The purpose of this paper was to describe the dose variation of fast neutrons in concrete ducts. The results can provide a basis for establishing criteria to aid engineers in designing shelter entranceways which will shield against initial neutron radiations from nuclear weapons. In addition, the results can aid in designing fast-neutron experimental facilities and predicting the dose variations where fast-neutron reflection from concrete is involved.

Work was carried out in two phases, theoretical and experimental. In the theoretical work, existing theory on the differential albedo concept was studied, and a semiempirical formula for the differential dose albedo in the form of a four-parameter equation was derived, based on a model of the physical phenomena of neutrons scattering in a semiinfinite concrete slab. In this derivation, some physical assumptions were introduced to simplify the derivation. Parameters for the semiempirical formula were obtained by a nonlinear regression method to have a best fit to the Monte Carlo data of Allen et al for fast-neutron reflection from a concrete slab.

From the differential albedo concept, a transport equation was derived to describe the neutron current reflection in a duct. This neutron transport equation was transformed to the dose transport equation, and a solution was obtained by an iterative method. The solution was further simplified by introducing physical assumptions and computational approximations. This simplified solution was coded in FORTRAN for a digital computer, and numerical values of dose were obtained by an IBM 1620 computer for three different ducts and three different neutron sources.

In order to study the subject experimentally, measurements of dosimeter response were made for three different ducts and three different sources of neutrons. Neutron sources and ducts used in experiments were the same as or at least very close to those used in theoretical caluclations.

After converting the numerical values of dose (calculations based on theory) to the dosimeter response (experimental results), comparisons were made between theoretical and experimental results in terms of attenuation factor (dosimeter response normalized to source strength at unit distance from the source).

In the comparison, an analysis was made of possible causes of the discrepancies between theoretical and experimental results. In this analysis, predictions were made of the discrepancies to be expected between theoretical and experimental results in order to see if the actual discrepancies follow the theoretical predictions. These predictions were based on the assumptions and approximations introduced in numerical computations of dose, and did not involve approximations in the basic theory itself.

It was found that we have very good qualitative agreement between theoretical and experimental results. Discrepancies followed the predictions very closely. In most of the cases under study, the discrepancies were explained very well by the error analysis. The only exception was that the theoretical results were higher than the experimental results near the duct corner in the first leg of the 2x2-foot duct (1) with the D(d, n)He3 neutron source, where it was predicted that experimental results should be higher. With the exception of that one case, the theoretical results were consistently lower than the expeximental results by approxirnately 15% in the first leg at the duct corner.

After corrections for known errors, theoretical results in the second leg remained lower than the experimental results by about 20 to 30%. These residual discrepancies arose from theoretical approximations used in the computations and random and possibly systematic errors in the experiment. These errors are discussed only qualitatively in Chapter 7.

Comparison between theory and experiment indicates that the most pronounced causes of discrepancies between theoretical and experimental results arises from uncertainties involved in albedo values and in ignoring the higher order in the theoretical calculation.

The general trend of both experimental and theoretical results is very similar to that predicted by Spencer et al21 in their study of thermal-neutron flux variations in a straight cylindrical duct. Futher, experimental and theoretical values of attenuation factors in the second leg of the 3x3-foot duct with T(d,n)He4 neutron source agree very well with those observed and predicted by Maerker et al,56 in their study of first-collision dose variation, although their neutron source was different from that used in this paper. They used leakage neutrons from the Tower Shielding Reactor, obliquely incident on the duct axis, while the neutron source of this paper was T(d,n)He4, monoenergetic and isotropic.