ANNEX 6 Evaluation of the Safety Performance Indicators Set (year 2018)

CONTENTS:

A. INTRODUCTION

State Office for Nuclear Safety (SUJB) executes the state administration and supervision of the utilisation of nuclear power and ionising radiation in order to assure achieving a required safety level. As the focus of the supervision consists in the evaluation and assessment of nuclear safety related activities and their results, SÚJB annually evaluates an achieved level of nuclear safety of operation of Dukovany NPP and Temelín NPP by using Safety Performance Indicators.

The Safety Performance Indicators evaluate four areas of the NPP operation:

1. Events,
2. Safety Systems Performance,
3. Barriers Integrity,
4. Radiation Protection.

The evaluation results of Safety Performance Indicators in the form of graphs for the monitored period (2013 – 2018 for Dukovany NPP and 2013 – 2018 for Temelín NPP) are given in appendices. The graphs mostly represent local values in the form of sum totals or averages of the unit values. Only for Safety System Unavailability, the indicated values are also at the level of the systems and for Barriers Integrity at the unit level.

Input data for the evaluation were acquired both from documents submitted by the operator and by SÚJB supervisory activities at Dukovany NPP and Temelin NPP.

B. EVALUATION OF THE SET OF SAFETY PERFORMANCE INDICATORS FOR DUKOVANY NPP

This section includes an evaluation of particular indicators of the monitored areas of operation of Dukovany NPP and their graphic representation is shown in Annex – Part I.

After 2016, almost all operational safety indicators were in a way “distorted” by serious findings in the area of poor documentation of welds and subsequent necessary inspection and possible repairs within the so-called “welds case”; for that reason, the shutdowns were prolonged at all units. In 2017, the operation of all units began to return to the usual tracks and in 2018 the length of outages returned to the expected values from the years before 2016. SÚJB informed about the bad evidence of welds by ČEZ for the first time in September 2015, and as a result of this case, large financial losses were incurred by ČEZ, due to the long-term shutdown of the units, and criminal cases were filed in this case, which were subject to investigation by the police in 2018.

In general, the evaluation of the set of operational safety indicators of Dukovany NPP for 2018 shows that the overall achieved status of nuclear safety in electricity production at Dukovany NPP is still maintained at a very high level.

In the following, the individual Safety Performance Indicators are grouped according to their classification in the respective areas.

1. Events

Group 1.A – Reportable events

The basic data for the evaluation of indicators of Group 1.A is the number of reported events in 2018, i.e. events that conform to the specifications in Table 2 of the Safety Guide on Nuclear Safety 1.1.

Indicator 1.A.1 - The number of events reported to the nuclear safety regulatory authority (graph 1.A.1) has been around the long-term mean value of 53 reported events per year in recent years; in 2016 this number decreased to 49 resp. 41. This was due to prolonged shutdowns due to the 'welds' cause. In 2017, 56 events were reported to SÚJB and in 2018 48 events were reported. Taking into account the statistical error, the number of reported events is thus around the long-term mean value (53). The number of safety-related events reported by SÚJB in 2018 returns to the average statistical values of previous years after the “weld case” and in the number of 6 it is again around the equilibrium average, which is the expected value for statistics of such small numbers.

In 2018, no events were rated at EDU by INES = 1. The final evaluation of Event 56/17, which occurred on Unit 2 diesel generators in 2017 and the issue of last year's Safety Performance Indicators File Evaluation, has not yet been resolved, was eventually rated INES = 0.

In 2018, a total of 7 events (events 6, 8, 10, 25, 33, 39, and 45) were evaluated at the Dukovany NPP with INES = 0. The two events (events no. 20 and 58) have not yet been finally decided whether to rate them INES = 0 or to be assessed as events outside the INES scale.

Indicator 1.A.2 - Human failure (Chart 1.A.2) through the HFI index reflects the proportion of human failure in the total number of reported events. The development in the area of human failure in both the number of events and the HFI index has long been consistent with the average number of events reported. Only in 2017 compared to previous years the number of human factor events increased to 43. This increase was probably indirectly connected with the „weld case“, when for the reason of f.e. installing scaffolding to perform X-ray analysis of welds, a few events occurred due to unrecorded technology interference carried out by the scaffolding builders. In 2018, the number of events with a human factor of 35 returned to the expected values.

Group 1.B – Actuation of the protection and limitation systems

Results of the indicator "Unplanned Unit Scrams" are shown on graph 1.B.1,2.

In 2018, as in the previous eight years, no unplanned reactor scram occurred.

A Dukovany NPP reactor had to be manually shut down for the last time in 2005 and the last automatic shutdown of the reactor occurred in Unit 4 in 2010.

During the first phase of I&C renewal, the HO 2 functions were partially replaced by reactor protection (fast automatic shutdown) and partly by a new RLS system which replaced the previous HO 3 and HO 4 protections. Graph 1.B.3-5 thus shows the number of actuations of RLS -3 and RLS-4. As can be seen from the graph, after 2017, when there was no actuation of RLS-3 protection and no actuation of RLS-4, in 2018 there were 2 actuations of RLS-3 and 4 actuations of RLS-4.

RLS-3's first actuation occurred at Unit 2 on 10 March 2018; when, in MODE 3, the RLS unauthorized operation (HO3, HO4) was signalled due to a device defect.

The second actuation of RLS-3 occurred on April 30, 2018 at Unit 4, when at the reactor power of 100%, failure of MCP1 occurred from Ltot. in SG1 and there was subsequent correct functioning of the automatics to operate RLS-3, thus reducing reactor and turbine performance and stabilizing the unit at reactor power NR = 73%.

Compared to the year 2017, when there were no drops of control rods, there were 2 such events in 2018. In 2015, there were also 2 cases, in 2016 1 case, and before that the last drops were registered in 2009 with 2 control rods. The statistics of this indicator mean that it is rather random events and statistics of small numbers. If it were a trend, it would show from the behaviour of this indicator in the coming years.

Group 1.D – Limits and Conditions

Compared to the year 2017, when there were 4 violations of LaP at NPP Dukovany, there was no violation of this basic operating document in 2018 (see Graph 1.D.1).

The value of indicator 1.D.3 "Temporary Exemption from Limits and Conditions" in 2018 increased slightly compared to last year. The reason for the 63 temporary changes of the Limits and Conditions was mainly the drainage of the ESW related to the implementation of OP 73/2018 and the inspection and repair of welded joints and the replacement of the orifice plates on the ESW at the TQ23,43,63W01 exchangers. The work went without complications and the filling of ESW3 was properly tested, including ELSIII. The evaluation of OP 73/2018 was handed over to SÚJB as fulfilment of the condition of the SÚJB Decision itself. Other temporary changes of Limits and Conditions were issued in connection with the implementation of investment project 7129 - Completion of the 3rd SFSP cooling circuit (TG17 system).

As in the previous period, all temporary changes in the Limits and Conditions were authorized by the Office in 2018 to implement actions that, after their implementation, increase the nuclear safety of the units.

2. Safety Systems Performance

Group 2.A – Safety System Unavailability

The group is monitored by means of indicator "Safety System Unavailability" for specific safety systems, see graphs 2.A.1.a – g.

From the graphs of sub-indicators for individual systems (2.A.1a-g) it can be seen that in recent years the increase of this parameter was connected with non-meeting[1] the Limits and Conditions after the reconstruction of the ESW system piping. In 2018, there were shorter periods of non-meeting[1] Limits and Conditions for reconstruction, and therefore in 2018 there was also a slight decrease of this parameter for all BSs.

Group 2.B – Failure of safety systems

According to the indicator “Starting Failures of Safety System” (graph 2.B.1), in 2018 a single starting failure of SS occurred at all units. This event no. 25/18/2 occurred on September 17, 2018 at Unit 2 during the test of the 3-minute running of the 2TH61D01 pump prescribed at Limits and Conditions when the drive did not start. As it was an incident on the safety system, it was rated as a safety-relevant event and was also investigated.

Similarly, the behaviour of safety systems in operation is monitored in the indicator 2.B.3.With the exception of 2013, when there was a single run failure on the TJ system, no BS failed to run since 2005, including in 2018.

3. Barriers Integrity

Group 3.A – Nuclear fuel

The condition of nuclear fuel is monitored by the indicator "Fuel Reliability Index" (FRI, graph 3.A.1) and the indicator "The Number of Leaky Fuel Assemblies" (graph 3.A.2).

The fuel reliability formula is based on the empirical formulas and its results thus must be considered in terms of possible failure load. In practice, two or three levels of the values of the Fuel reliability factor are assessed:

- more than 19 Bq/g – the reactor core contains, with great probability, one to two defects;
- less than 19 Bq/g – the reactor core does not contain, with great probability, any fuel defect; all design values of the Fuel
- reliability factor less than 0.04 Bq/g are just corrected to the limit 0.04 Bq/g by reason of limited operation of the empirical formulas.

[1] and at the same time implementing corrective measures

Out of the comparison the graphs of these two indicators their interconnection is apparent. Annual values FRI factor at Dukovany NPP very low long-term.

The highest FRI of 1.84 Bq/g on Unit 1 was recorded in 2016, and in 2017 the value on Unit 1 decreased to 1.19 Bq/g, which was the highest value achieved in 2017. Similarly, in 2018 the highest FRI value of 0.59 Bq/g was detected again at Unit 1. However, it should be noted that these values are still far below the value that should indicate a leaking fuel and therefore no leaking fuel assembly was identified in 2018.

During the whole operation time of Dukovany NPP, only 7 fuel assemblies were excluded from the operation.

Group 3.B – Containment

The graph of indicator 3.B.1 assesses the tightness of hermetic areas through the results of the periodic integral test (PERIZ/OZIK). The operator's effort to systematically improve the tightness of EDU units started in all four units already in 2001 and from that year on, the block tightness has improved or oscillated around very acceptable values with a few minor variations. Since 2011, PERIZ/OZIK tests have been carried out with an interval of 2 years, even blocks in even years and odd blocks in odd years. From 2018 onwards, another philosophy of conducting PERIZ tests according to the unified HVB was carried out, such that in the even year the PERIZ tests were carried out on HVB I (Units 1 +2), in the odd year on HVB II (Units 3+4). In 2018, tightness tests were carried out at Units 1 and 2.

At Unit 1, the PERIZ test was performed, where the integrity of hermetic areas was verified by gradual pressurisation to a pressure of 50 kPa with a time duration of 8 hours and then the measured value was extrapolated to a project pressure of 150 kPa. By measuring and extrapolating the measured values, the tightness value of the hermetic space of Unit 1 was determined to 6.816%/24 h, which is the expected value compared to the tests from previous years.

At Unit 2, the PERIZ test carried out by measuring and extrapolating the measured values determined the tightness value of Unit 2 hermetic spaces at 3.382%/24 h, which is also the expected value fluctuating around the mean value for Unit 2.

The measured and above-mentioned extrapolated values of the periodical integral tightness test of hermetic areas (PERIZ / OZIK) are well below the permissible limit value of 13%/24 h. In the case of the highest measured value measured in Unit 1 in 2018, it is only about half of the permitted value. On all other units, the value was always lower.

All measured values are in the range of expected values with respect to previous years, i.e. they follow the tightness of previous years and show good tightness of hermetic areas of all EDU units.

In connection with inspections of hermetic areas, the SÚJB issued in 2011 the decision ref. SÚJB/OK/1664/2011, which approved the change of PPK EDU, consisting in extension of the period of performance of the periodic integral test (PERIZ) from 12 to 24 months. Since this change periodic integral tests (PERIZ) were performed on odd blocks (blocks 1 and 3) and in even years on even blocks (blocks 2 and 4). In 2017, periodic integral tests were performed on all 4 units and due to operational circumstances, from 2018 onwards a new scheme of periodic integral testing was carried out, so that the 1st and 2nd unit (I. HVB) will have periodic integral tests (PERIZ) performed from 2018 on in even years and at 3rd and 4th unit (II. HVB) periodic integral tests (PERIZ) will be performed from 2019 on in odd years. This decision was also applied in 2018.

4. Radiation Protection

Group 4.A – Staff

The indicator "Collective Effective Dose per Unit" (graph 4.A.1) monitors collective effective dose of NPP staff, suppliers and visitors converted per one unit.

In 2018, the indicator concerned 794 NPP radiation workers and 1572 suppliers' radiation workers. The value corresponds to the length of outages and the extent of work performed. The total collective effective dose for 4 EDU units is shown separately for NPP personnel and suppliers in graph 4.A.2. It shows that the collective effective dose of NPP radiation workers is stable at around 10% and that around 90% is the collective effective dose of supplier radiation workers, which is due to the fact that overhauls are carried out by contracted supply activities.

The division of activities between NPP and supplier personnel is also reflected in the indicators “Average Individual Effective Dose” (Graph 4.A.3) and “Maximum Individual Effective Dose” (Graph 4.A.4). The values for 2018 correspond to the extent of work performed. None of the employees exceeded the dose optimization limit of 10 mSv per year.

During 2018, one radiation worker had to be specially decontaminated (graph 4.A.5). It was a contractor worker who carried out the reactor activities within Unit 2 outage.

Group 4.B – Radioactive Releases

The indicators "Gaseous Releases" and "Liquid Releases" evaluate the operation of Dukovany NPP in terms of radioactive releases.

Graph 4.B.1 "Effective dose from gaseous releases" for the indicator "gaseous releases" represents the exposure of a representative person obtained by calculation from an authorized model for the current discharge of radionuclides into the atmosphere and the current meteorological situation in the evaluated year 2018. In the long-term trend, the exposure of a representative person from discharges to the atmosphere shows a steady state.

Graph 4.B.2 “Effective dose from Liquid releases” for the indicator “Liquid releases” represents the exposure of a representative person obtained by calculation from an authorized model for the current discharge of radionuclides into the watercourse and the current hydrological situation in the year under review. The effective dose from discharges to watercourses is therefore influenced by the average flow rate in the Jihlava River in 2018, which was below the long-term average due to warm weather and therefore this value is slightly increased in 2018.

EVALUATION OF THE SET OF SAFETY PERFORMANCE INDICATORS FOR TEMELIN NPP

This section includes an evaluation of particular indicators of the monitored areas of Temelin NPP operation and their graphic representation is shown in Annex – Part II.

The year 2018 is already the 16th year, when the operation of the Temelín Nuclear Power Plant is also evaluated using operational safety indicators. Statistically, this is a period when it is already possible to reliably perform a similar statistical comparison as at EDU.

1. Events

Group 1.A – Related events

Since 2007, as in EDU, the number of Reportable Events (RE) that were originally specified by the "Communication Agreement" instead of the previously used Safety-Related Events (SRE) and that have been specified since 2013 in the safety guide BN-JB-1.1 (Utilization of operational experience on nuclear installations, which is currently being followed) has been taken as the basis for evaluating Group 1.A indicators.

Indicator 1.A.1 "Related Events" shows the number of Reported Significant Events (RE in the graph) over the past 6 years. Since 2010, the number of Reported Major Events has been decreasing, in 2013 the lowest number of events (35) was recorded, which was the minimum since the start of operations. In 2016, compared to 2015, the number of reported events increased by 9 to a total of 52 significant events reported, which was the highest value so far for this endpoint. In 2017, the number of reported events returned to 43, and in 2018 the number of Reported Major Events even dropped to the lowest level of 33. Whether this is a trend in the decline of significant events since 2016, this will show only in the following years. However, the number of Reported Major Events in 2018 suggests safe and reliable operation of both Temelín NPP units.

The number of events in chart 1.A.1 “Related events” classified by INES = 0 (marked BSE in the chart) increased by 2 to 16 in 2016 compared to 2015 and then decreased to 8 in 2017, and in 2018 the number of decreased again to only 5, which is the lowest value in the last 8 years. INES level = 0 were evaluated in NPP Temelín NPP events No. 22 (contamination of contractor's staff in room C325a at the Auxiliary Service Building for Primary Systems (BAPP) of 16 February 2018), event no. 31 (1VF30 - Absence of EWS flow to Containment of March 11, 2018), Event No. 71 (Defect ZK 1VF30S17 on displacement 1VF30D02), Event No. 77 (unsealing of fuel in the reactor core during U2C15 campaign of 16 July 2018) and Event No. 78 (2YC00B01 - Finding a foreign object in the reactor on 12 July 2018).

The number of events rated INES = 1 at Temelín NPP (marked as SSE in the chart 1.A.1 “Related Events”) was zero in 2016 and 2017, in 2018 there was one event rated INES = 1. It was Event No. 153/18/2 - “Leakage of route 2VB20Z201.1 - violation of Limits and Conditions A.3.6.2B”, which occurred at Unit 2 of the Temelín NPP on 6 November 2018.

As part of the monitoring of the Human Factor Impact Indicator (graph 1.A.2), a total of 17 events were identified in 2018, the root cause of which was the human factor, out of a total of 33 related Events, which is 52%. Compared to 2017, the number of events with human factor influence is higher by 3, both in absolute number of events and in percentage, where it increased even by 19%. It is thus evident that the human factor's share of events is still not decreasing. The influence of the human factor is a very important factor for NPP events and it is therefore necessary to continue to monitor the influence of this factor closely. Both the Office and the operator are trying to eliminate the human factor influence by better training of operating personnel or better supervision of the performed activities, and to reduce the number of events. However, as graph 1.A.2 shows, the trend of reducing the influence of HF has not been very successful so far. The SÚJB will continue to monitor this area in 2019 as part of its inspection activities, and the Office's inspectors will continue to require the operator to continue to receive even better training with an emphasis on the quality of each employee's work on the possibility of their work's impact on event prevention.

Group 1.B – Actuation of the protection and limitation systems

Similarly, in the previous 6 years and in 2018, there was no unplanned ROR (reactor scram on the basis of primary causes in PRPS system) and no shutdown of the reactor by LS (d), see graph 1.B.1,2 and graph 1.B.1,2a.

