RUPTURE ACCIDENT IN A BWR OFFGAS CHARCOAL TREATMENT SYSTEM

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To date, the charcoal treatment system is the most widespread technique used to reduce airborne releases from the BWR main condenser offgas pathway to "near-zero" figures. The physical process involved is a selective adsorption of fission noble gases onto the charcoal, causing delay and eventually radioactive decay of most radionuclides. As a matter of fact, you can achieve delay times of a good deal of days for Xenon and a few days for Krypton, depending on their adsorption properties. The overall decontamination factor, defined as the ratio of inlet to outlet concentration, can range from 100 to 10000, according to several parameters. Under these conditions, the radiological impact of the mixture discharged can become almost negligible. Figure 1 illustrates a schematic diagram of a BWR charcoal treatment system showing the most important equipment involved.

Up to now, the offgas treatment design has been basically focused on the decontamination factor needed to comply with existing regulations, in terms of individual and collective doses to the public, during normal plant operation.

On the other hand, a possibility of accidents concerning the spillage of charcoal mass (e.g. due to an earthquake) has to be considered. Owing to the presence of thousands or even tens of thousands of curies adsorbed on the charcoal tanks, the potential risk to the public in case of desorption may be considerable.

HISTORICAL BACKGROUND

As nearly all of the noble gas charcoal treatment aspects, even this one has been deeply investigated by Underhill (1,2). In the meantime the U.S. Nuclear Regulatory Commission (NRC) assigned a study on the subject to the Battelle National Laboratory (BNL) (3).

The U.S. Regulatory Guide (R.G.) 1.98 (4) has set up analysis criteria: equipment seismic class had to comply with the 500-mrem limit dictated by R.G. 1.29. According

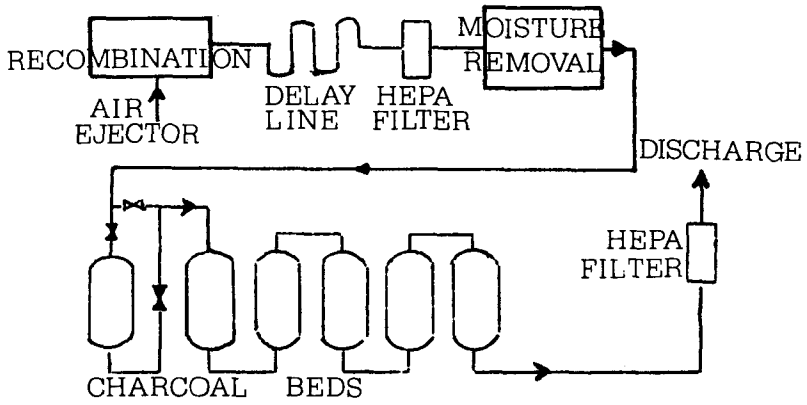

Figure 1. Flowsheet for an offgas ambient-temperature charcoal treatment system.

to the present NRC position; seismic criteria have to be applied to tank support elements and offgas building (5). General Electric's statement claims that calculated site boundary doses result anyway below the regulatory limit (6).

In the framework of the Alto Lazio nuclear power station licensing procedure (Preliminary Safety Analysis Report), the rupture accident has been assessed with the aim of deciding whether seismic class had to be prescribed for charcoal tanks or not. Seismic class was eventually chosen: R.G. 1.98 hypotheses were adopted for calculation.

DESIGN AND OPERATION FEATURES

This paper gives indicative results arising from Underhill's hypotheses (2) that appear more realistic than those of R.G. 1.98: especially the assumption that the whole noble gas inventory is released further to the accident looks overconservative. The most relevant parameters affecting the accident impact can be related to: 1) Offgas mixture conditions (inlet radioactivity, mixture type) 2) Treatment plant variables (transport time in the delay line, air flowrate, charcoal temperature and humidity, number of beds, bed mass, charcoal diffusivity) 3) Accident conditions (offgas production history, depth of spilled charcoal, mixing coefficient) 4) Site conditi-

ons (site boundary distance, wind speed, metereological class, building cross-section, time elapsed after the accident) 5) Regulatory position. (7)

The two most interesting parameters to be assessed are the air flowrate and the charcoal depth after the accident. The combination of both gives rise (Fig.2) to "safety" and "non-safety" areas, having established the 500-millirem limit in between.

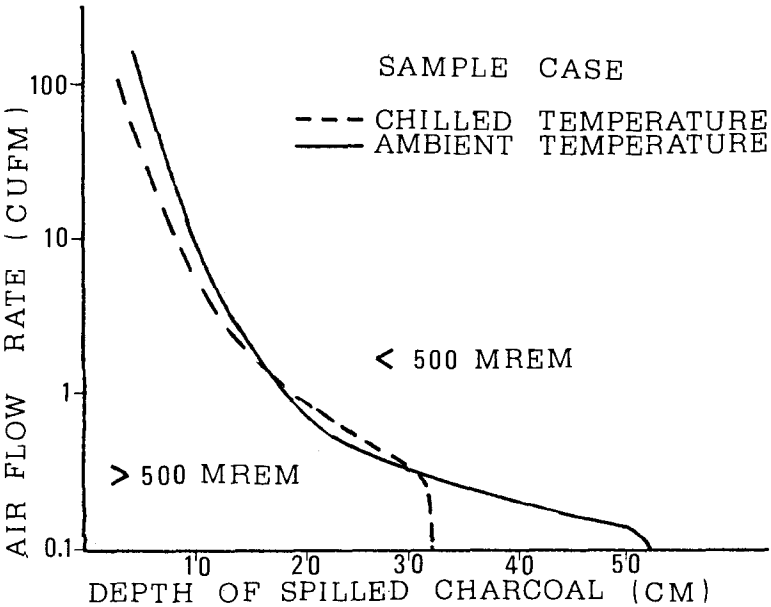

Figure 2. Effect of air flowrate and charcoal depth in complying with the 500-millirem limit.

The relevance of the stream flowrate can be readily seen; thus, ensuring a minimal flow will be enough to respect the above limit. This idea physically means spreading the inlet activity among several charcoal beds instead of storing it up on the first one: the concentration gradient inside the charcoal diminishes and so does - under the same conditions- the motive power for airborne post-accident transport. Such an evaluation could drive designers to install an extra air injection line, to be used when carryover air is insufficient and/or radioactivity noticeable. However, since an increased flowrate adversely affects the charcoal residence time, a few spare beds could become a necessity in order to retain the increased activity transport during normal operation.

The layer depth further to the accident is of the utmost concern: a few centimeters can be enough in order to ensure that the majority of noble gases are retained and then decayed before escaping into the environment. A possible suggestion could be that a layout criterion should avoid the spillage of the charcoal on a vast surface.

Besides, a seismic design - at least for the first-in-line bed where most activity accumulates - could be very effective in order to greatly reduce any risk.

CONCLUSION

The B.W.R offgas charcoal treatment system appears a powerful device for reducing doses to the public during normal operation; however, the presence of relevant activities stored up on the charcoal can be a source of risk in case of a spillage accident.

The most interesting solutions to cope with this problem can be applied through both design and operating features. Among the design features, an adequate seismic class and/or a "tight" layout seem worthwhile, among the operation features, a minimal air flow could prevent "steep" activity gradients inside the beds.

Last but not least, the rupture accident analysis cannot be separated -at a design stage- from other design aspects of the offgas treatment system: any modification will have impact on other design decisions.

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