# ANNEX 6 Evaluation of the Safety Performance Indicators Set
**(year 2003)**

CONTENTS:



Appendices:

## 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, SUJB annually evaluates an achieved level of nuclear safety of operation of Dukovany NPP using of Safety Performance Indicators.

Regarding the NPP commissioning, the year 2003 was the first year when the Safety Performance Indicators were evaluated for Temelín NPP. It involved the adoption of data acquisition and application of software tools used for the evaluation of Safety Performance Indicators of Dukovany NPP, at Temelín NPP.

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

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

The evaluation results of Safety Performance Indicators in the form of graphs for monitored period (1998 - 2003 for Dukovany NPP and 2003 for Temelín NPP) are stated 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 operator and by SUJB supervisory activities at Dukovany NPP and Temelín 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 Appendix – Part I.

The evaluation of Safety Performance Indicators for 2003 shows a relatively constant high level of assurance of nuclear safety and radiation safety in power generation in Dukovany NPP.

### 1. Significant Events

Group 1.A – Reportable events

The basis for the group 1.A indicators is the evaluation of reportable events according to the NPP Event specification. The indicator 1.A.1 "Reportable Events" was included into the set of Safety Performance Indicators in 2003 and it superseded indicator "The Number of Safety Related Events", thus the values shown in the graph in or before 2002 represent only the total number of events evaluated according to the International Nuclear Event Scale (INES), the way the indicator was originally defined. This indicator therefore cannot be evaluated in terms of the trend.

To compare the present time with the previous years, the sub-indicators 1.A.1a and 1.A.1b could be used. Common graph of these sub-indicators shows sustained decrease of the number of events evaluated according to the INES for the entire monitored period, when the values for last three years could be considered as stable. One safety significant event according to the INES was recorded at Dukovany NPP in 2003.

The change of monitoring and evaluation methodology for events significant in terms of the nuclear safety reflected also in the indicator "Human Factor" (graph 1.A.2), in particular in its Human Factor Index. This indicator, in comparison with previous years, considerably decreased; however it is caused by a greater number of events related thereto. The state of absolute number of reportable events with an influence of Human Factor on their occurrences is relatively steady.

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

For indicators "Unplanned Unit Scrams" and "Manual Unit Scrams" (a common graph 1.B.1,2) the final value is, same as last year, one scram manual. The state achieved in this case for the past years can essentially be evaluated also with the conclusion that the probability of the need for the unit scram is, such as the events of the INES ≥ 1, at the level of accidental small numbers.

The results of indicator "Automatic Power Reduction/Limitation by Emergency Protections $2^{nd}$ – $4^{th}$ type" are shown in a common graph 1.B.3-5 and for the whole six-year period they show a slight decrease.

There were three cases of control rod drops. Although this value belongs to the highest ones, it lies within an average range of the period evaluated by graph 1.B.6.

Group 1.D – Limits and Conditions

In 2003 indicator "The Number of Violations of the Limits and Conditions" (graph 1.D.1) achieved the value zero, which means that the Limits and Conditions were not violated in this year. In terms of the evaluation of a six-year period this result is achieved for the second time.

Indicator "Exceptions from the Limits and Conditions" (graph 1.D.3) equals to zero for the third time in a monitored period.

## 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.

The graphs of the system sub-indicators show the decrease in value for all evaluated systems. At the same time, the value of SSU for the spray system exceeds significantly the average, as every year.

Group 2.B – Failure of safety systems

According to the indicator "The Number of Starting Failures" (graph 2.B.1) in 2003 two failures of the diesel generator plant (DG) occurred. Both failures of the diesel generator plant (DG) are caused by exceeding of the time required for connection to provided feeding. Remaining systems TJ (emergency core cooling system – high pressure part), TH (emergency core cooling system – low pressure part) and TQ (spraying system) hold the maximum level for several years already – no starting failure.

In a similar way, indicator 2.B.3 monitors the behaviour of safety systems in operation. Over the long term, for the entire monitored six-year period, no failures of safety systems in operation are recorded. Therefore, it can be said that their reliability in operation was 100%.

## 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 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. All annual values of the indicator FRI in 2003 are on the level 0,04 Bq/g. The fuel leaks were not identified and hence no fuel assemblies were discarded. Totally six leaky fuel assemblies were discarded to the spent fuel storage pool in the whole operation period of Dukovany NPP.

Group 3.B – Containment

One indicator only in graph 3.B.1, using results of the Containment periodic integral tightness testing, evaluates the tightness state of hermetic areas. The trend of systematic increasing of the 1st, 3rd, and 4th units' tightness commenced in 2000 was confirmed in 2003. These units repeatedly achieved the lowest historical values of leakage in 24 hours during the Periodic integral tightness testing. However the leak values at the Unit 2 show rather counter-tendency. From the graph it is evident that in spite of this negative trend the Unit 2 is the second tightest unit. The test results of hermetic area of the Unit 4 in 2003 confirmed its highest tightness.

## 4. Radiation Protection

Group 4.A – Staff

Indicator "Collective Effective Dose per Unit" (graph 4.A.1) monitors collective effective dose of the staff of NPP, suppliers and visitors converted per one unit. The indicator value achieved the lowest level for the period monitored by the graph, in spite of the fact of extensive activities on steam generators during outages.

The following graph 4.A.2 of indicator "Collective Effective Dose" represents the distribution of collective effective dose among the staff of NPP and suppliers. From the graph it is evident that the effective doses for the staff of NPP in the entire monitored period descend and that the values for suppliers achieved the lowest levels over the last two-year period. The values of graph 4.A.3 "Specific Collective Effective Dose per Capita" correspond with the facts mentioned above and evidence that the collective effective dose did not descend through decreasing the number of radiation workers but through the ALARA (As Low as Reasonably Achievable) process.

The graph 4.A.4 of the indicator "Maximum Individual Effective Dose" corresponds with the results of the Collective Effective Dose (CED) shown in the graphs 4.A.1-3. The employees of supply organisations are exposed to the irradiation more than the staff of Dukovany NPP. However, neither unscheduled irradiation nor over-irradiation occurred for the period stated.

Indicator "The Number of Workers with Special Decontamination" is one of the indicators of safe work with the source of ionizing radiation.

Group 4.B – Radioactive releases

The indicators "Gaseous Releases" and "Liquid Releases" evaluate the operation of Dukovany NPP in terms of radioactive releases. Their graphs 4.B.1 and 4.B.2 document that the committed effective doses from the releases are in both cases lower for the population in a calendar year than the limits (the limit for gaseous releases is 40 μSv and 6 μSv for liquid releases).

The release of liquid tritium primarily gives higher value of the committed effective dose from liquid releases in 2003.

## C. EVALUATION OF THE SET OF SAFETY PERFORMANCE INDICATORS FOR TEMELÍN NPP

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

In 2003 the Unit 1 was under test operation and Unit 2 has been under test operation since April. The set of Safety Performance Indicators applicable in 2002 for Dukovany NPP was used for the processing and changes to the set made for 2003 will be applied for Temelín NPP evaluation in 2004. According to world practice only the values of indicators for 1st unit could be considered as start values of indicators. For 2nd unit the values in 2004 will be considered as start values of indicators. Therefore, the evaluation results of individual indicators for Temelín NPP are not stated.

## D. CONCLUSION

Based on the results of particular Safety Performance Indicators for 2003 we can state that the hitherto high level of nuclear and radiation safety in power generation in Dukovany NPP was confirmed in most evaluated areas.

Evaluation of the trends of the reportable events number and the indicator for human factor in the area of Significant Events proved the high level achieved in the previous years.

Evaluation of the 2nd area –Safety Systems Performance – also shows a very good level, even with the best results for monitoring period.

In 2003 the area of Barriers Integrity is altogether the most successful for the whole history of Dukovany NPP operation.

Based on the results of particular indicators in the field of Radiation Protection we can state that the radiation protection in Dukovany NPP is on a high level. Different expressions of the collective effective dose as a scale of fulfilment of the program for radiation protection toward the ionising radiation indicate stable decrease of absolute and relative values. Both liquid and gaseous releases are maintained on very low level.

The above summary of the results of particular areas of the set of Safety Performance Indicators provided a sufficient overview of the state and assurance of nuclear and radiation safety in operation of Dukovany NPP and did not indicate any hazardous aspects.

The processing of Safety Performance Indicators for Temelín NPP in 2003 provided source data for the 1st unit and the data acquisition system was verified over a period of the year.

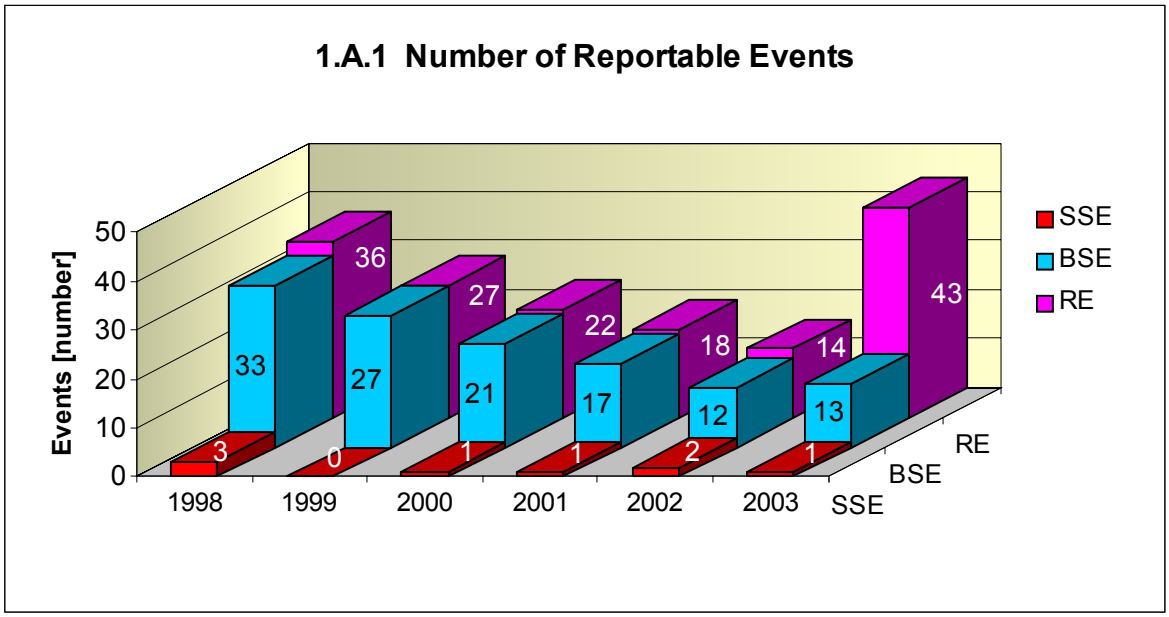
## E. ABBREVIATIONS:

| | |
|---|---|
| **ALARA** | As Low As Reasonably Achievable |
| **INES** | International Nuclear Event Scale |
| **L&C** | Limits and Conditions |
| **NPP** | Nuclear Power Plant |
| **SUJB** | State Office for Nuclear Safety |