The limitation system of other types (a, b, c) was actuated only by 7 LS (b) in 2018 on June 8, 2018 during the repair of the RC/LC alarm signaling on the 1st cluster of the 10th group, on 10. 10. 2018 restart of processor in cluster control card 07-32 (2nd cluster/6th group), on 28. 10. 2018 deviation of measured and desired position> 5 steps for cluster 07-32 (2nd cluster/6th group), on 30 October 2018 in connection with the replacement of control cards in the PUP cabinet according to DP, the measured position of the 2nd cluster dropped/ 6. group and 2nd cluster/3. group on DKS, on 28 October 2018 from cluster 09-40, 2nd cluster from group 3 recurrence of the event, when the cluster position indicator control unit was replaced and on 9 December 2018 - cluster 13-32 (3. cluster/7th group) - see graph 1.B.3-5. From the long-term point of view it can be stated that even though it is a statistic of small numbers, the observed values in 2018 are in the area of expected values of the actuation of LS (a), LS (b) and LS (c).

As in the previous four years, the LS (d) limitation system (i.e. the drop of all clusters into the reactor core) was not affected either by manual intervention or by its automatic action.

Group 1.D – Limits and Conditions

In 2018, as mentioned above, on November 6, 2018, there was one violation of LaC on Unit 2. It was event no. 153/18/2 - "Leak of route 2VB20Z201.1 - violation of LaC in LPP A.3.6.2B", which for these reasons was also rated INES = 1 (see Graph 1.D.1 Violation of the Limits and Conditions). After two years, when there was no LaC violation event, one this event is recorded in graph 1.D.1 - LaC violations in 2018.

Despite this one event, it can be stated that the operation on both Temelín NPP units in 2018 was successful in terms of this indicator. Each LaC violation is itself an important event and therefore all LaC violation events are analyzed and investigated in great detail. Both the operator and SÚJB then place great emphasis on correctly and purposefully formulated and then fulfilled corrective measures, which are saved after the investigation of each event, in order to avoid recurrence of the event. At the end of the investigation, this is also inspected by SÚJB. This was also the case here.

In 2018, there were a total of 3 requirements for a temporary change of the LaC (see graph 1.D.3) that were approved by the SÚJB decision. The changes were related to the issuance of amendment No. F559 - "Implementation of LTA WSE fuel assemblies to the Unit 1 reactor at Temelín NPP" and implementation of project change F012 - "Implementation of UIS

Integration and modification of displays” and implementation of action No. C576 – reconstruction of ESW pipelines at Units 1 and 2.

2. Safety Systems Performance

Group 2.A – Safety System Unavailability

The „BS Unavailability” increased in 2017 compared to the year 2016 and 2017 level which fully corresponds to the change of the LaC for the implementation of Action No. C576 - Reconstruction of the ESW pipelines at Units 1 and 2.This is also fully reflected in the growth of individual sub-indicators of BS values. In the longer-term follow-up, these values can be expected to return to the expected average values (graphs 2.A1a - g), thus stabilizing these indicators at the expected mean values, related only to non-operability due to prescribed tests and checks on the device.

Group 2.B – Failure of safety systems

In 2018 there were no starting failures of the safety systems. In 2017 dated July 14, 2017 for slow start of DG (connection time 10.123 sec. was longer than required 10 sec.), Only this one event No. 101/17 was registered.

Regarding the other graph in this group of monitored safety systems, no system failure occurred in 2018 (graph 2.B.3).

3. Barriers Integrity

Group 3.A – Nuclear fuel

The state of nuclear fuel is monitored by the indicator "Fuel Reliability Index" (FRI, graph 3.A.1) and the indicator "The Number of Leaky Fuel Assemblies" (graph 3.A.2).

In 2018, the eighth campaign ended on Unit 1 and the seventh with new TVSA-T fuel ended on Unit 2. The FRI values for individual units in 2018 were 7.85 Bq/g for Unit 1 and 50.17 Bq/g for Unit 2. Compared to 2017, these values decreased slightly (61.02 Bq/g in Unit 1 and 13.71 Bq/g in Unit 2) - see graph 3.A.1. These values then correspond to the detected leaking fuel assemblies (graph 3.A.2).

During outages for refuelling in 2018, the FRI value corresponded to the detection of leaking 5 fuel assemblies. No leaking fuel assemblies were identified at Unit 1 in 2018. A total of 5 leaking fuel assemblies were identified at Unit 2 (see report no. 77/2018 of 16 July 2018). In one case it was a fuel assembly that was in the reactor core only 1 year from the planned 4-year fuel campaign (FA - CA28), in three cases it was a fuel assembly that was in the reactor core for 3 years (FA - DS03, DS05 and DS13) and in the last case it was already spent and thus discarded fuel assembly after its stay for 4 years in the reactor core (FA - DP03). Due to indicated leaks, all leaking fuel assemblies have been replaced by new ones - see graph 3.A.2. Statistically, the fuel assemblies leak around the expected mean values.

Group 3.B – Containment

In this group, there is only one indicator, which evaluates the results of the Periodic integral tightness testing, tightness condition of hermetic areas in graph 3.B.1.

PERZIK tests are carried out with a period of 4 years and last performed in 2015 on Unit 1, where the measured value was 0.1232% of the permitted 0.4%, and in 2017, it was performed on Unit 2, where the measured value was 0, 1357%. The measured leakage shows very good results in both cases, which are only less than one third of the permitted value. In addition, the graph shows that the tightness of the containment is consistently good. This corresponds to the project's expectations and international experience.

4. Radiation Protection

Group 4.A – Staff

The indicator "Collective Effective Dose per Unit" (graph 4.A.1) monitors collective effective dose of NPP staff, suppliers and visitors converted per one unit. In 2018, this indicator concerned 682 NPP radiation workers and 1276 supplier radiation workers. The indicator "Collective Effective Dose" (graph 4.A.2) monitors total collective effective dose of Temelin NPP in distribution of NPP staff and suppliers. Increased collective effective doses in some years are due to the increased volume of work in the controlled area during outages. In 2018, there was a slight increase in the collective and average individual effective dose for this reason.

There was also a slight increase in the indicator "Maximum Individual Effective Dose" (Graph 4.A.4) for both personnel and suppliers, which corresponds to the above-mentioned increase in the volume of work in the controlled area. However, none of the employees exceeded the dose optimization limit of 10 mSv per year.

In 2018, no radiation worker had to be specially decontaminated (see graph 4.A.5).

Group 4.B – Radioactive Releases

Graph 4.B.1 "Gaseous Releases - Committed Effective Dose" represents the exposure of individuals from the most exposed population group acquired by calculation from the authorized model for current radionuclide effluent to the air and the current meteorological situation in the evaluated year. In recent years, this indicator has remained at fractions of the annual authorized limit of SÚJB, which is 40 μSv for gaseous releases. In 2018, this indicator reached 0.01 μSv.

Graph 4.B.2 "Liquid Releases - Committed Effective Dose" represents the exposure of individuals from the most exposed population group acquired from the authorized model for current radionuclide effluent to the stream and the current hydrological situation in the evaluated year.

The annual authorized limit for liquid releases is 3 μSv. In 2018, 0.6 μSv was released, which is 20% of the authorized limit, a slight decrease compared to 25% of 2017.

C. CONCLUSION

From all the above information and evaluation of the results of monitoring of individual areas of the particular Safety Indicators, it shows that this file provides a good overview of the state and provision of nuclear safety and radiation protection during operation of all EDU and Temelín NPP units.

From the values of the individual Safety Indicators of monitored parameters, no parameter inexplicably deviated from its expected value in 2018. In general, all parameters compared to 2017 were within the statistical error around the mean value

and, unless there was a slight improvement, there was no unexplained deterioration in any of the parameters.

Regarding the share of human factor in the number of monitored events, the achieved values at Dukovany NPP in 2018 with 17 events caused by human factor out of the total number of 48 events (35%) compared to Temelín NPP, where also 17 events caused by human factor The number of 52 events (52%) is better, however, from long-term follow-up these values are also within the statistical error around the equilibrium expected values. The impact of the human factor on the safe operation of a nuclear installation is very significant, and therefore it is necessary to continuously train in a high-quality and intensive manner especially the operating personnel and constantly emphasized the quality of the human factor for the prevention of events. For this reason, the SÚJB will continue to monitor in 2019 as part of its inspection activities and the Office's inspectors will continue to require the operator to continue the trend of better training and the operator increasingly emphasizes the area of quality of each employee and his / her human performance for prevention.

There was no indicator that deviated somehow and could signal deterioration in trends and could become a risk in the future. However, it is still necessary that all processes at both power plants proceed according to the valid legislation and according to the approved documentation. Safe operation and outages must continue to be given great attention by both the operator and SÚJB as part of its inspection activities.

In 2016, the Safety Indicators file also discussed the issue of the fuel leakage indicator at Temelín NPP, when the number of leaking fuel assemblies exceeded the value of 15 in 2015. In 2016, however, this indicator returned to the expected normal values and this was confirmed in 2017, when in both years a total of 6 leaking files were eliminated. In 2018, 5 leaking files were detected. It turns out, therefore, that this area is a statistic of small numbers, so only in the coming years will it be shown whether this trend is confirmed and it is a return to the expected - anticipated values. However, this is a very important indicator, as a leak in the fuel assembly leads to higher concentrations of radioactivity in the primary circuit and this is related to the necessity of final disposal of radioactive products with the processing and disposal of radioactive products, i.e. the radioactive burden on the environment. However, as the PBU shows, this indicator was historically the highest in 2016, and yet there was no significant environmental burden. Nevertheless, SÚJB inspectors will continue to pay increased attention to the operator's activities, which may have an impact on the leakage of fuel assemblies as well as other activities related to the spread of radioactivity into the natural environment, including radioactivity processing.

D. ABBREVIATIONS:

AŠP	Activated and fission products
AZ	Reactor core
BL	Safety limit
BS	Safety system
BSVP	Spent fuel storage pool
ČEZ	Business name of the Czech utility - joint stock company ČEZ, a. s.
DG	Diesel generator
E	Individual effective dose
EDU	Dukovany nuclear power plant
ETE	Temelin nuclear power plant
GO	Overhaul
HA	Hydro-accumulator
HMG	Time schedule
HP	Hermetic premises
HN PG	Steam generator auxiliary feed-water system (Dukovany NPP)
INES	International Nuclear Event Scale
JB	Nuclear safety
JE	Nuclear power plant
LIJB	SÚJB local inspectors
LS (a,b,c,d)	Limitation system (various actuation functions)
LaP (L&C)	Limits and Conditions
LPP	Limiting condition for operation
NT	Low-pressure system
NOS	Protection system setting
OKJZ	Nuclear installation inspection section
OROPC	Fuel cycle radiation protection section
OZIK	Repetitive containment integrity test
PG	Steam generator
PBU	Safety indicator(s)
PERIZ	Periodic integral tightness testing
PERZIK	Periodic containment integrity test
PRPS	Primary reactor protection system
RB	Reactor unit
RC	Regional center
REAZNII	Automatics of emergency power system – category II
ROR	Reactor scram
S	Collective effective dose
SAOZ (SHCHAZ)	Emergency core cooling system
SHN PG	Steam generator emergency feed-water system (Dukovany NPP)

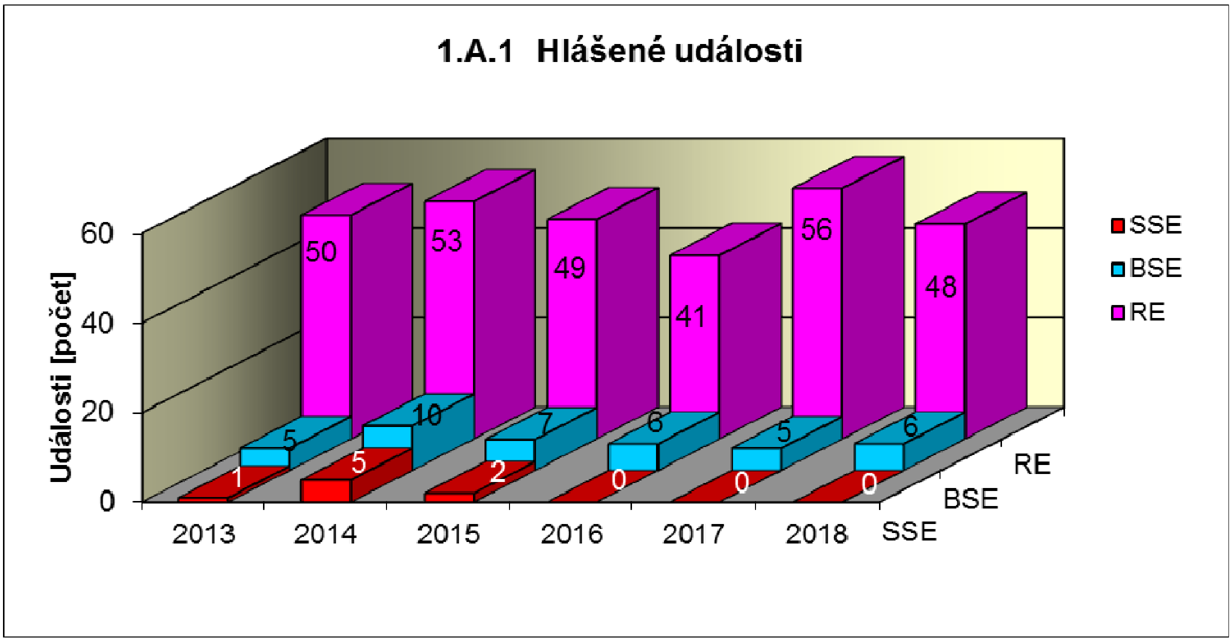
SW	Software
SZB	Safety assurance system
TJ	High-pressure emergency core cooling system
TH	Low-pressure emergency core cooling system
TQ	Dukovany NPP spray system / Temelin NPP emergency core cooling systems and spray system
TX	Emergency steam generator feedwater system (Temelin NPP)
VT	High-pressure system
ZIK	Structural over-pressure test
ZKOB	Safeguards and protection testing

1. Significant Events

1.A Reportable events

Graph of indicator 1.A.1 monitors the development of number of reportable events (RE) including its division according to the evaluation of the International Nuclear Event Scale (INES) into significant events (SSE, INES > 0) and the below scale events (BSE, INES = 0).

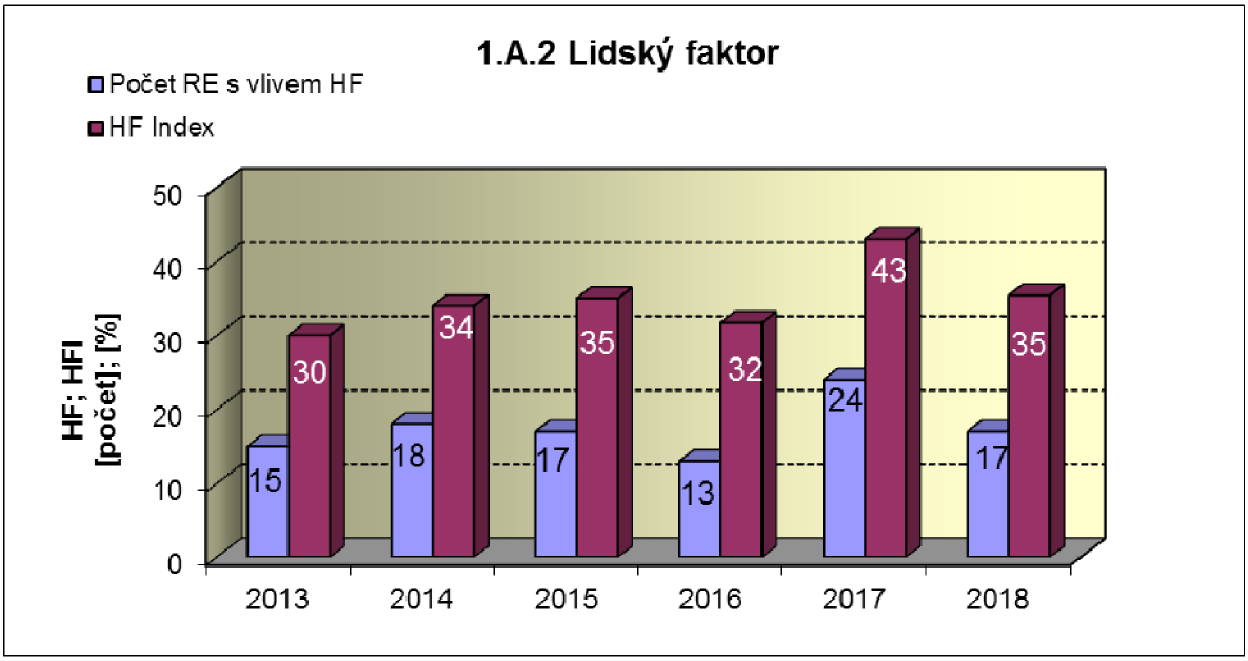
1.A.1 Number of Reportable Events



Events [number]

Graph 1.A.2 evaluates the influence of the human factor upon occurrence of reportable events. The indicator is expressed by the number of the reportable events with an influence of human factor (HF) and its percentage share (HFI).

