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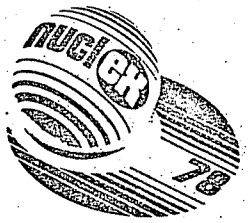

TECHNICAL MEETING

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INFLUENCE OF THE DEMANDS OF THE REGULATION OF RADIATION PROTECTION ON A PLANT DESIGN SHOWN IN AN EXAMPLE OF AN AIR-COOLED STORAGE PLANT FOR SPENT LWR FUEL ELEMENTS

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Influence of the demands of the regulation of radiation protection on a plant design shown in an example of an air cooled storage plant for spent LWR fuel elements

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Summary:

The main demands of the German regulations of radiation protection which have an influence on the planning of nuclear plants are declared. The instruments which fulfill these demands and are available at NUKEM will be introduced.

When nuclear plants are designed the principles of protection against radiation for the staff and the population are considered from the very beginning and therefore the law orders and international rules are taken into account.

These principles are:

- the radiation exposure of the staff and the population has to be as low as possible according to the state of art,
- radioactive materials may be emitted from a nuclear plant only after control,
- fixed installed components for protection against radiation are to be preferred to other protection device,
- a nuclear plant must be protected against accidents and sabotage.

The limit values for radiation exposure are defined by law. For the Federal Republik of Germany the law demands the following:

- The immission dose due to outgoing air and effluent must not exceed the value of 30 mrem/a whole-body dose, respectively 90 or 180 mrem/a organ dose on normal operation. The radiation exposure of professionally exposed people must not exceed 5 rem/a whole-body dose and 15 respectively 30 rem/a organ dose.
- Assuming accident the maximum radiation exposure values which are to be defined by the licensing commission must not be exceeded in the surrounding of the plant. The maximum permissable dose for nuclear power plants is 5 rem whole-body dose, respectively 15 or 30 rem organ dose.

The NUKEM GmbH, Hanau, who are specialiced in the field of the external fuel cycle, plans and builds nuclear plants and systems such as factories in which fuel elements are assembled, storage for irradiated fuel elements plants and systems for radioactive waste processing from nuclear power plants and reprocessing plants.

A group of experts is concerned with the planning who has the experience to fulfill and guarantee the legal demands for protection agianst radiation in the industrial practice with a minimum of loss of time and expenditure.

The aim of this work is to guarantee the licensing of a plant.

The main concerns of this group are:

- the radiation protection including the instrumentation
- the guarantee for a low environmental radiation due to radioactive emission in normal operation and in accident condition
- the control of criticality of all components
- control of fission products
- quality control
- protection against sabotage (protection of the object)
- the realization of atomic licensing
- conventional security (fire protection)
- protection of the plant against natural events and events due to civilization.

An example of these works is the following development of a barrier plan of an air-cooled storage for spent LWR fuel elements:

This work was carried out on request of Kernkraftwerk Planungsgesellschaft Wien with the aim to investigate a system for long-term and maintenance-free storage of spent fuel elements for the nuclear power plant Tullnerfeld.

Fig.1 outlines the characteristic features of such a storage. The fuel elements are stored in containers directly in the cooling air. The after decay-heat produced by the fuel elements is carried off by natural convection. The radiation shielding is carried out by the storage cell.

Radioactive material can be released from the storage cell according to the paths outlined on fig.2:

- Fission products and actinides from fuel elements which were damaged either in the reactor or in the storage get into the can in gas or solid form.
  In this release the nuclides H-3, Kr-85, Ru-106, J-129, Cs-134 and Cs-137 are important.

- Due to permeation gaslike nuclides, especially H-3 but also in a small amount Kr-85 are released from undamaged fuel elements.

- On the fuel element surface crud is deposited during the operation of the reactor which contains activation products of the primary system, e.g. Co-60, Mn-54 and fission products from damaged fuel elements, e.g. Ru-106. This crud adheres to the

fuel elements slightly. Especially when handling the fuel elements it may come off the surface.