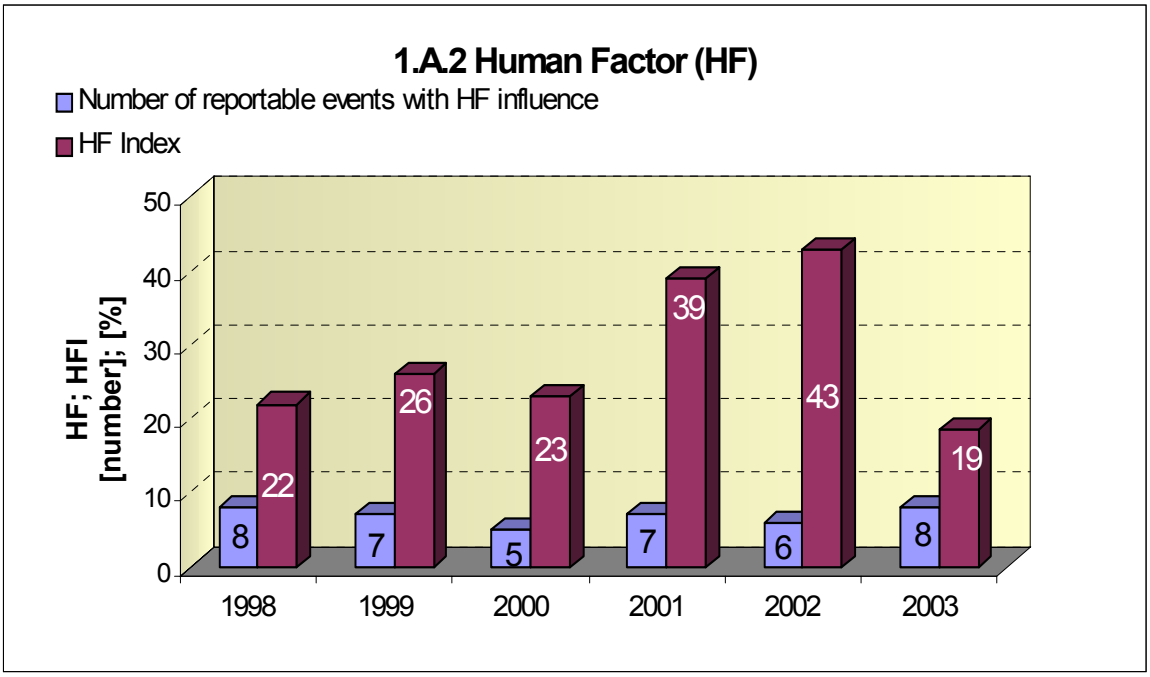
# 1. Significant Events

## 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). Until 2002 the RE indicator was equal to summary of SSE and BSE.

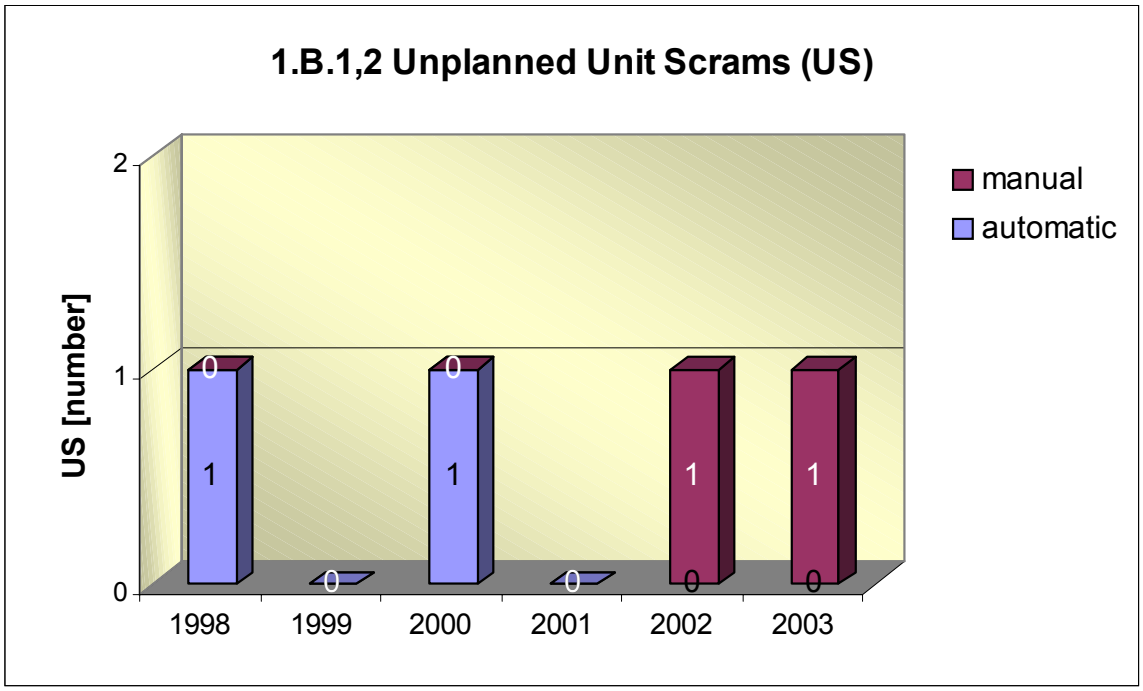



Graph 1.A.2 evaluates the influence of human factor upon occurrence of reportable events. Until 2002 the number of reportable events corresponds with number of events according to INES. The indicator is expressed by the number of the reportable events with an influence of human factor (HF) and its percentage share (HFI).

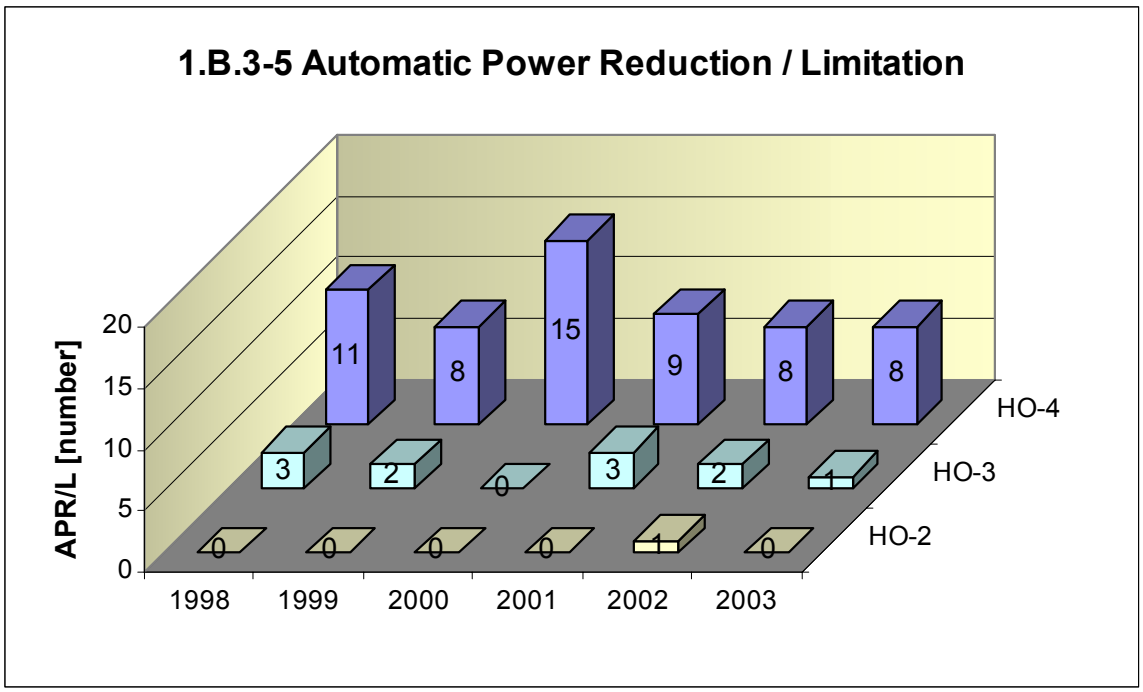


### 1.B Actuation of the protection and limitation systems

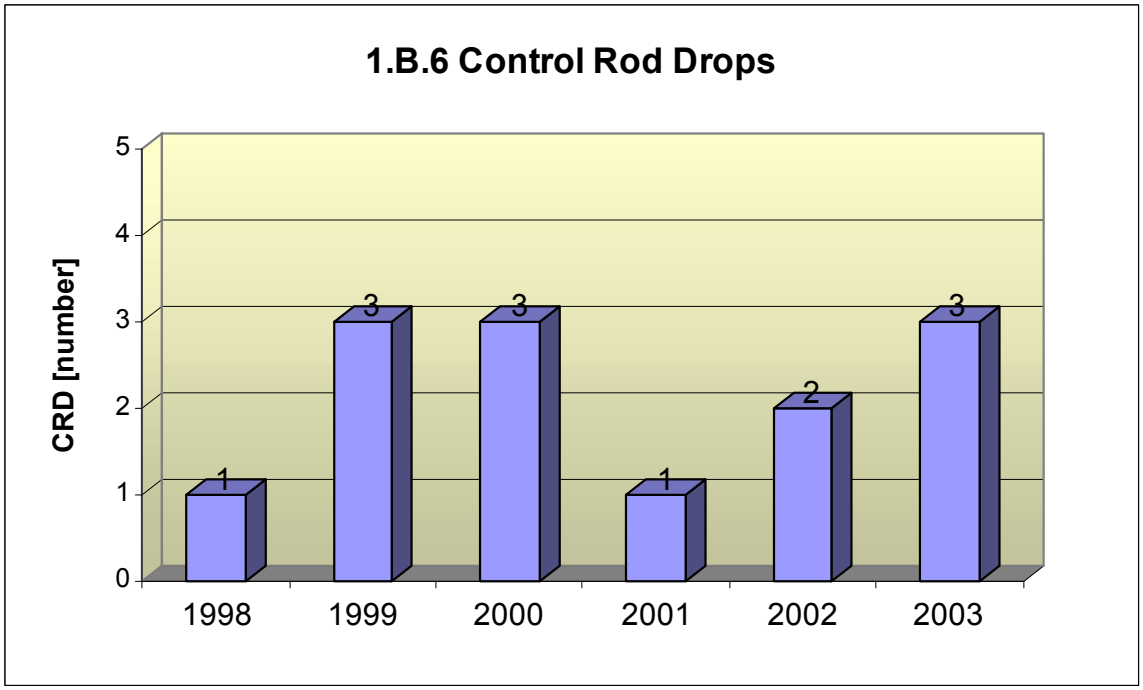
Graph 1.B.1,2 summarises the total number of unplanned unit scrams (US) (reactor in MODE 1 or 2) with resolution of manual and automatic shutdown. The term unplanned means that the scram was not an expected part of the planned test.




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).