1.A.2 Human Factor



HF, HFI [number]

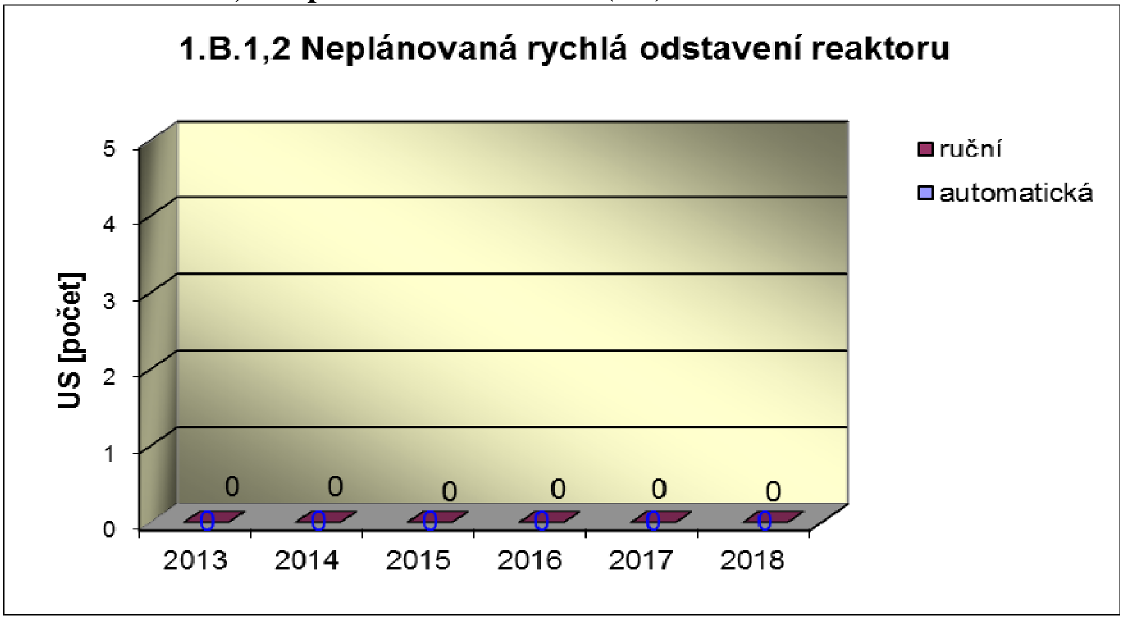
Number of reportable events with HF influence

HF Index

1.B Actuation of the protection and limitation systems

Graph 1.B.1,2 summarises the total number of unplanned unit scrams (US) (reactor in MODE 1 or 2) with resolution of manual and automatic shutdown. The term unplanned means that the scram was not an expected part of the planned test.

1.B.1,2 Unplanned Unit Scrams (US)



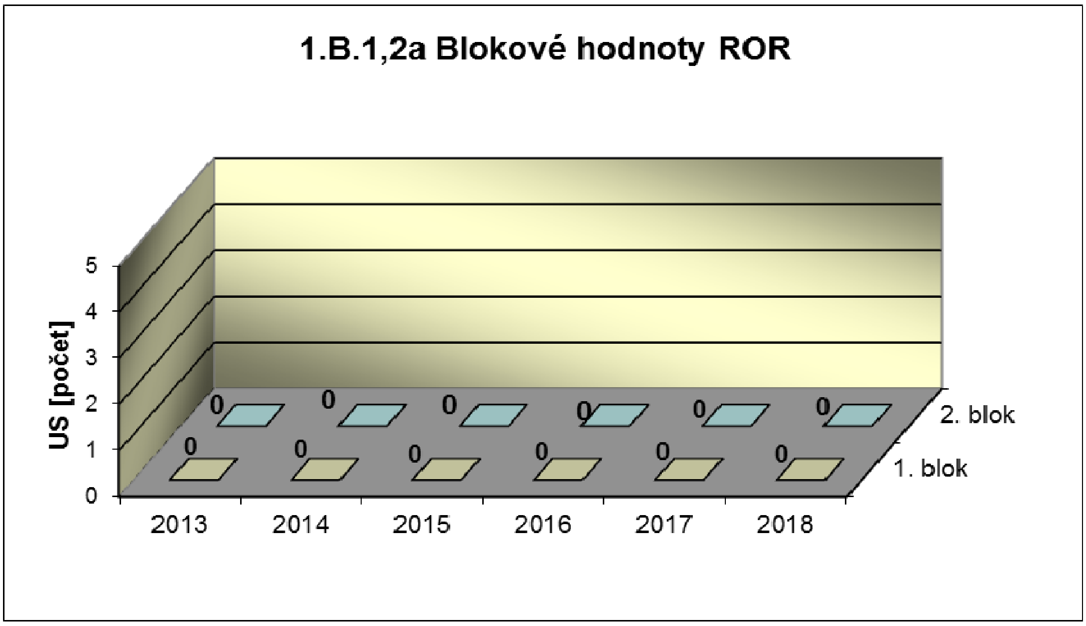
US [number]

manual

automatic

Graph 1.B.1,2a compares unit values of unplanned reactor shutdowns, including manual.

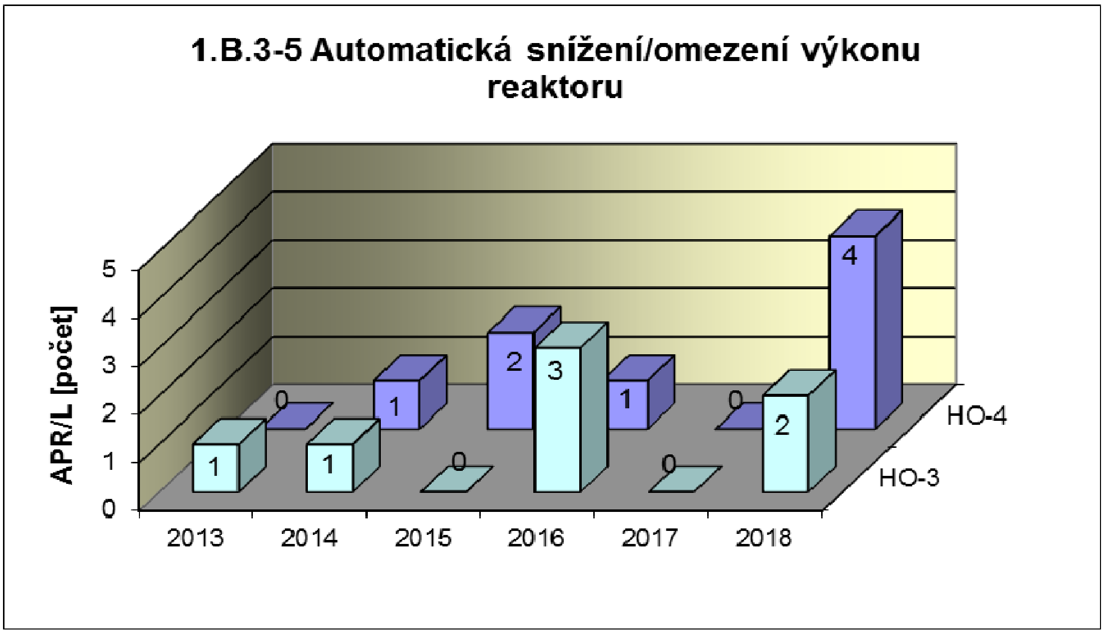
1.B.1,2a Unplanned Unit Scrams – Unit Values



US [number]
Units 1 - 2

A common graph of indicators 1.B.3-5 presents the number of unplanned automatic power reduction (APR) by emergency protection of the 2nd – 4th type (HO-2, HO-3 a HO-4).

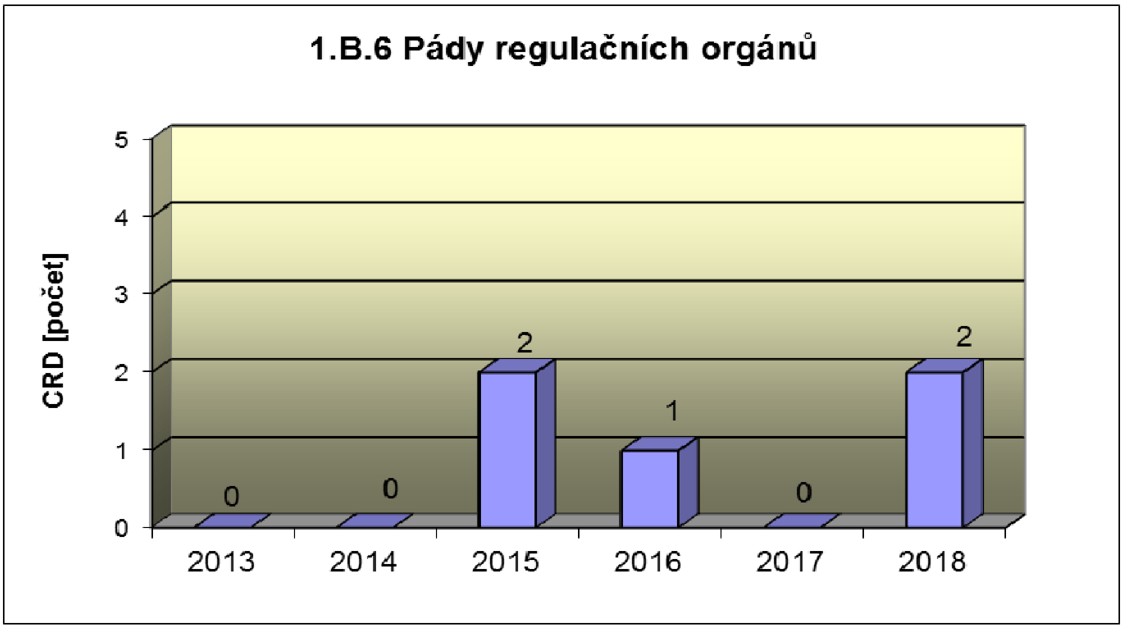
1.B.3-5 Automatic Power Reduction/Limitation



APR/L [number] / year / type

Graph 1.B.6 presents the development of the number of control rod drops (CRD).

1.B.6 Control Rod Drops

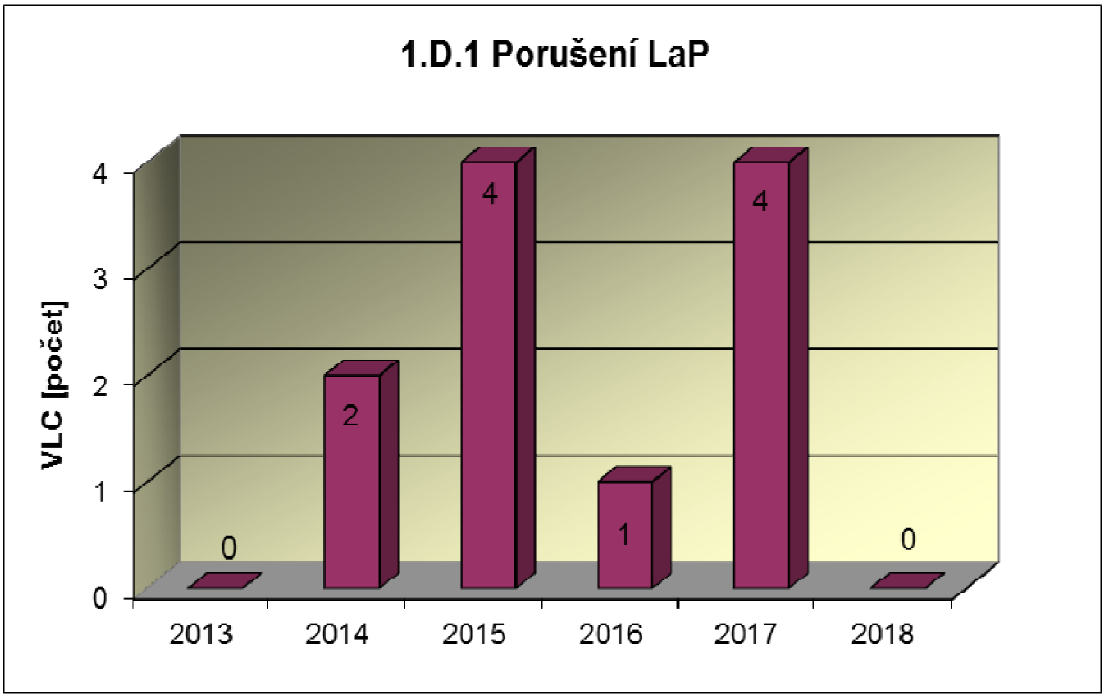


CRD [number]

1.D Limits and Conditions

Graph 1.D.1 summarises violations of the Limits and Conditions (VLC) detected by the Regulatory body or reported to the Regulatory body by the licensee.

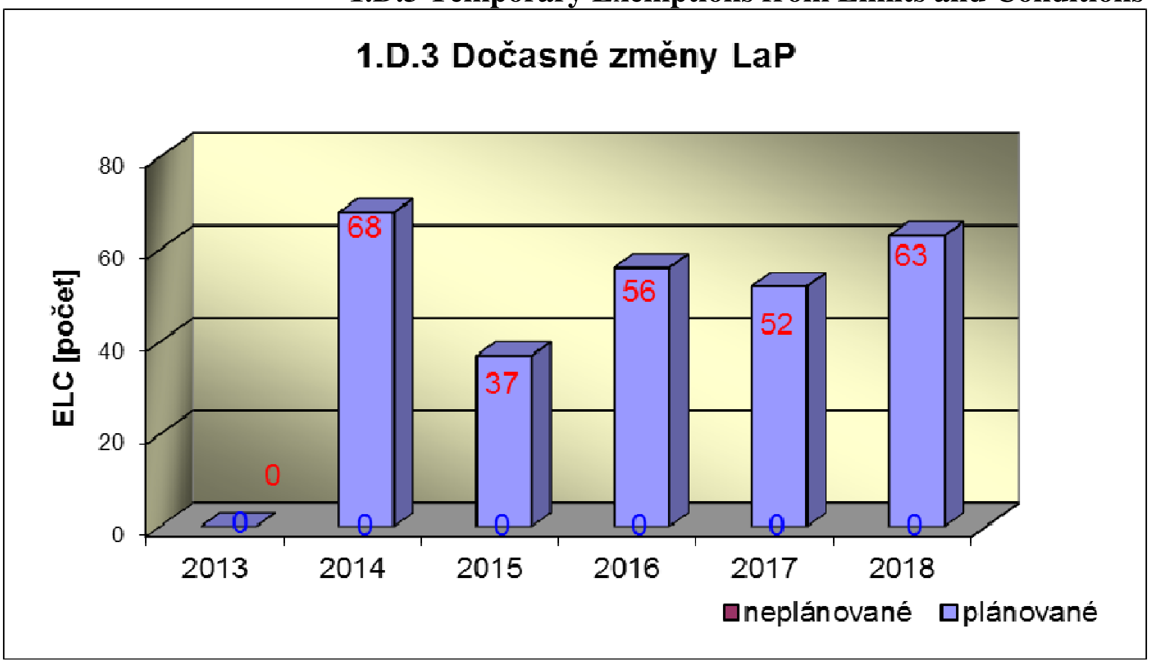
1.D.1 Violation of Limits and Conditions



VLC [number]

Graph 1.D.3 summarises the number of planned and unplanned exemptions from the Limits and Conditions (ELC) approved by the Regulatory body including those requiring SUJB approval and however not drawn for various reasons.

1.D.3 Temporary Exemptions from Limits and Conditions



ELC *[number]*
unplanned

planned

2. Safety Systems Performance

Area 2 monitors and evaluates availability of the following safety systems (BS) in group A:

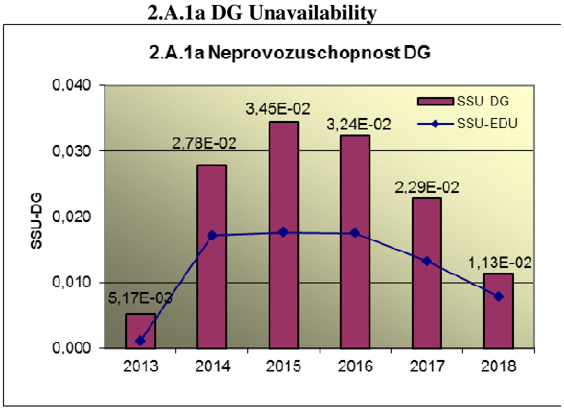
- diesel generators	**DG**
- high pressure emergency core cooling system	**TJ**
- low pressure emergency core cooling system	**TH**
- spray system	**TQ**
- hydro-accumulators	**HA**
- steam generator auxiliary feed-water system	**HN PG**
- steam generator emergency feed-water system	**SHN PG**

and in group B failure of diesel generator (DG), high pressure emergency core cooling system (TJ), low pressure emergency core cooling system (TH) and spray system (TQ) in starting and operation.

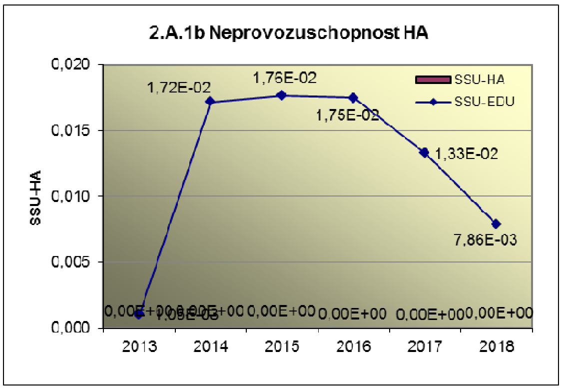
2.A Safety system unavailability

Unavailability of particular safety systems (SSU_S) - graphs 2.A.1.a – g, is defined as the ratio of the total time of unavailability of an evaluated safety system to the total time when its availability was required. In addition, these combined graphs express the ratio of unavailability of respective safety system to the “general” safety system of the site.

