3 - days comprehensive course (TOS)

Theory and Pratice of Sampling of Heterogeneous Materials and Processes

This course presents The Theory of Sampling (TOS) in a novel systematic way presenting six Governing Principles (GP) for guiding optimal application of four Sampling Unit Operations (SUO). The course hallmark is its practical approach with abundant examples and facilitating case histories, focusing more on an overview framework understanding and less on the abundant mathematical background details. Starting out by covering sampling from stationary lots as a means of 'learning the ropes', via the critical issue of proper sampling in the laboratory, the course concludes with a comprehensive focus on industrial and technological process sampling. This course facilitates effective competence and know-how transfer to scientists, technicians, engineers, process operators, laboratory personal and managers.

Course brief

A set of six Governing Principles (GP) and four Sampling Unit Operations (SUO) cover all practical aspects of sampling and provides a comprehensive framework for all stakeholders, scientists (academic staff, Ph.D. students), technologists, process engineers, process operators, laboratory and industry personnel, focusing on the necessary competence needed to guarantee that all primary sampling, splitting, sub-sampling and sample preparation stages are fully representative (procedures, equipment, maintenance). There is a special part on "proper sampling in the analytical laboratory".

KHEC is a world- leading educational and competence building international consultancy for representative sampling in all technological and industrial sectors. At all stages, from primary sampling, sub-sampling and sample handling in the lot-to- aliquot pathway, KHEC has a professional obligation to act on behalf of the client's interest regarding all sampling matters¹.

In close cooperation with customers, KHEC also develops sampling solutions for non-standard cases and applications. KHEC is a responsible partner from procedures to verification of existing and new installations. All design and procedure suggestions follow the guidelines given by TOS offering the potential for realising optimal fit-for-purpose solutions for each customer's specific needs.

1. "A Tale of two Laboratories I & II" https://www.spectroscopyeurope.com/sampling

This 3-day course provides a complete introduction to the TOS for stationary lots and for dynamic lots. The course also makes the critical connection to process engineering, Process Analytical Technologies (PAT) and multivariate data analysis (chemometrics).

Course goal

The course overview gives full insight into how to guarantee that all primary sampling, and subsequent sub-sampling (splitting) and sample preparation before analysis is documentable as representative (procedures, equipment, maintenance). After the critical primary sampling step, correct (unbiased), mass reduction (splitting) in the subsequent sub-sampling in the laboratory also needs to be 100% compliant with TOS in order to ensure valid analytical results. It is often unknown, or is willfully neglected, that the Total Sampling Error (TSE) is by far the dominating contribution to the total Measurement Uncertainty (MU), typically 10-25 X larger than the Total Analytical Error (TAE). This is a fact neglected by the discipline of Measurement Uncertainty (MU); TOS provides a seamless integrated solution.

This course provides attendees a comprehensive overview of the Theory of Sampling (TOS) for stationary lots as well as process lots and in the laboratory, including powerful facilities with which to characterise lot heterogeneity, called Replication Experiments (RE) and variographic characterization which allows for improved process understanding and total process system measurement system validation.

Representative sampling is the critical success factor for achieving optimal analytical accuracy and precision - as needed for reliable decision making in science, technology and industry. All steps in the lot-to-aliquot pathway shall be compliant with DS3077 (2013)¹, today's de facto international standard for representative sampling.

There is significant added value in a common TOS competence in order to maximise clients' and customers' potential only to use representative solutions and equipment. This collaboration is furthered through general and dedicated in-house seminars and courses on "Theory and Practice of Representative Sampling, TOS".

1. DS3077 (2013) "Representative Sampling – Horizontal Standard" www.ds.dk

Sampling bias – behind the myth

The sampling bias has a fundamentally different nature than the analytical bias, sadly negating all attempts of 'sampling biascorrection'. This is undoubtedly the greatest surprise provided by this course. Instead TOS provides a set of practical ways to achieve "sampling correctness" (unbiasedness) by informed understanding, design and application of the generic sampling process and the relevant equipment. The course overview gives full insight into how to guarantee that all primary sampling, and subsequent subsampling (splitting) and sample preparation before analysis is documentable as representative (procedures, equipment, maintenance).

