RADIATION SAFETY ASSURANCE AT THE CZECH NUCLEAR PLANTS: REGULATORY REVIEW

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Abstract
The Czech Republic has achieved good results in the category of nuclear power plant operational safety in the long term. A significant part of that general safety is the wide area of radiation protection. Occupational exposure values are visible images among other OECD NEA results. The Czech Republic has reached the lowest collective doses in the category of light and heavy water reactors. There are many factors contributing to consistently low and stable occupational exposures. One of them is operational safety culture represented by the fuel cladding tightness. Volume activity of the primary circuit and discharges into the environment are derived from the cladding tightness and impurities brought into the primary circuit. Primary circuit activity and radioactive discharges influence both occupational exposure and doses to the people in the vicinity of the plants.
This paper summarizes the results of the fuel cladding failure investigation at the Czech nuclear power plants (hereinafter referred to as the “NPP”). Fuel cladding failures are considered to be significant sources of radioactive wastes, discharges and sources of primary circuit contamination. All the stated factors are discussed and analyzed as generators of exposures. Some differences between the Dukovany Nuclear Power Plant and the Temelin Nuclear Power Plant have been found in primary circuit volume activities as well as in several components of discharges. The experience obtained at each individual plant in the Czech Republic, i. e., the Dukovany NPP and the Temelin NPP, constitutes the most relevant source of information for further improving their operation in terms of radiation protection and advanced radiation protection performance. Comparison of the radiation sources at the Dukovany NPP and the Temelin NPP brings about valuable results applicable to the feedback process.
This paper assesses the above stated effects from the point of view of daily activities of the Czech national regulator, the State Office for Nuclear Safety (hereinafter referred to as the “SONS”).

1. Introduction

Safety performance indicators (SPI) appear to be a very strong tool of the SONS for basic assessment of radiation protection level achieved at the Czech NPPs. The SONS uses several sets of these indicators, each for a different purpose. The basic SPI set was established in the early 1990´s and, in 1991, it was used for the first time in the Dukovany NPP. The SPIs specified in the IAEA guides were modified according to the Czech (originally Czechoslovak) conditions. Five of these SPIs are identical with those used by WANO. Based on the experience and knowledge obtained from annual evaluations, this basic set was revised in 1998. Subsequently, it was extended and, in 2003, was used also for NPP Temelin operation evaluation. The SONS collects specified data throughout the year using its own inspection findings and licensee’s information, which are subject to SONS requirements. Four areas of power plant operation are evaluated:

1.1. Significant Events
1.2. Safety Systems Operation
1.3. Barrier Integrity
1.4. Radiation Safety

The SONS regularly publishes a summary document as an appendix to the Annual Report. The document is also attached to the "National Report under the Convention on Nuclear Safety" [1]. In addition to the basic set of SPI [2] the SONS operates further SPI set, which serves in the daily feedback process as a working SPI set. This working set for radiation protection in the case of fuel cladding failure and its consequences is presented in this contribution.

2. Fuel cladding failures

The basic indicator showing the state of the second barrier between fission products sealed under the cladding and the primary circuit coolant is the Fuel Reliability Indicator [3]. Its mean values for both the Dukovany and Temelín NPPs are in Fig. 1.