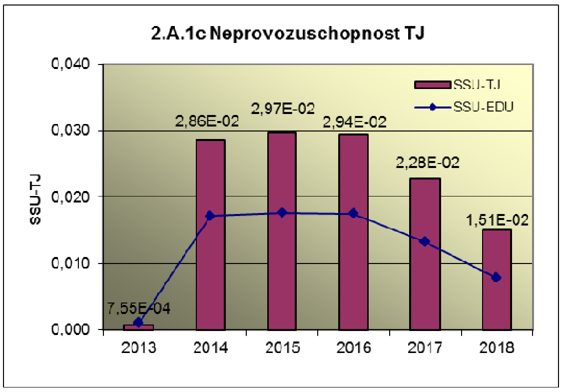
2.A.1a DG Unavailability



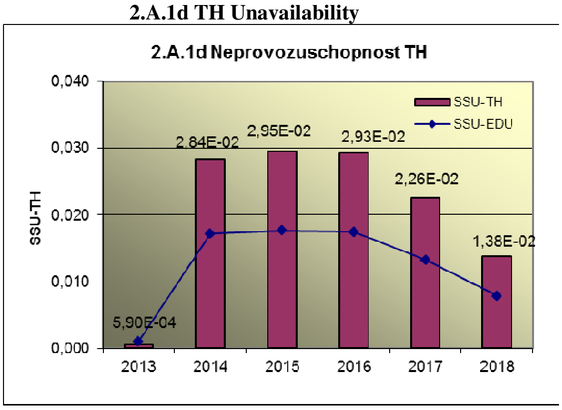
2.A.1b HA Unavailability



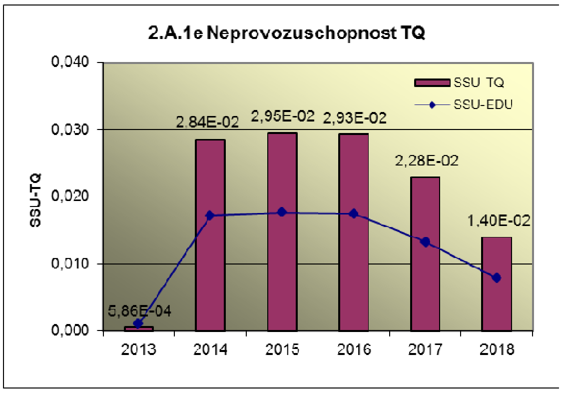
2.A.1c TJ Unavailability



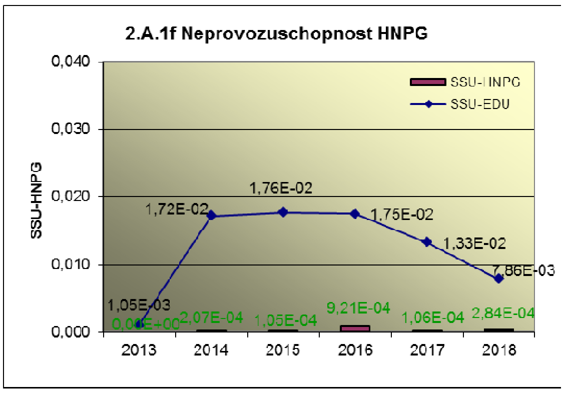
2.A.1d TH Unavailability



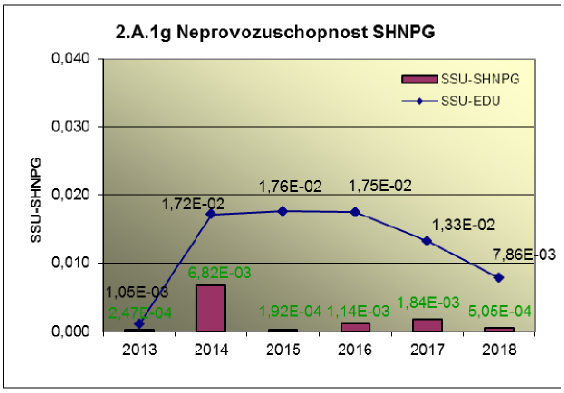
2.A.1e TQ Unavailability



2.A.1f HNPG Unavailability



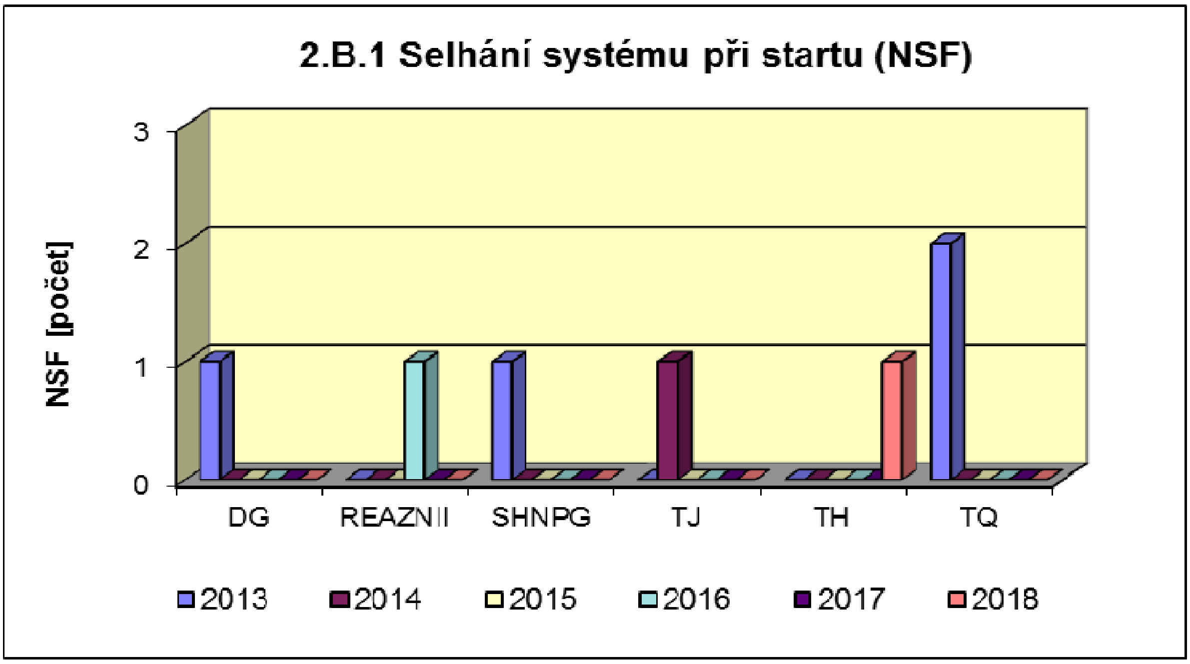
2.A.1g SHNPG Unavailability


2.A.1g Neprovozuschopnost SHNPG
SSU-SHNPG
SSU-SHNPG
SSU-EDU
0,040
0,030
0,020
0,010
0,000
1,05E-03
2,47E-04
1,72E-02
6,82E-03
1,76E-02
1,92E-04
1,75E-02
1,14E-03
1,33E-02
1,84E-03
7,86E-03
5,06E-04
2013
2014
2015
2016
2017
2018

2.B.1 Failure of safety systems

Graph 2.B.1 indicates the number of starting failures of the safety system (NSF), i.e. the state when the respective system, possibly set after the command to start, does not achieve nominal performance characteristic or its failure (shutdown) occurs within 30 minutes after its start.

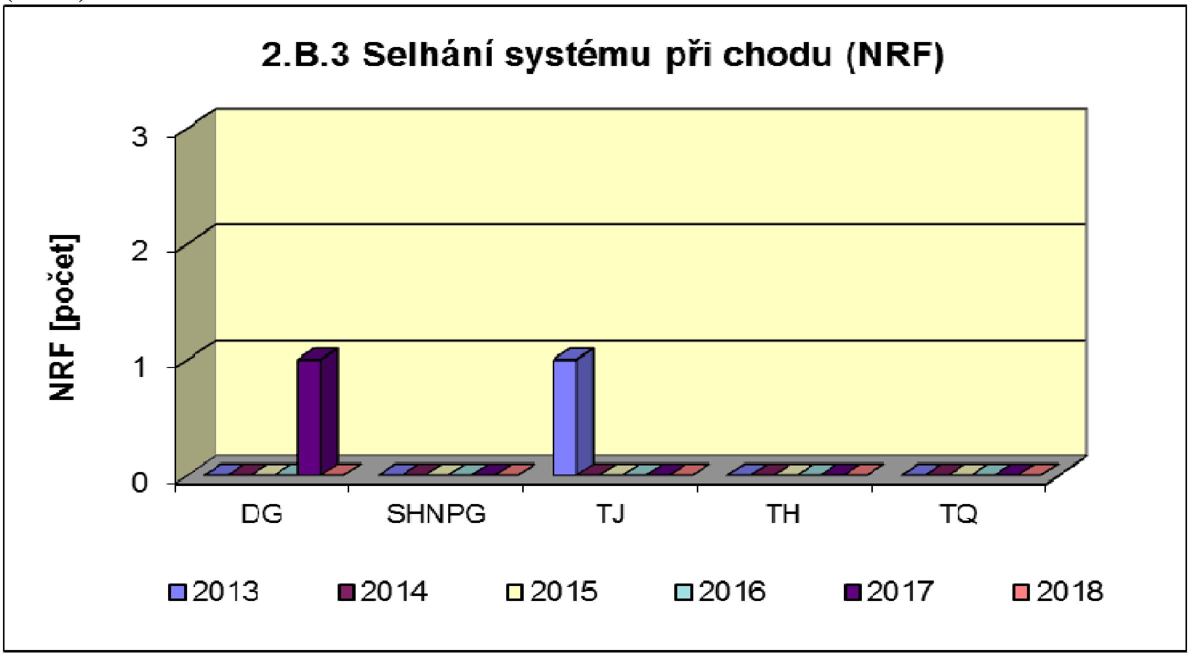
2.B.1 Starting Failures of Safety System (NSF)



NSF [number]

Graph 2.B.3 indicates the number of running failures of safety system (NRF), i.e. the number of states when failure shut down of respective system, drive, possibly set occurs at nominal performance characteristics for the time exceeding 30 minutes since its starting.

2.B.3 Running Failures of Safety System (NRF)



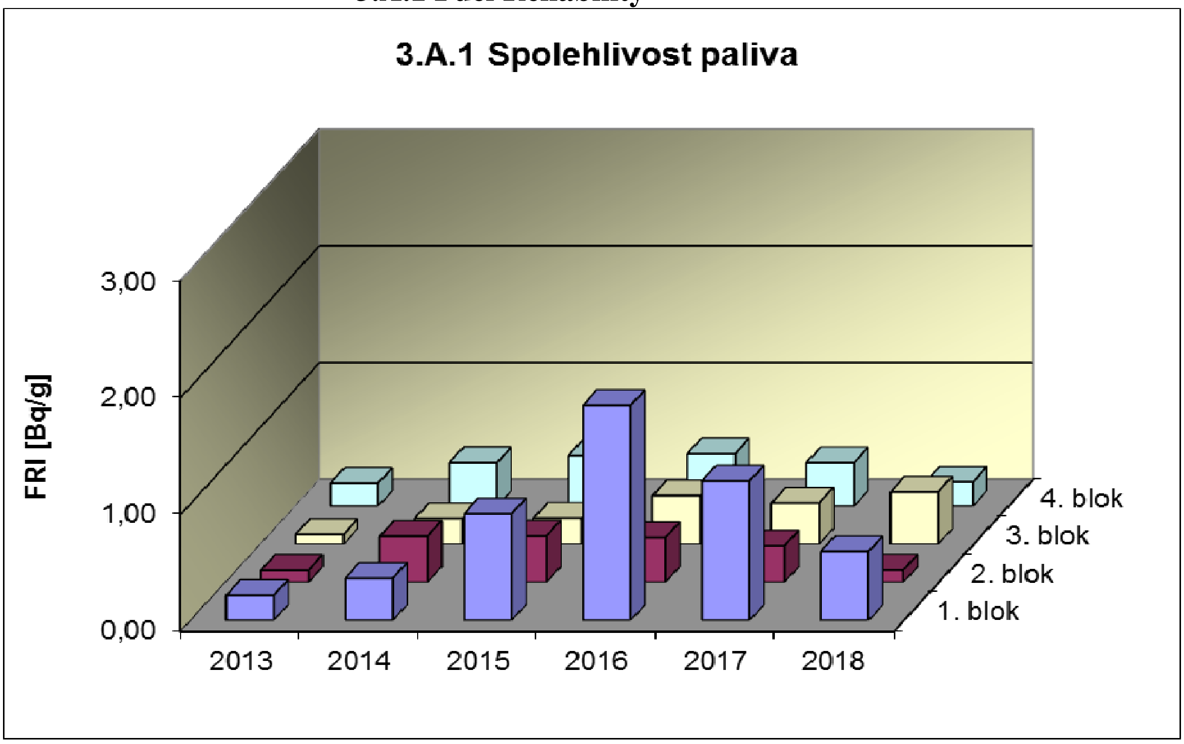
NRF [number]

3. Barriers Integrity

3.A Nuclear fuel

Graph 3.A.1 monitors fuel reliability of particular units through the values of FRI - Fuel reliability index. The value FRI ≤ 19Bq/g expresses that reactor core most likely does not contain any steady fuel defects.

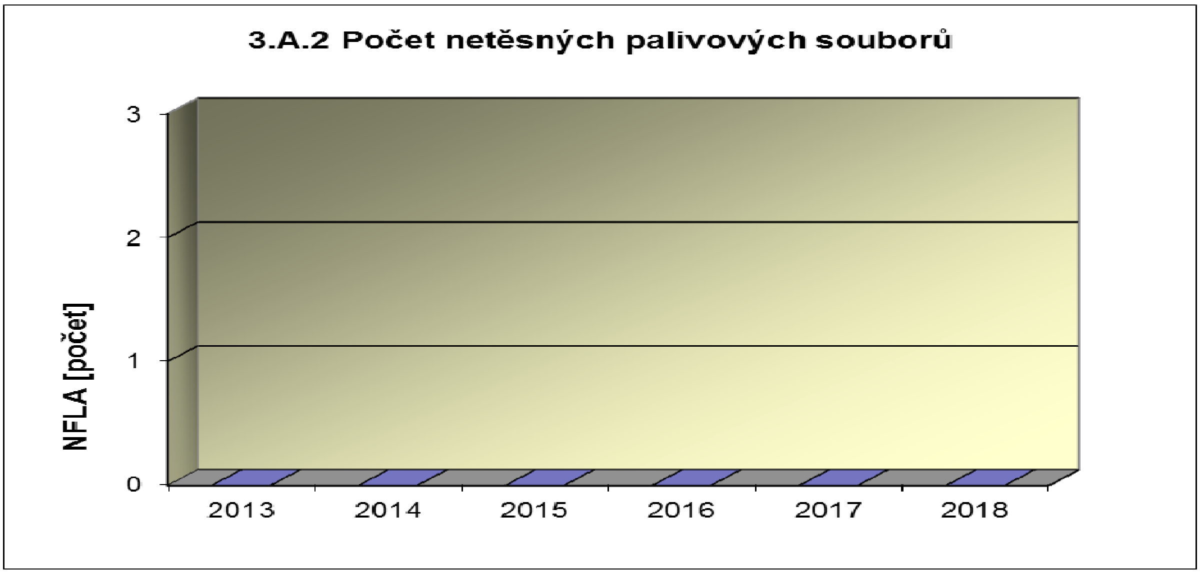
3.A.1 Fuel Reliability



Units 1 - 4

Graph 3.A.2 indicates the number of leaky fuel assemblies (NLFA) that had to be put out of operation due to their inadmissible leakage.

3.A.2. Number of Leaky Fuel Assemblies

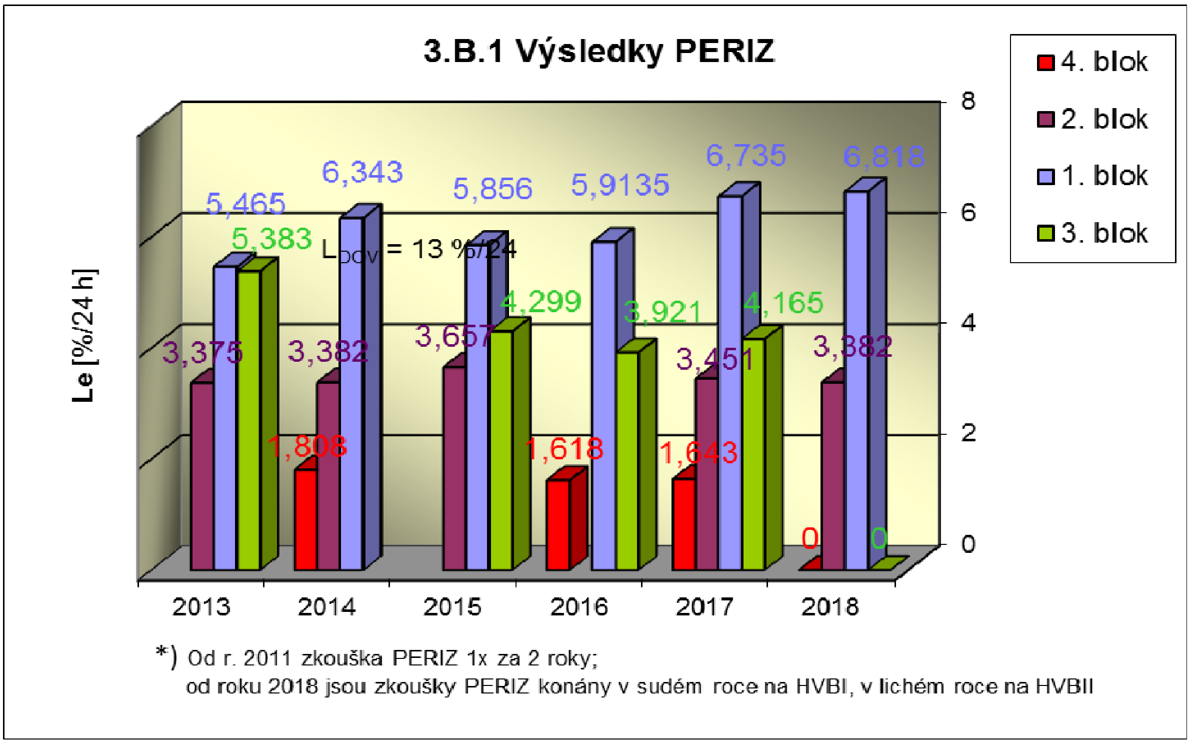


NFLA [number]

3.B Containment

Graph 3.B.1 states the results of Containment periodic integral tightness testing (L_e), i.e. the results of leakage tests of hermetic areas executed by overpressure 150 kPa lasting 24 hours. Extrapolated results are included for the tests with a lower pressure and dwell.
From 2011 – unit testing period = 1x/2 years.

