IV/2
A NEW RECYCLING-PLANT FOR METALS, CONTAMINATED BY NATURALLY OCCURRING RADIONUCLIDES

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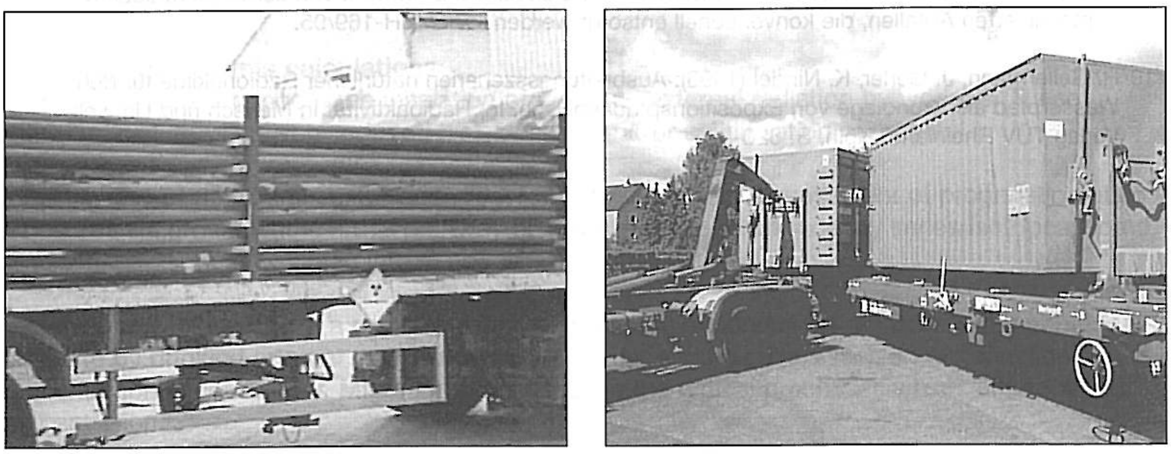
Introduction
Many European gas wells coproduce a significant amount of radionuclides, which contaminate the gas-leading equipment. After being contaminated the parts are unsuitable for direct recycling or reuse.

In addition the scrap is contaminated by mercury, which often occurs in European gas-fields. Without a pre-treatment for decontamination these materials has to be rejected for reuse [1].

As a spin-off from CARLA, the recycling plant for low-level radioactive waste, Siempelkamp has developed a new recycling plant for metals, contaminated with naturally occurring radioactive materials (NORM) accompanied by impurities of mercury and organic components [2]. This design led to the GERTA plant, put into operation in January 1998.