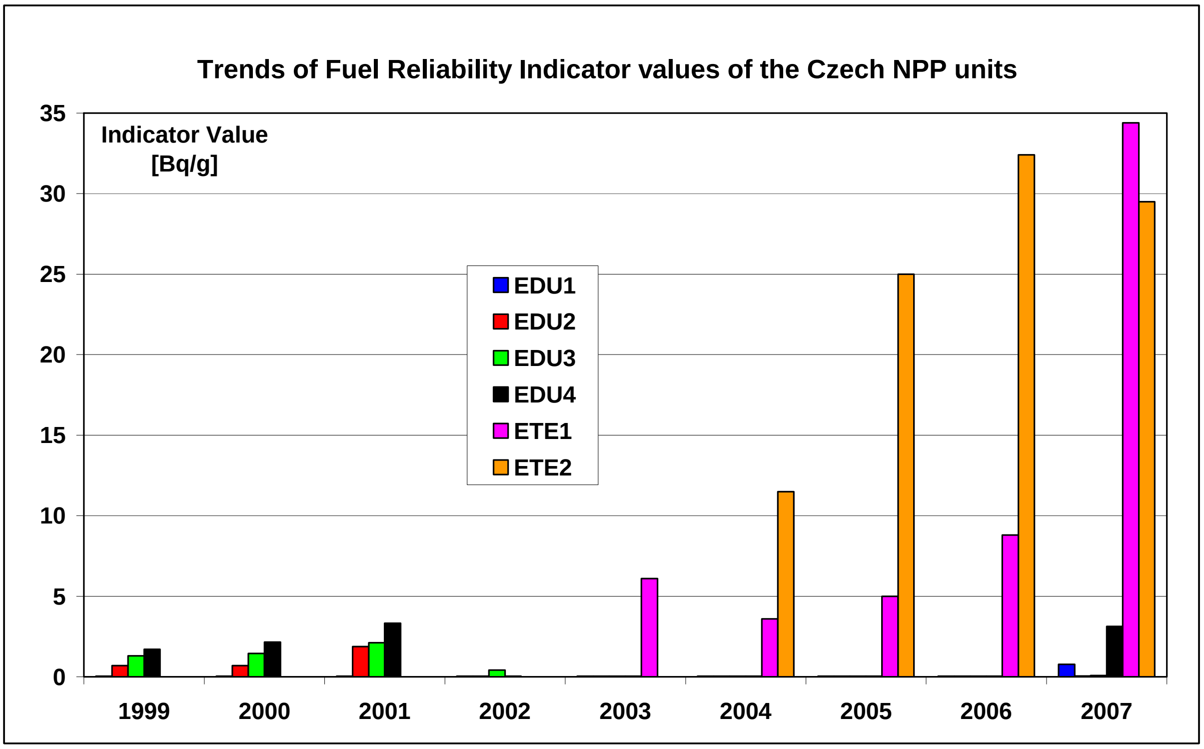

Fig. 1. Fuel Reliability Indicator values in the Czech NPP units between 1999 and 2007
EDU1 to EDU4, Dukovany units 1 to 4; ETE1 and ETE2, Temelín units 1 and 2

As seen in Fig. 1 there are no significant leakages from the fuel Dukovany NPP units while the fuel cladding at Temelin NPP is not tight. The SONS analyzed the situation related to the Temelin fuel leakage immediately after the limit of 19 Bq/g was exceeded (Figs 2 and 3).

