



DEVELOPMENT AND LICENSING OF A MELTING PLANT FOR CHERNOBYL SCRAP

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Abstract

One decade after the accident at unit 4 of the Chernobyl nuclear power station, a melting plant for radioactively contaminated metallic materials, the so-called SURF facility, is being planned and licensed for erection in the direct neighbourhood of the NPP area. Main goal is the recycling of the material, largely decontaminated by the melting process, by means of manufacturing of casks and containers for waste disposal and of shielding equipment.

The melting plant will be part of the Ukrainian waste handling centre (CPPRO). The technology is based on the long-term experience gained at Siempelkamp's CARLA plant in Krefeld.

Within 1995 and 1996 the licensing conditions were defined, the licensing documents prepared and the formal procedure initiated. The complex is scheduled to start operation in 2001, in case the necessary financing is allocated. To this end, the proposed site of the facility has undergone the state assessment. The technical documentation for construction is at the stage of development.

MOTIVATION AND DESIGN BASIS

Within the remediation and restoration programme for the Chernobyl exclusion area, the erection of a waste handling centre (CPPRO) in the close vicinity of the Chernobyl nuclear power plant is being realised step by step. A melting facility, the so-called SURF plant (Smelter for the Ukrainian Radwaste Facility) is defined as a core element for handling of radioactively contaminated metallic material, by means of which the waste volume shall be drastically reduced and the largely decontaminated materials could be recycled.

The Central Waste Processing Enterprise was established by the GOSKOMATOM directive No. 380 of November 16, 1995. The supplement to this directive (No. 28 of January 21, 1997) specifies the goals and functions of the Enterprise as follows:

- ◆ Collection, reprocessing, interim storage and transport of radioactive wastes originated from the 1986 accident, plant operation as well as wastes arising from decommissioning operations at the CNPP units and the Ukrytie.

- ◆ The Central Enterprise has been called upon to implement the waste management provisions set forth in the Ukrainian Laws „Utilisation of Nuclear Power and Nuclear Safety“, „Radioactive Waste Management“, as well as the State Program for radioactive waste management.

On May 6, 1997, the President L. Kuchma signed the order No. 388/97 which transforms the Ukrainian State Committee on the Utilisation of Nuclear Power (GOSKOMATOM) into a State Department of Nuclear Power under the Ministry of Energy.

Therefore, the Ministry of Energy takes over the management of radioactive wastes and the respective facilities located in the Chernobyl Exclusion Zone.

This presidential order lifted the inter-institutional confusion caused by the „Ministry of Accidental Situations and Protection from the Consequences of the Chernobyl Accident“ controlling the waste management aspects.

As part of the solution of the Chernobyl Zone problem, the Central Enterprise will include a complex for smelting of radioactive metal (the SURF Project). In the course of analysis of the required capacity and technologies, the plant offered by Siempelkamp has been selected. The smelting complex comprises scrap cutting and blasting shops, and a melting hall which contains induction and electric arc furnaces.

The melting technology is based on the separation effect of the radiologically dominant nuclides during the melting process, which leads to a transfer of these radionuclides from the basic material into the process waste such as slag and filter dust. Slag and filter dust representing only a few percent of the initial mass can be safely disposed off after additional volume reduction in a permanent final repository.

The technology is based on the long-term experience gained at Siempelkamp's CARLA plant in Krefeld. This plant has been licensed per § 3 of the German Radiation Protection Ordinance and used commercially since 1988. Up to now, more than 10,000 Mg of contaminated scrap from European nuclear installations have been melted and recycled in the nuclear field [1].

In order to provide adequate input data for the SURF plant design and the suitable equipment, an on-site evaluation was performed within the EU-sponsored TACIS programme [2]. It showed that radioactively contaminated metallic material is being stored openly at 48 locations within the 30 km exclusion zone. The main part with approx. 60,000 Mg is located in the immediate vicinity of the Chernobyl plant consisting of spare parts such as pipes, vessels and electronic equipment. In total, an overall mass of metal scrap of minimum 100,000 Mg was estimated, not including the unregistered emergency dumps and the metallic structural materials expected to arise from plant decommissioning.

