. An alternative could be to establish a water treatment plant in the nearest safe harbour.

To illustrate the economical advantage of dewatering, the case where the dredged material contains 95 % water can be used. Assuming theoretical dredged volume of 15 000 m³ would give approximately 300 000 m³ for disposal at an assumed cost of around 400 NOK/metric ton (500 NOK/m³) giving a cost of 150 mill. NOK. If it needs to be fully dewatered, the cost would be 7.5 mill. NOK. Dewatering will normally be much less costly than the disposal cost and would therefore be recommended in such a case.

The amount of sediments *inside* the wreck has an assumed volume of 10 m³ (chapter 4.6). It is assumed that wreck parts will be salvaged together with the sediments that are inside and that mortal remains inside have to be removed. Dewatering of these sediments is not assumed to give any major cost reduction.

6.2 Elemental mercury and surplus water

There will probably be a need to collect spilled elemental mercury from both inside and outside the wreck. This could be done with a simplified suction method and result in two main phases, elemental mercury and contaminated sea water. Before delivery to recycle or disposal, it would be cost effective to separate water from elemental mercury. This could be done by decanting and/or filtration. The surplus water can be treated at an approved treatment facility for contaminated water. Due to the high cost of recycling and disposal for elemental mercury, any reduction of surplus water will be cost saving.



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7 FUTURE DEMANDS

DNV has been in contact with “The Zero Mercury Working Group” (/6/) to get information about the work with phasing out mercury in the EU area and which legislation that is expected to come in the (near) future. The Zero Mercury Working Group was officially launched on the 7 April 2006, but has been operating since beginning of 2005. It is an international working group of 140 NGOs (non-governmental organisations) based in all 27 EU Member States, and potential EU Member States. The group works in close co-operation with the European Environmental Bureau (EEB). The aim of the group is to reach “Zero emissions, demand and supply of mercury, from all sources we can control, in view of reducing to a minimum, mercury in the environment at EU level and globally.”

7.1 Legislation

Norway is presently not a member of the European Union, but it has signed the EEA (European Economic Area) with the union. By this agreement, Norway is in practice following all the EU legislation and treaties.

7.1.1 EU decisions and proposals

- The EU decided in 2001 to phase out priority substances in the Field of Water policy before 2020 (decision 2455/2001/EC). Among “priority one hazardous substances” is mercury included meaning that discharges, emissions and losses of mercury have to cease or be phased out by 2020 (not being used anymore).
- The EU is working on a new proposal (dated October 26th 2006) with a more restrictive policy on mercury. The proposal aims at banning export of metallic mercury and ensuring safe storage of surplus mercury. The proposal is not a law yet, it has first to be approved both by the Council (Ministers of the EU 27 member states) and the European Parliament.²
- The EU commission has proposed that export of metallic mercury from the EU shall be prohibited from July 1st 2011.³
 - Metallic mercury from the chlor-alkali industry, cleaning of natural gas, non-ferrous mining and smelting operations shall be disposed of according to the Waste directive (safe disposal).

² They are at 1st reading stage, which means that the proposal has gone through the Parliament and Council, but since there is no agreement on several points yet, they have to go through 2nd reading, and if no compromise is found it will have to go for Conciliation.

³ The Commission has proposed July 1st 2011 and the Parliament has proposed December 1st 2010, and the Council supports the Commission's proposal July 1st, 2011.



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- The proposal from the Council has an opening for temporary storage (more than one year) or permanent storage of metallic mercury in salt mines and in deep underwater hard rock formations, or temporary storage (not permanent) in above ground facilities. This is not finally decided yet.⁴
- The European Parliament proposes also that mercury compounds containing more than 5% mercury per weight, and mercury-containing products which are already banned in the EU, should be included in the scope of the export ban.⁵
- No final disposal operation should be permitted until the special requirements and acceptance criteria are adopted.
- In an amendment to the proposal in June 2007, the European Parliament suggested that the Member States should submit information on movements of metallic mercury, cinnabar ore and mercury compounds entering or leaving their country /7/. (Amendment 10).

The definitions for the requirements of the temporary storage, permanent storage above ground facility have still to be worked out by the EU. Especially the rules for regarding the definition of deep underwater hard rock formation will be important for disposal in Norway. Depending on what is defined by “deep water formation” a permanent storage in Norway could be excluded at many sites.

7.1.2 Norway

Norway introduced an action plan for reduction of mercury emissions in 2005 (Handlingsplan for å redusere utslipp av kvikksølv) /8/.

The following targets have been set:

- 1) Reducing mercury emissions significantly within 2010 compared to the 1995-levels
- 2) Emission and use of mercury shall be stopped within 2020.

January 1st 2008 an amendment to the Norwegian Product Regulation (Produktforskriften) came into force which prohibits “to produce, import, export, sell and use substances preparations that contain mercury or mercury compounds”. As mentioned earlier, it is unclear if the mercury from U-864 will be considered as a product.

7.1.3 Sweden

Waste containing more than 0.1 % mercury has to be stored in deep rock formation from 2015. Sweden has an export ban on mercury waste containing more than 0.1 %.

⁴ The Parliament said that they at the moment only want temporary storage in salt mines or above ground facilities, and has proposed that a fund is created where the industry would put aside money to be used when technologies for final disposal would be available, for example by solidification followed by placement in salt mines or deep bedrock.

⁵ The Council is not supporting this position at the moment, it wants only metallic mercury to be banned from export, however many individual member states do support widening the scope.



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7.2 The future market for recycling/disposal of mercury

The market for buying and selling mercury will probably be decreasing due to that the EU legislation will be more restrictive. Today there are still approximately 30 chlor-alkali plants in Europe which use mercury in the production and these are the main users of mercury today. The chlor-alkali industry plans to largely phase out the mercury cell process in Western Europe by 2020. Already, some Western European countries have phased out their mercury cell chlor-alkali plants, or have announced plans to phase them out by 2010. However, the largest chlor-alkali plants in France, Germany, Italy, Spain and the UK, expect to have their plants operating after 2010. New chlor-alkali plants will not be using mercury-cell process according to the IPPC (Integrated Pollution Prevention & Control) directive (96/61 EC).

7.2.1 Recycling (export) of mercury from U-864

The most probable scenario is that both the demand and supply of mercury in the EU will be reduced gradually. The chlor-alkali industry, which is the largest consumer and supplier of mercury, is gradually phasing out mercury, but it is expected to take many years probably at least until 2020. However from 2011 they will have to bring the surplus mercury to a safe disposal if the EU proposal comes into force. This will reduce the mercury supply because they can no longer recycle the mercury.

At the moment it does not look as there are any EU directives which will ban an export of the U-864 mercury inside the EU provided that the Norwegian authorities will allow such an export.

7.2.2 Treatment and disposal of mercury from U-864 in Norway

Depending on how EU defines a “deep water formation” as a permanent storage, it could cause problems finding a suitable location for disposal in Norway. The problem consists in that most storage locations in rock are relatively shallow (<100 m) but may still have stable physical and chemical conditions. The waste industry is working on new technologies for treatment (stabilising) mercury which could simplify a final disposal in Norway.



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- /2/ <http://www.kystverket.no/arch/img/9281615.pdf>

- /3/ <http://www.kystverket.no/arch/img/9281613.pdf>

- /4/ <http://uboaat.net/technical/batteries.htm>

- /5/ http://www.regjeringen.no/Upload/MD/Vedlegg/Forskrifter/product_regulation_amendment_071214.pdf

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- /7/ <http://www.europarl.europa.eu/sides/getDoc.do?type=TA&reference=P6-TA-2007-0267&language=EN&ring=A6-2007-0227>

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