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This course has a special focus on setting up simple, yet powerful facilities to characterise lot heterogeneity, Replication Experiments (RE) and variographic characterization for improved process understanding and total process system measurement system validation.

Course literature

The course includes a comprehensive literature documentation, including the world's first standard dedicated exclusively to representative sampling, DS3077 (2013).

DS 3077 (2013) "Representative Sampling – Horizontal Standard" https://webshop.ds.dk/da-dk/standard/ds-30772013

Esbensen, K.H. & Julius, L. (2013) "DS 3077 Horizontal—a new standard for represent tative sampling. Design, history and acknowledgements", TOS Forum 1, p. 19-22 doi: 10.1255/tosf.7

Esbensen, K.H. (2015) Materials Properties: Heterogeneity and Appropriate Sampling Modes. J. AOAC Int. vol. 98, pp. 269-274. http://dx.doi.org/10.5740/jaoacint.14-234

Esbensen, K.H., Wagner, C. (2014). Theory of Sampling (TOS) vs. Measurement Uncertainty (MU) – a call for integration. Trends in Analytical Chemistry (TrAC) 57, 93-106

Esbensen, K.H. & Julius, L.P. (2009). Representative sampling, data quality, validation – a necessary trinity in chemometrics. in Brown, S, Tauler, R, Walczak,R (Eds.) COMPREHENSIVE CHEMOMETRICS, Wiley Major Reference Works, vol. 4, pp.1-20. Oxford: Elsevier

Petersen, L, C. Dahl, K.H. Esbensen (2004). Representative mass reduction in sampling – a critical survey of techniques and hardware. Chemometrics and Intelligent Laboratory Systems, vol. 74, Issue 1, p. 95-114

Esbensen, K.H. & Mortensen, P. (2010). Process Sampling (Theory of Sampling, TOS) – the Missing Link in Process Analytical Technology (PAT). in Bakeev, K. A. (Ed.) Process Analytical Technology. 2.nd Edition. pp. 37-80. Wiley. ISBN 978-0-470-72207-7

Minnitt, R.C.A. & Esbensen, K.H. (2017) Pierre Gy's development of the Theory of Sampling: a retrospective summary with a didactic tutorial on quantitative sampling of one-dimensional lots. TOS Forum 7, p. 7-19. doi: 10.1255/tosf.96

Esbensen, K.H, Paoletti, C, Theix, N. (2015) (Eds) Journal AOAC International, Special Guest Editor Section (SGE): Sampling for Food and Feed Materials. pp. 249-320 http://ingentaconnect.com/content/aoac/jaoac/2015/0000 0098/00000002

Esbensen, K.H., Paoletti, C. & Minkkinen, P. (2012). Representative sampling of large kernel lots – I. Theory of Sampling and variographic analysis. Trends in Analytical Chemistry (TrAC), 32 pp.154-165

Minkkinen, P., Esbensen, K.H. & Paoletti, C. (2012). Representative sampling of large kernel lots – II. Application to soybean sampling for GMO control. Trends in Analytical Chemistry (TrAC), 32 pp. 166-178

Esbensen, K.H., Paoletti, C. & Minkkinen, P. (2012). Representative sampling of large kernel lots – III. General considerations on sampling heterogeneous materials. Trends in Analytical Chemistry (TrAC), 32 pp. 179-184

Course presenter



Professor Kim H. Esbensen, owner KHE Consulting (KHEC) Copenhagen

This course is offered as a 2 + 1 day comprehensive course; the venue is either at KHEC's domicile, Copenhagen or at client's location (in-house course).

The course is also offered in a compact 1-day overview format.

Contact

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