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File Criteria

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EXTERNAL CONTAINMENT BUILDINGS FOR REACTOR FACILITIES

Condition of Containment during Refueling and Maintenance

1. An external containment building is provided to enclose a reactor facility when the following conditions apply:
 - (a) There is a credible possibility that radioactive materials having airborne potentiality could be released from the reactor assembly.
 - (b) The quantity of such released material could be sufficiently large that its dispersal under pessimistic atmospheric conditions could give exposures to individuals beyond the site boundaries in excess of permissible emergency doses.
 - (c) The number of people and their distribution in the areas beyond the site boundary which could receive exposure doses are such that their immediate evacuation in case of reactor accident would be difficult to accomplish or unreasonable to require.

2. Where external containment vessels are required, one of three general types of conceptual plans is used, depending on circumstances and requirements in particular situation: 1) a "high integrity," "absolute" containment vessel, 2) a partial containment supplemented by controlled, purified release and 3) a time-sequenced, pressure-relieving, reactivity-retaining vessel for cases where pressure buildup and reactivity release do not occur simultaneously.

3. Characteristics and use of "high integrity" containment vessels:
 - (a) These vessels are used when radioactivity release, usually though not necessarily accompanied by pressure buildup, may occur and it is necessary to retain the radioactivity.
 - (b) The vessel must be built to withstand with sufficient safety margin pressures as high as any that it may be necessary to

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contain. If the vessel is of metal, its design and construction should be carried out in accordance with the applicable sections of the ASME Unfired Pressure Vessel Code, with special attention given to components or features to which the Code does not apply. The design pressure of a vessel built to Code requirements may be chosen as 1/2 of the maximum pressure expected to occur from any credible accident (thus vessel failure would be expected only at pressures of double the maximum pressure expected); and the maximum test pressure to which the vessel is subjected should be equal to the maximum pressure ever expected.

(c) The permissible leak rate to be specified for the vessel and to be verified by tests before reactor startup and at specified intervals thereafter, must not exceed that which would result in exposures to people beyond the site boundary in excess of the permissible emergency doses in the event that the worst credible reactivity release accompanied by the largest pressure buildup inside the vessel should occur under pessimistic conditions of atmospheric dispersal.

(d) If leak tests are carried out at one pressure, the calculations of volume leakage at a higher pressure shall be based on a $P^{\frac{1}{2}}$ relationship between volume flow and pressure; not on a linear relationship.

(e) Where accidents with the reactor could cause the generation of shockwaves on projectiles, sufficient protection against these must be provided to insure that the vessel will not be breached thereby.

where walls of the containment vessels are penetrated by

ventilation ducts or other conduits which are normally open to the outside or could be opened by accident, these penetrations must be provided with automatic valves which would close in sufficient time after an accident to prevent escape of radioactivity released inside the vessel.

- (g) The requisite pressure capacity and leakage specifications must be maintained at all times the reactor is in active status.

4. Use of "Controlled Release" Containment Vessels:

- (a) Semi-tight buildings, equipped with means for controlled exhaust through suitable filters, scrubbers, etc. to maintain reduced internal pressure and thus prevent outleakage through holes and cracks, may be used where reactor characteristics and location are suitable. This concept is most applicable where potential accidents would build up little or no pressure, hence would not damage the exhaust purification devices and would not require excessive air release to reduce internal pressures below ambient, and where the location is such that gaseous effluent not easily collectible in purification systems could be released to the atmosphere without potential hazard to large number of people.
- (b) The maximum radioactive effluent from this facility considered to be credible must not present a potential threat of exposure of people beyond the site boundary to doses in excess of the permissible maximum dose.

5. The separated pressure - radioactivity release concept:

- (a) This containment plan may be used for reactor facilities in which it can be shown that release of radioactivity would follow

by a definite time interval, not precede or accompany, any pressure surge which might arise inside the containment vessel. The plan then is to leave the containment open, or allow it to open automatically, until any pressure surge has been exhausted, to be followed by secure automatic closing of the openings for retention of any radioactivity subsequently released.

- (b) The containment vessel would, by this plan, be a "high integrity" vessel (3 above), but its pressure capacity would only need to match the requirements of the post-pressure situation; not the maximum pressure buildup.