3.B.1 Results of Containment Periodic Integral Tightness Testing



Units 1 – 4

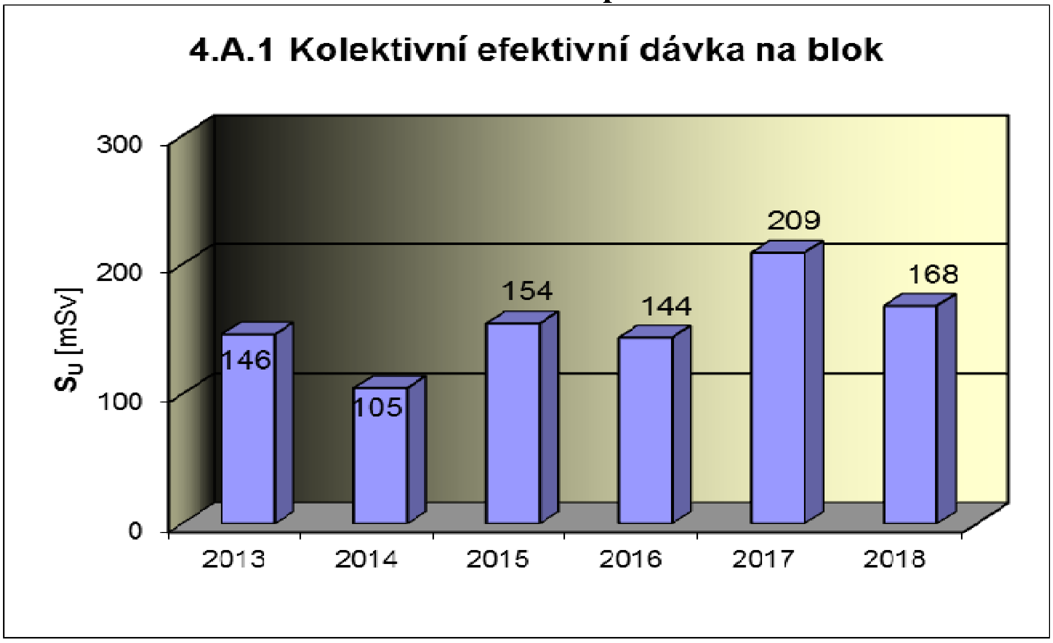
**) Since 2018 the testing PERIZ is performed in even-numbered years at Units 1+ 2 and in odd-numbered years at Units 3+4*

4. Radiation Protection

4.A Staff

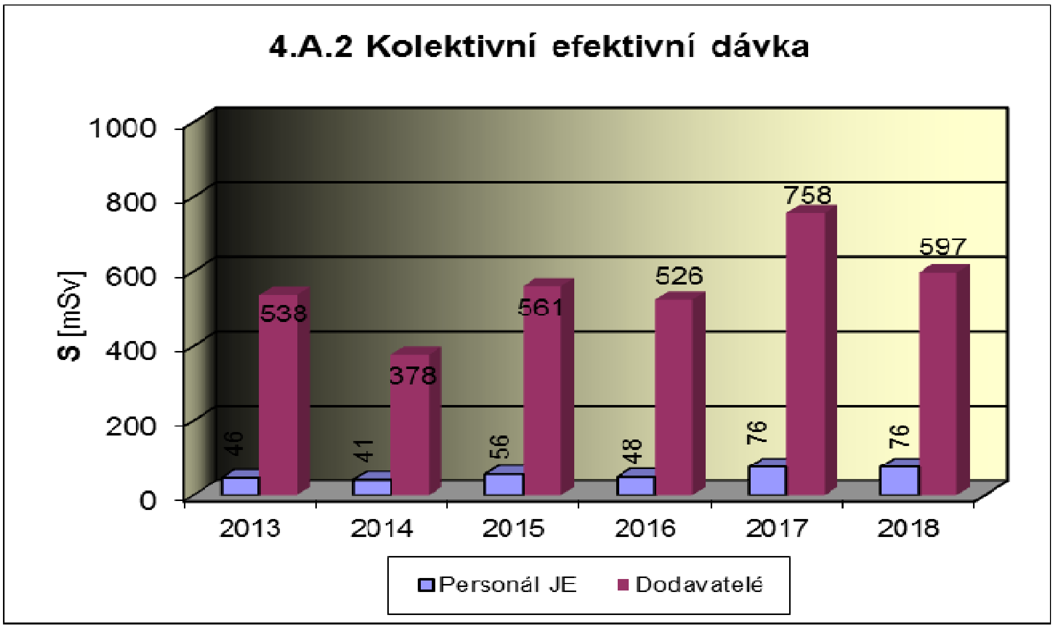
Graph 4.A.1 indicates collective effective dose (CED) received by the staff of NPP (including suppliers and visitors) during monitored period, measured by basic film dosimeters and expressed by mean value per unit.

4.A.1 Collective Effective Dose per Unit



Graph 4.A.2 indicates collective effective dose received by the staff of NPP and suppliers during monitored period, measured by basic film dosimeters.

4.A.2 Collective Effective Dose

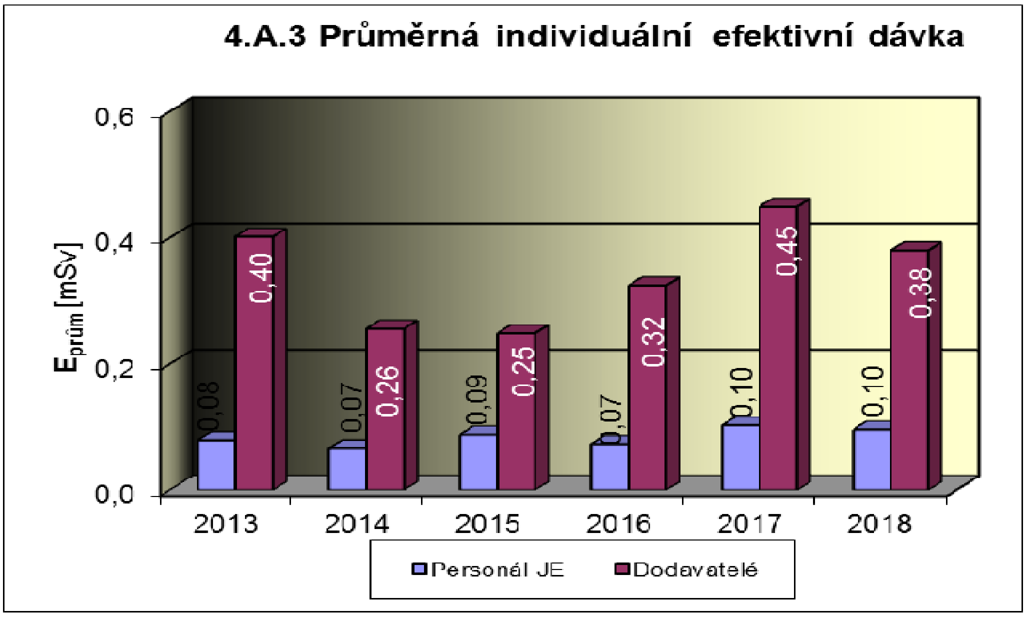


NPP Staff

Suppliers

Graph 4.A.3 indicates specific collective effective dose received by the staff of NPP and suppliers during monitored period, measured by basic film dosimeters and express by value per one radiation worker.

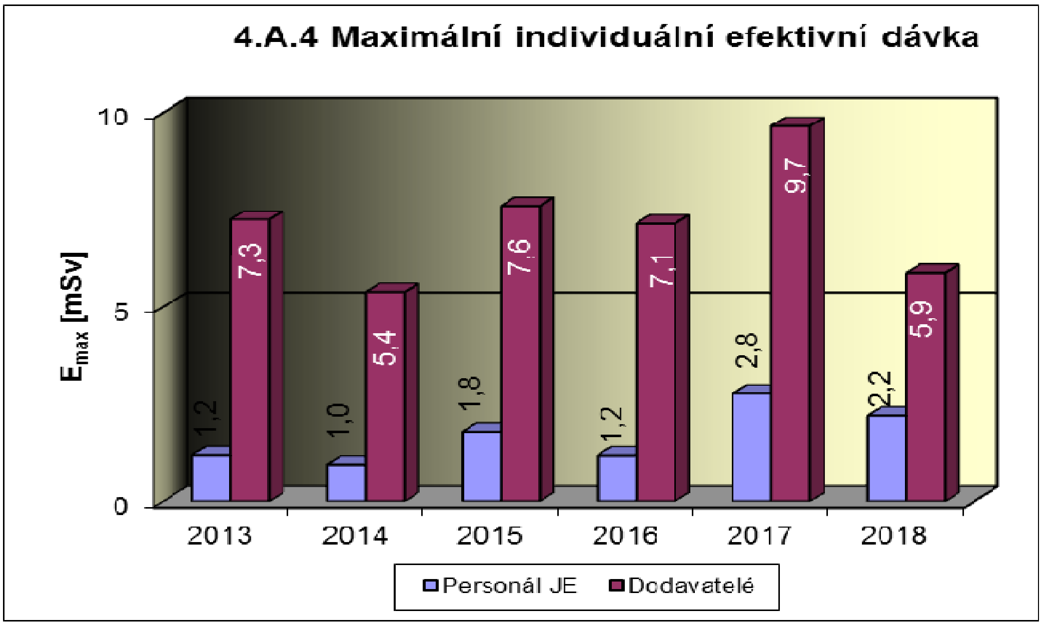
4.A.3 Specific Collective Dose per Capita



NPP Staff
Suppliers

Graph 4.A.4 indicates maximum individual effective dose received by one particular employee of NPP and one particular employee of supplier during monitored period, measured by basic film dosimeters.

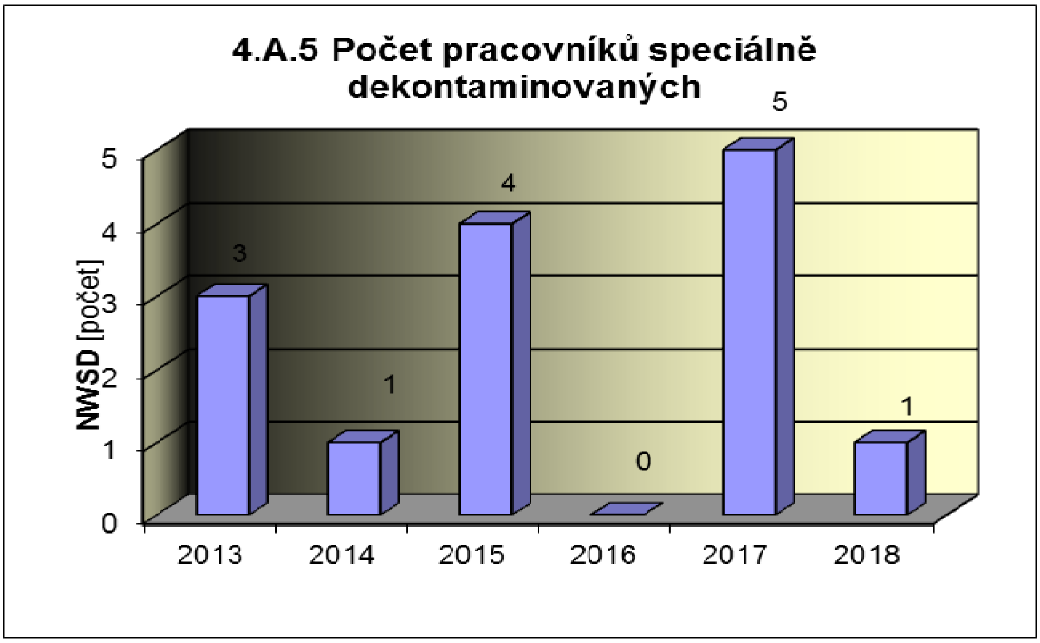
4.A.4 Maximum Individual Effective Dose



NPP Staff
Suppliers

Graph 4.A.5 indicates number of workers (NPP and suppliers) subjected to a special decontamination under medical supervision.

4.A.5 Number of Workers with Special Decontamination

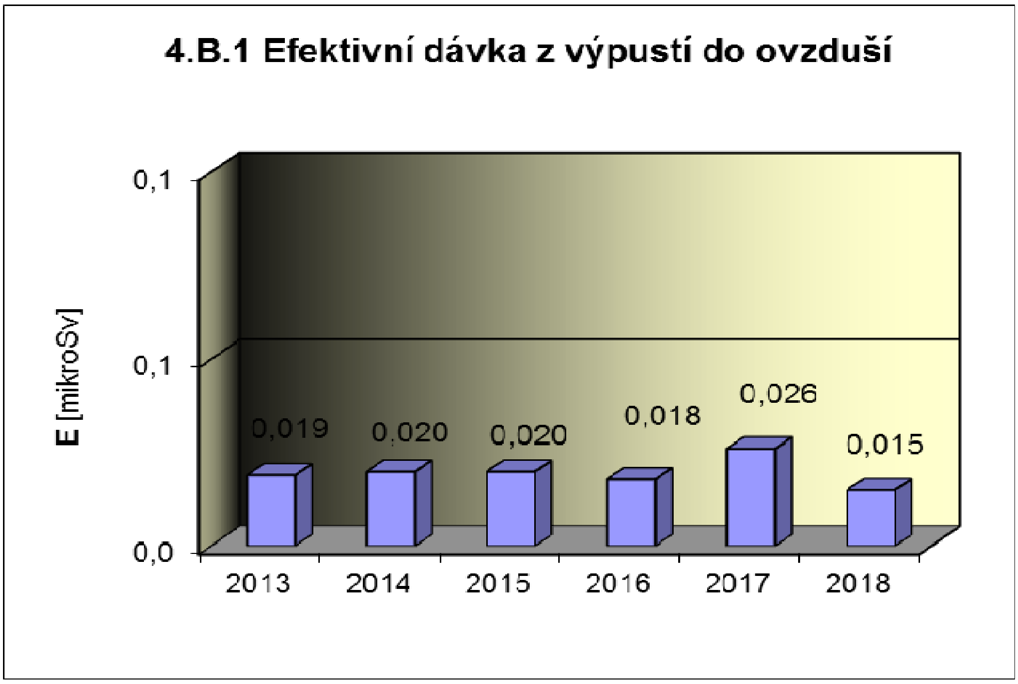


NWSD [number]

4.B Radioactive Releases

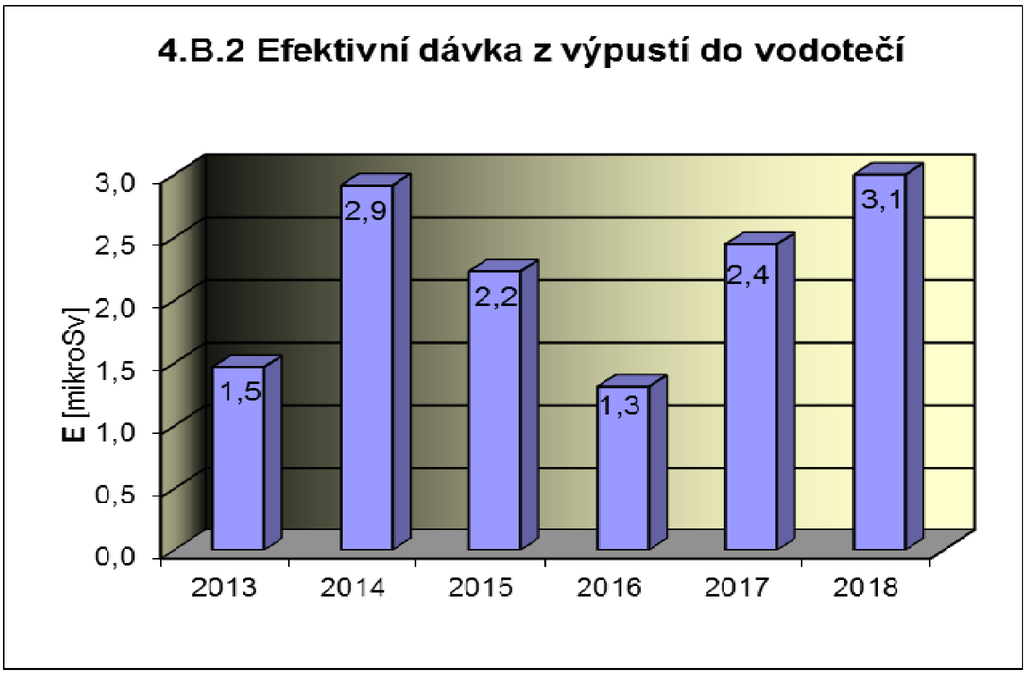
Graph 4.B.1 indicates the committed effective dose for an individual, which arises from radioactive gaseous releases from NPP.

4.B.1 Gaseous Releases – Committed Effective Doses



Graph 4.B.2 indicates the committed effective dose for an individual, which arises from radioactive liquid releases from NPP.

