# Lean management and “One-Piece-Flow” for PCDD/F and PCB analysis to reduce the turn-around time in smaller laboratories compared to classical batch operation

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## Introduction

There is a constant need from clients of analytical labs to reduce the turn-around time of the analytical process. This is even more challenging for the combined analysis of the 17 PCDD/F and 12 WHO-PCBs. Smaller labs, equipped with just one MS instrument, do often think they are not able to perform PCDD/F and PCB analysis within one day having more than one sample. With Lean Management and the establishment of the “One-Piece-Flow” these labs are able to meet this challenge, with the same analytical quality and the same production costs.

## Materials and Methods

The following instruments have been used for the single steps:

- homogenisation → one Buchi Mixer B-400
- extraction → one Dionex™ ASE™ 350
- evaporation → two Buchi rotary evaporator R3
- clean-up → one LCTech DEXTech Pure[1]
- measurement → one Thermo Scienific™ DFS™ equipet with DualData-XL[2]

All necessary steps have been recorded and the required times have been documented in Table 1.

| | Registration | Homogenisation | Extraction | Evaporation | Clean-Up | Evaporation | Measurement | Data Evaluation | Reporting | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| **EBT** | 5 min | 20 min | 10 min | 5 min | 3 min | 15 min | 2 min | 15 min | 5 min | 80 min |
| **TBT** | 0 min | 0 min | 25 min | 25 min | 55 min | 0 min | 55 min | 0 min | 0 min | 160 min |
| **Total BT** | 5 min | 20 min | 35 min | 30 min | 58 min | 15 min | 57 min | 15 min | 5 min | 240 min |

Table 1: Necessary time for all analytical steps (EBT → employee binding time; TBT → technical binding time; BT → binding time)

Additionally the following conditions have been defined:

- seven samples per day
- three full time employees (8h per day) qualified for all analytical steps
- opening hours 8am to 8pm

In Table 2 the “One-Piece-Flow” procedure for the seven samples incl. all QA/QC procedures is shown, considering that the two employees are working 8am to 5pm and the third employee from 12pm to 8pm.

| Process\Time | 8am | 9am | 10am | 11am | 12pm | 1pm | 2pm | 3pm | 4pm | 5pm | 6pm | 7pm | 8pm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Registration** | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ | | | | | | |
| **Homogenisation** | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ | | | | | | |
| **Extraction** | Blank | QS | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ | | | | |
| **Evaporation** | Blank | QS | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ | | | | |
| **Clean-up** | | Blank | QS | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ | | | |
| **Evaporation** | | | Blank | QS | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ | | |
| **Measurement** | Tuning | Cal check | Toluene | Blank | QS | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ | |
| **Data Evaluation** | | | | | Blank | QS | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| **Report** | | | | | Blank | QS | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |

Table 2: Established “One-Piece-Flow” (Blank → blank sample, QS → Quality sample, Tuning → tuning of HRMS, Cal check → calibration check injection, Toluene → Measurement blank, ① sample number one, ②sample number two, … )

The batch operation was also done using the same conditions, manual clean-up procedure instead of DEXTech pure and one DFS without Dual Data XL. Using the batch operation procedure all seven samples have been reported on the 4th day after arrival (Table 3).

| Step | Registration | Homogenisation | Extraction | Evaporation | Clean-up | Evaporation | Measurement | Data Evaluation | Reporting |
|---|---|---|---|---|---|---|---|---|---|
| **Day** | 1st | | | 2nd | | | 3rd | 4th | |
| **Finished** | 9am | 12pm | 6pm | 10am | 4pm | 7pm | 8pm | 10am | 12pm |

Table 3: Batch operation with final time for finished steps having 7 samples analysed

## Results

Compared to the classical batch operation procedure using the “One-Piece-Flow” it is possible to have results for the 17 PCDD/F and 12 WHO-PCBs within the same day, three days earlier than using the classical batch operation procedure.

With a fully established “One-Piece-flow” (see Table 2) the first results for PCDD/F and PCB can be reported six hours after the sample has arrived. The results of the further six samples will be reported in intervals of one hour after the first sample. Also the necessary QA procedures like the blank sample and the quality sample are covered and finished before the samples will be reported, to make sure that all results are valid.

Taking into account, that during a routine working say the sample appearance may vary between three and ten samples per day, this system is capable to buffer such a variation in sample appearance, having the results for all samples arrived on one day ready latest on the following day.

## Conclusions

The here shown “One-Piece-Flow” can give smaller labs (<2000 samples for PCDD/F and PCB per year) an advantage in speed, one day instead of four days. A lab that already is equipped with one DFS, one ASE 350 and the required evaporation and homogenization tools, just need to invest in the Dual Data XL upgrade and an automated clean-up tool that is running just one sample at the time. So the change in the production cost per sample will not be significant (if any) compared to the batch operation. For larger labs (>2000 sample per year) other steps and considerations will be necessary, but also there the consequent implementation of the “One-Piece-Flow” will speed up the lab performance.

## References

[1] **LCTech** LCTech application note Default methods DEXTech Pure, (2018), LCTech GmbH, Obertaufkirchen
[2] **Mehlmann H.** MAXIMIZED PRODUCTIVITY FOR DIOXIN, PCBs and PBDE ANALYSIS USING DUALDATA MODE WITH MAGNETIC SECTOR GC-HRMS, (2018), Thermo Fisher, Bremen