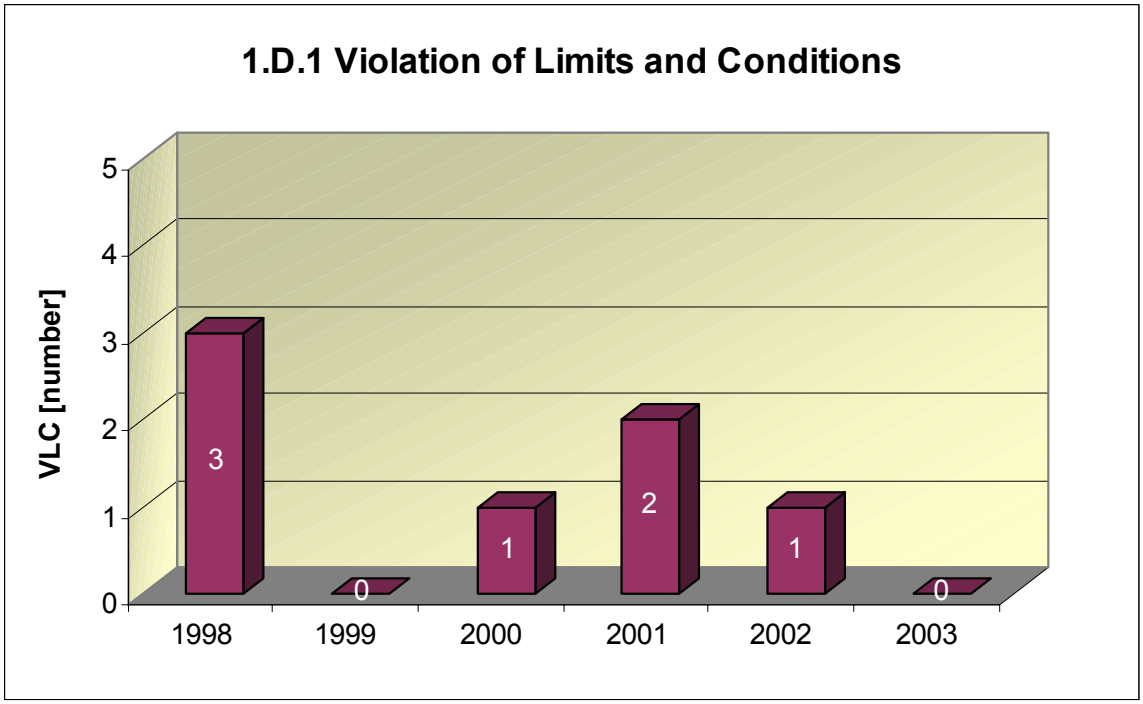


Graph 1.B.6 presents the development of the number of control rod drops (CRD).

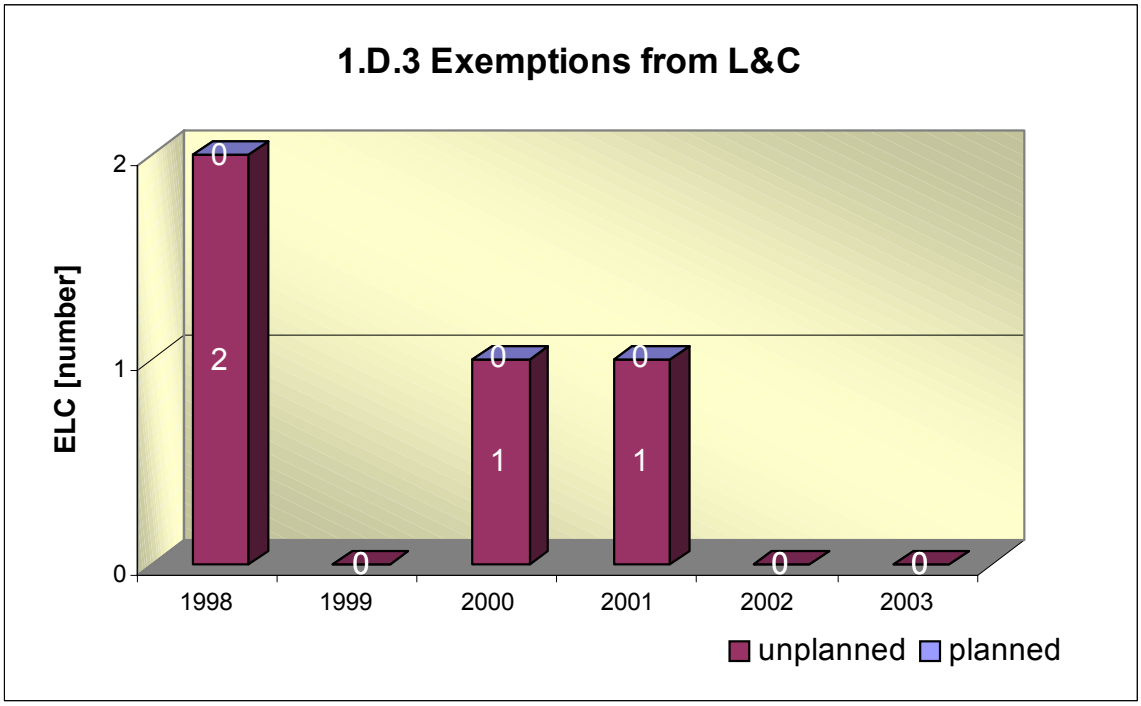


### 1.D Limits and Conditions

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.




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 required SUJB approval and however not drawn for various reasons.



# 2. Safety Systems Performance

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

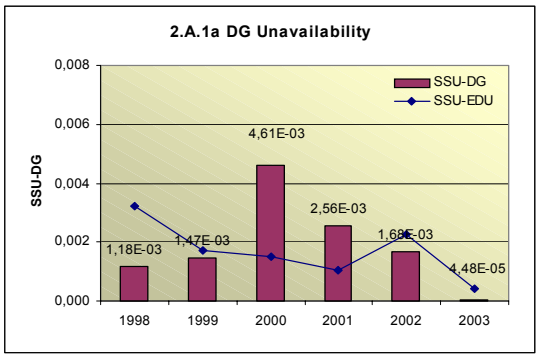
| | |
|---|---|
| - diesel generators | **DG** |
| - high pressure emergency core cooling system | **TJ** |
| - low pressure emergency core cooling system | **TH** |
| - spray system | **TQ** |
| - hydro-accumulators | **HA** |
| - steam generator auxiliary feed-water system | **HN PG** |
| - steam generator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

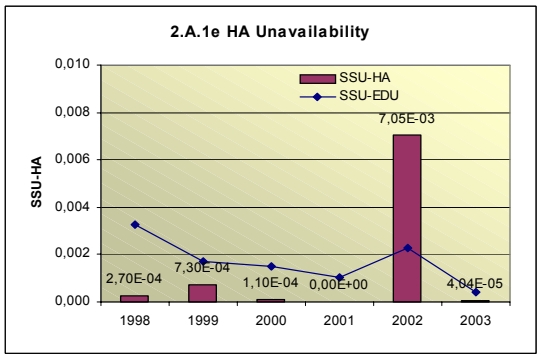
and in group B failure of diesel generator (DG), high pressure emergency core cooling system (TJ), low pressure emergency core cooling system (TH) and spray system (TQ) in starting and operation.

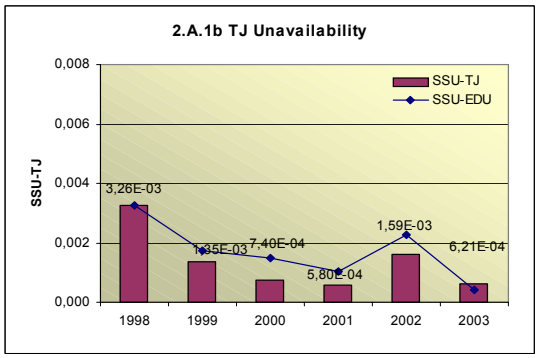
## 2.A Safety system unavailability

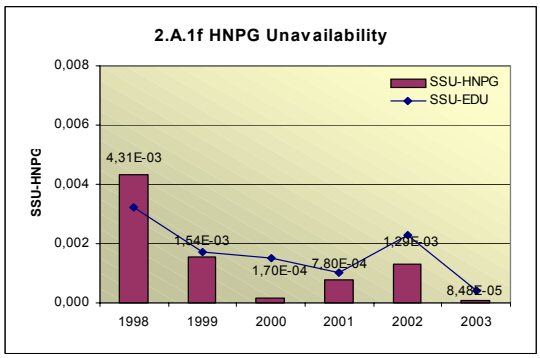
Unavailability of particular safety systems ($SSU_S$) - graphs 2.A.1.a – g, is defined as the ratio of the total time of unavailability of an evaluated safety system to the total time when its availability was required. In addition, these combined graphs express the ratio of unavailability of respective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

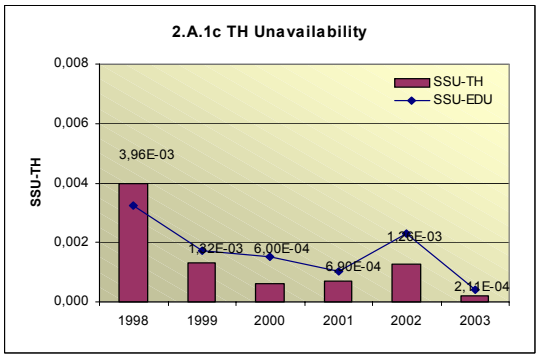
.