Radioactive material from the fuel elements accumulates in the can. A part of this activity gets into the storage cell either by permeation or by leckage.

Activity which is generated by activation of the construction material in the storage plant itself and which is released together with the cooling air on the surrounding due to erosion leads to neglectable environmental dose and needs no further consideration. Fig.3 shows the barrier plan which consists of the fuel element, the can and the off-gas system in four variants.

The fuel element principally consists of the barriers fuel-matrix (UO_2) and the cladding (Zirkaloy). The barrier systems of the fuel can and the off gas system can be influenced by construction.

The variants 1 and 2 have the can open. The can is supposed to seperate the cooling stream from the off gas stream. The receiving hall of the storage plant is kept under depression so that released activity is exhausted and then released over the stack by control.

Variant 2 contains an aerosol and iodine filter in the off-gas stream as a barrier against radioactivity release. The effectiveness of the fuel element barriers is limited in both variants as both the Zirkaloy cladding as well as the UO_2-matrix may be damaged by oxidation.

The third variant consists of a closed can. The barrier effectiveness of the can is based on 2 effects:

- Incapsulation of radioactivity
- Protection of fuel elements against oxidation.

Variant 4 shows a fuel element incapsulated in a metal matrix. On the outside of the can is a permeation barrier for tritium. This barrier system additionally fulfills here following tasks:

- The realease of aerosol-radioactivity, fission product nobel gases and iodine from the fuel elements is prevented
- The release of tritium is limited.

Table 1 outlines the environmental exposure of the 4 barrier variants. According to the recommendation of the German commission of radiation protection a non-site-specific calculation was carried out for an emission height of 20 m.

The first variant can not be realized as the limits of the regulations for radioactive protection are exceeded.

In variant 2 the radioactive exposure is lower than the limits of the regulations of radiation protection due to the off-gas system. Decontamination factors of 100 for aerosoles and 10 for iodine were assumed.

The third variant with a closed fuel element can show a much lower environmental exposure than the 2nd. Due to the demand of the regulations of radiation protection for the lowest possible radiation exposure this variant is to be preferred. This barrier plan enables a simple plant construction with relatively low investment- and operation expenses. This variant offers itself for the intermediate storage of spent fuel elements.

In variant 4 it is pointed out that due to special proceedings the release of activity can be lowered to minimum values which are not measurable.

The reason for those special proceedings is mainly the assumption for the planning: a long term and maintenance free fuel element storage should be guaranteed.

These examples show how much the demands of the regulation of radiation protection influence the planning of nuclear plants. For best and most economic planning results experts are needed who are able to:

- survey the relevant nuclear laws, regulations and rules
- prove that these laws, regulations and rules are observed
- To combine the ideas about safety of both the engineers and the licensing commission.

Table 1: Environmental exposure in various barrier plan mrem/a

Nuclide	critical organ	maximum permissable dose	open can	open can + off gas system	closed can 1)	closed can with metal matrix permeations barrier
H-3	whole-body	30	10	10	3	2×10^{-2}
Kr-85	whole-body	30	8	8	10^{-2}	10^{-3}
Ru-106	lung	90	10^{2}	1	3×10^{2}	10^{-3}
J-129	thyroid	90	10^{2}	10	2	10^{-3}
Aerosole	lung	90	10^{2}	1	10^{-3}	10^{-3}