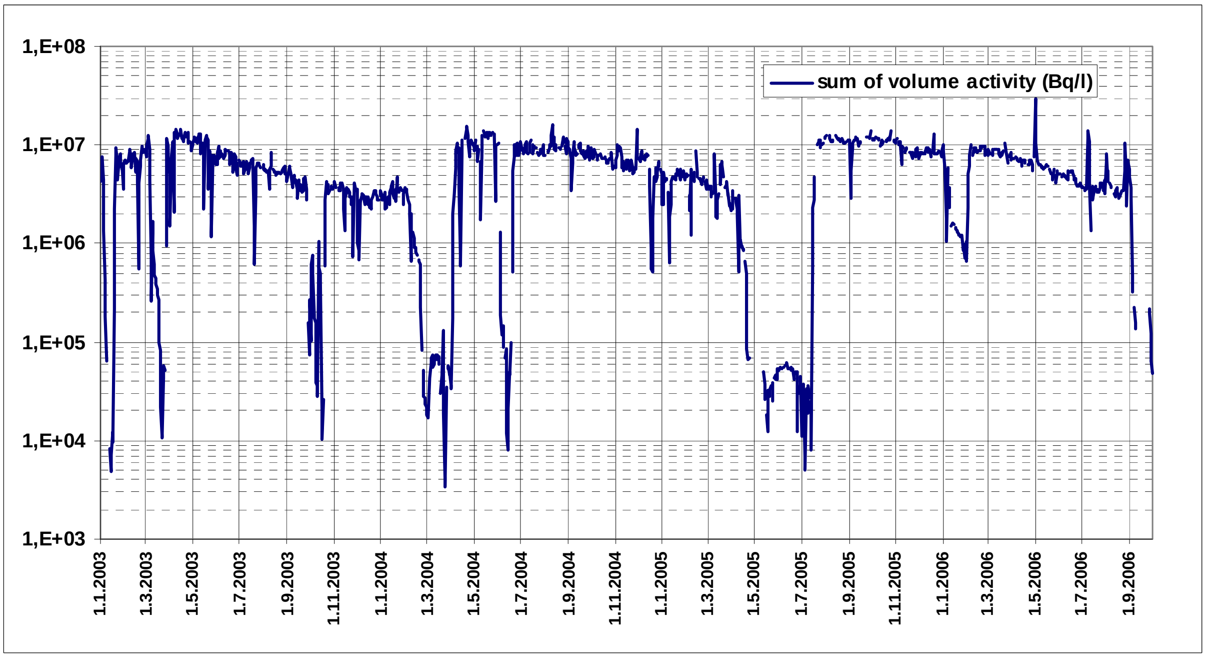

Fig. 2. Volume activity sum during the 2nd and the 3rd campaign at the Temelin NPP Unit 2

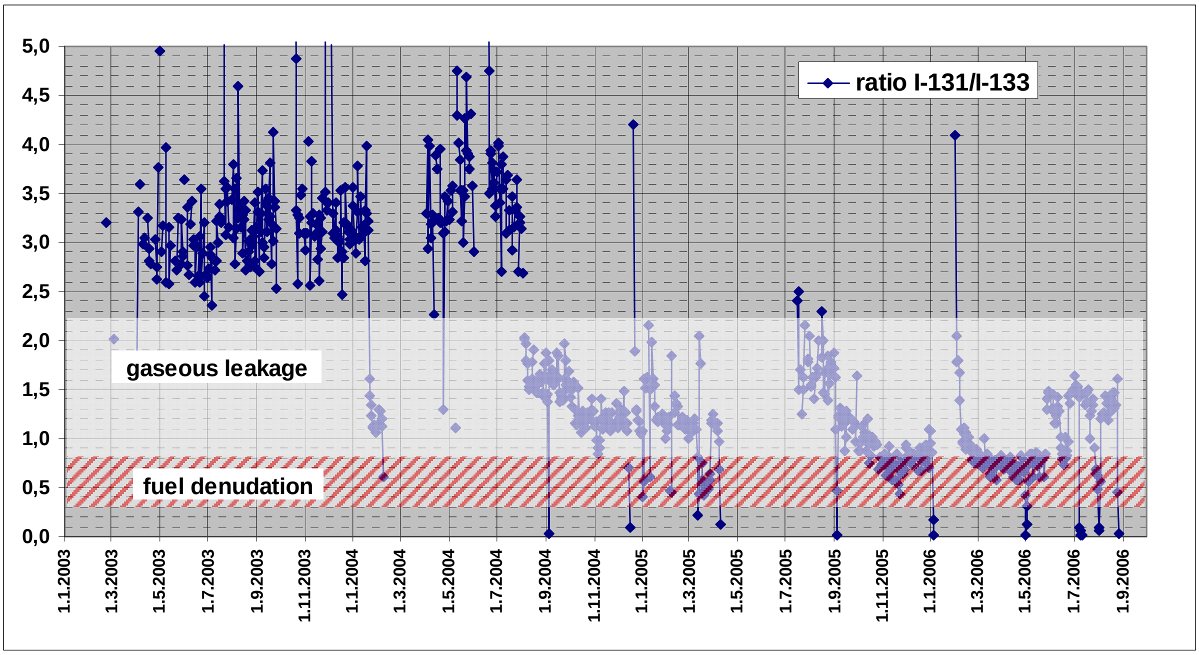

Fig. 3. Trends in ratio of 131I to 133I activities during the 2nd and 3rd campaigns at Temelin NPP Unit 2

For a better analysis of the situation, new working indicators I and Xe based on the 131I/133I and 133Xe/135Xe fission product ratios were introduced (Fig. 4).
Using indicators I and Xe, areas where fuel is still tight can be identified and the progress of fuel cladding leakage can be observed. Because volume activities of fission products in the primary coolant are recorded daily by the licensee, these working indicators help the SONS react quickly and independently to everyday situations. For determination of the number and size of leaks, special detailed methods are used by the licensee.