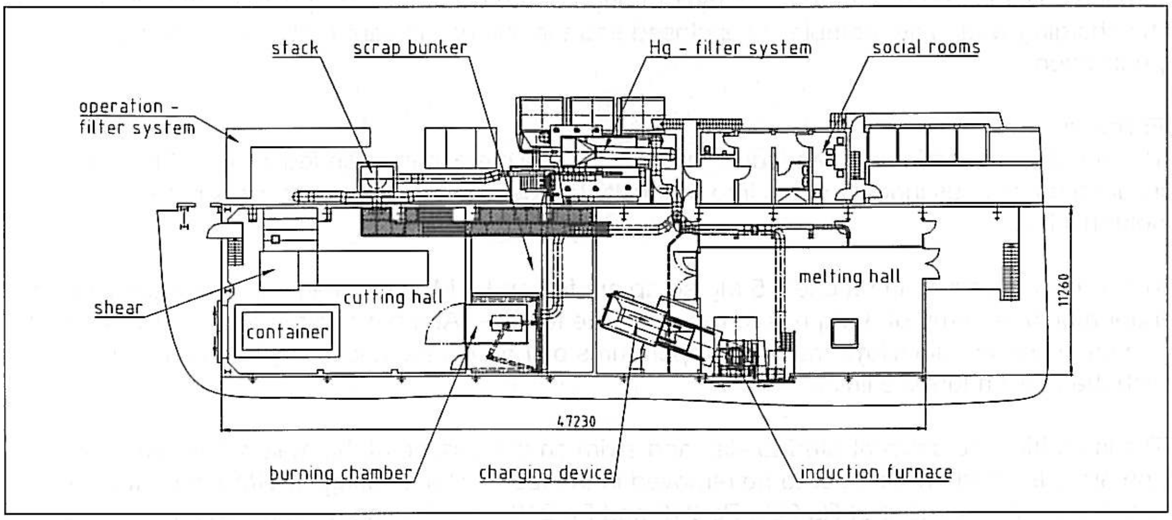
Variation of shipping-systems

Input Criteria
With a capacity of 2.000 Mg/a the plant has the permit to handle metallic scrap with a NORM contamination < 500 Bq/g. In addition a mercury content lower than 1 wt-% is allowed. 5 % organic compounds are accepted. Excluded is material with contents of lead due to the possibility to damage of the furnace.

Materials with NORM are shipped to Siempelkamp by several types of containers or as bulk-ware. 20'-containers, containers for multi-bucket systems or roller tippers, rail- and roadcargo is accepted.

Structure of the plant
Based on a mains frequency furnace with a capacity of 8 Mg, Siempelkamp has optimised the following elements of the recycling process: Furnace, exhaust system, flue gas purification, preparation of the input materials. As the aim of development Siempelkamp defined the protection of staff and environment and the maximum yield of mercury-free and non-radioactive product. In a two years period of development 500 Mg of scrap has been molten, examined and recycled. The optimum combination of mentioned elements was discovered.

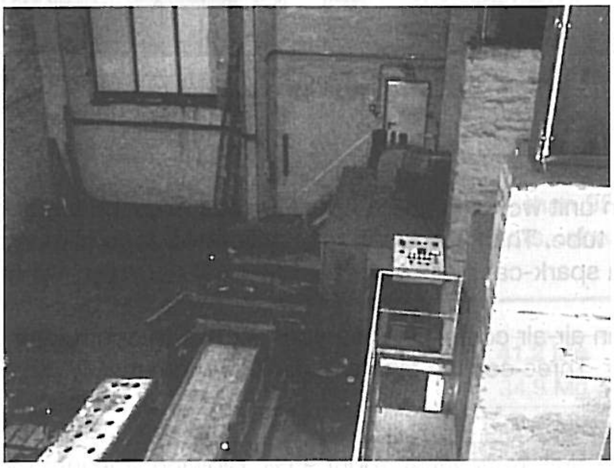
The recycling plant is devised in six units:
1. Storage space
2. Dismantling shop
3. Intermediate Storage
4. Furnace
5. Flue gas purification
6. Locker room, offices



Plan of the GERTA plant [3]

Outdoor storage
A sealed area for pre-storage and handling of the incoming scrap is installed on the Siempelkamp field. Approximately 500 Mg of scrap can be stored.

Dismantling shop
The input is decomposed and cut in the dismantling shop. This area is located in the GERTA hall separated from the furnace area by a crane-gate. Several devices are in use to produce chargeable parts with a maximum size of 300 x 300 x 300 mm. Cavities are opened, and spots of mercury are removed if possible. An alligator shear cuts tubes with a maximum diameter of 100 mm. In the separately exhausted cutting-chamber, large components could be cut by using a gas- or plasma-cutting-torch.


Dismantling shop

The dismantling shop is deventilated with 20.000 m^3/h to remove mercury contents in the air. If the mercury-content exceeds 100 μg/m^3 the staff has to wear gas-masks.