The on-site measurements showed furthermore the dominance of Cs 137 and Sr 90 leading to a maximum specific β - γ -activity of approx. 400 Bq/g as well as the very low portion of α -activity.

THE PLANT DESIGN

According to these results a plant throughput of approximately 10,000 Mg/a was defined with the option to enhance the capacity by modular units.

Main data and the general arrangement of the overall plant are presented in Fig. 1, the process flow with the main procedural steps in Fig. 2. The main elements of the SURF plant can be roughly described as follows:

- The melting shop:

In order to ensure a high degree of availability and with regard to the expected broad range of incoming material and their dimensions, two different furnace types have been planned for, i. e. an induction and an electric arc furnace. Crucible induction furnaces which are operated at medium frequency are the ideal melting aggregate for bulky parts composed of various materials. The advantage of the discontinuously charged electric arc furnace lies with its specific larger crucible diameter which permits charging with larger pieces of scrap. For redundancy reasons, both furnaces are housed in separate low-pressure enclosures each with their individual filter technology. They are controlled from a joint control station (Fig. 3).

- The blasting shop:

All incoming materials ought to be blasted prior to further treatment, especially in order to cover highly contaminated parts. Blasting takes place in a tight enclosure where a negative pressure is produced by strong suction, so that no dust particles can escape to the environment. The blasting material envisaged is medium grain-sized steel shot which has good stripping qualities.

- The granulator:

As an alternative utilization concept for the cast iron, granulating is implemented. The main process of the granulating technique is given by the injection of the melt via a special nozzle into a water bath.

- Main auxiliary systems:

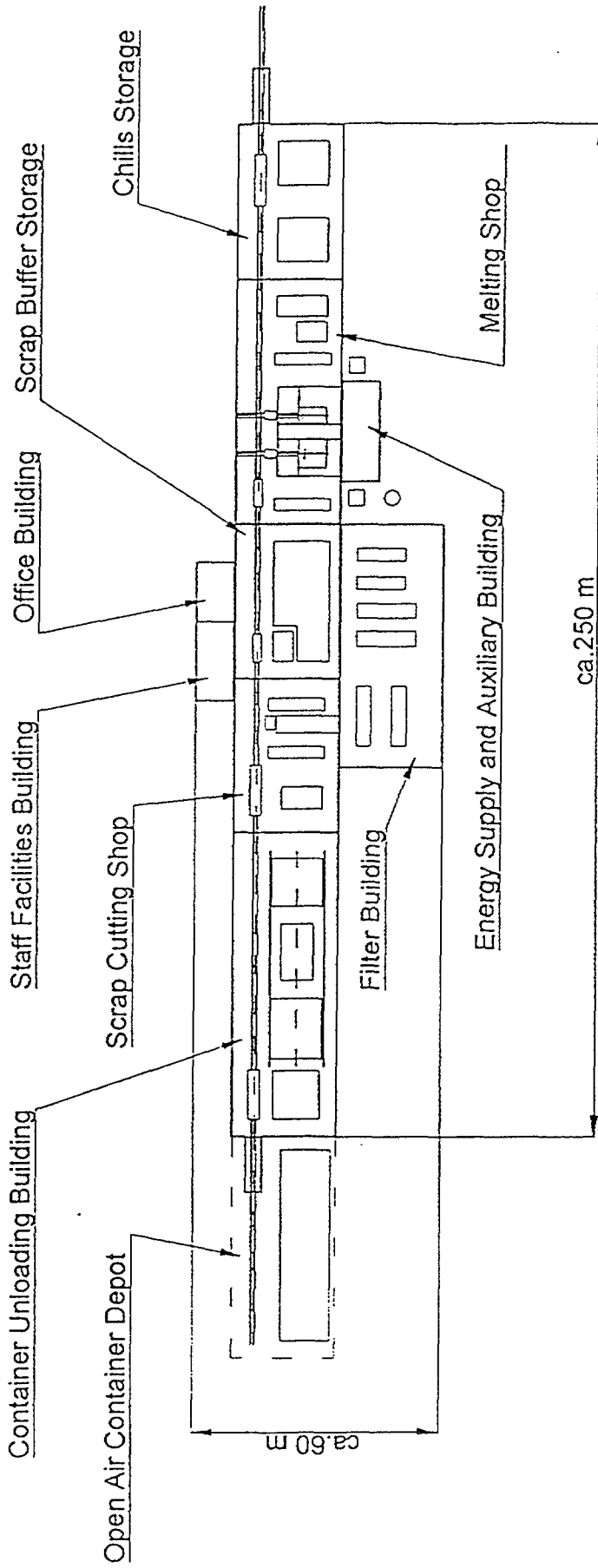
The air is filtered by 6 simultaneously operating filter systems with an overall discharge rate of 390,000 m³/h. The filter systems for the blasting shop, the cutting area and the furnace casings consist of a high efficiency cyclone, a bag filter and a HEPA-filter and meet nuclear standards.