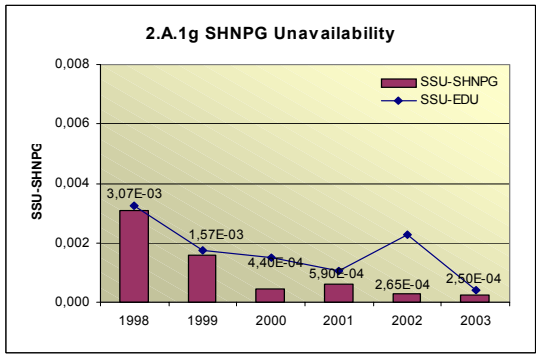


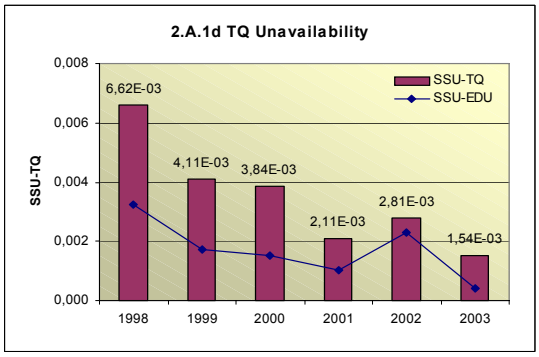



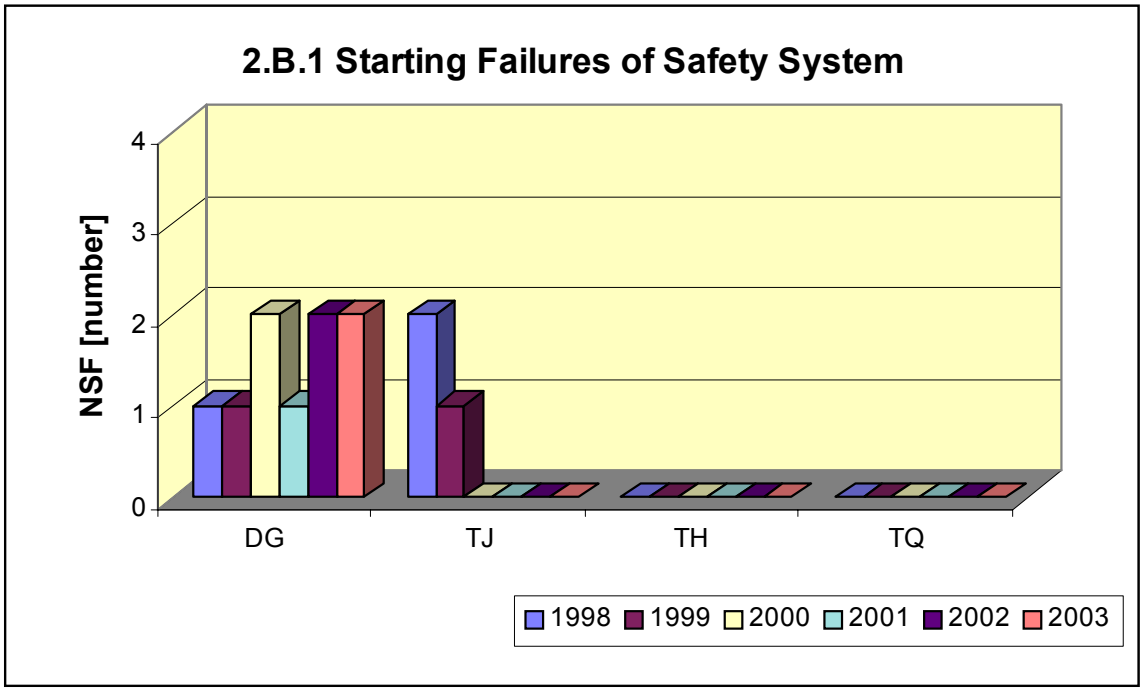



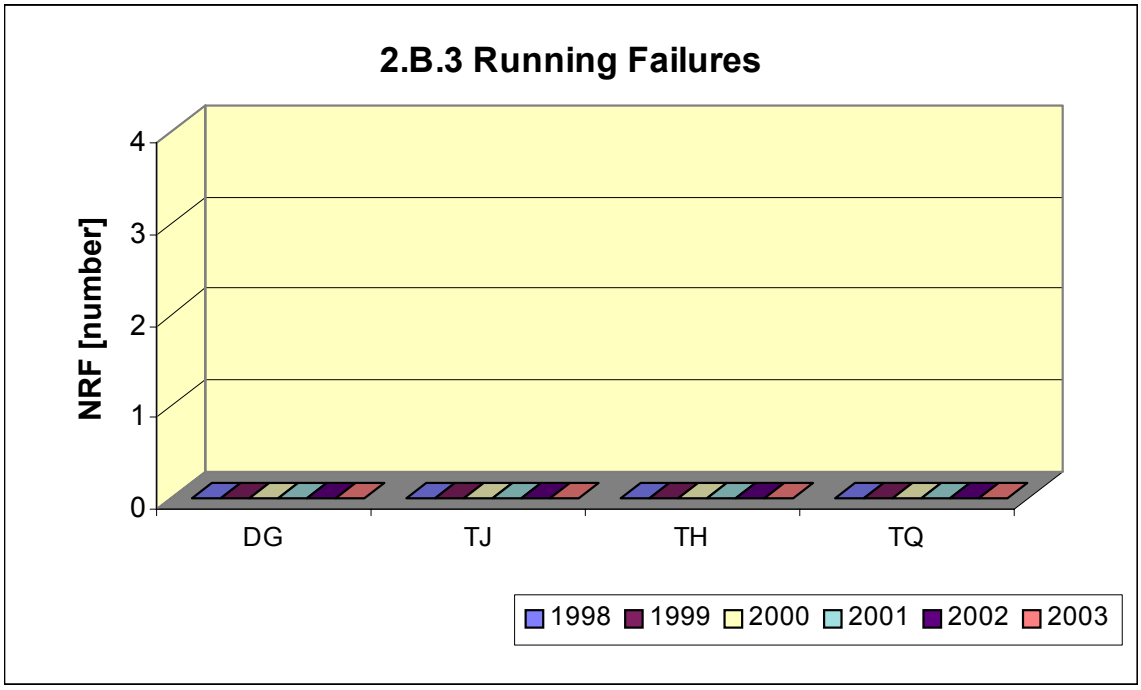



**2.B Failure of safety systems**

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.



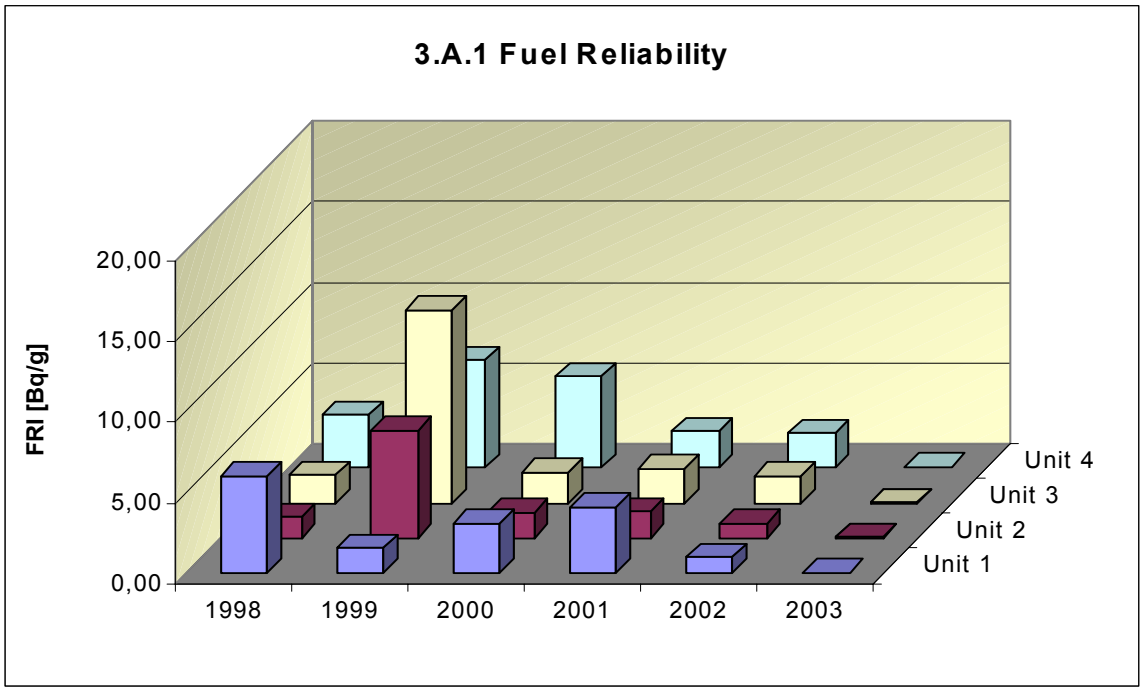

Graph 2.B.3 indicates the number of running failures of safety system (NRF), i.e. the number of states when failure shut down of respective system, drive, possibly set occurs at nominal performance characteristics for the time exceeding 30 minutes since its starting.



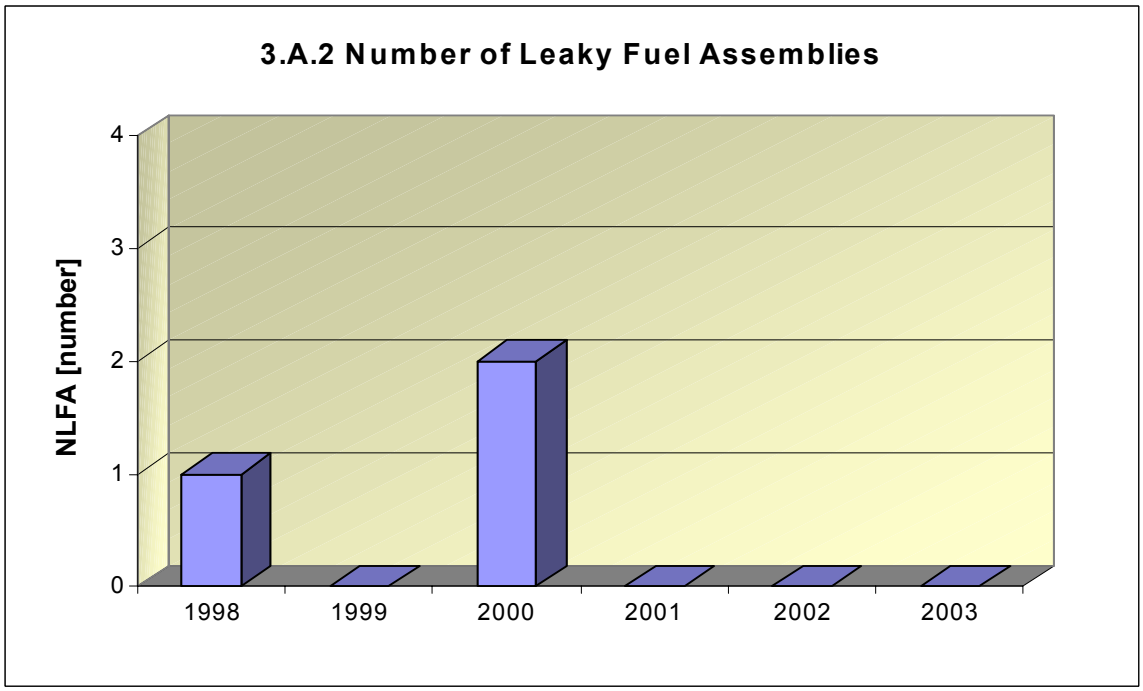
# 3. Barriers Integrity

**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.

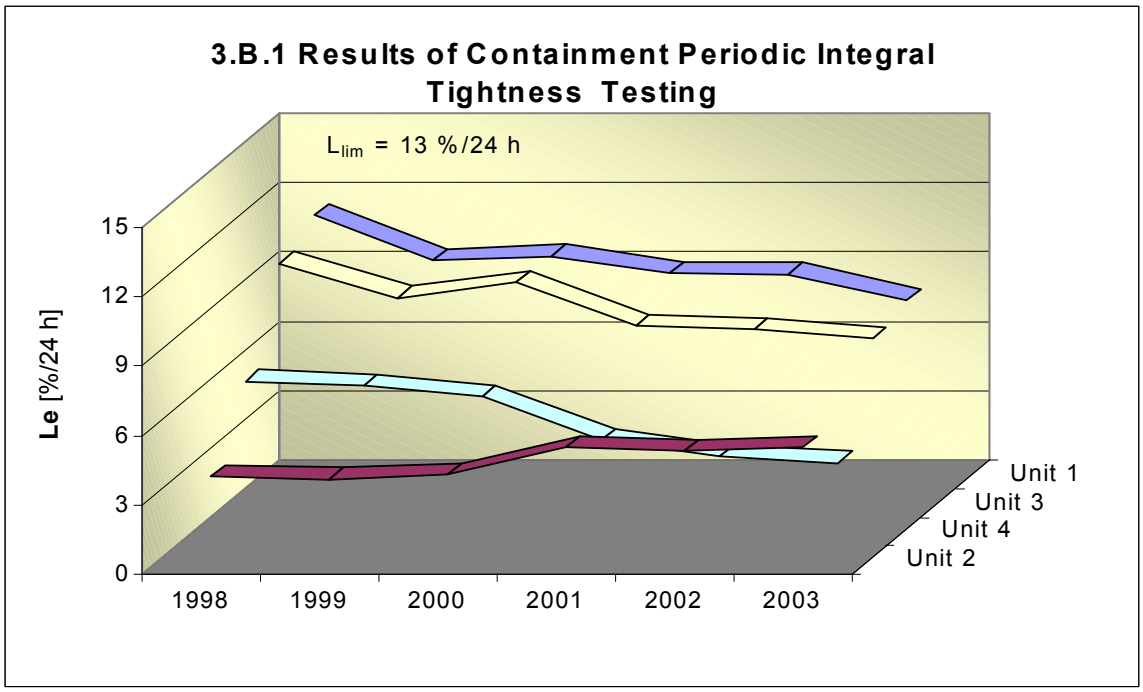



Graph 3.A.2 indicates the number of leaky fuel assemblies (NLFA) that had to be put out of operation due to their inadmissible leakage.