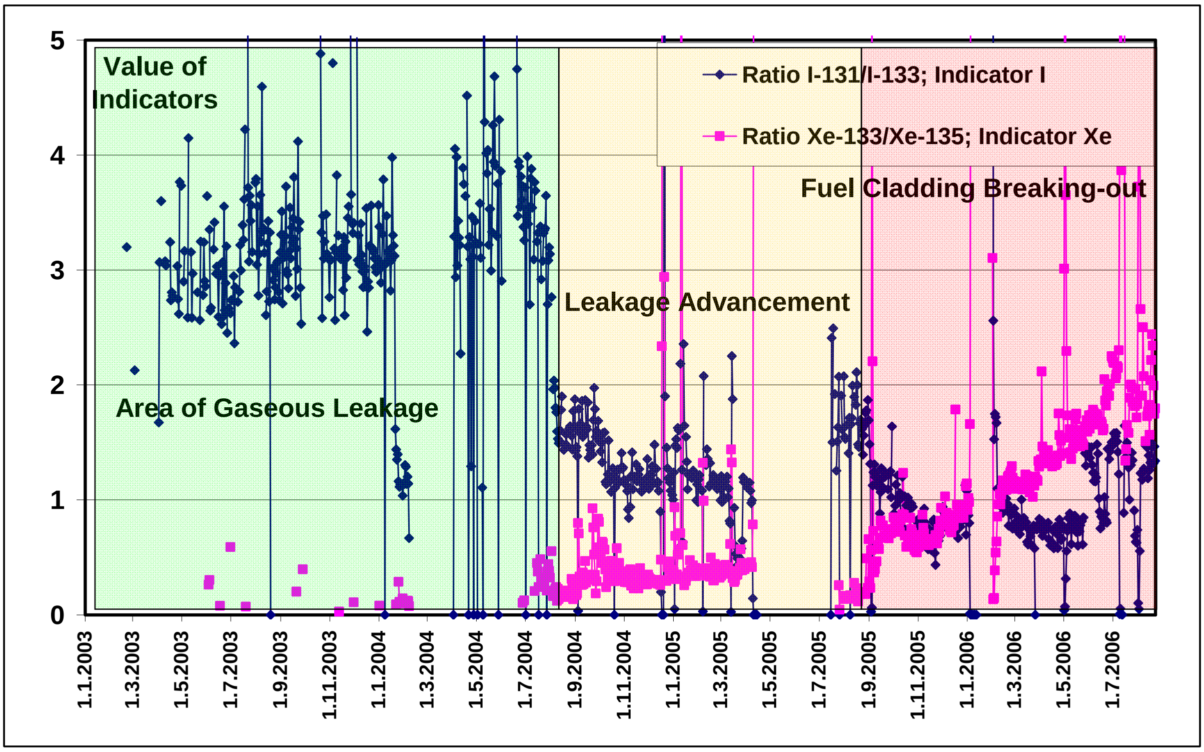

Fig. 4. Fuel cladding leakage indicators at Temelin NPP Unit 2 between 2003 and 2006

3. Consequences of fuel cladding failure

Possible effects of leaking fuel on discharges from and collective doses in the Czech NPPs are shown in Figs 5, 6 and 7.