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CONTROL SYSTEMS

1. There must be instruments, equipped with automatic level and rate of rise trips, capable of responding to the neutron flux in the start-up range.
2. There must never be less than 2, preferably 3, independent flux monitoring channels.
3. If normal instruments at any range are all similar, it is desirable that these be backed up by a scrambling mechanism of another type.
4. On reactors having power levels of 1 Mw or less, both flux level and period scram protection must be employed at all times.
5. On reactors above 1 Mw, flux level scram protection must be employed at all levels. Period scram is not mandatory in the operating range.
6. Arrangement for a scram only on trip coincidence from 2 channels may only be employed if there are at least three independent channels from which the coincidence trips can originate.
7. During start-up or operation at levels substantially below nominal maximum power, at least one level scram (neutron, gamma, temperature) must ride down in the near vicinity of actual level at any time, and be advanced as necessary as the power increases.
8. There must be periodic check by appropriate signal input or mock up source of the actual response of each safety channel over the whole response range, including activation of the alarm, trip or scram device.
9. Insofar as possible all safety channels must be so constructed that their failure will cause shutdown.

CONTROL SYSTEMS

Continued.

10. In any flux detector there must be an interlock which will cause reactor scram if the high voltage supply to the chamber deviates substantially from the proper value.
11. Interlocks of all sorts should be chosen with great care. It is essential that the necessary ones be provided, but it is hazardous to provide more than are needed. Once chosen, a safety interlock must never be by-passed or deactivated by the operating staff.
12. Safety interlocks must be so arranged that range changes of indicators do not deactivate or move the position of the alarm, trip, or scram point.
13. After any maintenance or alteration of a safety channel, a complete recheck of response must be made, including interlock activation by an appropriate impressed signal.
14. An automatic power level control system may not have capability of both a rapid delta k insertion and a large delta k insertion. In any case, the excess reactivity which may be inserted automatically may not exceed the equivalent value of β (beta) except in special circumstances.
15. When an automatically operated control rod of appropriate value reaches its limit of travel it may not automatically invoke shim withdrawal.

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CRITERIA FOR CONTROL RODS

In a thermal reactor employing a usual control rod system, the following general principles apply:

1. Reliance for safety and control should not rest on one rod only.
2. Each single rod should have a limited value of reactivity, usually not more than 3 or 4% delta k.
3. The rate of reactivity addition by rod movement should be limited; 10^{-5} to 10^{-4} delta k/sec is customary.
4. The total amount of reactivity capable of being added by the automatic control system independently of normal action of the operator, should be limited to values not substantially larger than Beta.
5. The maximum value of any single rod, the value of the regulating rod, the permissible rate of manual and automatic reactivity addition, and the speed of response of the emergency scram system, must be related to the inherent shutdown characteristics and the speed of the transient behavior of the reactor.
6. Rod withdrawal schedules and sequences necessary to safety should be insured by design features and interlocks, not left to administrative instructions and procedures.
7. Switches for manual rod withdrawal should be spring-loaded to open; i.e., requiring operation of continuous operator effort during rod withdrawal.
8. At least some of the rods, representing sufficient reactivity capacity for shutdown, must be provided with mechanisms and devices which will achieve rapid insertion in case of emergencies. The response times of these devices should be related to the potential inadvertent delta k insertions.
9. There should be some dependable back-up mechanism in addition to the primary rod insertion device to assist rod insertion in emergencies, e.g., gravity, springs, pneumatic pressure, etc.
10. There should be provided adequate shut-down capacity; e.g., never less than 4% delta k below critical.
11. The power level of the reactor should be continuously indicated

on appropriate instruments during operation and during shutdown when any manipulations whatever on the reactor are in progress.

12. Attention must be given to:

- (a) Positioning channels or guides which insure reproducibility of location but provides freedom of movement, particularly during scrams.
- (b) Mechanical adequacy of rod structures.
- (c) Thermal stresses and distortions of rods.
- (d) Corrosion or solubility of rod components.
- (e) Buoyancy or flow effects of coolant or moderator.
- (f) Nuclear burning of rod poison.
- (g) Radiation damage in rod materials.

2.



① Joint position = bubbles etc.
② Joint regulation = X-ray, etc.

Temp
flap
Temperature
flap

1. monitoring ^{flap} internal ^{flap} fluctuations in a large reactor. (or backing away on ^{empty membrane})

cellular culture

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alloys