DOSE ESTIMATION IN CASE OF LOCA FOLLOWED BY CORE MELT-DOWN IN THE ARGOS PHWR-380 MWe

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Argos PHWR-380 is a medium size nuclear power station (380 MWe) with a pressurized heavy water reactor of the pressure vessel type, fuelled with natural uranium or advanced fuels. It was designed by ENACE S.A. (Argentina's nuclear engineering company) and is thought to be particularly suitable for developing countries. The plant uses the technology employed in Atucha I unit (a 367 MWe NPP, which has been operated since 1974) and Atucha II plant (a 745 MWe NPP, which is under construction) but with enhanced safety features and significant upgrading.

It is ensured that the Argos complies with the demanding safety requirements of the Argentine national regulatory authority and with relevant international safety standards, guides and recommendations.

In this study it was analyzed the influence of release height and retention of radionuclides inside the containment on the consequences of a hypothetical loss of coolant accident (LOCA) followed by core melt-down.

One of the lessons learned in the field of nuclear safety is the need of ensure the confinement of radioactive material during these hypothetical accidents. For that purpose the Argos is equipped with a venting system (fig. 1) which is designed to prevent the disruption of the containment and the consequent uncontrolled release of radioactive materials into the environment that could occur in such an extreme case. If the pressure increases unexpectedly within the containment, the venting system is designed to stabilize the pressure at a safe value by regulating the release of excess gases and steam into the atmosphere through the filter system. Argos has a high free volume/power ratio. The design criterion is that the result of this hypothetical and extremely unlikely situation will be such that even the critical group of the population would not be exposed to projected doses higher than 0.1 Sv (this level would not usually justify radiological intervention or counter-measures).

To demonstrate the effectiveness of this system three different cases of release after loss of coolant accident (LOCA) followed by core melt-down were analyzed: immediate release after accident, containment overpressure failure (approx. 16 to 19 days after accident) and controlled release (the activity is released through stack approximately 12 days after accident with a flow rate of 0.5 m^3/s to keep the pressure at a safe value. It was supposed that filter system is not operative). The selected accident is a medium LOCA (0.1 A rupture). Large LOCA is excluded for the Argos reactor because the occurrence probability is several orders of magnitude lower than for an event considered improbable.

CONSEQUENCES ANALYSIS

The dispersion of the activity released into the atmosphere was estimated using Pasquill's model (flat terrain siting was supposed). The lowest wind speed possible for each weather condition was adopted. Ground level releases were supposed to occur at 10 m height. Stack height is 41 m. The critical group is located 1 km away from the NPP.

The activity inventory was estimated with ORIGEN-2 computer code, for the corresponding average fuel burnup. Release coefficients as function of temperature and behaviour of aerosol and iodine inside the containment were also considered. The latter effect was estimated using NAUA Mod. 4 computer code. Tritium inventory was supposed to be completely released. The exposure paths considered are: inhalation, ingestion and external irradiation due to cloud passage and to deposit on ground. Countermeasures were not taken into account.

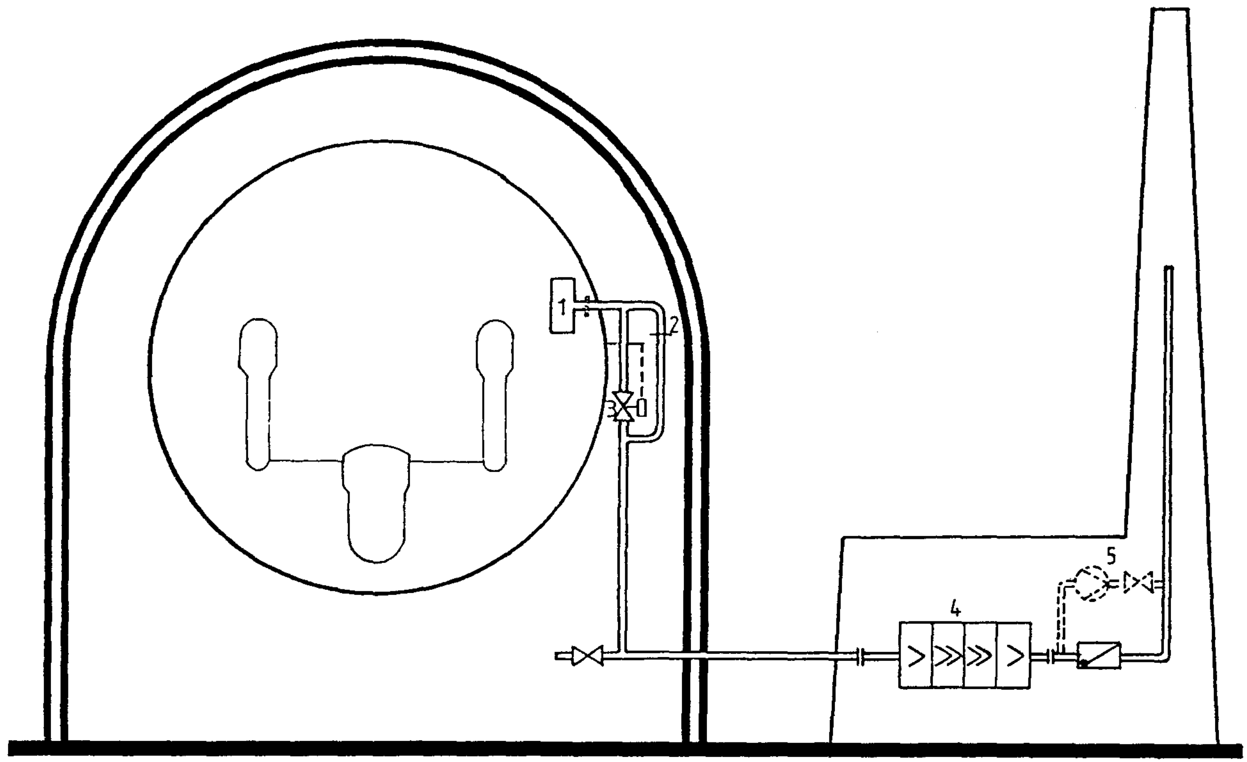
The estimated doses values for the critical group (x = 1 km) show that the influence of controlling the release increases with the stability of weather condition. The ratio between dose in case of controlled release and dose due to immediate release after accident is 0.3 for weather condition D (the most probable) and 0.002 for condition F (the most unfavorable). The ratio between dose due to controlled release and dose in case of containment overpressure failure is 0.56 for condition D and 0.04 for condition F.

It was also observed that the influence of release height increases with the stability of weather condition. For condition D the dose to the critical group in case of release through stack is approximately 40% from the value in case of ground level release. For weather condition F the value is 0.3%.

The release height, retention of iodine and aerosol inside the containment during a larger time period and the favorable free volume/power ratio are the main factors which lead to lower doses in case of controlled release: 25 times lower than in case of containment overpressure failure and 500 times lower than the value in case of immediate release.

Reference: Argos PHWR-380 "Argentina offers a 380 MWe PHWR with enhanced safety features". A.J. Gonzãlez et al. Nuclear Engineer ing International. May 1987.

Fig. 1 - Vented Containment System



1 - Drop Separator
2 - Rupture Disk
3 - Valve Actuated by Internal Pressure
4 - Filters
5 - Bypass