4.B.2 Liquid Releases – Committed Effective Doses

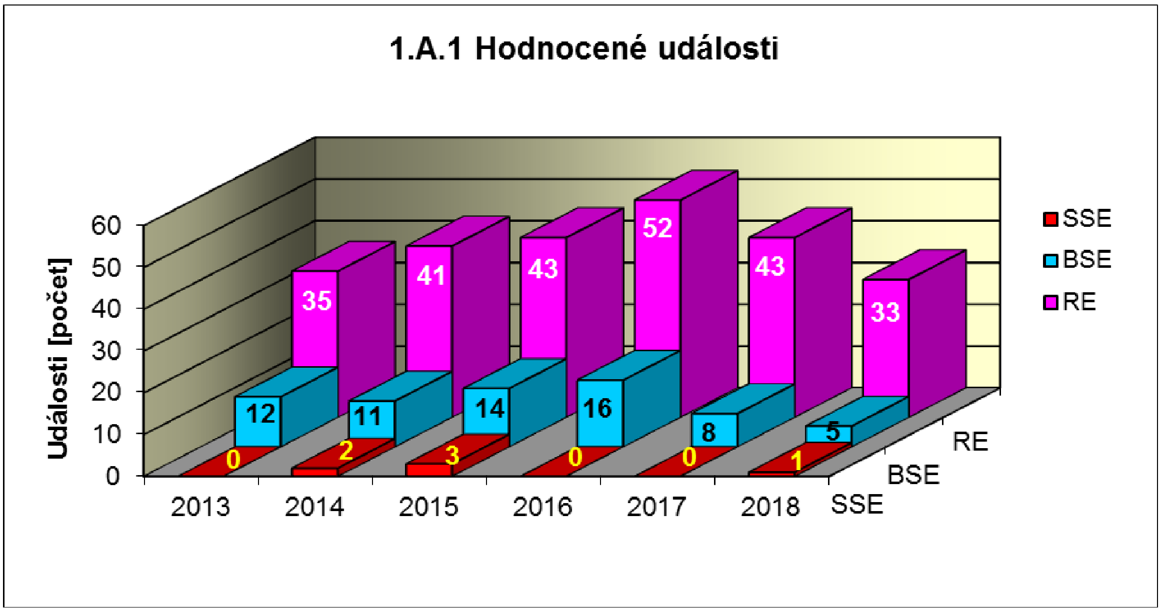


1. Significant Events

1.A Related events

Graph of indicator 1.A.1 monitors the development of the number of related events (RE) including their division according to the evaluation of the International Nuclear Event Scale (INES) into significant events (SSE, INES > 0) and the below scale events (BSE, INES = 0).

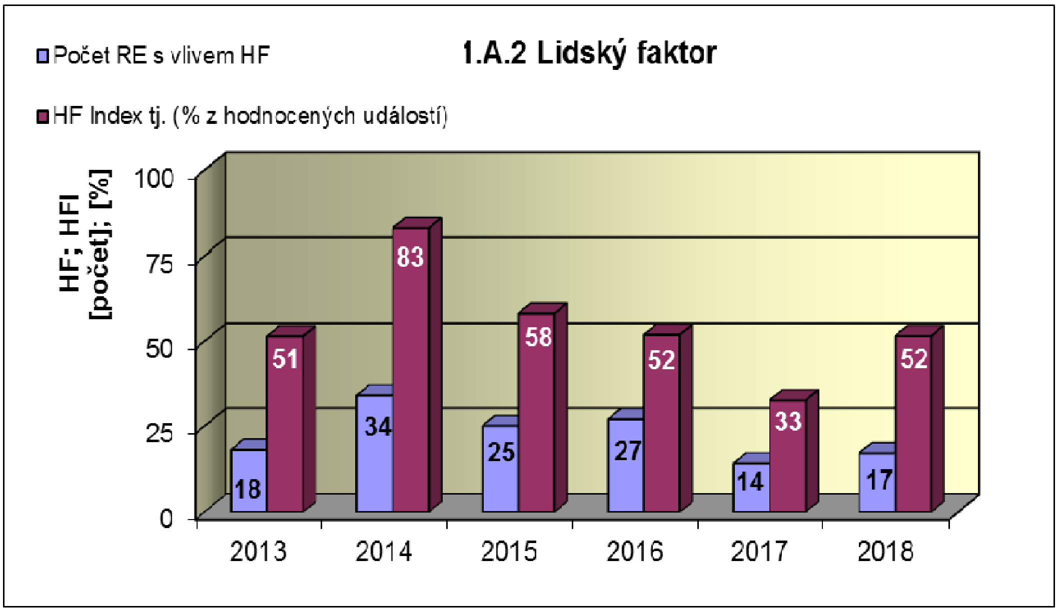
1.A.1 Related Events



Events [number]

Graph 1.A.2 evaluates the influence of the human factor upon occurrence of safety related events. The indicator is expressed by the number of the safety-related events with an influence of human factor (HF) and its percentage share (HFI).

1.A.2 Human Factor

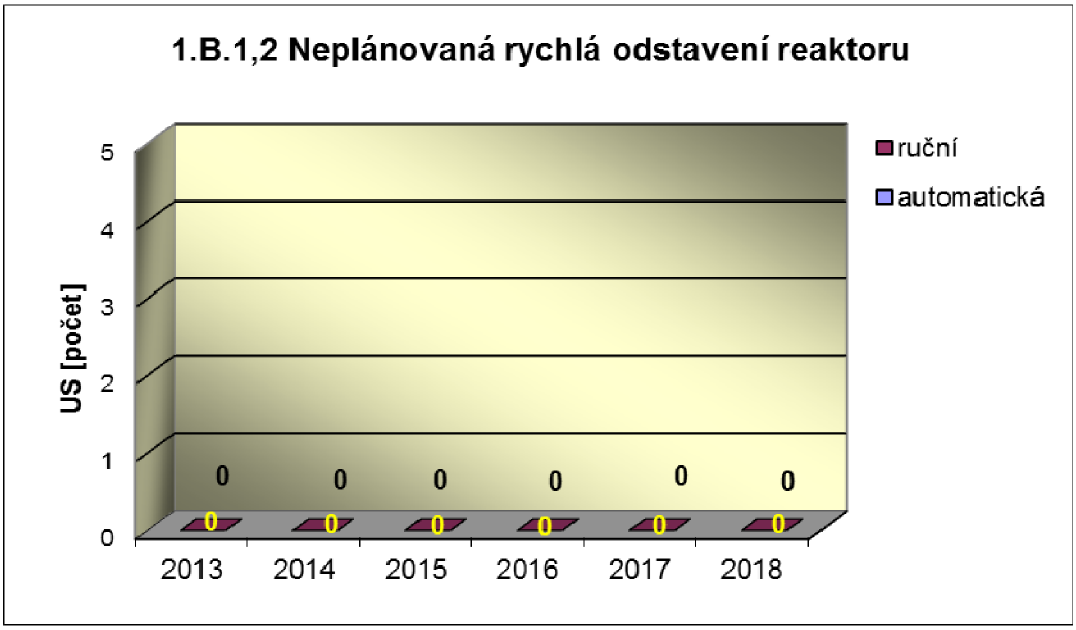


HF, HFI [number]
Number of RE with HF influence
HF Index [% from evaluated events]

1.B Actuation of the protection and limitation systems

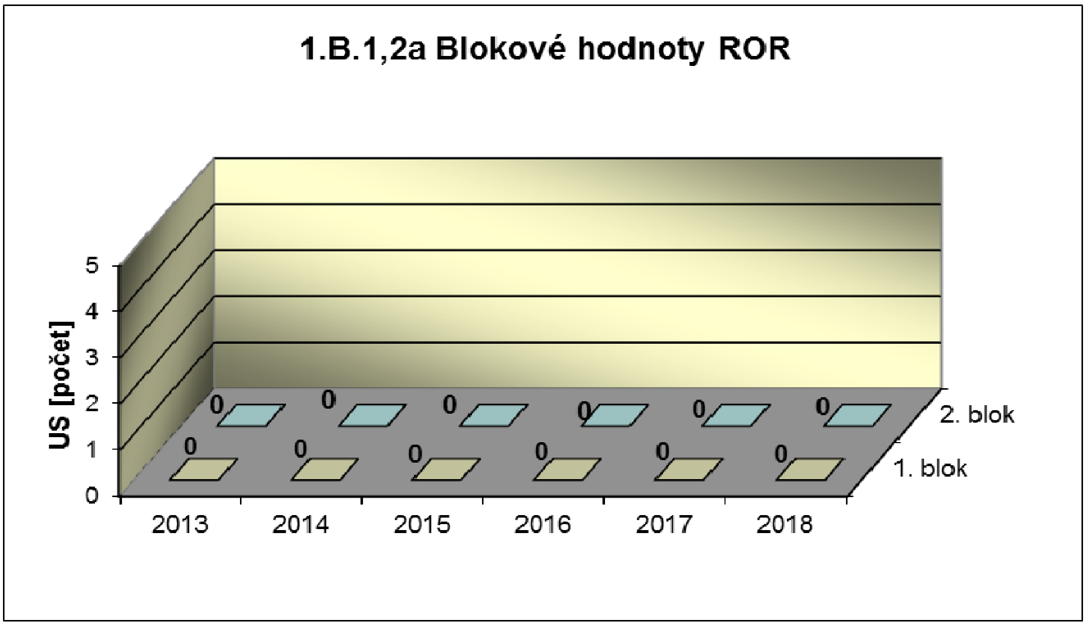
Graph 1.B.1,2 summarises the total number of unplanned unit scrams (US) (reactor in MODE 1 or 2) with resolution of manual and automatic shutdown. The term "unplanned" means that the scram was not an expected part of the planned test.

1.B.1,2 Unplanned Unit Scrams (US)



US [number]
manual
automatic

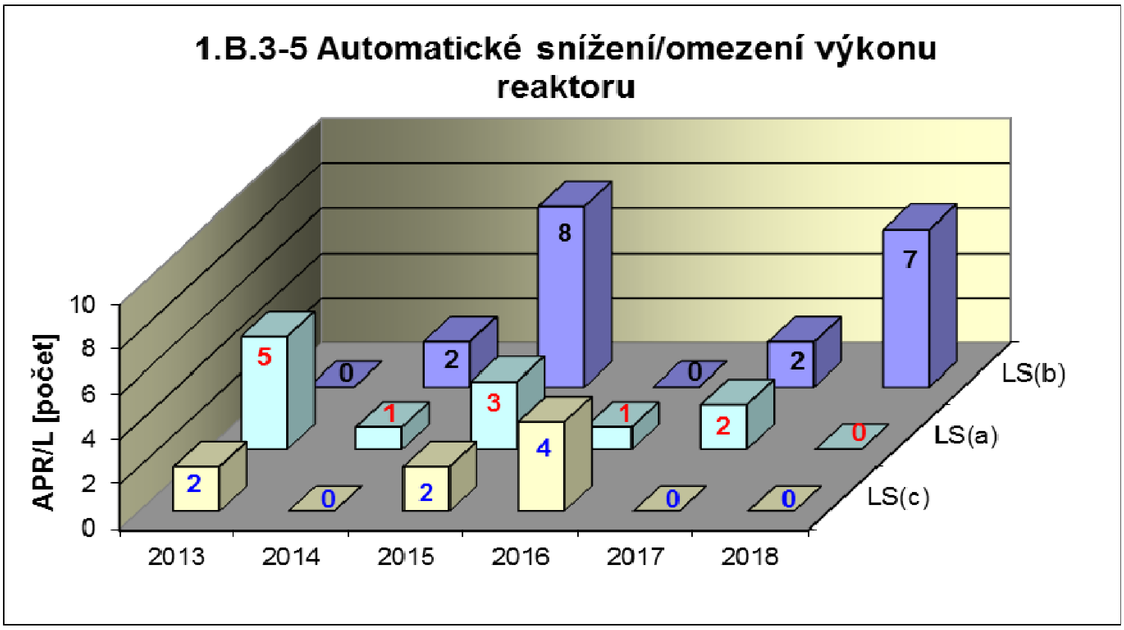
1.B.1,2 a Unplanned Unit Scrams – Unit Values



US [number] / year / unit 1 – 2

A common graph of indicators 1.B.3-5 indicates the number of limitation system (LS) incorporation with a, b, c types.

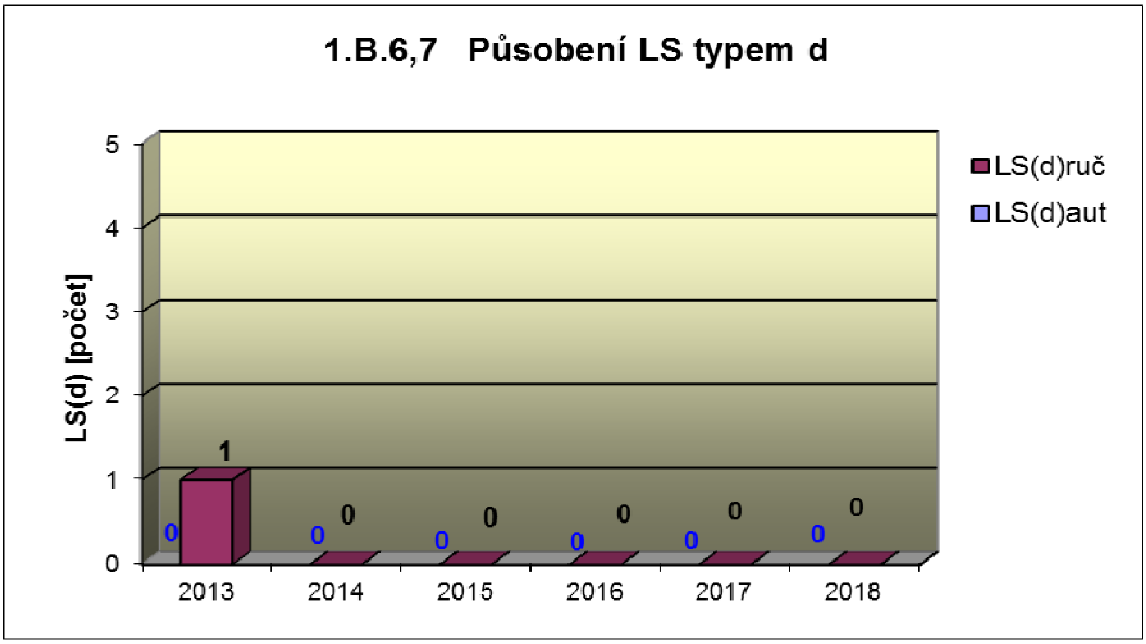
1.B.3-5 Automatic Power Reduction / Limitation



APR/L [number]

Graph 1.B.6,7 summarises the total number of unplanned reactor scrams with action of the limitation system (LS(d)) (reactor in MODE 1 or 2) with resolution of manual and automatic shutdown. The term "unplanned" means that the scram was not an expected part of the planned test.

1.B.6,7 Limitation Systems function (d) Actuation

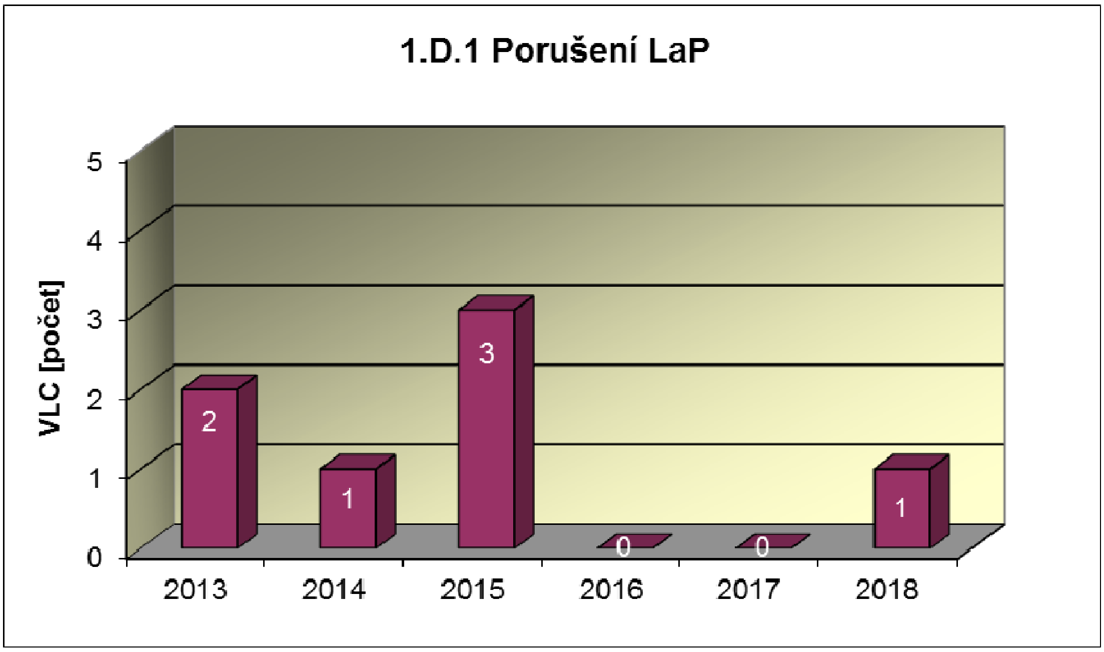


LS(d) [number]
LS manual
LS automatic

1.D Limits and Conditions

Graph 1.D.1 summarises violations of the Limits and Conditions (VLC) detected by the Regulatory body or reported to the Regulatory body by the licensee.

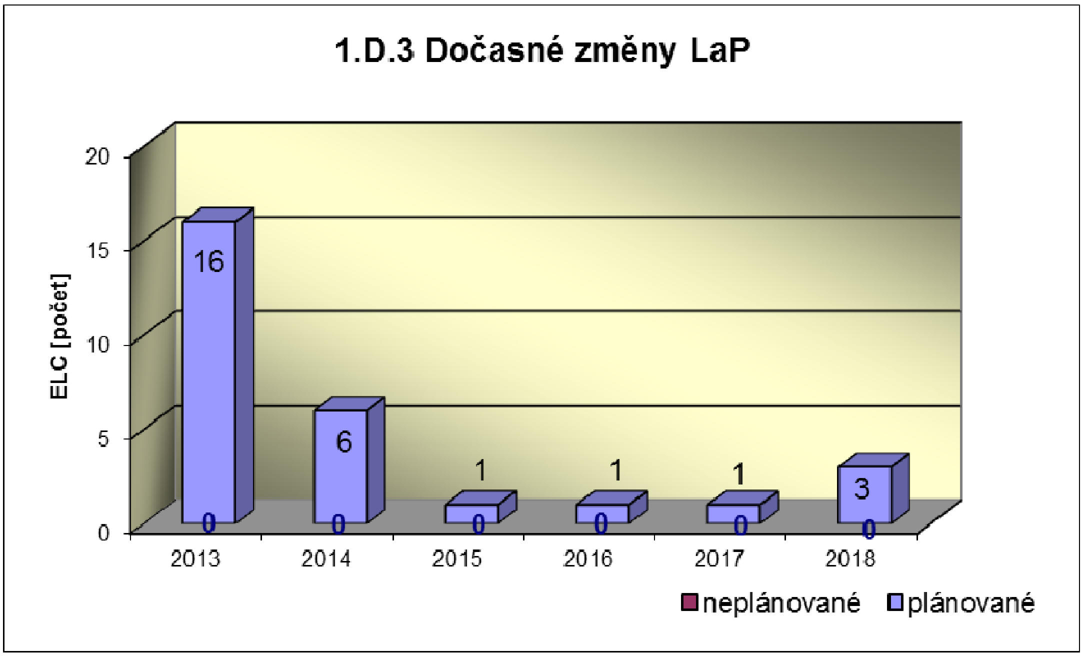
1.D.1 Violation of Limits and Conditions



VLC [number]

Graph 1.D.3 summarises the number of planned and unplanned exemptions from the Limits and Conditions (ELC) approved by the Regulatory body including those requiring SUJB approval and however not drawn for various reasons.