Besides torch-cutting devices two saws are foreseen for cutting thick-walled parts such as shafts. The main equipment is a heavy-duty hydraulic scrap shear with a cutting force of approx. 600 Mp.

The transportation system consists of a single track which covers the whole length of the plant. Flat battery-operated trolleys run on this track.

- Radiation protection concept:

The melting plant has been planned under consideration of the ALARA principle. This means that all radiation exposure is kept as low as reasonably achievable considering economic and social factors.



- melting aggregates: 1 induction furnace
1 electric arc furnace
- melting capacity: 10.000 t/a
- filter capacity: 390.000 m³/h
- power requirement: 20 MW

FIG. 1. SURF - melting plant Chernobyl. Main data and general arrangement.

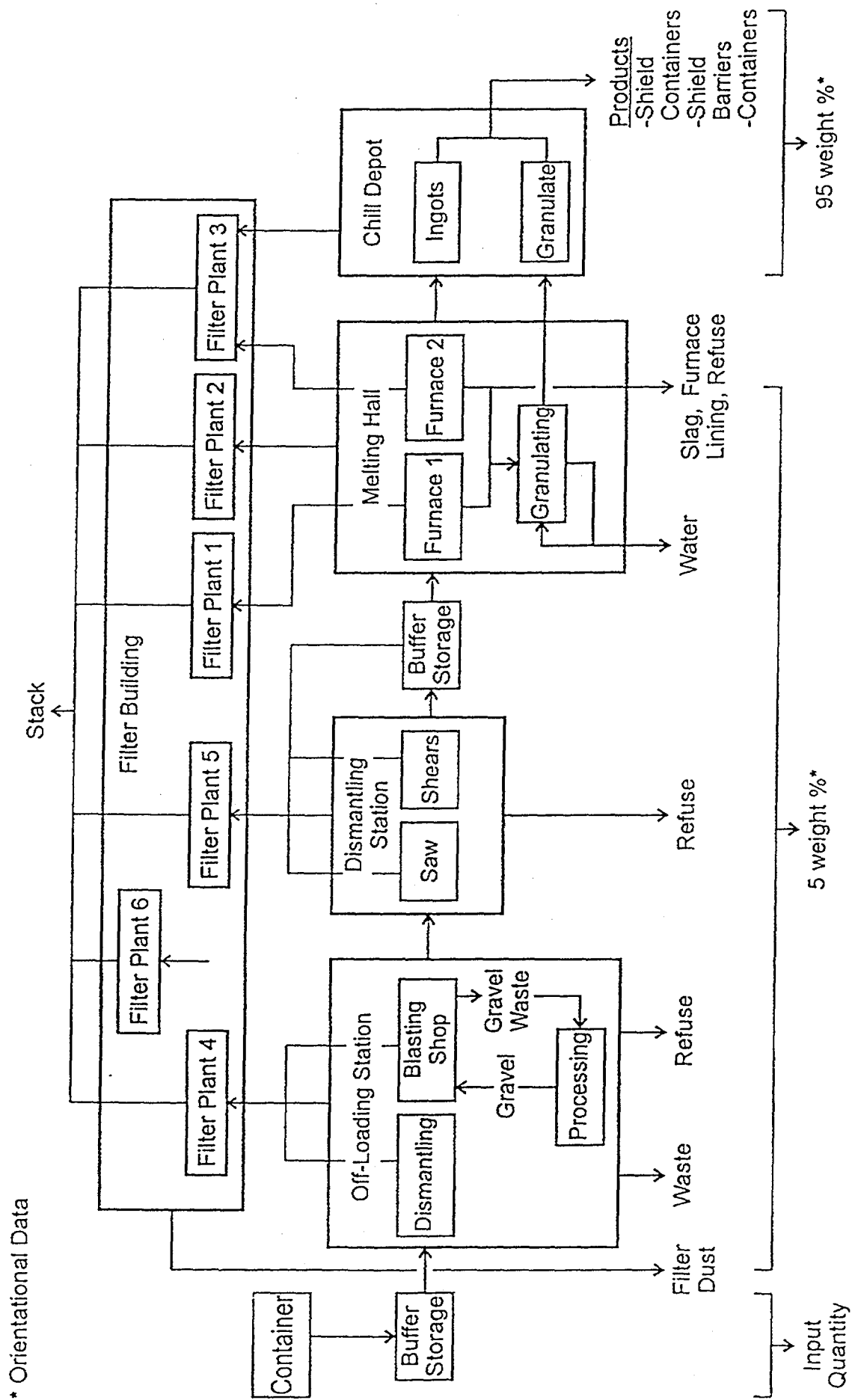


FIG. 2. SURF - melting plant Chernobyl. Flow diagram of material stream.