### 3.B Containment

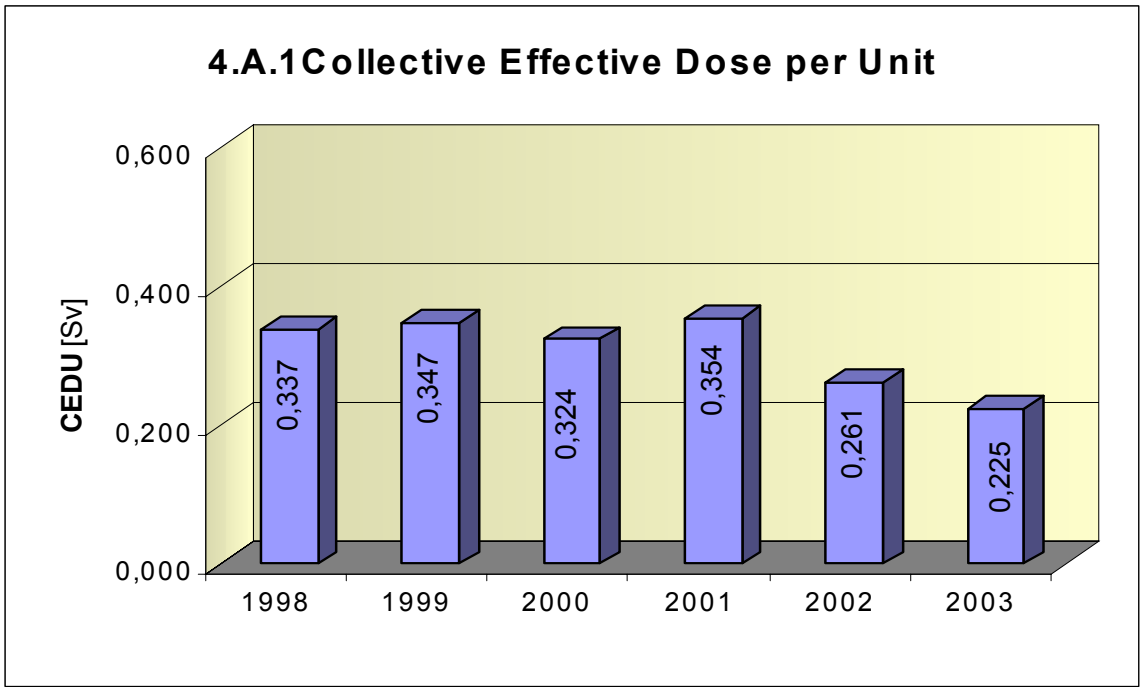
Graph 3.B.1 states the results of Containment periodic integral tightness testing ($L_e$), i.e. the results of leakage tests of hermetic areas executed by overpressure 150 kPa with the dwell 24 hours. Extrapolated results are included for the tests with a lower pressure and dwell.



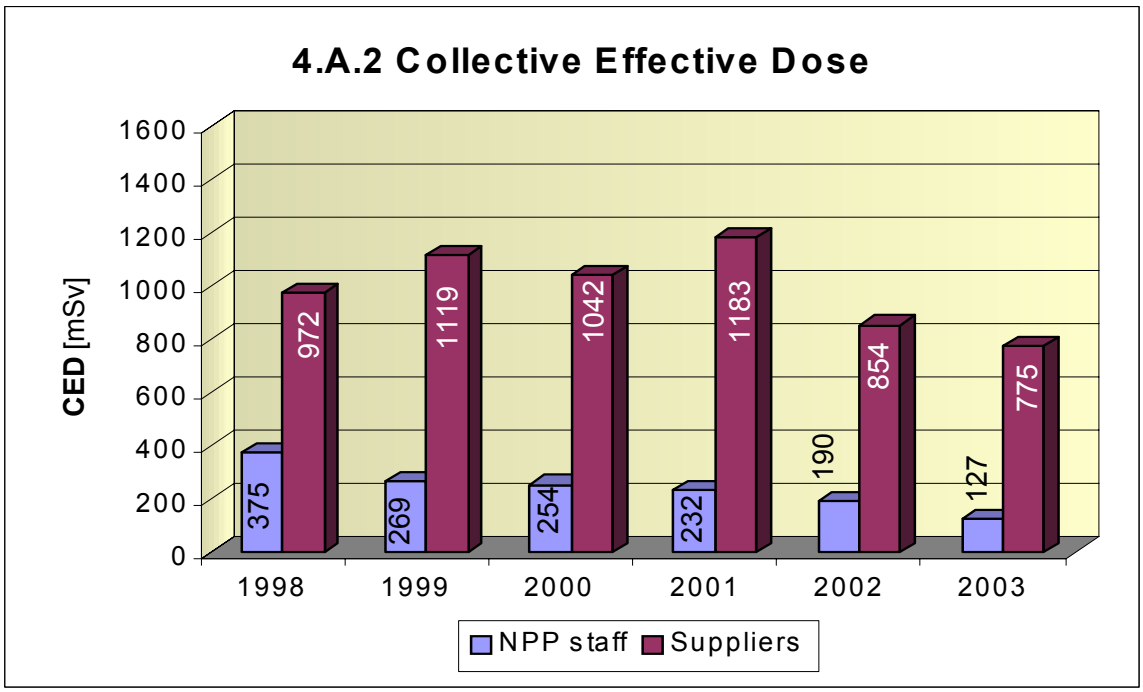
# 4.Radiation Protection

## 4.A Staff

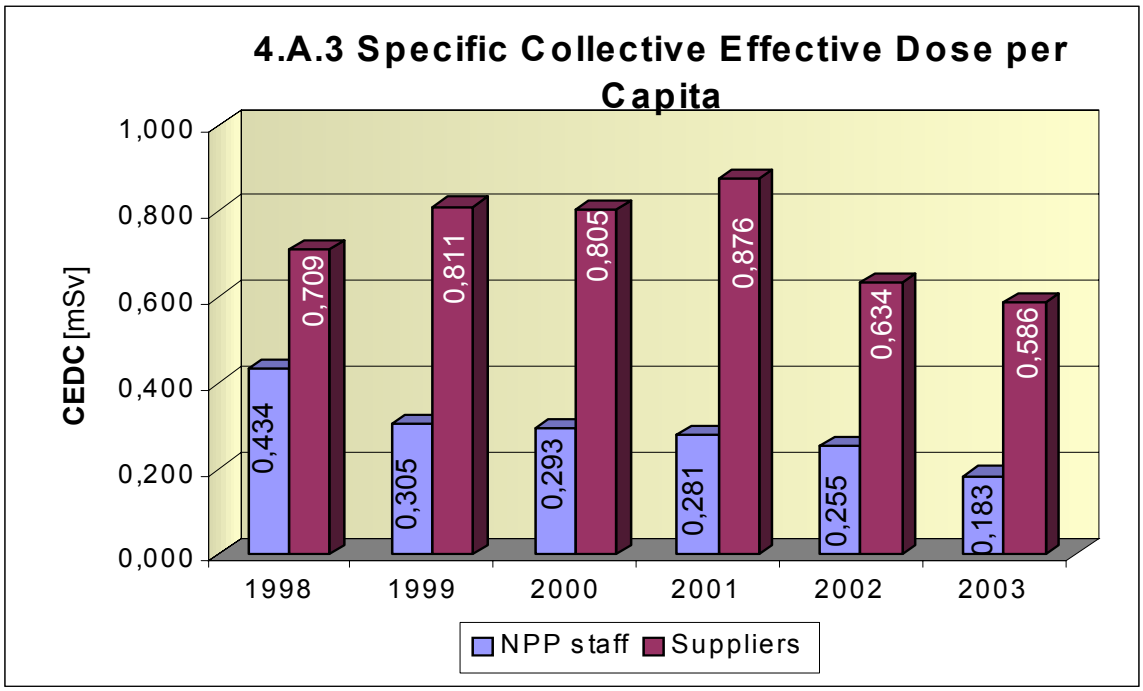
Graph 4.A.1 indicates collective effective dose (CED) received by the staff of NPP (including suppliers and visitors) during monitored period, measured by basic film dosimeters and expressed by mean value per unit.



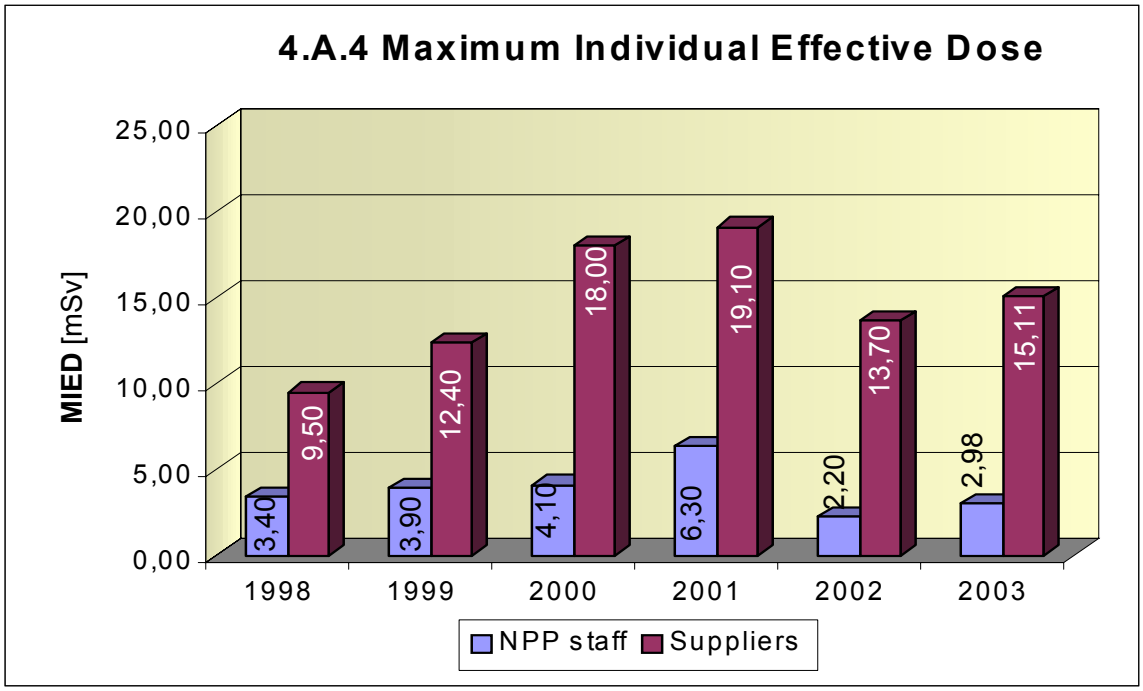

Graph 4.A.2 indicates collective effective dose received by the staff of NPP and suppliers during monitored period, measured by basic film dosimeters.