1.D.3 Temporary Exemptions from Limits and Conditions



ELC [number]
unplanned
planned

2. Safety Systems Performance

Area 2 monitors and evaluates availability of the following safety systems (BS) in group A:

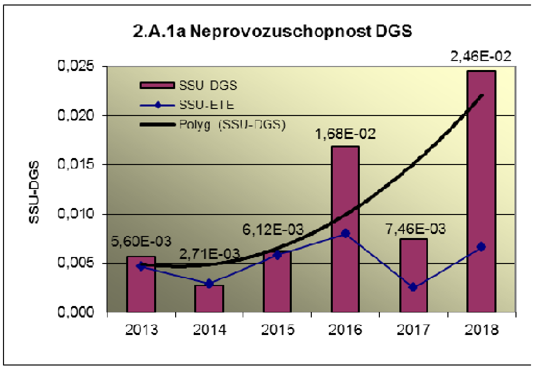
- system diesel generators	**DGS**
- spray system	**TQx1**
- low pressure emergency core cooling system	**TQx2**
- high pressure emergency core cooling system	**TQx3**
- boric acid emergency injection system	**TQx4**
- hydro-accumulators	**HA**
- steam generator emergency feed-water system	**TX**

and in group B failure of diesel generator (DG), spray system (TQx1), low pressure emergency core cooling system (TQx2), high pressure emergency core cooling system (TQx3), boric acid emergency injection system (TQx4) in starting and operation.

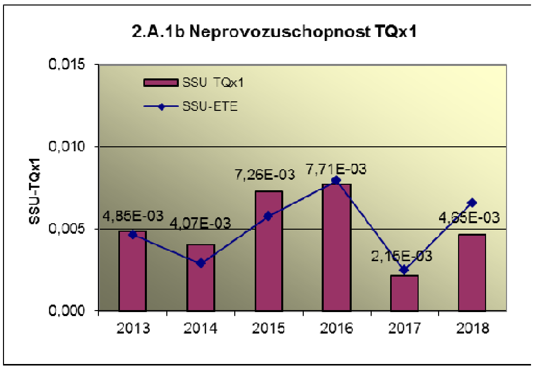
2.A Safety system unavailability

Unavailability of particular safety systems (SSUs) - graphs 2.A.1.a – g, is defined as the ratio of the total time of unavailability of an evaluated safety system to the total time when its availability was required. In addition, these combined graphs express the ratio of unavailability of respective safety system to the "general" safety system of the site.

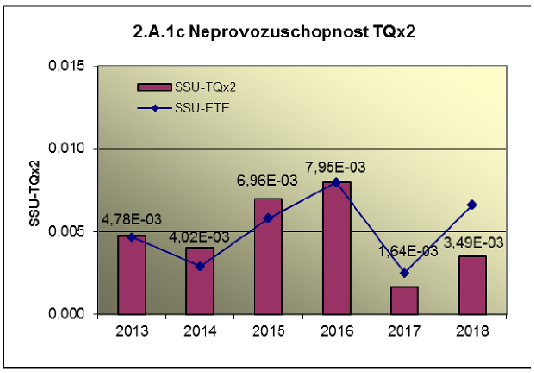
2.A.1a DGS Unavailability



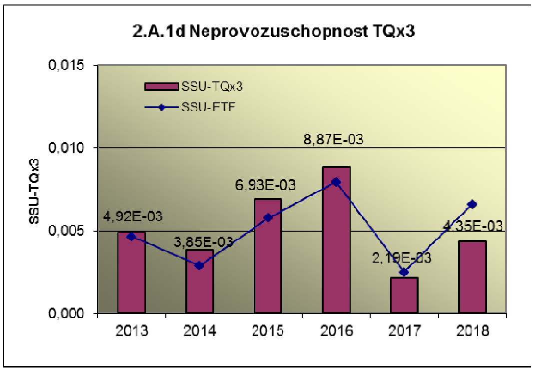
2.A.1b TQx1 Unavailability



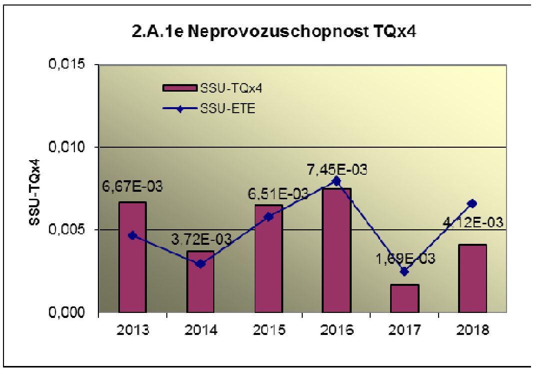
2.A.1c TQx2 Unavailability



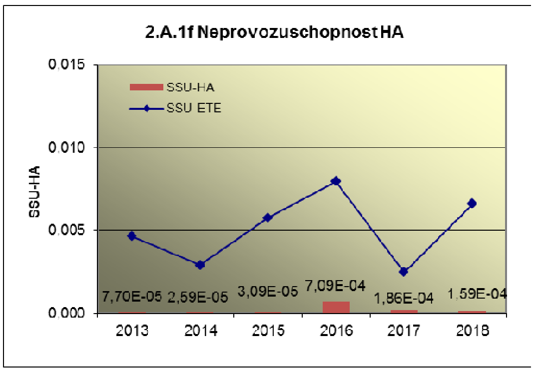
2.A.1d TQx3 Unavailability



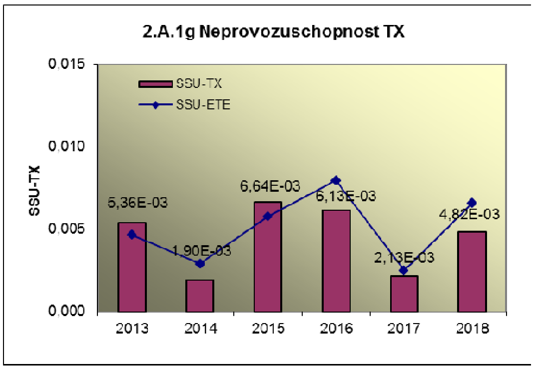
2.A.1e TQx4 Unavailability



2.A.1f HA Unavailability



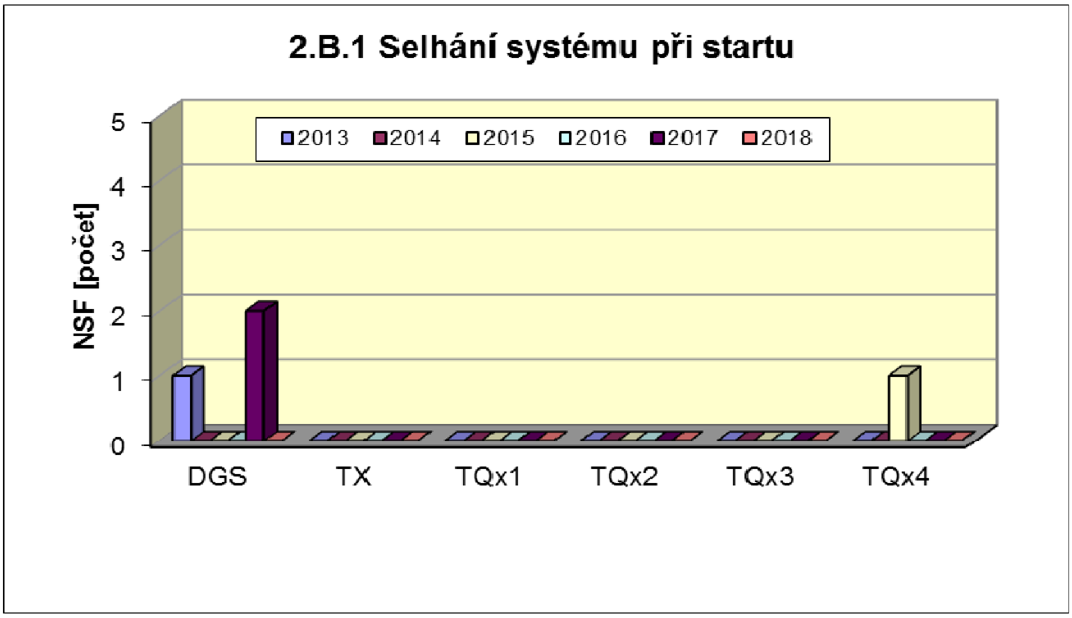
2.A.1g TX Unavailability



2.B Failure of safety systems

Graph 2.B.1 indicates the number of starting failures of the safety system (NSF), i.e. the state when the respective system, possibly set after the command to start, does not achieve nominal performance characteristic or its failure (shutdown) occurs within 30 minutes after its start.

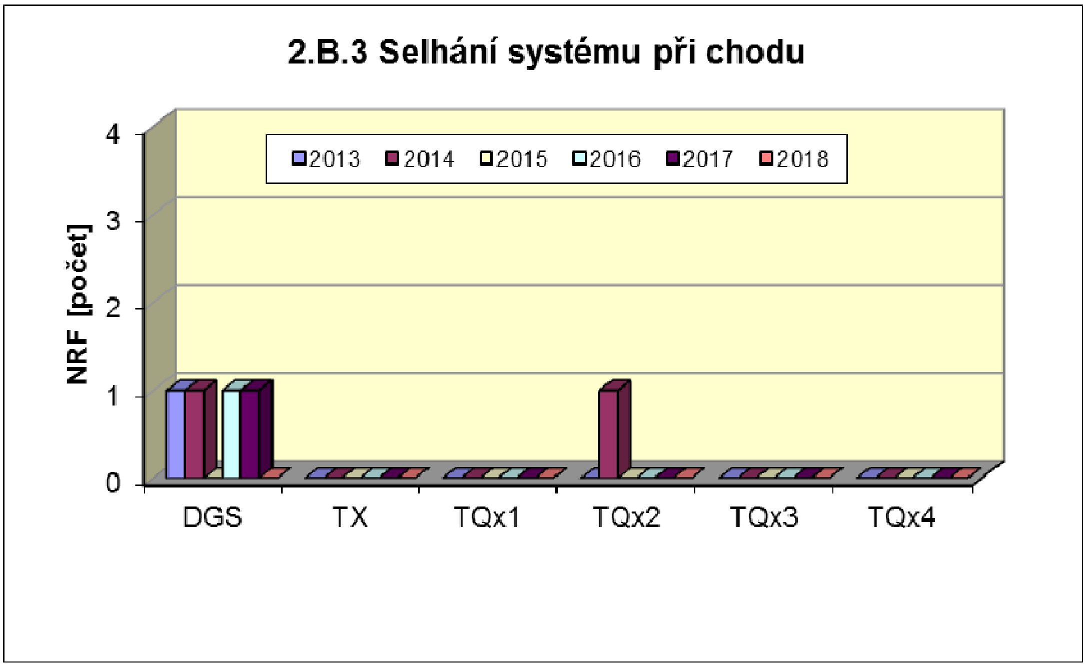
2.B.1 Starting Failures of Safety System



NSF [number]

Graph 2.B.3 indicates the number of running failures of safety system (NRF), i.e. the number of states when failure shut down of respective system, drive, possibly set occurs at nominal performance characteristics for the time exceeding 30 minutes since its starting.

2.B.3 Running Failures



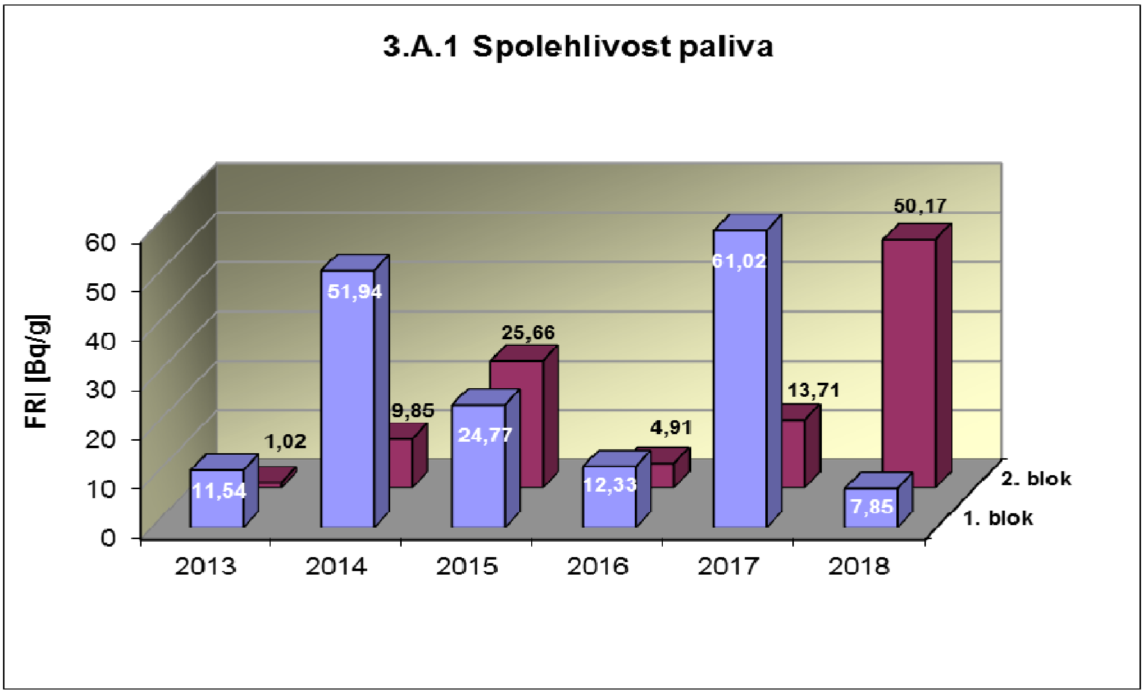
NRF [number]

3. Barriers integrity

3.A Nuclear fuel

Graph 3.A.1 monitors fuel reliability of particular units through the values of FRI - Fuel reliability index. The value FRI ≤ 19Bq/g expresses that reactor core most likely does not contain any steady fuel defects.

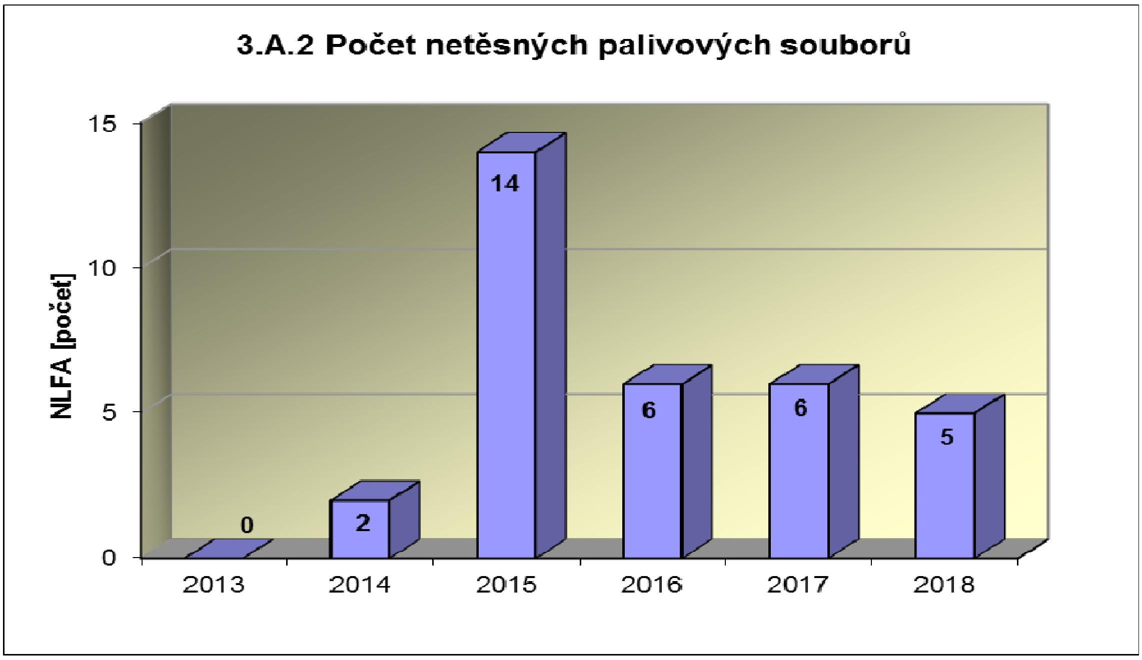
3.A.1 Fuel Reliability



Units 1 - 2

Graph 3.A.2 indicates the number of leaky fuel assemblies (NLFA) that had to be put out of operation due to their inadmissible leakage.