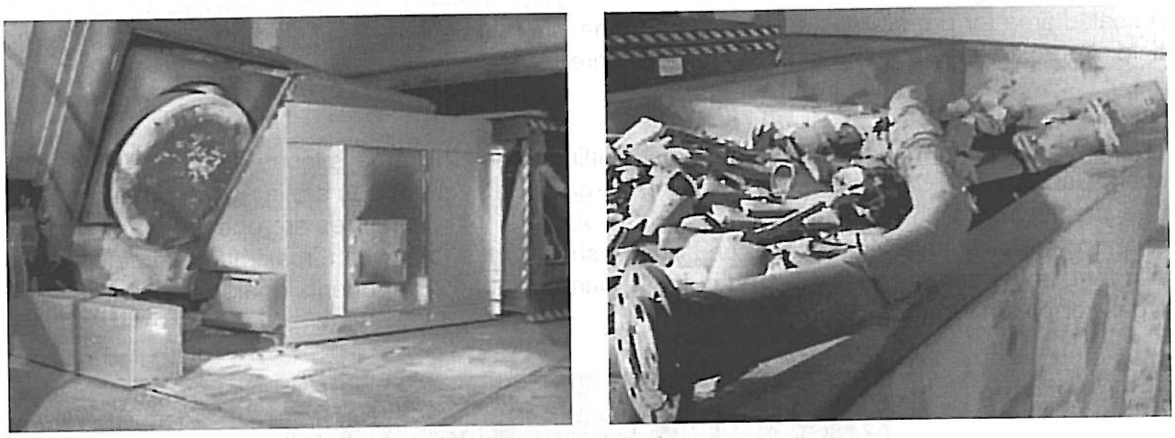
Storage
The scrap bunker serves as a puffer for cut materials. Due to the intermediate running of dis-assembling unit and melting unit and the separation between the different origins of the scrap we have to use three bunkers. The feed for two weeks can be stored here.

When changing operation from disassembling to melting, scrap is filled from the bunker into the charging wagon. This wagon roles automatically through the gate to its end-position. Then the furnace cover is lowed onto the conveyer through of the wagon. In this position, the furnace and the charging wagon are completely enclosed and the flue gas is captured and led to the gas purification.

Furnace
The scrap is molten in an 8 Mg induction furnace. The metal has to be fed into a 3 Mg-sump to insure a continuous induction-flux into the melt. The density of the scrap itself is not sufficient to hold this flux.

The furnace operates in batches. 5 Mg scrap are fed and 5 Mg of molten iron are poured into the ingot mould. A sump of 3 Mg has to remain in the furnace. At a temperature of 1.350°C the metal is molten. For certain alloys melting-temperatures of 1.500°C are necessary and can be realised with the chosen furnace lining.

The impurities are concentrated to slag and swim on the surface of the melt or they vaporize and are adsorbed on the dust to be removed in the fabric filter. Melting NORM-scrap, the radio-active impurities consist of Ra 226, Po 210 and Pb 210. After having removed the slag using slag producing additives by the slag grabber, the melt is cast into the ingot mould.



Furnace and intermediate storage

Flue gas purification
The flue gas purification unit works in four steps. Flue gas from the furnace and flame cutting room are unified in one tube. This tube leads to a cyclone to separate large particles. Additionally the cyclone serves as a spark-catcher.

Then the gas is led to an air-air cooler. This component has to control the input-temperature of the following fabric filter. Three cooling fans are started automatically depending on the furnace output temperature.

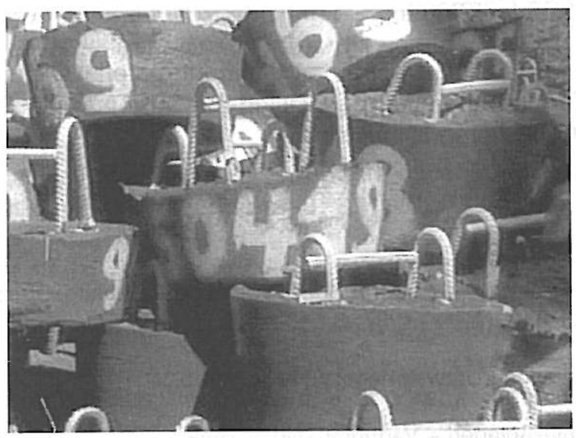
The fabric filter insures a dust removal at about 95%. Blowing lime into the air stream reduces bonding of the fabrics by oil or tar from the gas cutting or furnace. A remarkable amount of mercury is removed from the flue gas adsorbed to the separated dust.