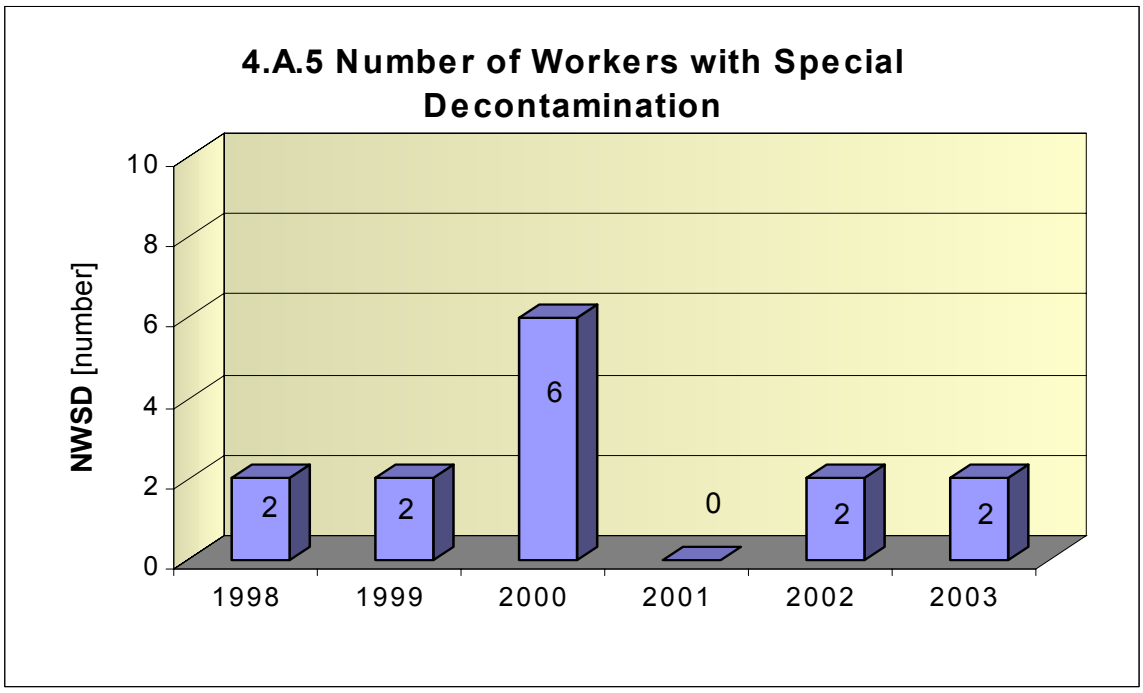
Graph 4.A.3 indicates specific collective effective dose received by the staff of NPP and suppliers during monitored period, measured by basic film dosimeters and express by value per one radiation worker.




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.

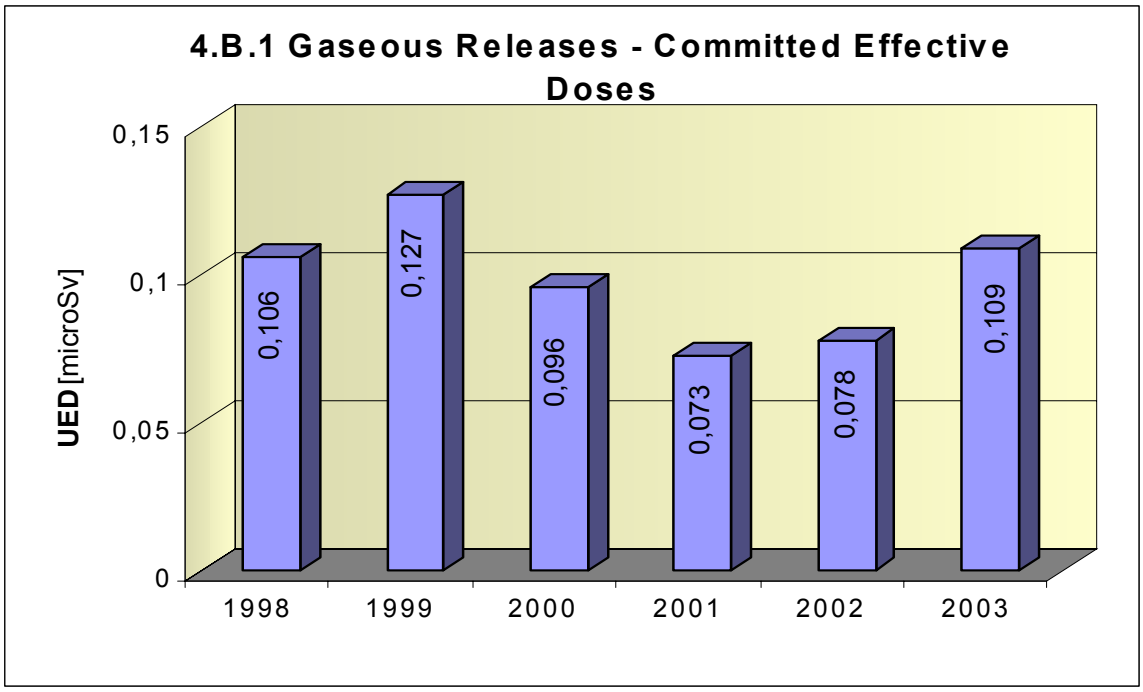



Graph 4.A.5 indicates number of workers (NPP and suppliers) subjected to a special decontamination under medical supervision.

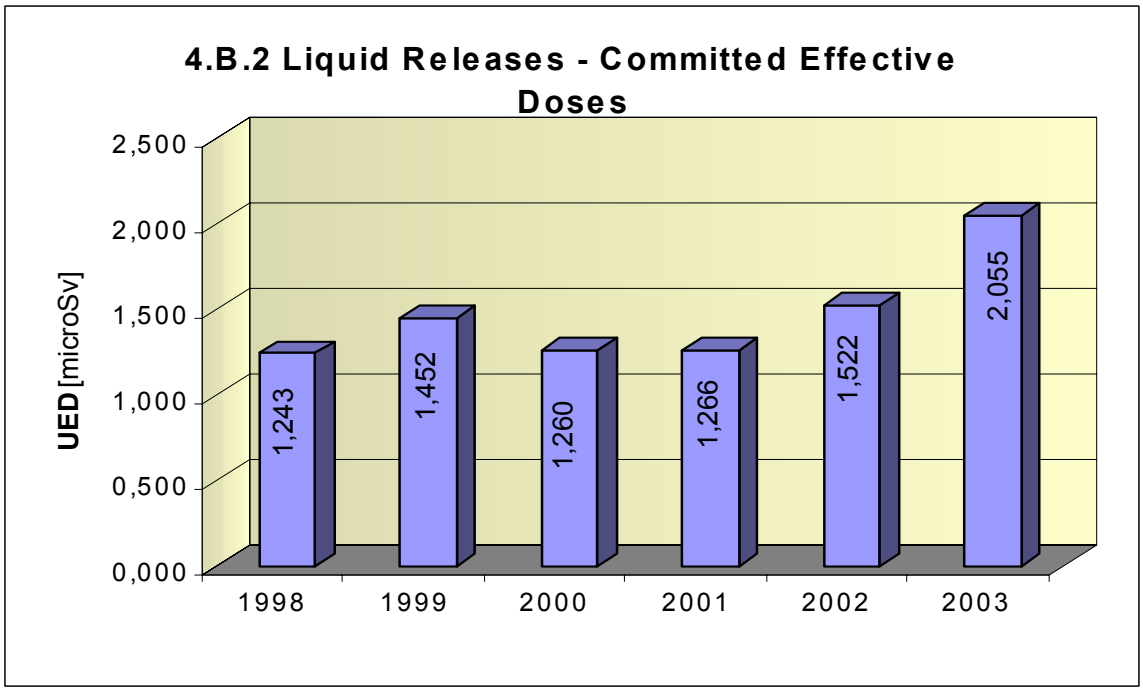

4.A.5 Number of Workers with Special Decontamination
NWSD [number]
10
8
6
4
2
0
2
2
6
0
2
2
1998
1999
2000
2001
2002
2003

### 4.B Radioactive Releases

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



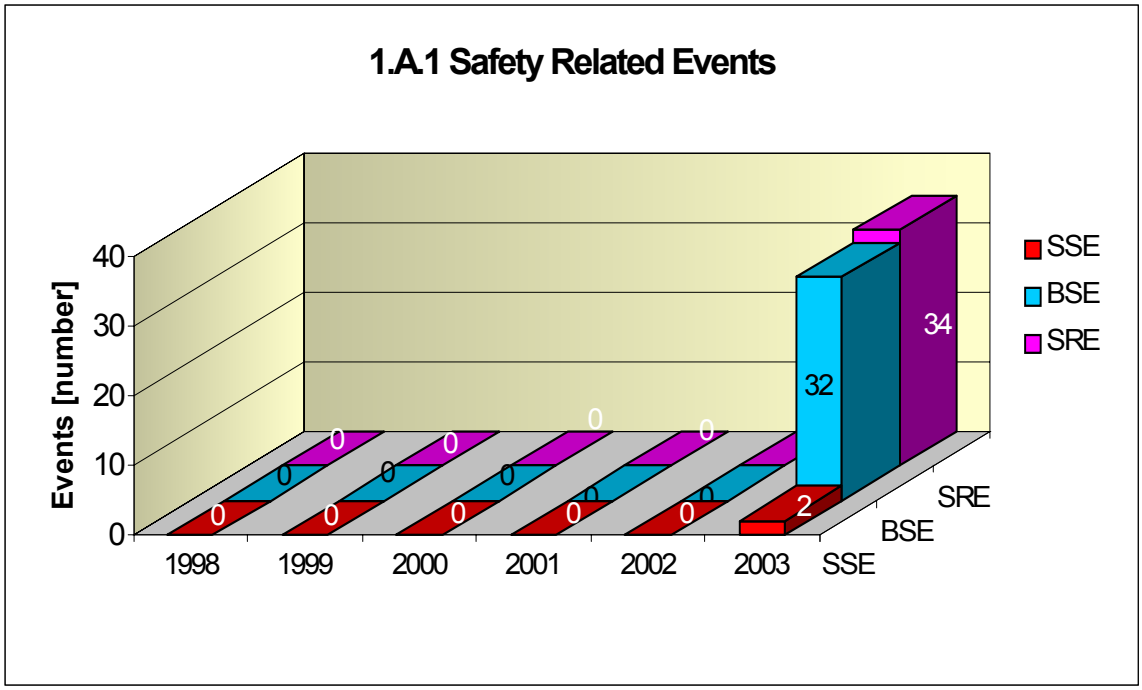

Graph 4.B.2 indicates the committed effective dose for individual, which arises from radioactive liquid releases from NPP.