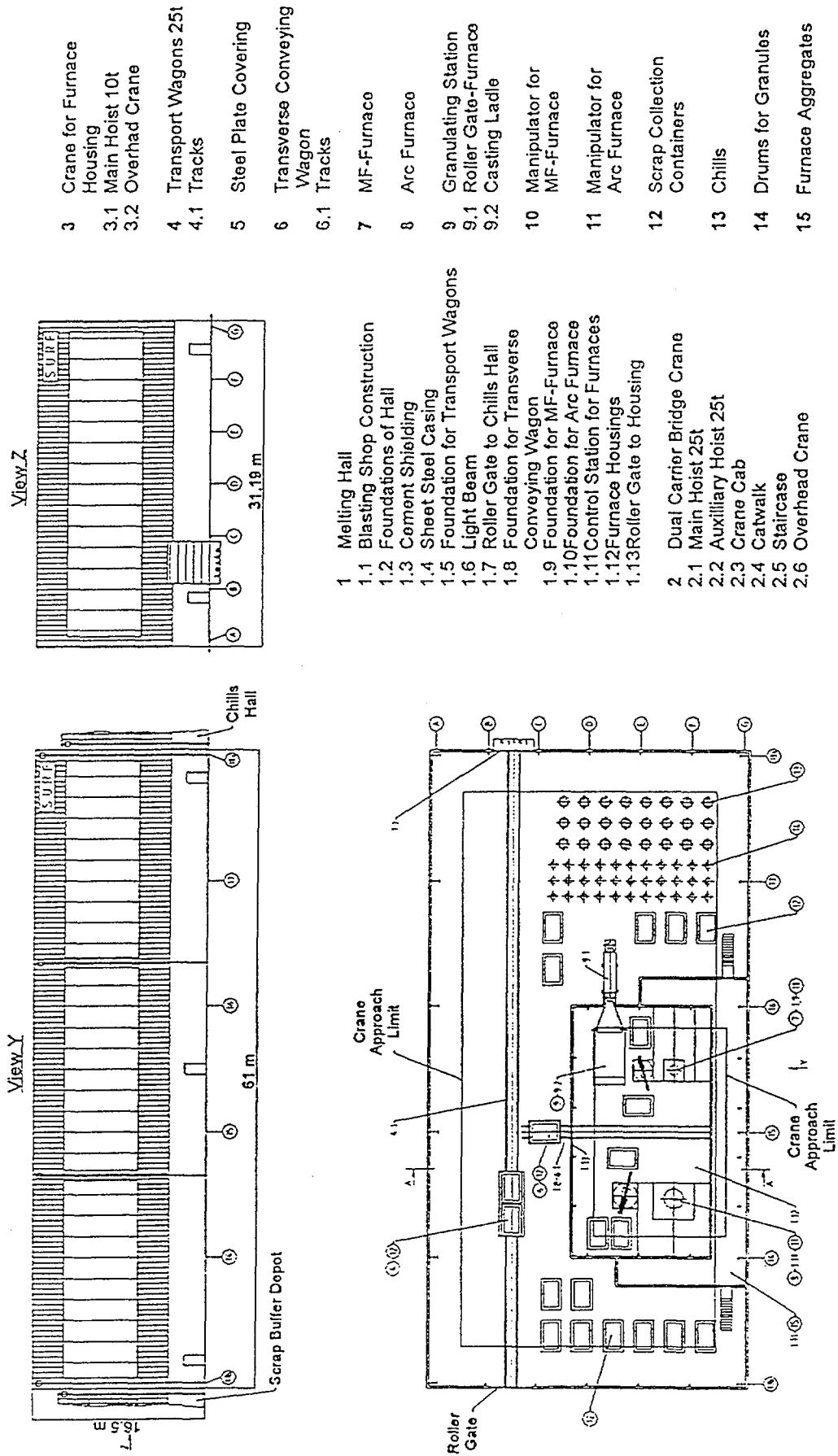


FIG. 3. SURF - melting plant Chernobyl. Melting hall.

Possible danger to the personnel of the melting plant exists in form of external exposure from the contaminated scrap as well as the incorporation of radionuclides during handling. To minimize the exposure risk, special clothing and breathing masks (type P 3) are required for work areas with higher radiological impact. Model calculations have shown that even under conservative assumptions regarding α -activity the dose rate can be evaluated as very low in comparison with the annual dose limits of 50 mSv/a defined for the category A personnel working in the Chernobyl area.

THE RECYCLING CONCEPT

Due to the special situation in the Chernobyl area and the general requirements for the handling of nuclear waste within the 30 km-zone, the recycling concept for the melted material has been defined as follows:

- manufacturing of casks and containers for storage and final disposal of radioactive waste,
- production of shielding equipment such as plates, beams and cubes of different geometries and sizes to be used for the sarcophagus work at unit 4 and other shielding tasks within the 30 km-zone (e. g. storage facilities).

In both recycling regimes casting of ingots and granules as intermediate products can be realized for the following final product line. With view to the present conditions granulation seems to be the favourable procedure.

THE FIRST LICENSING STEPS

Licensing requirements

In continuation of the basic design work, in January 1995 the European Commission ordered a follow-up study on preparation of the licensing procedure for the SURF plant with the following main objectives [3]:

- Elaboration of the frame conditions for the licensing procedure
- Evaluation of the relevant Ukrainian regulations including present regulation drafts
- Adequate transfer of the German regulations with special emphasis on adaptation to specific local conditions in the Chernobyl area
- Compilation of the licensing file.

According to the previous conceptual work, and, under consideration of the legal requirements, the CARLA plant with its supplementary facilities at Siempelkamp's Krefeld location has been confirmed as a pilot technique. This procedure assured a direct know-how transfer and enabled the implementation of the German licensing know-how.

Consequently, the Ukrainian authorities approached the German local licensing authority, the Bezirksregierung Düsseldorf, for assistance and consultant tasks, especially to obtain a formal statement on licensibility of the technical equipment of the SURF plant according to German regulations.

The adaptation to the specific Ukrainian conditions and the formal licensing procedure would then be covered by the Ukrainian authorities.

