STATISTICAL STUDIES ON THE LIMITATION OF SHORT-TIME RELEASES FROM NUCLEAR FACILITIES

K. Heinemann, K.J. Vogt

Central Division for Radiation Protection
Kernforschungsanlage Jülich, Federal Republic of Germany

The licenceable annual release volumes from a nuclear facility are calculated, on the assumption of a constant release rate, from the dose limit values, the radioecological transfer and dose factors, the release height, and the site-specific long-time diffusion factors which are dependent on the exposure pathway. In this paper, a statistical investigation relating to the necessity of limiting individual releases is being presented. In this connection, it is being checked whether a limitation of the hourly release volume will also be required in addition to the limitation of the daily release volume to 1/100 of the annual release volume as stipulated in the directive /1/ of the Federal Republic of Germany.

For the statistical investigation it is being assumed that the same radioecological and biological parameters can be used for releases featuring a constant release rate and for individual releases, so that only the different diffusion factors are to be taken into account. For calculating the radiation exposure, the following exposure pathways must be considered: gamma submersion, beta submersion, soil radiation, inhalation and ingestion. The exposure due to beta submersion and inhalation is proportional to dry deposition on the soil or on vegetation (fallout). For the determination of soil radiation and ingestion doses, the deposition due to precipitations (washout) is also required in addition to the fallout. It is therefore sufficient to compare the long-time diffusion factors for fallout, washout and gamma submersion with the corresponding quasi-longtime diffusion factors. As is illustrated in detail in /2/, the quasi-diffusion factors are ascertained by superposition of the short-time diffusion factors (hourly values), averaged over the 30° sector and featuring, in each specific case, release rates of 1/100 of the annual release volume for 100 statistically selected hours. This is being carried out using the meteorological statistics of Jülich for the year 1977. Each quasi-longtime diffusion factor is calculated 25 times with different data records of always 100 hours, so that a statistical statement is possible.

In the case of fallout and gamma submersion, calculations were carried out for the release heights of 50, 100 and 200 m. For the formulation described in /1/, it may be shown /2/ that the ratio of quasi-longtime to longtime washout factor does not depend on the release height and source distance.

The results summarized in Table 1 show that the quasi-longtime diffusion factors vary by the respective long-time diffusion factors. The arithmetic mean values coincide (except for washout) with the long-time diffusion factors. In the case of washout, the geometric mean value of the quasi-longtime washout factors corresponds better with the long-time washout factor. This may be explained by the larger variations naturally resulting from the fact that, on an average, it rains less than ten times during the 100 hours which enter into each individual calculation of the quasi-longtime washout factors. In the bottom line of the table on cumulative frequency distribution, the standard deviation of the quasi-longtime diffusion factors from their mean value corresponding to the associated long-time diffusion factor is shown. It may be observed that the standard deviations for all exposure pathways and release heights (except for washout) range between 34 and 45 per cent. This means that the quasi-longtime diffusion factor only exceeds the double long-time diffusion factors in less than 1 per cent of cases (3σ-error). In the case of washout, the standard deviation is four times as high. This would lead to the conclusion that, after all, the long-time washout factor is exceeded by the factor 5 in less than 1 per cent of cases. For, the high upward deviations result from the hours involving high precipitation intensities. For a high precipitation intensity, however, the proportional formulation of washout coefficient and precipitation intensity is overconservative according /4/ and /5/. A proportionality constant fixed for a mean precipitation intensity overestimates the washout coefficient for a high precipitation intensity approximately by a factor of 5, so that the maximum underestimation due to the long-time diffusion factor should not be rated more pessimistically for washout in this range than for any of the other exposure pathways.

However, this possible additional exposure due to short-time releases does not occur in reality because

- not all of the individual releases occur within one hour
- a considerable portion of total releases is made up by quasi-continuous releases, so that short-time releases are reduced
- the number of short-time releases never corresponds to the theoretically possible value of 100
- in the case of several emission sources at one site, as a rule, the releases via the individual stacks are restricted, so that the individual release corresponds to less than 1/100 of the total release of the site
- for long-lived nuclides, the accumulation over 50 years to be performed according to model /1/ will lead to a compensation of the individual maxima falling on different wind directions and source distances.

In summary, it may therefore be concluded that a limitation of short-time releases to 1/100 of the permissible annual release value under the conditions of /1/ is considered to be sufficient for a realistic assessment. If a more conservative approach is preferred, a limitation of individual releases to 1/200 of the annual value would come into consideration. An application of the long-time diffusion factors to individual releases thus delimited would lead to a minor underestimation of the environmental impact calculated according to /1/ in less than 1 per cent of cases.

REFERENCES

/1/ Der Bundesminister des Innern
Allgemeine Berechnungsgrundlagen für die Strahlenexposition bei radioaktiven Ableitungen mit der Abluft oder in Oberflächengewässer
Gemeinsames Ministerialblatt 1979, 371

/2/ K. Heinemann, K.J. Vogt
Statistische Untersuchungen zur notwendigen Begrenzung der Tages- bzw. Stundenemissionsmengen
Internal Report ZST-Bericht Nr. 0306

/3/ F. Rohloff, E. Brunen, H.D. Brenk, H. Geiß,K.J.Vogt
LIGA - Ein Programm zur Berechnung der lokalen individuellen Gammasubmersionsdosis durch Abluftfahnen aus kerntechnischen Anlagen
KFA Report Jül-1577, January 1979

/4/ A.C. Chamberlain
Deposition of iodine-131 in Northern England in October 1957
Quarterly Journal of the Royal Meteorol.Society 8, 1959, 350

/5/ J. Porstendörfer
Radioaktive Aerosole und deren Deposition in der Biosphäre
Forschungsbericht 1978 bis 30.04.1979, to be published

Table 1 Cumulative frequency distribution, mean value and standard deviation of the ratio of quasi-longtime to long-time diffusion factors at the maximum of the long-time diffusion factor

	cumulative frequency (%)						
exposure pathway	fallout			gamma submersion			washout
release height	50 m	100 m	200 m	50 m	100 m	200 m	
ratio smaller than							
0.2	0	0	0	0	0	0	12
0.4	8	12	12	0	0	0	28
0.6	24	20	16	0	12	28	40
0.8	40	48	44	16	40	44	48
1.0	60	80	80	68	64	56	60
1.2	76	88	88	72	64	64	60
1.4	92	96	96	80	80	80	68
1.6	100	100	96	84	84	88	72
1.8			96	96	88	96	72
2.0			96	96	96	100	76
2.2			100	96	100		76
2.4				96			76
2.5				100			76
3.0							92
4.0							92
5.0							96
6.0							96
7.0							100
mean value							
arithmetric	0.90	0.84	0.84	1.08	1.07	0.99	1.40
geometric	-	-	-	-	-	-	1.01
standard deviation	0.34	0.36	0.38	0.42	0.45	0.44	1.58