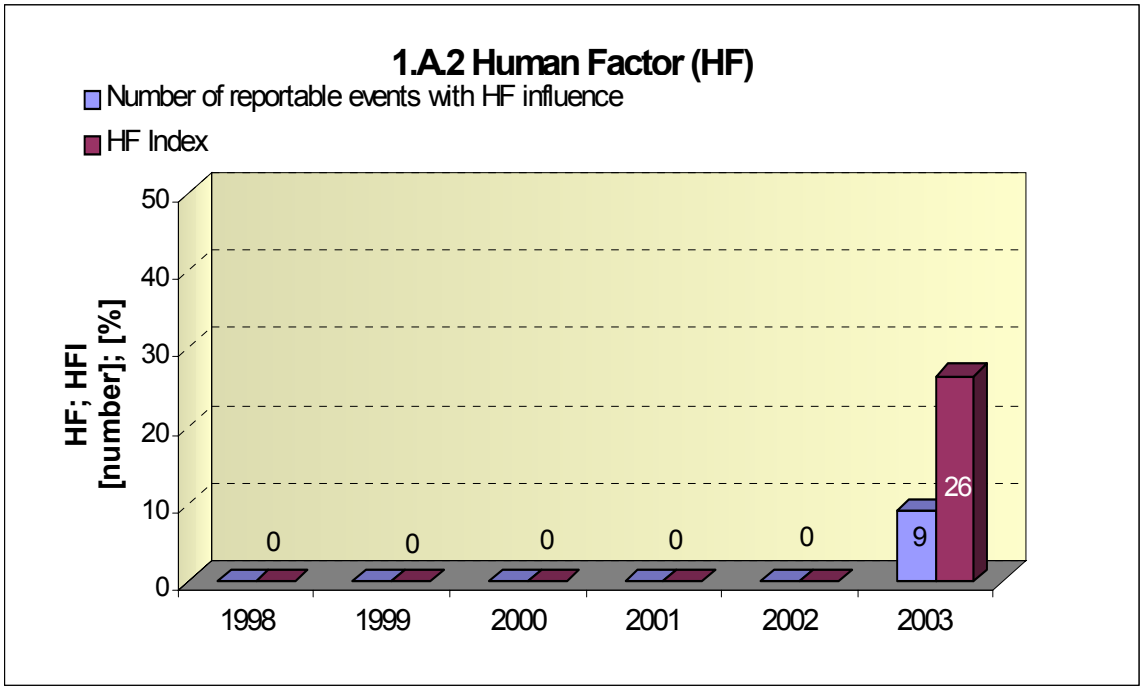
# 1. Significant Events

## 1.A Safety related events

Graph of indicator 1.A.1 monitors the development of the number of safety related events (SRE) 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).

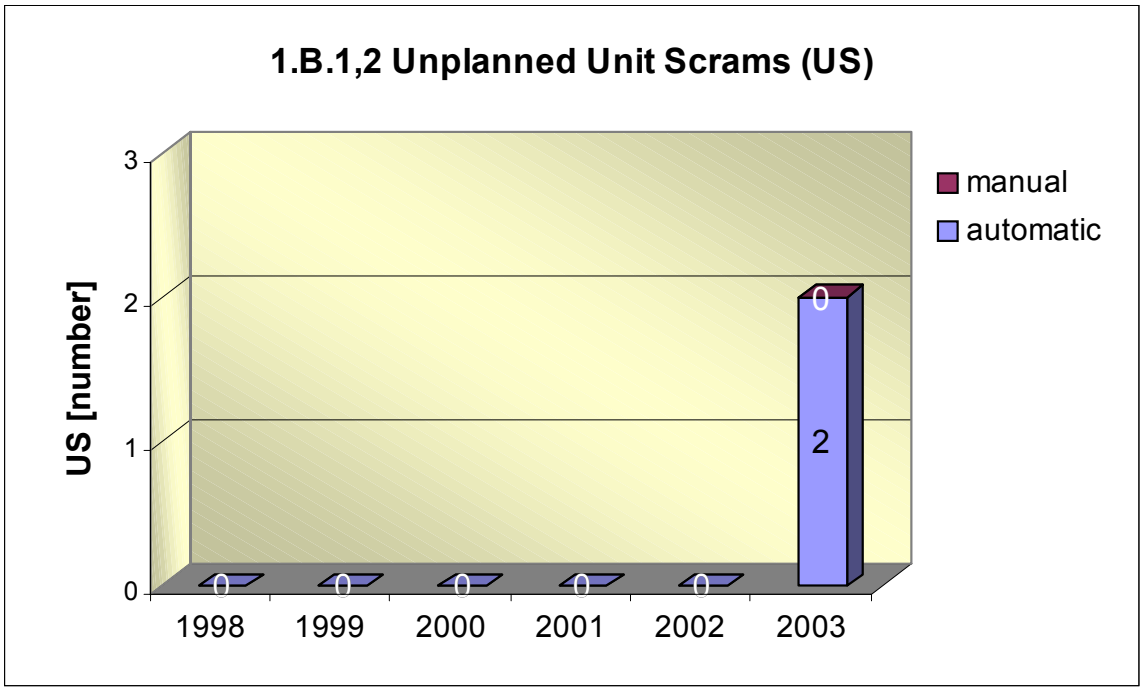



Graph 1.A.2 evaluates the influence of human factor upon occurrence of safety related events. The indicator is expressed by the number of the safety-related events with an influence of human factor (HF) and its percentage share (HFI).

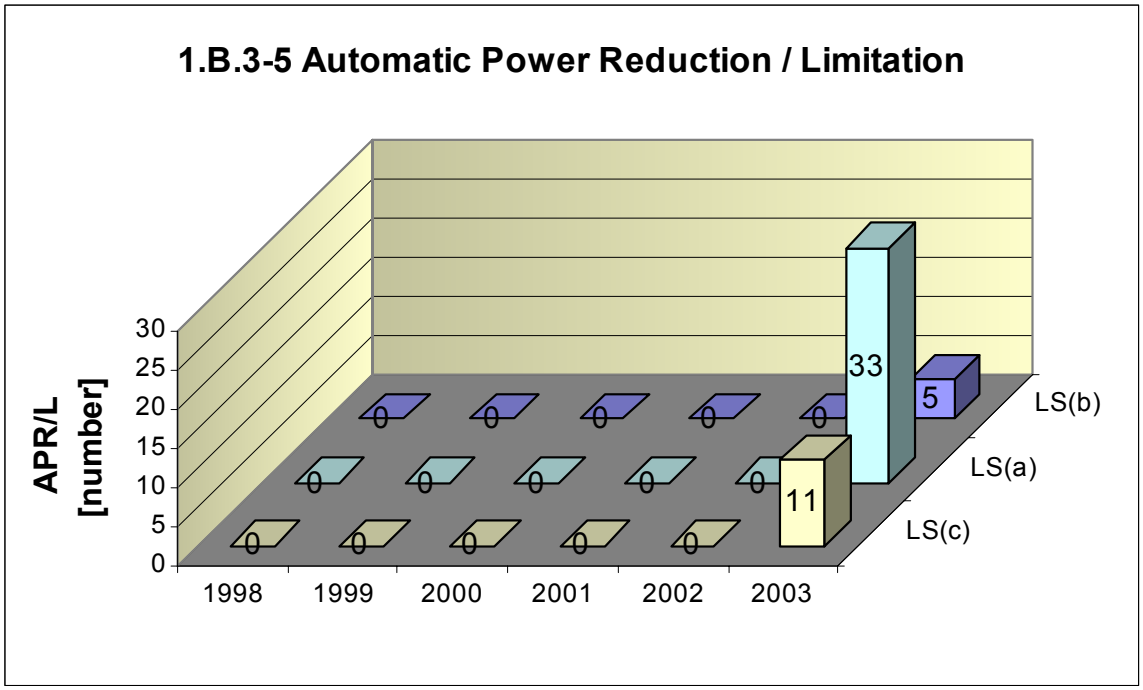



### 1.B Actuation of the protection and limitation systems

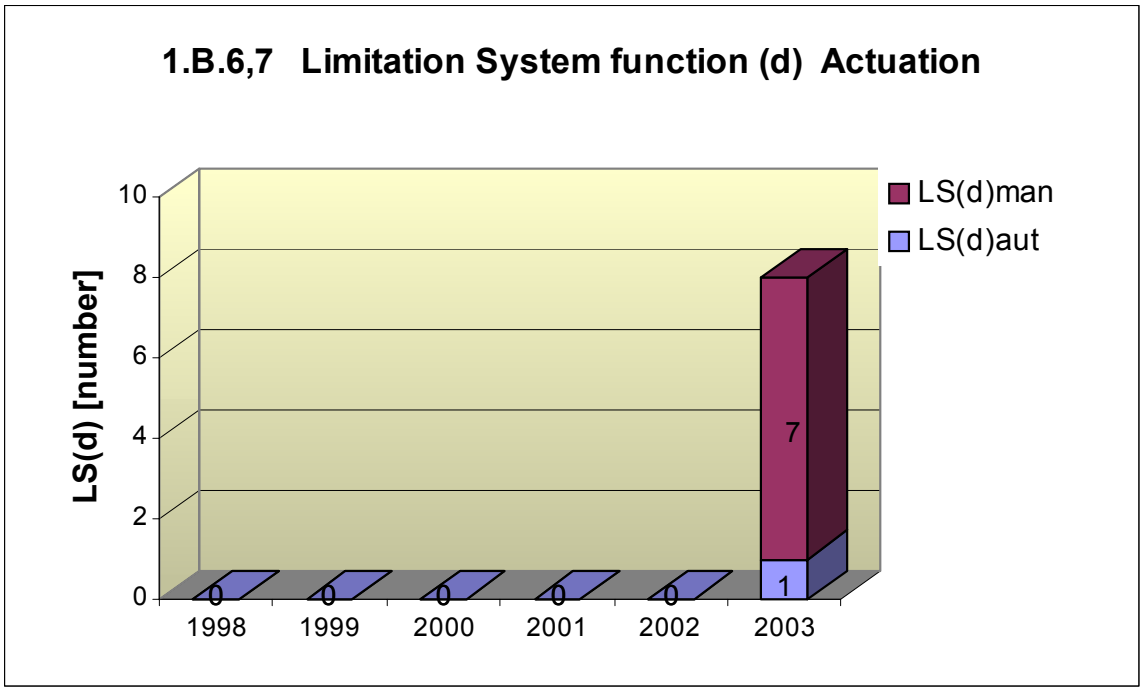
Graph 1.B.1,2 summarises the total number of unplanned unit scrams (US) (reactor in MODE 1 or 2) with resolution of manual and automatic shutdown. The term "unplanned" means that the scram was not an expected part of the planned test.




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

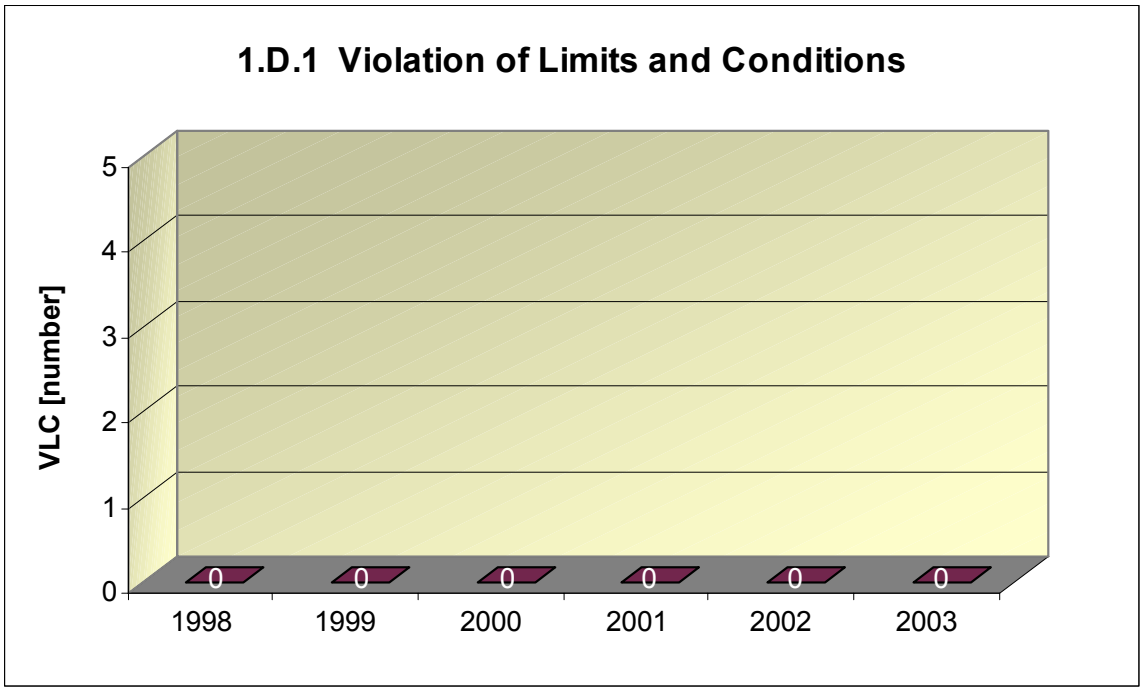



Graph 1.B.6,7 summarises the total number of unplanned reactor scrams with action of the limitation system (LS(d)) (reactor in MODE 1 or 2) with resolution of manual and automatic shutdown. The term "unplanned" means that the scram was not an expected part of the planned test.