The joint adjustment of the main design criteria was successfully elaborated as can be shown with Fig. 4 giving the basic survey of design requirements for the SURF plant in comparison to the CARLA values.

Subject	Design values	
	CARLA	SURF
1.) Handling	200 Bq/g α, β, γ 100 Bq/g U 233, 235, Pu 239, Pu 241 (fission material) open and sealed 1000 Bq/g "naturally" contaminated materials	1000 Bq/g 1000 Bq/cm ²
2.) Utilization after melting		
a) within the nuclear field	200 Bq/g α, β, γ 100 Bq/g fissable	1000 Bq/g 100 Bq/g fissable
b) released	old: 1 Bq/g α, β, γ new: $10^{-4} A_{Fr} \text{ Bq / g}$ (Residue regulation)	α : 7,4 Bq/g β, γ : 74 Bq/g
3.) Waste (slag, dust, furnace lining)	old: 5 Bq/g new: $10^{-4} A_{Fr} \text{ Bq / g}$ i.e. Co 60: 5 Bq/g	7,4 Bq/g α 74 Bq/g β, γ
4.) Exhaust air	$10^{-6} A_{Fr} \text{ (Bq / m}^3\text{)}$ i.e. Cs 137: 0,5 Bq / m ³ Co 60, Sr 90: 0,05 Bq / m ³	0,15 Bq / m ³ α, β, γ
5.) Liquid waste	not applicable	optional: Granule waste water into NPP liquid waste system

FIG. 4 a. SURF - melting plant Chernobyl. Design requirements.

Subject	Design values	
	CARLA	SURF
6.) Dose rate	1,5 rem/a 15 mSv/a (2000 h/a)	5 rem/a 50 mSv/a (only Cat. A required) (1700 h/a)
7.) Areas		
Surveillance area	x	-
Control area	x	x
	No prohibited area Full protection during open handling	No prohibited area Full protection during open handling
8.) Throughput	4000 t/a	20000 t/a
9.) BlmSch		
Dust	$\leq 1 \text{ mg / m}^3$ (Law: $\leq 20 \text{ mg / m}^3$)	20 mg / m^3
Noise	55 dB	80 dB
UVP	No	Yes
CO, NO_x, SO_2 negligible	x	x

*) A_{fr} = free limit for activity

FIG. 4 b. SURF - melting plant Chernobyl. Design requirements.

Site approval

According to the Ukrainian regulations the formal detailed plant licensing application has to be preceded by the licensing of the plant site on the basis of an assessment of three potential sites. Main criteria are safety aspects and infrastructural issues, but also technical-economic topics.

Fig. 5 shows the three assessed sites around the power plant area. As result of the detailed evaluation, option 3 has been selected, offering especially advantages for the erection of the overall CPPRO plant.

Formal licensing procedure

On the basis of all the boundary conditions described above a licensing file has been elaborated consisting of the technical plant concept and a detailed description of the safety characteristics with main emphasis on radiation protection activities. The German local authority attested the licensability according to German regulations. This led to the initiation of the formal licensing procedure by the official application placed on December 28, 1995.

Within 1996, detailed discussions with the Ukrainian authorities took place giving their positive expertise. This expertise was presented to the Ukrainian Board of Ministers, which gave a positive vote for this site. A decision of the site of the SURF-facilities is made by this act.