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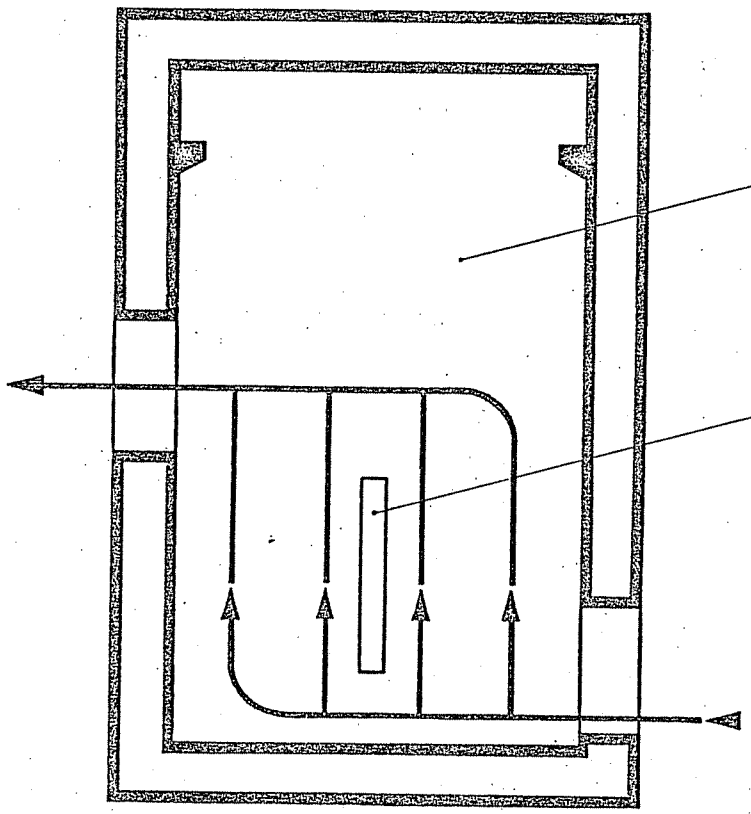
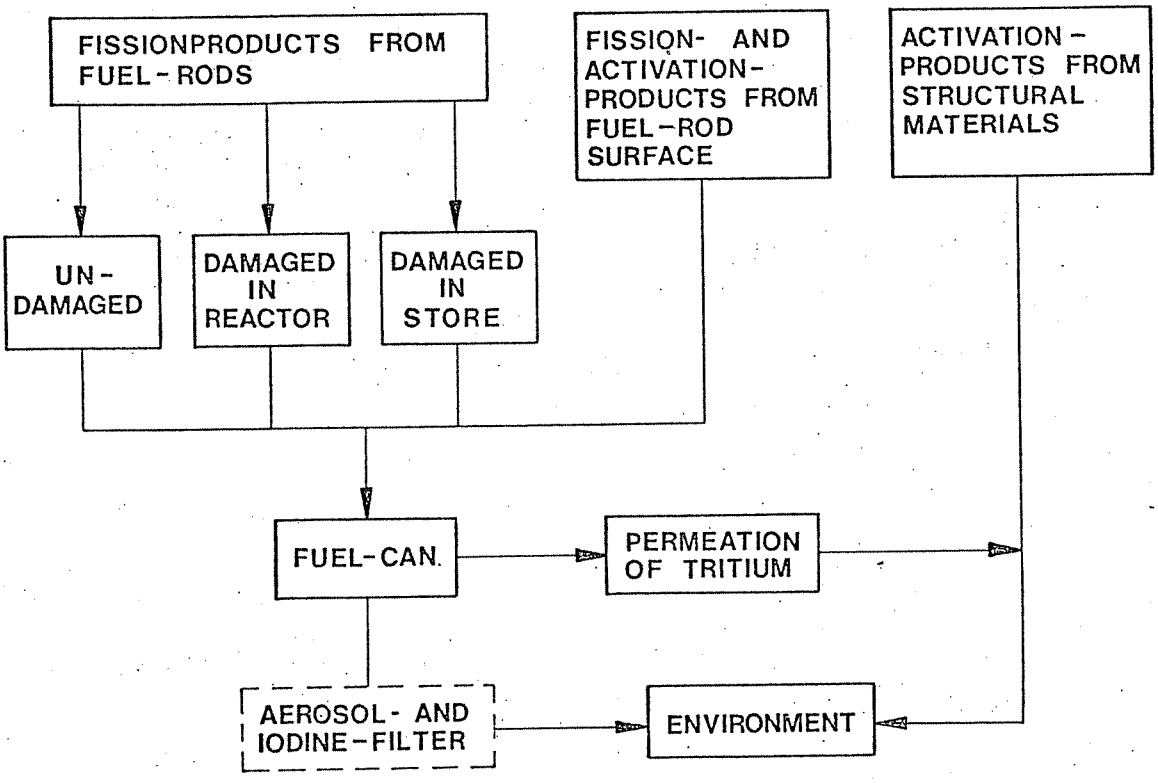
