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Triskelion Report Summary

Socio-Economic Analysis of proposed Occupational Exposure Limit for Benzene

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Executive summary

Introduction

ECHA published a proposal in support of Occupational Exposure Limit values (OELs) for Benzene in the workplace, on request by the European Commission. Based on this proposal, the Risk Assessment Committee adopted an opinion for the European Commission in which it recommends an 8-hour time weighted average OEL of 0.05 ppm (0.16 mg/m^3) and a biological limit value (BLV) of 0.7 µg benzene/L urine or 2 µg S-phenylmercapturic acid (SPMA)/g creatinine (sampling: end of exposure or end of working shift). The European Commission has commissioned an impact assessment of the proposed OELs for benzene and other substances for which new values have been proposed. This SEA is intended to be used as an important input for that impact assessment.

Anticipating on the difficulties to conduct such exercise, the Aromatics Producers Association of CEFIC, supported by Concawe, has mandated Triskelion to study the impact of implementation of an OEL of 0.5 ppm, 0.2 ppm, or 0.05 ppm on benzene producing and consuming companies. This report presents the resulting feasibility assessment.

Goal and objectives

This feasibility assessment was composed of the following elements:

1. Review of current occupational exposure patterns relative to controls in place
2. Assess the technical feasibility of implementing OELs of 0.5 ppm, 0.2 ppm, or 0.05 ppm
3. Estimate the investment cost for process plant modification relative to current OELs and current exposure levels
4. Estimate the impact on operating cost of producing and consuming companies relative to current OELs and current exposure levels

Methodology

In this study the following benzene producing and consuming sectors and representing sectors were analysed:

1. Production of benzene and benzene containing streams (in refineries and steam crackers; included are also aromatics plants where benzene is extracted from these streams, these plants are usually situated in a refinery or a site with a steam cracker); further indicated as ‘Manufacture’;
2. Use of benzene or benzene containing streams as an intermediate (e.g. to produce styrene or cyclohexane); further indicated as ‘Intermediate’;
3. Distribution of benzene and/or of benzene containing streams (e.g. naphtha’s or petrol); further indicated as ‘Distribution’;
4. Use of benzene containing streams as motor fuel (professional); further indicated as ‘Professional fuel use’.

Data collection was largely performed by a questionnaire that was distributed amongst benzene and benzene containing streams producing and consuming industry (survey).

All responses were cross-checked by the Triskelion experts and, if necessary, additional information was requested from the respondents.

Current exposure levels were related to controls in place. Very strict criteria were used to compare current exposure levels with OELs to ensure a very low probability of exposure levels above the OELs. All exposure levels being reported are potential exposure levels, over 8 hours if full shift. When the exposure levels are short-term or task-based levels, this is clearly stated. All exposure levels do not take into account the use of personal protective equipment (PPE). Actual exposure of workers can be considerably lower if PPE is properly used (depending on the kind of PPE used in most cases a reduction ranging from 4 to 40 fold). For the purpose of this feasibility assessment only the potential exposure levels were compared with the OELs. If there is apparent non-compliance based on this evaluation, the workers may in real situations be protected by PPE that ensures that their actual exposure is clearly below the OEL. All measured values below the limit of quantification were set to the limit of quantification for further analysis.
A cost assessment was performed based on reported costs for investments and other (annualized) costs in relation to three different potential exposure limits of 0.5 ppm, 0.2 ppm and 0.05 ppm.

A secondary data collection action was started after the analysis of the data from the questionnaires was largely completed. The reason for the secondary data collection was a lack of clear relation between control measures considered to be necessary to achieve compliance with the lowest OEL and insufficient specification of cost estimations in the questionnaire responses. A workshop with experts was organised to estimate standards investments costs per type of unit (refinery, steam cracker, distribution centre, gasoline stations), followed by further data gathering of information not yet available in the questionnaires.

