FEBRUARY 1974

U.S. ATOMIC ENERGY COMMISSION

REGULATORY GUIDE

DIRECTORATE OF REGULATORY STANDARDS

REGULATORY GUIDE 3.18

CONFINEMENT BARRIERS AND SYSTEMS FOR FUEL REPROCESSING PLANTS

A. INTRODUCTION

Section 50.34 of 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires, among other things, that each application for a construction permit for a production or utilization facility, including a fuel reprocessing plant, include the principal design criteria for the facility. Section 20.1 of 10 CFR Part 20, "Standards for Protection Against Radiation," states that licensees should make every reasonable effort to maintain radiation exposure, and releases of radioactive materials in effluents to unrestricted areas, as far below the limits specified in that part as practicable. Properly designed confinement barriers and systems in fuel reprocessing plants provide a principal means of reducing such exposures and releases. This regulatory guide provides information relative to establishing principal design criteria for confinement systems that will minimize the amount of radioactive material released to the environment or to areas normally occupied by personnel.

B. DISCUSSION

A principal objective in the design of fuel reprocessing plants is to prevent the uncontrolled release and dispersal of radioactive materials. These materials are ingredients of process fluids, process solids, and building ventilation gases. Release of radioactive materials is controlled by one or more individual confinement barriers and systems which successively restrict releases of radioactive material to the environment or into areas normally occupied by plant personnel. The confinement system design is affected by the design and operation of building ventilation and process offgas systems and by fire protection requirements. These items will be subjects of future guides.

Fuel cladding, fuel canisters, product or waste storage containers, or walls of process vessels or piping commonly provide the first confinement barrier to control releases of radioactive material. Additional barriers, as necessary for safety, are provided by ancillary process systems and equipment such as the process offgas system or gloveboxes, by process cell or vault walls, or by building walls. These additional barriers are designed to work in conjunction with the building ventilation system to limit the spread of airborne contamination which could be generated by leakage of either gases or liquids from process and storage vessels into process cell or vault air spaces and thence into other areas. Barriers also serve to prevent the spread of contamination via leakage of contaminated liquids and solids.

In order to limit the spread of radioactive materials, processing facilities are separated by confinement barriers into areas or zones of various levels of contamination. The building ventilation and process offgas systems aid in controlling the spread of airborne contamination through openings in barriers by regulating the direction of air or gas flow between these zones so that gas leakage is successively from zones of low potential for contamination to zones of higher potential for contamination. For example, air flow would be successively from the environs to building areas occupied by personnel, to potentially contaminated process areas, to the ventilation cleanup system, and thence to blowers for discharge to the atmosphere. The capacity of ventilation systems must be adequate in relation to confinement system requirements to assure that the velocity of gas flowing through any barrier opening is sufficient to prevent backflow of airborne contaminants through such openings and that air flow patterns are not disrupted by winds, movement of equipment or personnel, or temporary opening of passageways through confinement barriers.

Heat transfer fluids such as water, steam, and air provide potential pathways for release of radioactive materials to the environment. These fluids often circulate between radioactive and nonradioactive areas and are subject to contamination by leakage of process solutions through defects which may develop in heat exchanger components. Should these fluids be discharged to the environs, releases of radioactivity may occur. Barriers to release via this pathway are usually provided by intermediate heat exchangers located between the utility system and the process system. This serves to form a "closed-loop" (as opposed to a "once-through") heat transfer circuit in which the heat exchangers function as confinement barriers.

Piping penetrations through confinement barriers provide another potential pathway for release of radioactive material to the environment. These penetrations usually serve as conduits for instrument leads or serve to conduct cold chemical or utility fluids between zones formed by the barriers. During maintenance or remodeling activities, it may be necessary to isolate selected equipment items to assure confinement. In such penetrating lines an isolation valve located close to the confinement barrier can function as a confinement barrier by being closed during such activities.

In this guide, barriers are arbitrarily classified as "total" or "selective." Total barriers are those fabricated of impermeable materials which can be expected to prevent penetration of all confined material without regard to that material's physical or chemical nature. Examples of total barriers are pipe and vessel walls and walls of buildings and structures. Total barriers may also function as radiation shields. Information on design for this function may be found in Regulatory Guide 3.9. Selective barriers are mass transfer devices or filters and are usually employed to remove selected chemicals or particulate matter from a process or ventilation stream while allowing the bulk amount of the stream to pass through. Examples of selective barriers are adsorbers, scrubbers, distillation units, and particulate filters.

To verify continued integrity of barriers, monitoring devices are necessary. Where a total barrier is used for gas confinement, integrity may reasonably be inferred by monitoring the difference in pressure across the barrier and noting any deviation from normal. Where a total barrier is used for liquid confinement, leakage may be indicated by a liquid high-level alarm in a specially designated leakage collection sump or by analytical devices which measure and alarm contaminant intrusion into normally uncontaminated tanks or process streams. Continuous air monitors are used to indicate any breach in integrity of a total barrier or any loss of function of a selective barrier which would release radioactivity from a designated confinement area into a monitored area.

C. REGULATORY POSITION

1. Confinement systems and barriers should be provided to limit releases of radioactive material to restricted areas so that exposures to individuals are as low as practicable and that the concentrations are as low as practicable and do not exceed the limits specified in §20.103 of 10 CFR Part 20.

2. Confinement systems and barriers should be provided to limit releases of radioactive materials to unrestricted areas; they should be capable of withstanding the effects of design basis accidents, including natural phenomena, so that releases of radioactive materials are as low as practicable and so that they do not exceed the annual limit prescribed by §20.106(a) of 10 CFR Part 20.

3. Pipes penetrating confinement barriers should be equipped with at least one isolation valve located outside of and as close to the confinement barrier as is practicable.

4. Confinement zones should be established and should be bounded by confinement barriers. Generally, zones should be established on the basis of their function(s) which may include confinement of process fluids, process equipment, maintenance areas, operating areas, and process control areas. Zones should be arranged in order of contamination potential. The zones with the highest contamination potential should be situated adjacent to contaminated process areas and the zones with the lowest contamination potential at the outer areas of the process building.

5. Barriers should be designed with regard to the capabilities of the process offgas and the building ventilation systems. Barriers should be designed to withstand loadings due to pressure differentials imposed by these systems. Openings through barriers should be limited in size to preclude disruption of confinement or disruption of air flow patterns due to loss of pressure differential.

6. Barriers should be provided to prevent leakage of contaminated fluids into heat transfer fluids circulated into unrestricted areas. A preferred method for this is by use of closed primary and independent secondary heat transfer circuits.

7. To monitor the integrity of total confinement barriers for gases, devices should be provided to control and indicate pressure differentials between confinement zones. Alarms should be provided to indicate when pressure differentials are not maintained within a prescribed range. In addition, radiation monitoring devices with local alarms should be provided to indicate leakage of radioactive material through confinement barriers into normally inhabited areas.

8. To monitor the integrity of total confinement barriers for liquids, devices should be provided to

indicate and alarm upon liquid leakage through a confinement barrier.

9. To monitor the function of selective barriers, devices should be provided to indicate and alarm any deterioration or loss of function which may release radioactivity from designated confinement zones into other zones or to the environs. Devices such as CAMs (continuous air monitors) and stack monitors are acceptable.

10. Confinement systems should be constructed of nonflammable materials except where this is not possible because of special functional requirements, for example, gloves in gloveboxes.