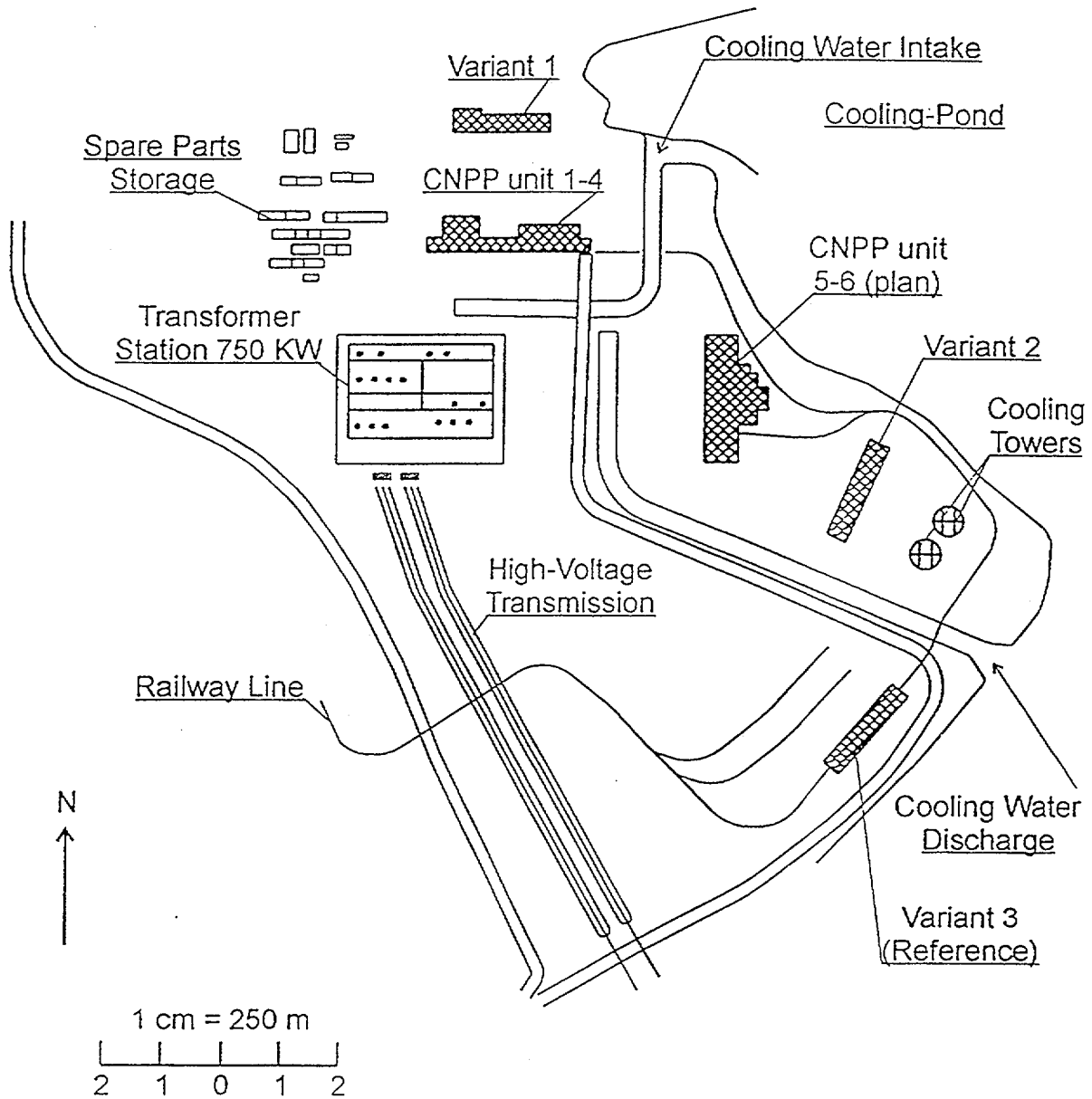


FIG. 5. SURF - melting plant Chernobyl. Site variants.

An other very difficult step is to come to a financial concept which guarantees the establishment of the SURF-facility at Chernobyl. One proposal is to obtain money from the G7-states where the money is distributed by the European Community, or to receive money directly from the European Community, using TACIS fundings.

More promising is the alternative of financing the plant by a credit being secured via HERMES. The Ukrainian government has already decided to ask for such a credit; today, the amount of 15 % of the total project volume as a first rate has to be paid.

Provided with proper funds, the engineering work is scheduled to be finished in 1998, the construction to start the same year. Commissioning is feasible in 2001.

ACKNOWLEDGEMENTS

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