Results

The total study took about 9 months. One hundred focal points returned 183 completed questionnaires. No responses were returned on the industrial use of streams containing benzene (which is consistent with industry view that benzene containing streams are used industrially only as gasoline blending streams or used to extract benzene in aromatics extraction plants) and too few responses on the formulation and (re-)packaging of benzene and benzene containing streams. Responses from all other sectors were considered sufficiently representative for analysing the impact on the sector.
The survey covered plants or locations that represented between 73% (Manufacture) and 15% (Professional Fuel Use) of a sector.
Benzene is also produced from coal, but no data have been collected on this sector. The overall impact of the proposed OEL for benzene are therefore probably an underestimation but do give insight in the order of magnitude. The situations upstream to the studied sectors (e.g. in oil exploration) were also not covered in this study.

Occupational exposure and control measures
Around 95 (59%) of the respondent describe facilities which need further reduction of exposures to consistently reach exposure limits below 0.5 ppm for all full-shift exposure situations.
In contrast only a limited number of respondents (three plants (3.5%) in Manufacture and 13 plants in Distribution (20%)), no plants in Intermediates) reported values consistently below 0.05 ppm for all the full shift exposure datasets they reported. The analysis has not

allowed to understand if those data are fully representative of the actual exposure situation in these companies. The reported figures do not necessarily mean that these companies would be fully compliant with an OEL of 0.05 ppm.

However, generally the higher OEL of 0.5 ppm has been indicated to be technically achievable as indicated by more than 90% of provided responses for Manufacture, Intermediate and Distribution.
In contrast, for the lowest OEL of 0.05 ppm, the large majority of respondents indicated it would be difficult or even impossible to reach this OEL, as indicated by more than 85% of provided responses for Manufacture, Intermediate and Distribution. The number of responses for Professional fuel use were too few for analysis.

A large number of technical control measures and other operational control measures is already in use at the plants. The type of control measures needed to lower exposure levels further is not principally different from the already used control measures. However, the number of pieces of equipment where more closed systems are needed and the number of other operational control measures, such as personal protective equipment, increases with lower OEL values. Other cost items, such as monitoring programs, are also increasingly relevant and needed at lower OEL values.

The most relevant necessary technical control measures needed for Manufacture, Intermediate and Distribution appear to be more closed pumps, such as double seal or sealless pumps. But similarly, more closed variants are needed for many other pieces of equipment. In total, a large number of different modifications is considered needed to possibly keep exposure levels below 0.05 ppm.

It is expected, that for maintenance and turnaround activities, the use of only technical control measures will be insufficient to reach exposure levels consistently below 0.05 ppm. Increased use of stringent personal protection, such as self-contained or air-supplied breathing air, will be needed. It is questionable, whether this can be done effectively in all situations and whether sufficient expert contract workers that can work with this kind of protective equipment are available.

Many remarks were made regarding specific issues that limit technical feasibility of achieving an OEL of 0.05 ppm as it is considered that this level essentially means that no emissions would be allowed. This relates also to situations in maintenance and turnaround, when equipment needs to be opened. It is considered that this would often require very stringent respiratory protection, such as supplied-air breathing apparatus. The options to use this kind of protection in some situations, when entering equipment, might be limited. The need for such protection would also limit the possible working hours and would lead to issues with scarcity of certified contractors for specific jobs. Furthermore, the additional time needed for e.g. cleaning and monitoring concentrations before opening equipment may result in planning difficulties that will lead to extra costs that cannot yet be estimated.

Technical feasibility is no guarantee for economic viability and significant concerns were raised by the respondents on the economic sustainability of an OEL at 0.05 ppm. And our study indicates that smaller plants expect to have more problems with economic sustainability of an OEL of 0.05 ppm.
Monitoring for an OEL of 0.05 ppm is technically very challenging. Many companies use direct reading instruments to indicate whether exposures are sufficiently low to start activities. Such instruments cannot yet measure low enough values for an OEL of 0.05 ppm.

Current monitoring systems, such as passive badges (level of detection ca 0.02-0.04 ppm) measuring the exposure to benzene over the full shift, can only be used to establish after the shift has been completed whether OEL has been exceeded.

