CERN comments to PFAS restriction consultation

SPECIFIC INFORMATION REQUESTS

1) **Sectors and (Sub-)uses**

I have information on this topic

The use of the F-gases in the particle physics experiments as gases for particle detection and related cooling is not included among the uses contemplated in Table 9 of the restriction proposal neither in the list of proposed derogations.

2) **Emissions in the end-of-life phase**

I don't have information on this topic

3) **Emissions in the end-of-life phase**

I don't have information on this topic

4) **Impacts on the recycling industry**

I have information on this topic

An extension of the F-gases use for particle detection and related detector cooling is needed for the continuation of the particle physics research activities until the end of the current physics program of the HL-LHC, planned to end by the mid 2040s.
Possibility to recycle the F- gases in use during- and at the end- of the use period should remain available.

5) **Proposed derogations – Tonnage and emissions**

I have information on this topic
See request number 6

6) **Missing uses – Analysis of alternative and socio-economic analysis**

I have information on this topic

Particle physics experiments, as those conducted at CERN's LHC, make use of F-gases for particle detection and related detector cooling.

A wide range of gas mixtures is used for the operation of different gaseous detectors for particle physics research. Among them are F-gases like C2H2F4 (Norflurane 1,1,1,2-Tetrafluoroethane - R134a), CF4 (Tetrafluoromethane - R14), C4F10 (Perfluorbuthane - R610) and C6F14 (Perfluorohexane - PFC-51-14), which are used because they allow to achieve specific detector performance that are necessary for data taking at the CERN experiments (i.e. detector sensitivity, detector stability, long term performance, time resolution, rate capability, etc.) in a very harsh environment (very low temperatures and high level of ionizing radiation). The concomitant cooling of the detectors is essential for the appropriate process of particle detection. Several F-gases are used in the detector cooling systems and are mainly built in a

cascading system to achieve temperatures around -50 °C. The type of gases, their quantities and the related number of systems are listed in the tables hereafter.

The detector gas systems of CERN experiments are equipped with gas recirculation plants, i.e. systems where the return mixture from the detectors is collected, cleaned and then re-used. These plants allow to reduce the gas consumption by at least 95%.
The gas recirculation cannot always be pushed to 100% because of two reasons:

a) the accumulation of Nitrogen in the gas mixture that cannot be filtered, and which causes the degradation of the detector performance,
b) the presence of leaks at the detector level that are not accessible and therefore very difficult to repair.

Point a) has been the subject of R&D studies for the development of specific gas installations able to remove impurities not easy to filter. Indeed, the gas mixture used for particle detection purpose makes extremely difficult the recuperation of the primary gases. Dedicated recuperation plants have been developed by CERN for CF4, C4F10 and R134a and they are currently used.
Concerning point b), CERN and the experiments are fully engaged in the research for specific techniques allowing to repair the faulty components in particle detectors.

In addition, an intense R&D activity is ongoing since many years in the detector community for finding environmentally friendly replacements of F-gases. However, finding a suitable replacement is particularly challenging because most of the experiment infrastructures (i.e. high voltage systems, cables, front-end electronics) as well as the detectors themselves cannot be replaced. Therefore, the R&D is focused on identifying new mixtures able to reproduce the same detector performance observed with the currently used mixtures. In one case, encouraging results have been obtained with a partial substitution of the R134a with CO2. However, for the moment the full replacement of F-gases within the existing detectors is not possible. Therefore, the economic impact of the substitution process cannot be estimated.

Regarding detector cooling, alternatives were found for some of the systems, that will result in a drastic reduction of the F-gases used. The implementation of the alternative system using CO2 instead of F-gases is planned by 2028. The residual quantity of F-gases is shown in the table hereafter.

R&D was also conducted in recent years to replace some existing F-gas detector cooling systems that cannot be fitted by the CO2 system mentioned above. HFOs and FKs were the main candidates under test, following the recommendations of the F-gas Regulation EU No 517/2014. The validation process of any new gas would require in depth tests for assessing the safety, the efficiency, and the reliability in the challenging radiation environment. Thus, estimating the economic and technical feasibility is impossible at this stage.

Furthermore, the schedule of the accelerators dictates strict time lapses for intervention on the gas systems located within the detectors. The next possible intervention slot will be in several years from now, namely after 2033.

In the light of the above CERN requests the following to be considered for the future regulation: CERN research activities require an exclusion of F-gas restrictions until the end of the current physics program linked to the operation of HL-LHC, provided alternative detector

technologies for future research programs are available in due time. An additional derogation for research activities and, in particular particle detection and related cooling is required in this context.

F-gas quantities used at CERN are:

The total quantity of each F-gas contained within the detector gas systems of CERN experiments is listed below:

F-gas	Number of installations where it is used	Total quantity present inside detectors (kg)
Norflurane 1,1,1,2-Tetrafluoroethane - R134a	7	250
Tetrafluoromethane - R14	5	420
Perfluorbuthane - R610	1	64
Perfluorohexane - PFC-51-14	1	350

The total quantity of each F-gas contained within the detector related cooling systems of CERN experiments is listed below:

F-gas/HFO/FKs	Number of installations where it is used	Total quantity present inside detector cooling systems (kg)	Total quantity inside detector cooling systems as of 2028 (kg)
Trifluoromethane R-23	1	40	0
HFC-404a	6	204	0
HFC-407c	2	3	3
HFC-410a	3	16	0
HFC-507	5	158	0
Norflurane 1,1,1,2-Tetrafluoroethane - R134a	6	17	0
HFO/HFC-449	2	150	150
Perfluoro(2-methyl-3-pentanone) NOVEC 649	2	884	884
Hexafluoroethane PFC-116	1	2	2
Octofluoropropane PFC-218	5	4140	600
Perfluorohexane PFC-51-14	20	27103	4000

The total quantity of each gas typically emitted by the detector gas systems of CERN experiments per year is listed below:

F-gas	Number of installations where it is used	Total quantity emitted by detectors per year (kg)	tCO2e
Norflurane 1,1,1,2-Tetrafluoroethane - R134a	7	56000	80080
Tetrafluoromethane - R14	5	1290	9533
Perfluorbuthane - R610	1	41	363
Perfluorohexane - PFC-51-14	1	410	3813

The total quantity of each gas typically emitted by the detector related cooling systems of CERN experiments per year is listed below:

F-gas	Number of installations where it is used	Total quantity emitted by the detector cooling systems per year (kg)	tCO2e
Trifluoromethane R-23	1	7	104
HFC-404a	6	1.5	6
HFC-407c	2	0	0
HFC-410a	3	0	0
HFC-507	5	0	0
Norflurane 1,1,1,2-Tetrafluoroethane - R134a	6	0	0
HFO/HFC-449	2	141	197
Perfluoro(2-methyl-3-pentanone) NOVEC 649	2	56	0.1
Hexafluoroethane PFC-116	1	0	0
Octofluoropropane PFC-218	5	616	5435
Perfluorohexane PFC-51-14	20	4804	44674

7) Potential derogations marked for reconsideration – Analysis of alternatives and socio-economic analysis

I don't have information on this topic

8) Other identified uses – Analysis of alternatives and socio-economic analysis

I don't have information on this topic

9) Degradation potential of specific PFAS sub-groups

I don't have information on this topic

10) Analytical methods

I don't have information on this topic