3.A.2 Number of Leaky Fuel Assemblies

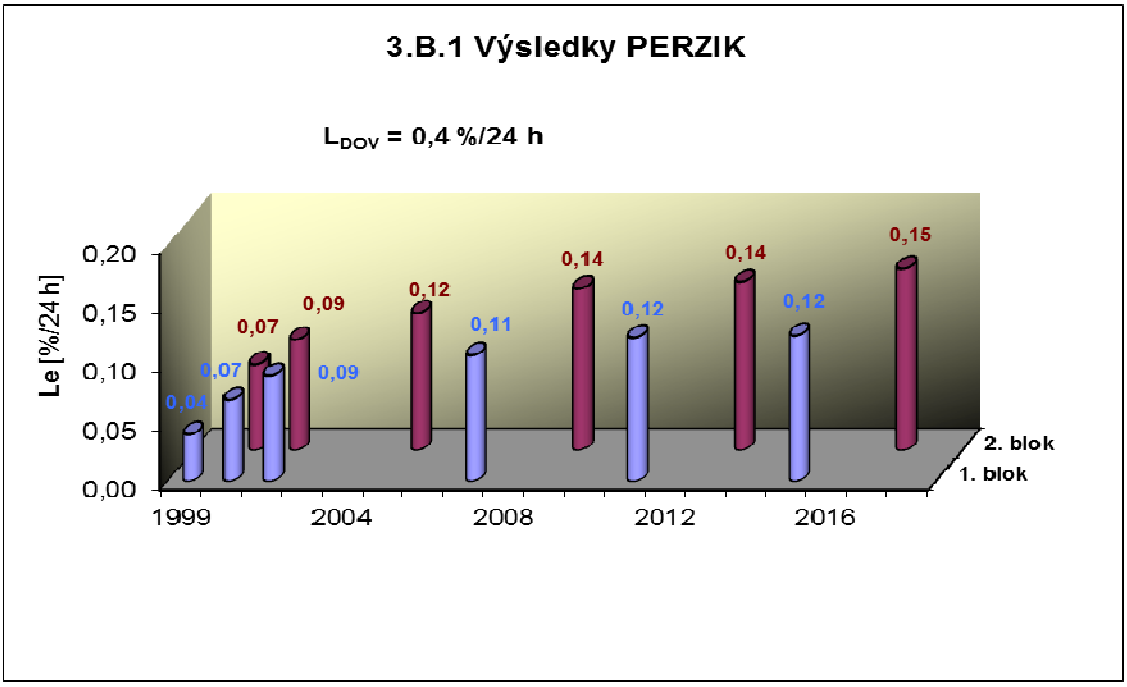


NLFA [number]

3.B Containment

Graph 3.B.1 states the results of Containment periodic integral tightness testing (L_e), i.e. the results of leakage tests of hermetic areas executed by overpressure 400 kPa lasting 24 hours during Containment integrity testing and extrapolated results are stated for Containment integrity repeated testing and Containment integrity periodic testing with lower pressure of 70 kPa and dwell.

3.B.1 Results of Containment Periodic Integral Tightness Testing



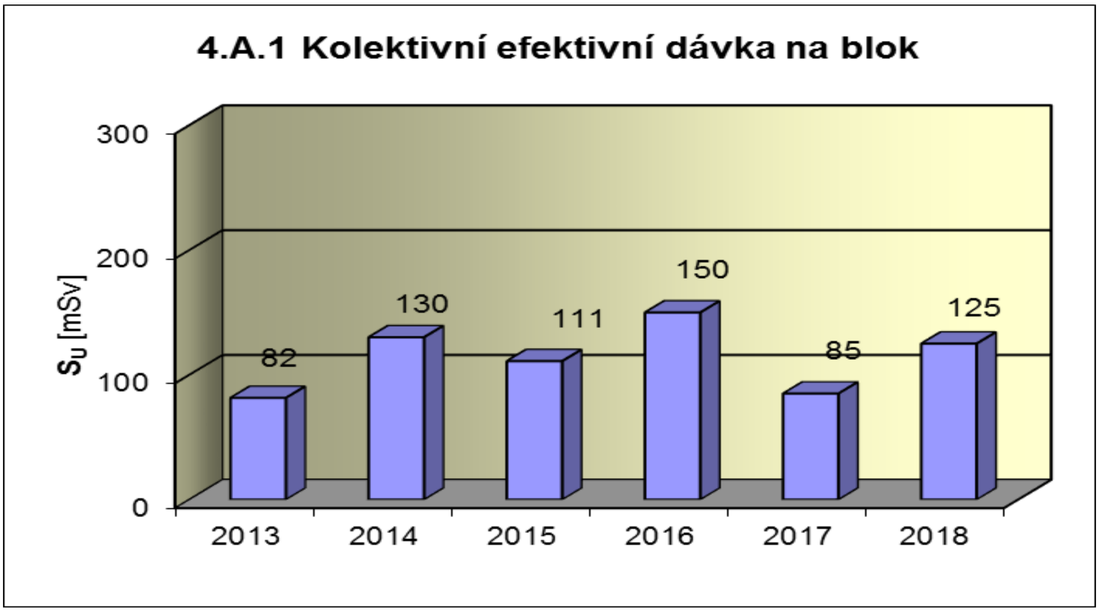
Units 1 – 2

4. Radiation Protection

4.A Staff

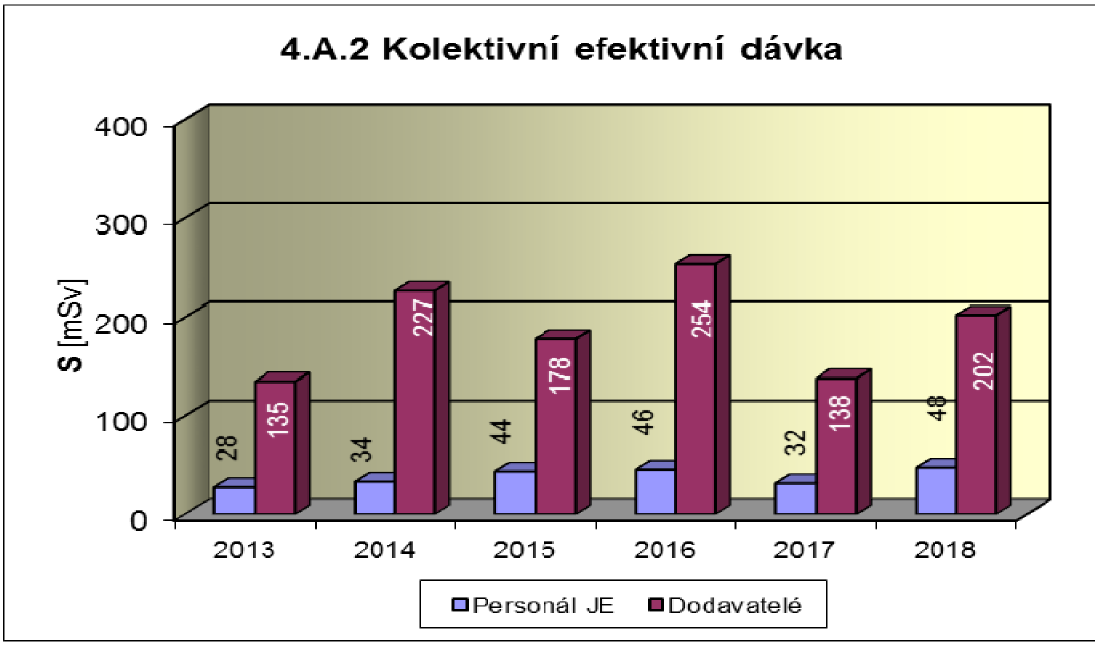
Graph 4.A.1 indicates collective effective dose (CED) received by the staff of NPP (including suppliers and visitors) during monitored period, measured by basic film dosimeters and expressed by mean value per unit.

4.A.1 Collective Effective Dose per Unit



Graph 4.A.2 indicates collective effective dose received by the staff of NPP and suppliers during monitored period, measured by basic film dosimeters.

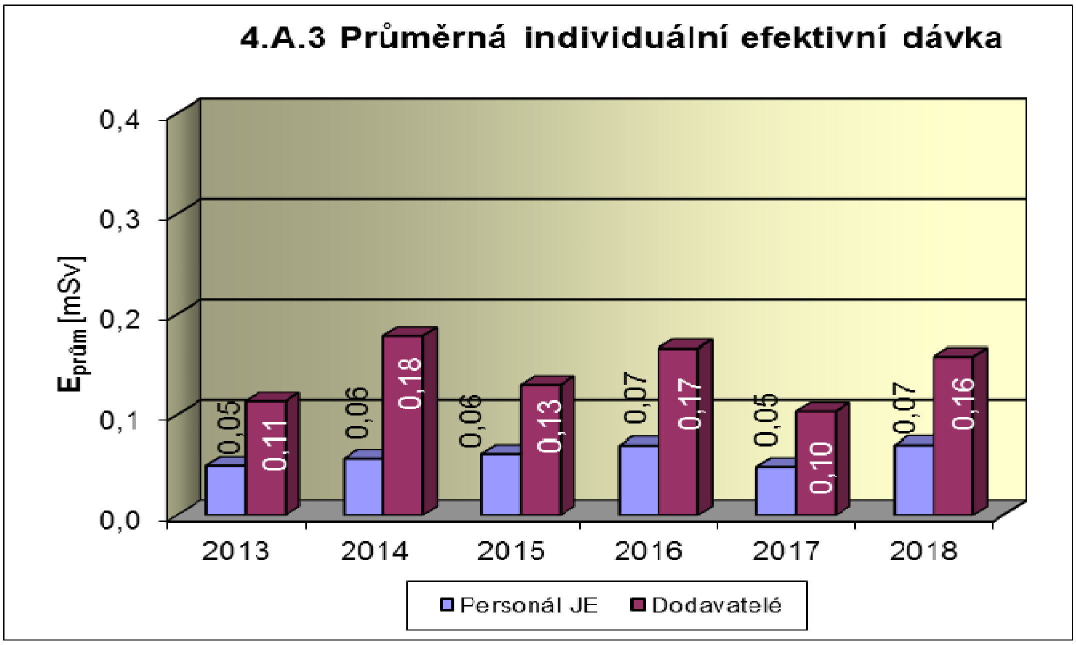
4.A.2 Collective Effective Dose



NPP Staff
Suppliers

Graph 4.A.3 indicates specific collective effective dose received by the staff of NPP and suppliers during monitored period, measured by basic film dosimeters and express by value per one radiation worker.

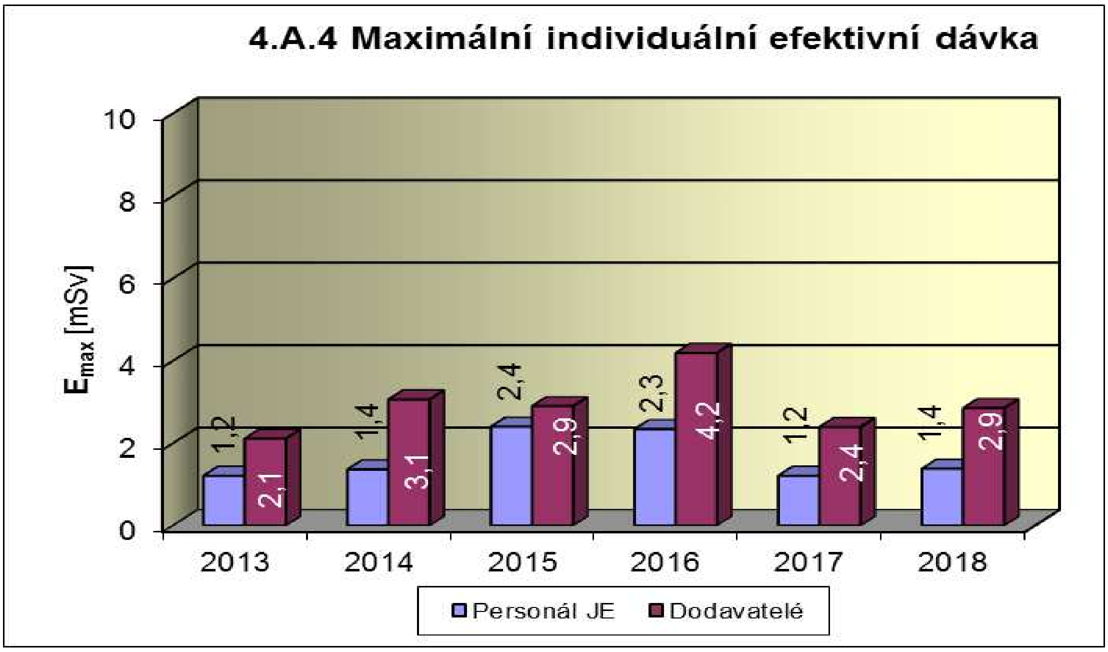
4.A.3 Specific Collective Dose per Capita



NPP Staff
Suppliers

Graph 4.A.4 indicates maximum individual effective dose received by one particular employee of NPP and one particular employee of supplier during monitored period, measured by basic film dosimeters.

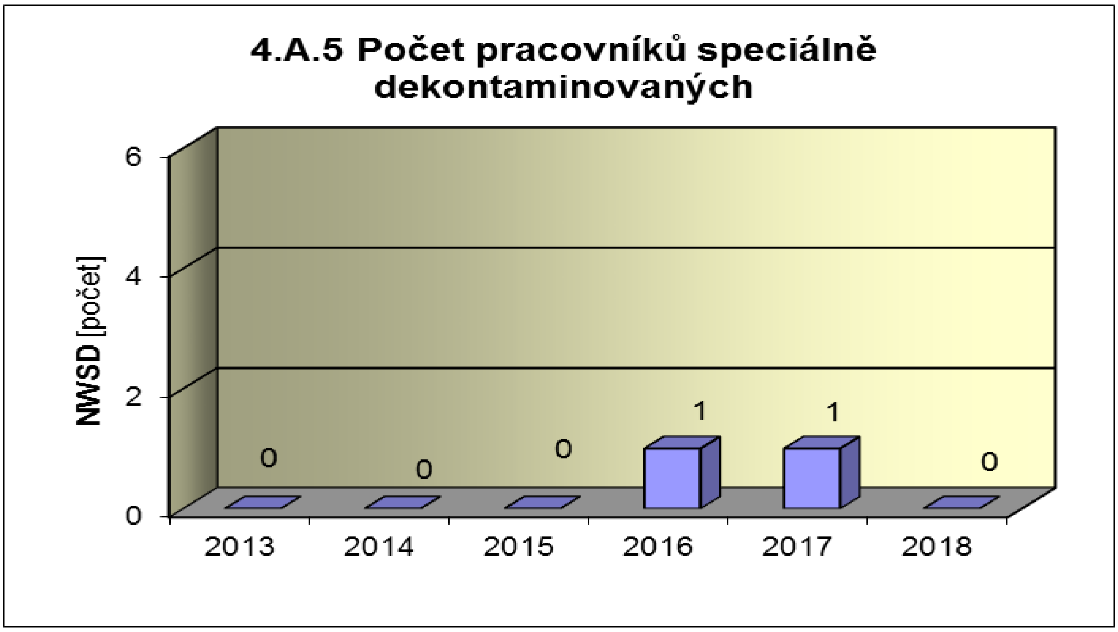
4.A.4 Maximum Individual Effective Dose



NPP Staff
Suppliers

Graph 4.A.5 indicates number of workers (NPP and suppliers) subjected to a special decontamination under medical supervision.

4.A.5 Number of Workers with Special Decontamination

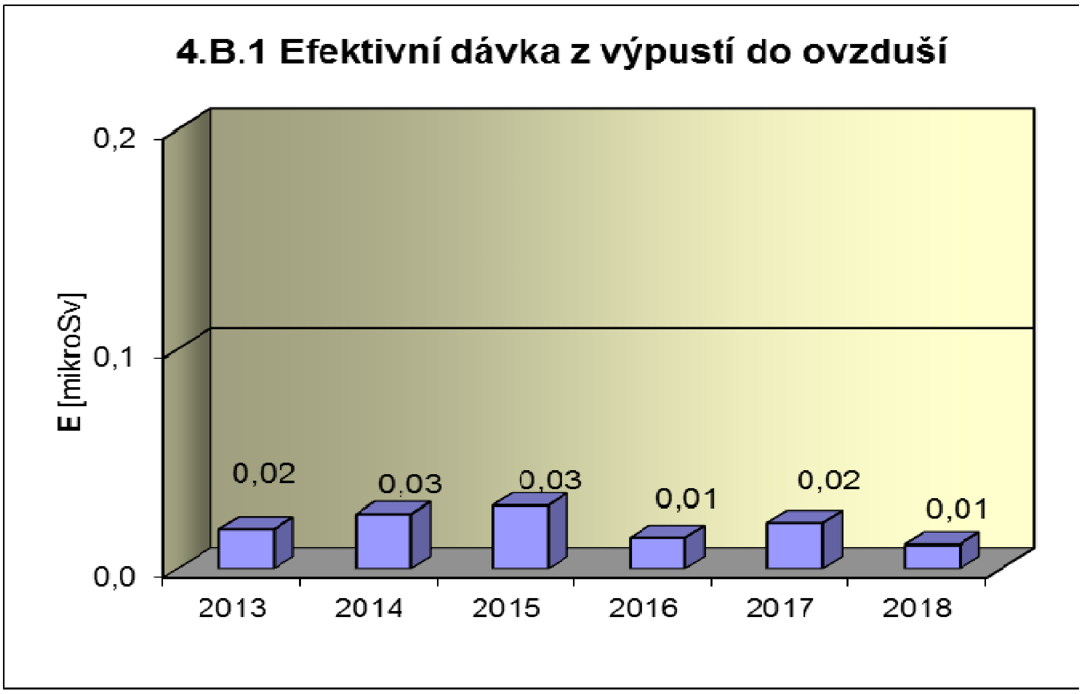


NWSD [number]

4.B Radioactive Releases

Graph 4.B.1 indicates the committed effective dose for an individual, which arises from radioactive gaseous releases from NPP.

4.B.1 Gaseous Releases – Committed Effective Doses



Graph 4.B.2 indicates the committed effective dose for an individual, which arises from radioactive liquid releases from NPP.

4.B.2 Liquid Releases – Committed Effective Doses