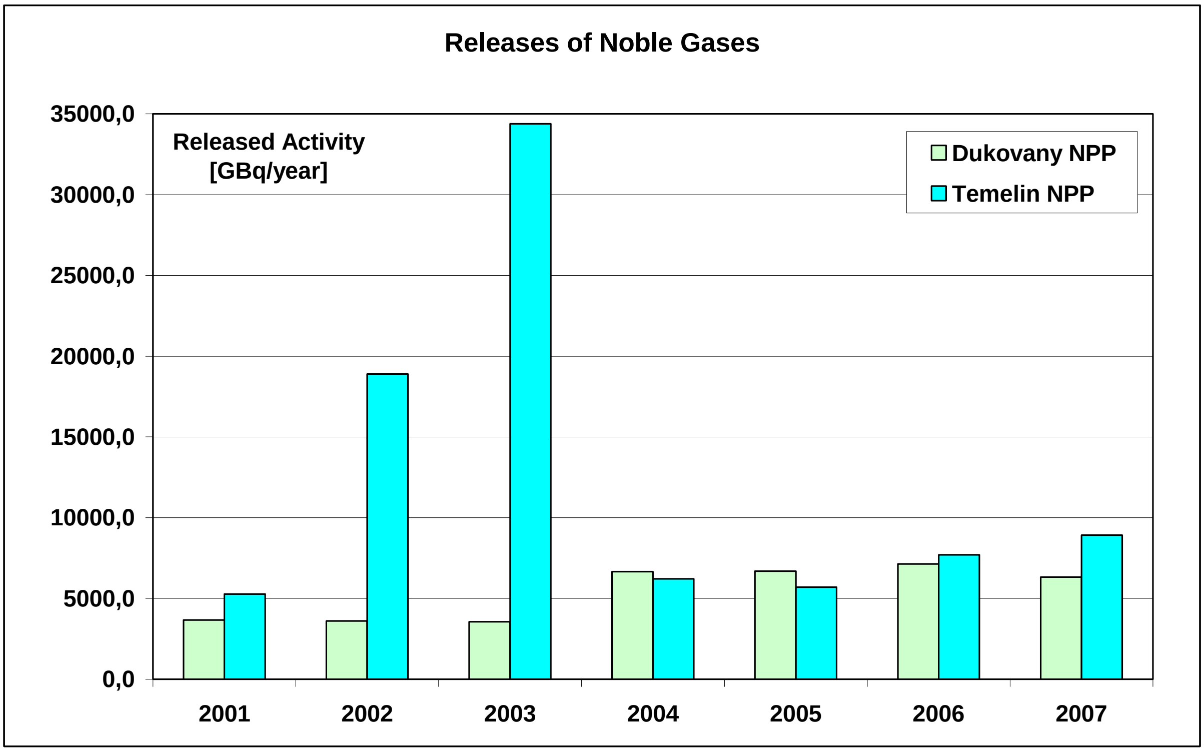

Fig. 5. Releases of noble gases

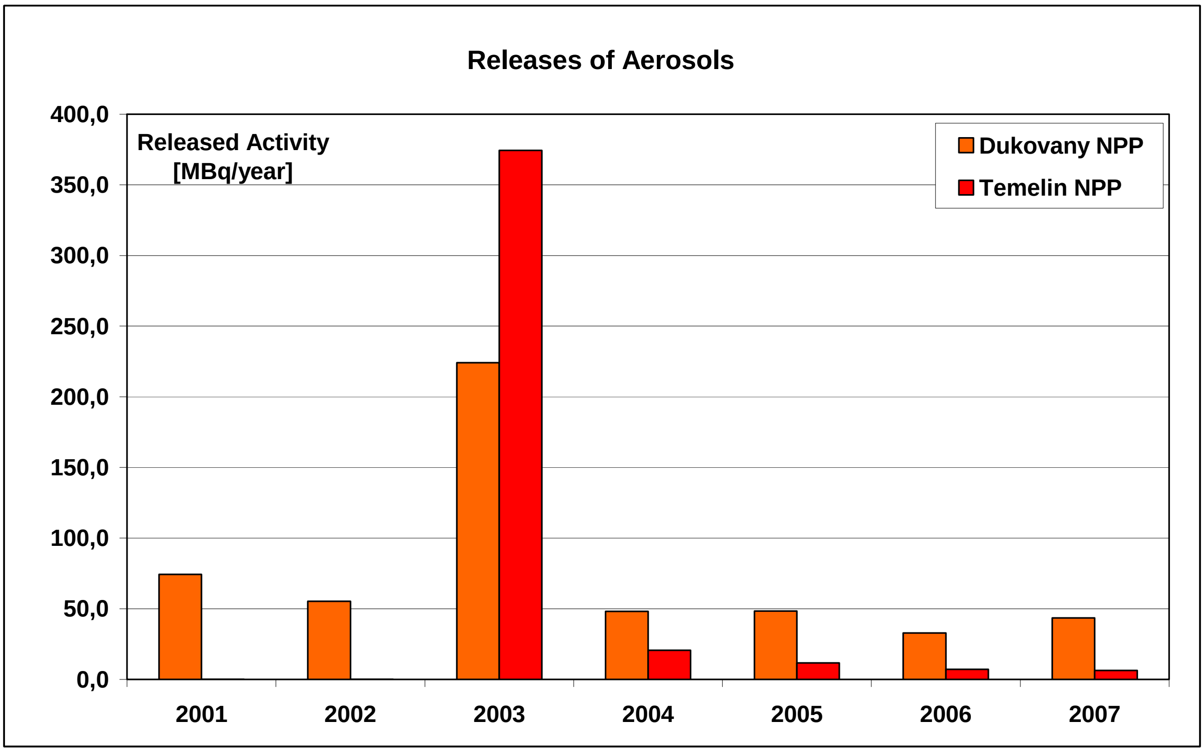

Fig. 6. Aerosols in gaseous discharges

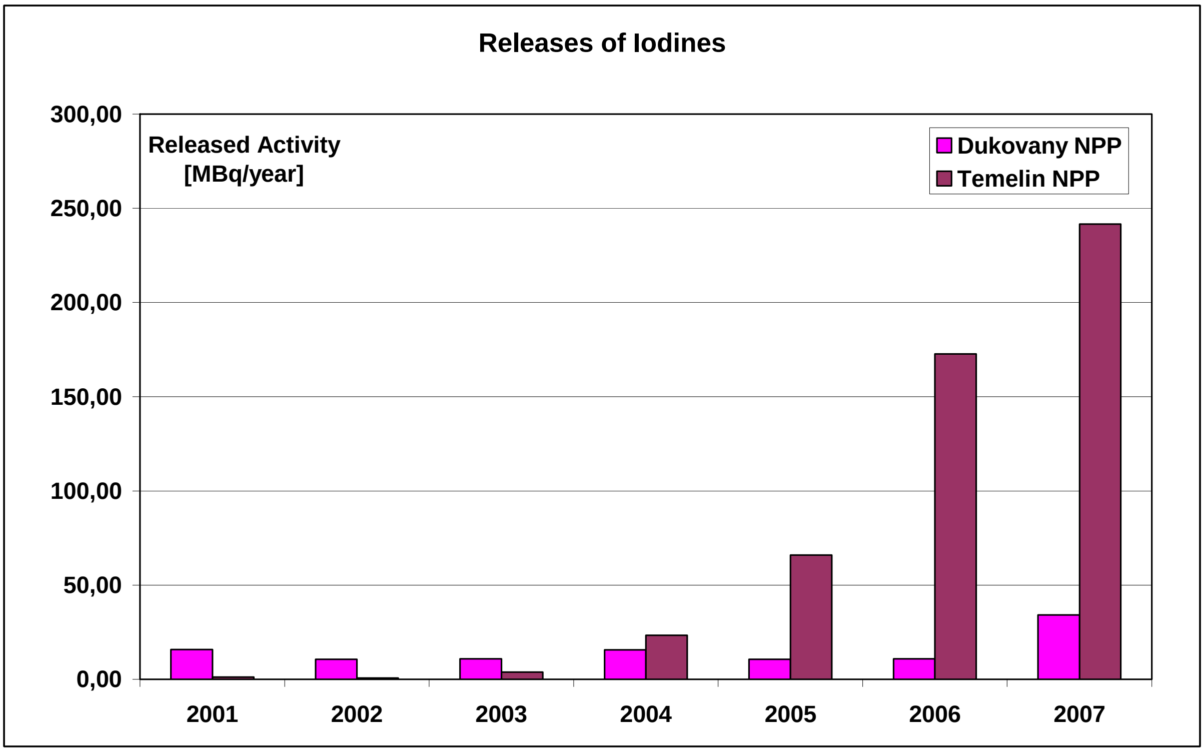

Fig. 7. Iodines in gaseous discharges

On comparison of the results in Figs 5 to 7 with in Fig. 4, relationships between the indicator function and discharges behavior are obvious. Even these partial results indicate clearly that leaking fuel significantly affects the releases. The effect of leaking fuel on CEDs is shown in Figs 8 and 9.

