True Flow Velocity Identification in Sampling Airborne Radioactive Materials from the Stacks and Ducts of Nuclear Facilities

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1. Introduction

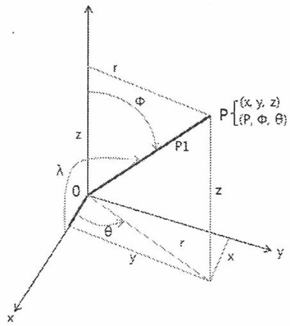
In the evaluation of the existing air-sampling system, angular or cyclonic flow, air velocity profile, gas concentration profile, and particle concentration profile are key components in evaluating the regulatory compliance and system control. If existing air-sampling systems are not designed to the performance requirements and recommendations of ISO 2889:2010(E), an evaluation of the performance of the system is advised. If deficiencies are discovered, a determination of whether or not a retrofit is needed and practicable is recommended.

Among the above profiles the velocity profile will be a focus of this work. A usual method to determining the velocity profile's adequacy is to calculate the coefficient of variance (COV) of the measured velocities along the measurement grid. The grid is a selection of points across a section based on the guidance in ISO 10780 for the centre 2/3 of the area of the stack or duct. Additional points or area may be added to adequately cover the region. The COV should not exceed 20 % over the centre region of the stack that encompasses at least 2/3 of the stack cross-sectional area.

2. Theory

2.1 Uniform Air Velocity

It is important that the gas momentum across the stack cross section where the sample is extracted be well mixed or uniform. Consequently, the velocity is measured at several points in the stack at the elevation of the sampling nozzle. The uniformity is expressed as the variability of the measurements about the mean. This is expressed using the relative coefficient of variance (COV), which is the standard deviation divided by the mean and expressed as a percentage. The lower the COV value, the more uniform the velocity. The acceptance criterion is that the COV of the air velocity must be less than 20% across the center two-thirds of the area of the stack.



2.2 True Air Velocity

In a Cartesian coordinate the flow velocity measured P can be designated as a vector

$$(x,\ y,\ z)$$

from the origin of a grid in the duct as shown in the left figure. The x-axis is the main flow direction. In a spherical coordinate, the point vector P becomes

$$(P1, \phi, \theta)$$

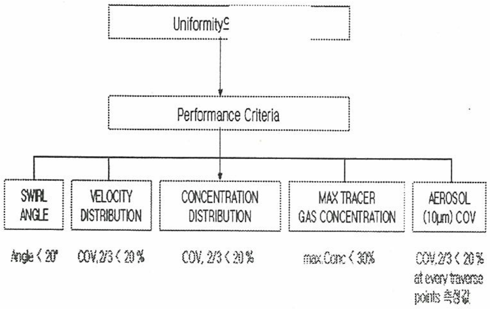
Since the air velocity measured in a duck is different from P, we need to convert it into P the true velocity. The measured velocity is a cosine of the true velocity. Using the scalar product of two vectors it is shown to be

$$P = \frac{x}{\tan \lambda}$$

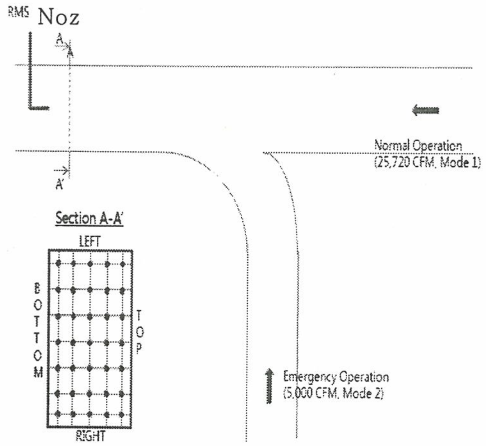
where λ is angle between P1 and x-axis. The measured air velocity X is converted to true vector P.

2.3 Experimental

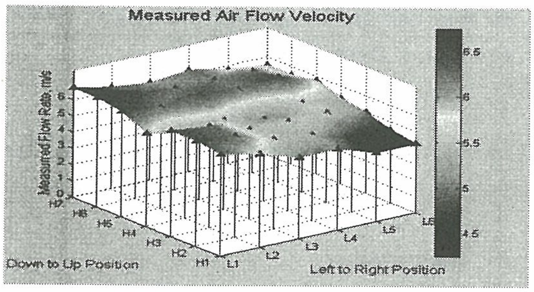
Over-all procedure is shown bellow.



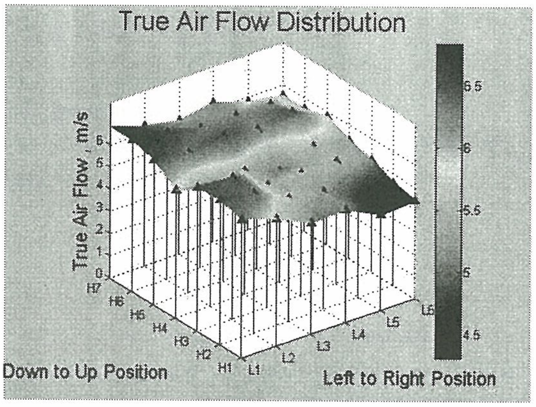
Duct shape and air flow configuration is shown bellow. The detail of this will be presented in the workshop.



2.4 Results



The measured air velocity is plotted as above.



The true velocity calculated thereof is shown bellow.

Analysis of the measured and calculated true values are summarized bellow.

	Measured,m/s	True, m/s
Avg	14.61	14.73
Std	2.06	2.07
Min	10.50	10.53
Max	16.75	16.85
COV	14.10	14.06

3. References

[1] Sampling airborne radioactive materials from the stacks and ducts of uclear facilities, ISO 2889, Second edition 2010-03-15.