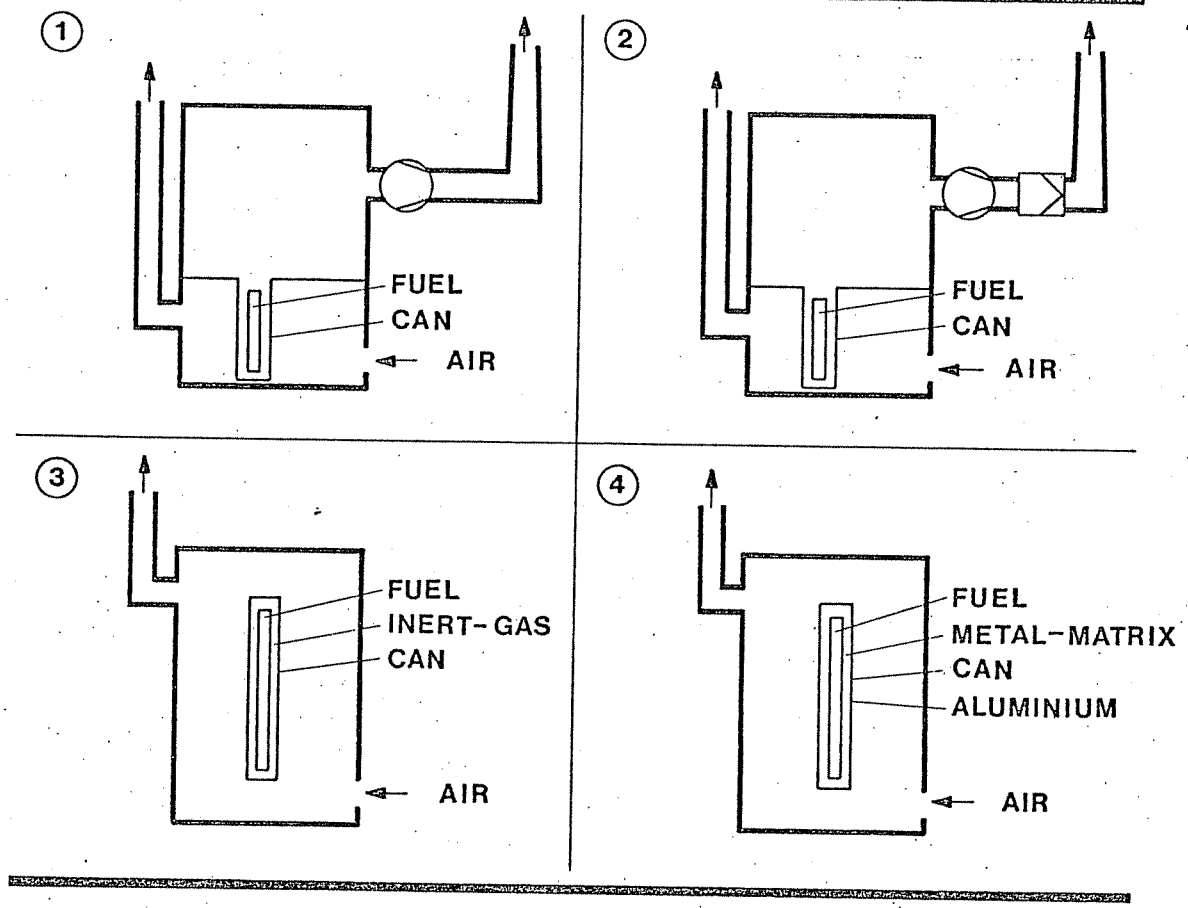


STORAGE CONCEPT



RELEASE OF RADIOACTIVITY FROM THE STORE



BARRIER-CONCEPTS