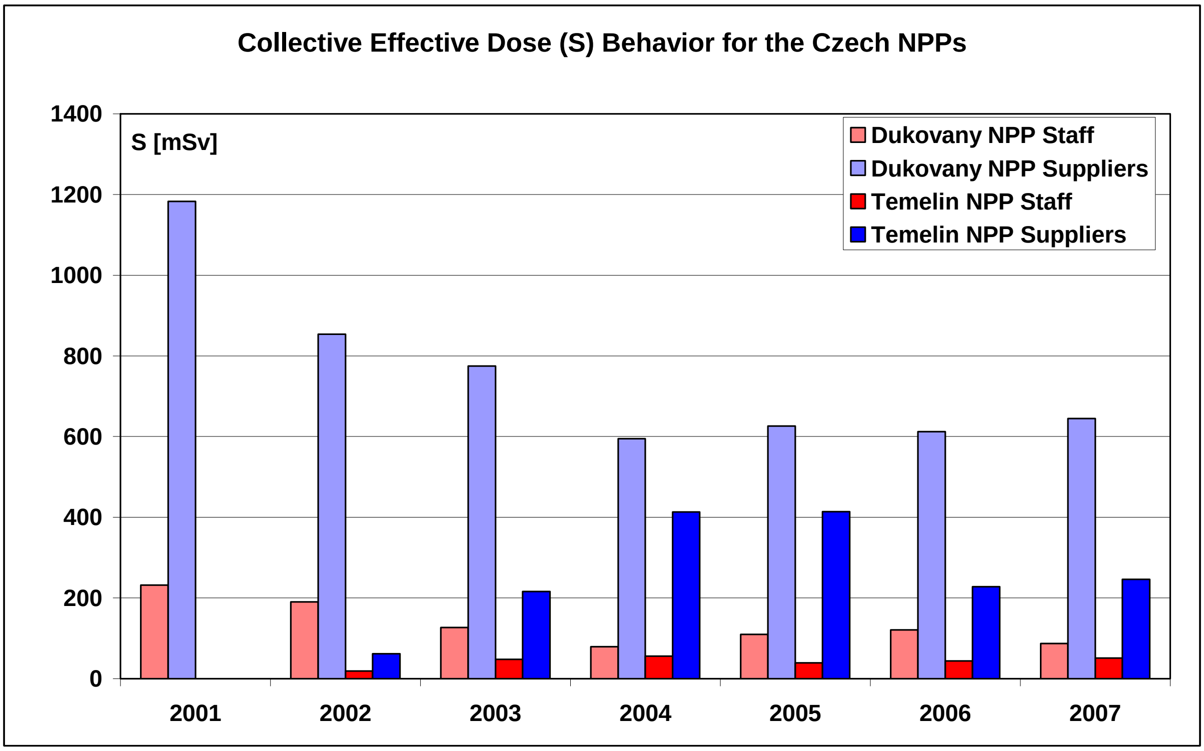

Fig. 8. Collective effective dose values for radiation workers at the Czech NPPs, from 2001 to 2007

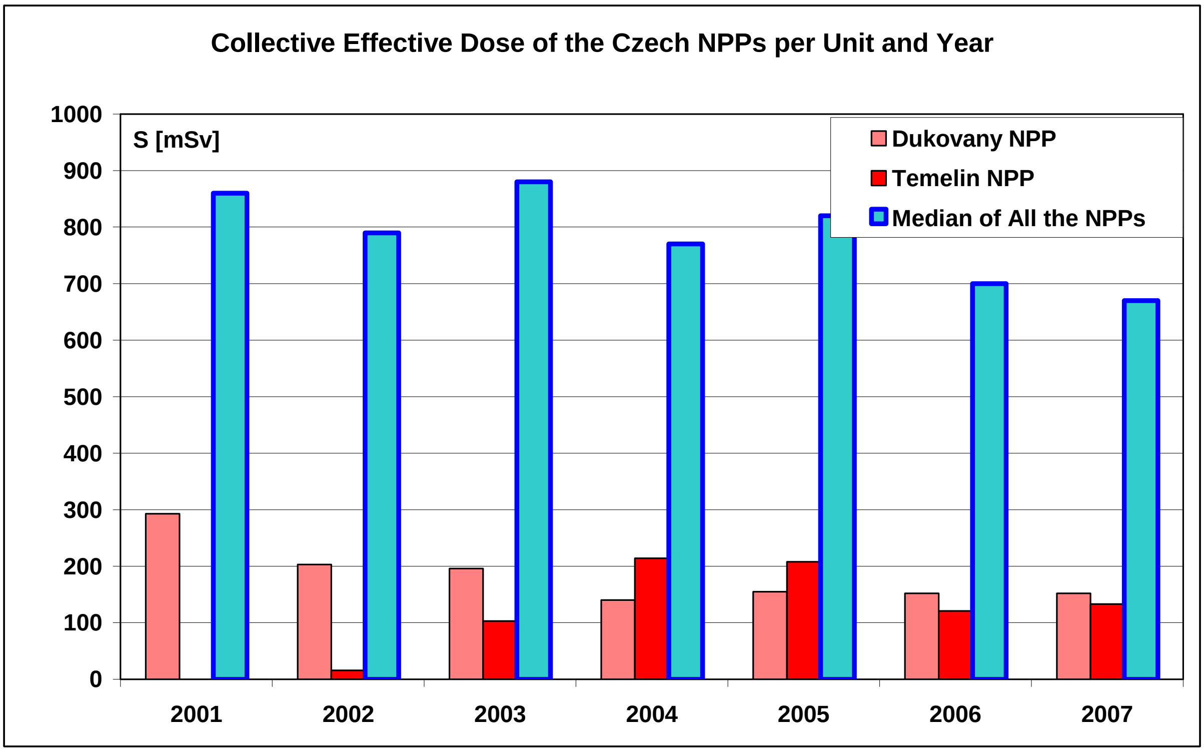

Fig. 9. Trends of the Czech collective effective doses per unit and year, from 2001 to 2007

Figs 8 and 9 show that the impact of increased fuel leakage on occupational exposure is none or only very small. The same is true for the impact on public exposure (Fig. 10).