Costs

The costs for control measures and other cost items needed to achieve the different OEL values was assessed via the questionnaires. An additional data gathering for the control measures and cost items for an OEL of 0.05 ppm was done via a workshop with experts investigating in more detail what equipment and measures would be required and what would be the operational cost of implementing such OEL.

Many respondents indicated that limited costs were needed to meet an OEL of 0.5 ppm, because this level is largely achieved thanks to technology evolution and self-imposed targets. For an OEL of 0.2 ppm, more costs would be needed. Experience from manufacturing sites in the Netherlands that was already meeting an OEL of 0.5 ppm due to self-imposed constraints and recently implemented an OEL of 0.2 ppm show that costs can be in excess of 20 million EURO for a single site. The costs were reported to increase very substantially at an OEL of 0.05 ppm. For all OEL values, the range in costs reported was very wide, reflecting the difficulty for some respondents to anticipate on final investment values and differences in their present situation. Also, the large number of changes, the variability of installations and the uncertainty of the effect of the changes lead to various cost aspects that cannot yet be estimated.

Therefore, an additional data gathering for the control measures and cost items for an OEL of 0.05 ppm was done with experts investigating in more detail what equipment and measures would be required what would be the capital and operational costs involved to implement such OEL. This resulted in additional estimates for some values.

The average estimated costs per plant or per service station and the number of plants and service stations in the EU were used to estimate the total costs for the sectors in the EU. This resulted in the following estimates.

*Table 1, Estimated total costs for the sectors in the EU to achieve compliance with the OELs of 0.5, 0.2 or 0.05 ppm (millions of Euros or millions of Euros/year).**

	CAPEX 0.5 ppm	**CAPEX 0.2 ppm**	**CAPEX 0.05 ppm**	**OPEX 0.5 ppm**	**OPEX 0.2 ppm**	**OPEX 0.05 ppm**
Manufacture	17	609	3738-4900	1	227	447-1101
Intermediate	184	487	1928	0.6	31	196
Distribution	149	292	943-1247	0	143	185

* CAPEX = capital expenditures; investments (millions of Euros); OPEX = operational expenditures; yearly operating costs (millions of Euros/year). Single figures are based on results from the questionnaires; ranges are based on the results from the questionnaires and from the additional data gathering with experts.

Regarding practical aspects of modifications needed, it was indicated in remarks, that the large-scale changes required would largely be made during planned turnarounds. These occur every so many years (e.g. between 3 to 8 years). Therefore, a substantial implementation period of several years would be needed to allow all modifications to installations to be made if an OEL of 0.2 or 0.05 ppm would be established.

Conclusion

Present inhalation exposure levels are not yet shown to be consistently below 0.5 ppm for all plants in the studied sectors, if the use of respiratory protection is not accounted for. The (limited) biomonitoring results also do not indicate that all plants are already consistently below 0.5 ppm. On the other hand, quite a number of datasets was already consistently below 0.2 ppm.
Keeping exposures below 0.05 ppm is clearly not reached at all yet, though some exceptions may exist.
The technical feasibility of an OEL of 0.05 ppm is questionable and monitoring the compliance with that OEL in a practical way, without only knowing the results after the fact, is not considered possible.

Estimated costs for complying with an OEL of 0.5 ppm are relatively low, they are higher for an OEL of 0.2 ppm and much higher for an OEL of 0.05 ppm. For 0.05 ppm, estimated total investment costs for the EU are between 900-1200 million Euros for Intermediates, around 1900 million Euros for Distribution and 3700-4900 million Euros for Manufacture. Estimated yearly operating costs for the EU for these sectors range between 185 million Euro/year and 450-1100 million Euro/year. There is insufficient information for Professional fuel use to estimate all these costs.

The implementation of all the control measures that are considered necessary would take years, because major changes can only be made during turnaround, which occurs every so many years and the amounts to be invested may discourage industry to further invest in such units.