Mercury, remaining dust and other organic impurities are removed in a fixed bed adsorber filled with activated carbon. Using this combination of apparatus the mercury-concentration in the stack does not exceed 50 μg/m³, ¼ of the permitted value. To improve the mercury-removal, the carbon is enriched with sulphur. The sulphur reacts with mercury to mercury-sulphate to be adsorbed on the activated carbon. As NORM-scrap is processed, vaporizable radionuclides, especially lead and radium, condense or are adsorbed on the dust to be removed in the fabric filter.

Flue gas purification

Products

As the main output the plant produces ingots with a weight of 1 Mg. These blocks are sold to be used for starting induction furnaces. The minerals adhered to the input metal and the metals which are insoluble in iron melt, are slaged. The slag is a glass-like by-product, which can be used in road construction.



Ingots for reuse

Siempelkamp has to dispose the dust and the mercury saturated activated carbon in a underground dump as waste. For the activated carbon a new recycling technology is in sight, so that only the dust has to be disposed in the near future.

Weight assessment

Using the described facility, a reduction of waste material at more than 95% is reached. Only 1 – 2 % of the input have to be disposed. Two examples of projects, where Siempelkamp processed NORM-scrap are shown in the following table.

	Exp. I		**Exp. II**	
Input:	**42,76 Mg**	**100 %**	**41,2 Mg**	**100 %**
Scrap	42,46 Mg	99,2 %	34,9 Mg	99,2 %
Lime	0,30 Mg	0,8 %	0,3 Mg	0,8 %
Output	**42,76 Mg**	**100 %**	**41,2 Mg**	**100 %**
Melt	38,87 Mg	90,9 %	30,7 Mg	87,4 %
Slag	2,28 Mg	5,4 %	3,7 Mg	10,6 %
Dust	0,66 Mg	1,6 %	0,5 Mg	1,4 %
Melting loss	0,95 Mg	2,1 %	0,24 Mg	0,6 %

Weight assessment

Most of the waste to dispose results from the lime injection into the flue gas. The melting loss has its origin in burned organic compounds on the scrap. Typical of these impurities is plastic inliner in flanges or bituminous layer on the tube surfaces.

Monitoring

The monitoring of the GERTA-process has to meet several requirements: The sufficient protection of the staff has to be documented, the environmental influence must be recorded and the quality of input and output should be traceable. The determination of activity in the materials, which are handled in the GERTA plant, is described in detail [4].

Due to the occurrence of mercury in most of the input materials an atomic absorption spectrometer with UV photometer is installed. It measures online the total content of mercury in the flue-gas. The measuring ranges between 1 µg/Nm³ and 500 µg/Nm³ with a resolution 1 µg/Nm³. The same technology is used to control the mercury-concentration at the working places. Exceeds this value the limit of 100 µg/Nm³, gas-masks have to be worn to protect the staff. In the cutting-room, the respirator has to be worn anyway all time. The monitoring of the staff includes a semi-annually medical examination.

Experience and outlook

Since starting the new plant, approximately 1500 Mg scrap has been molten. 1450 Mg was sold to the steel industry to close the material-cycle. 50 Mg of slag is reused as raw-material for road-construction. 660 Mg of the input metal was contaminated with natural occurring radioactive materials. Sources of these materials are off-shore-oil-wells, Eastern German and Dutch Gas wells and an oil well in North-Germany.

In the near future, the portion of NORM-scrap at the input material will grow due to the increasing amount of off-shore platforms to be scrapped. Using the GERTA technology a reasonable and ecological recycling of NORM-scrap is available.

References

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