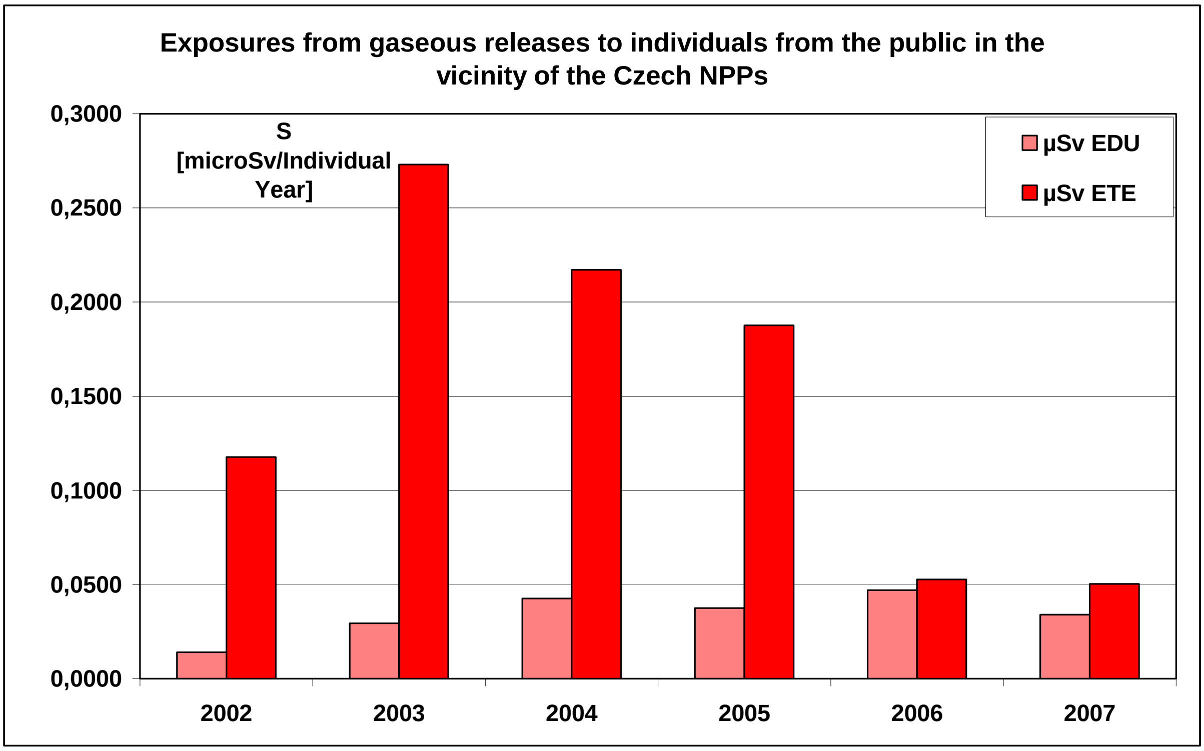

Fig. 10. Public exposures from gaseous releases, from 2001 to 2007[1]

[1] EDU is the Czech abbreviation for the Dukovany NPP and ETE means the Temelin NPP.

4. Conclusions

The Czech Republic has implemented the system of feedback as sets of different safety performance indicators. The basic level of these indicators is the official set of indicators annually revised and published in SONS official papers. The second level of the indicators is a working level serving basically for daily assessment of the licensee's activities. There is also the third level of the indicators used ad hoc for special cases.
This paper shows the utilization of above mentioned indicators in practice.

5. References

1. http://www.sujb.cz/?c_id=798SPIs
2. http://www.sujb.cz/?r_id=229
3. Operational safety performance indicators for nuclear power plants, IAEA-TECDOC-1141, Vienna, Austria, May 2000