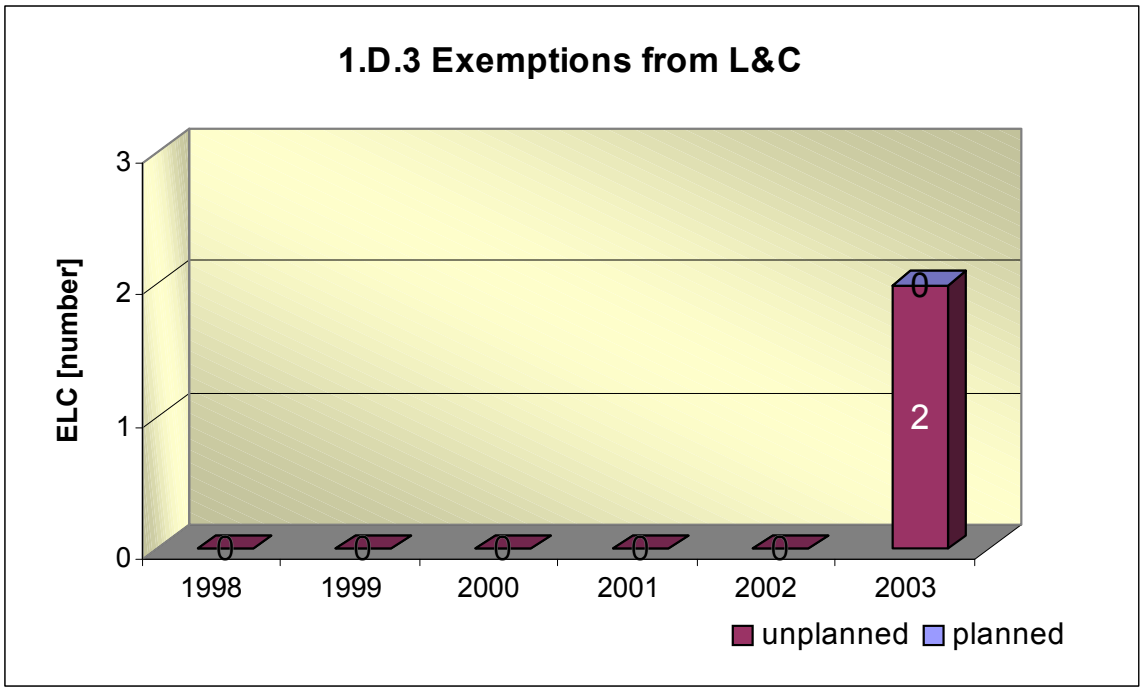


### 1.D Limits and Conditions

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.




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 required SUJB approval and however not drawn for various reasons.



# 2. Safety Systems Performance

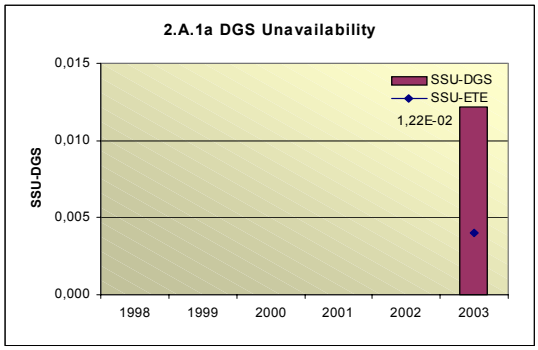
Area 2 monitors and evaluates availability of the following safety systems (BS) in group A:

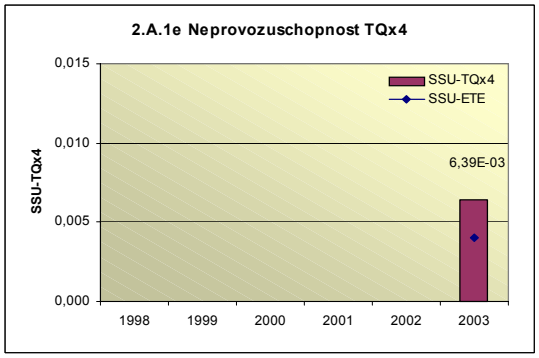
| | |
|---|---|
| - system diesel generators | **DGS** |
| - spray system | **TQx1** |
| - low pressure emergency core cooling system | **TQx2** |
| - high pressure emergency core cooling system | **TQx3** |
| - boric acid emergency injection system | **TQx4** |
| - hydro-accumulators | **HA** |
| -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

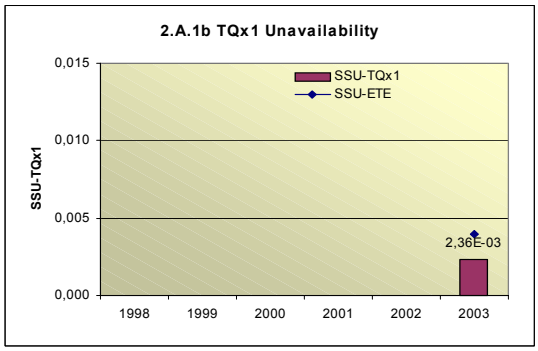
and in group B failure of diesel generator (DG), spray system (TQx1), low pressure emergency core cooling system (TQx2), high pressure emergency core cooling system (TQx3), boric acid emergency injection system (TQx4) in starting and operation.

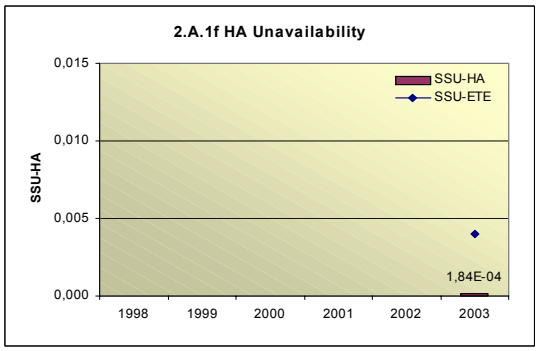
## 2.A Safety system unavailability

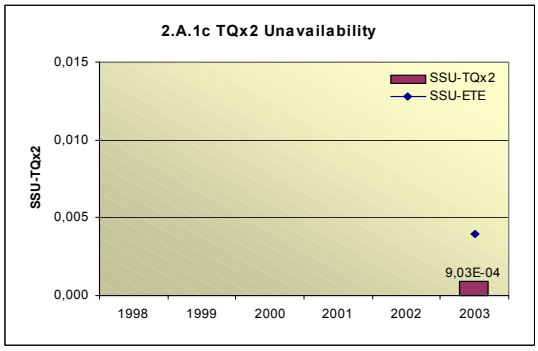
Unavailability of particular safety systems ($SSU_S$) - graphs 2.A.1.a – g, is defined as the ratio of the total time of unavailability of an evaluated safety system to the total time when its availability was required. In addition, these combined graphs express the ratio of unavailability of respective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

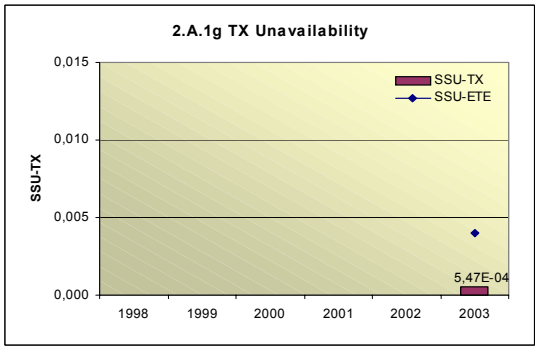


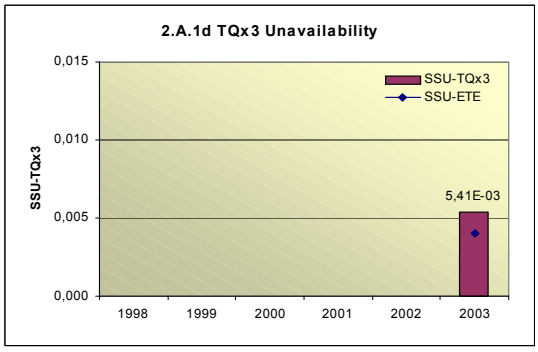



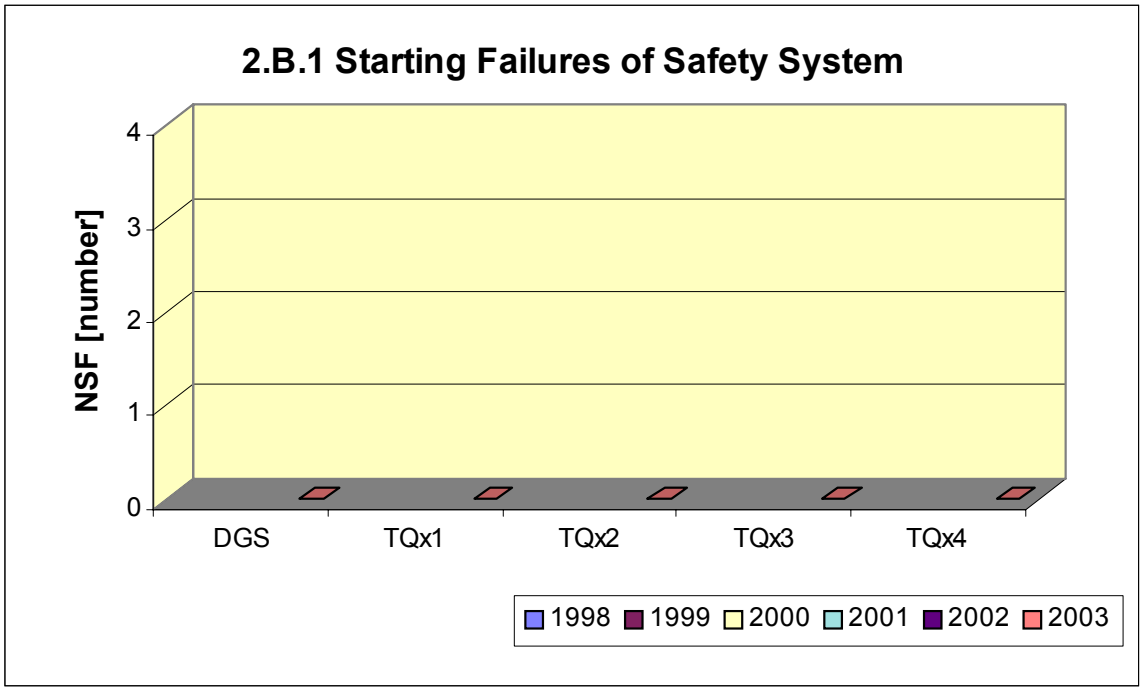



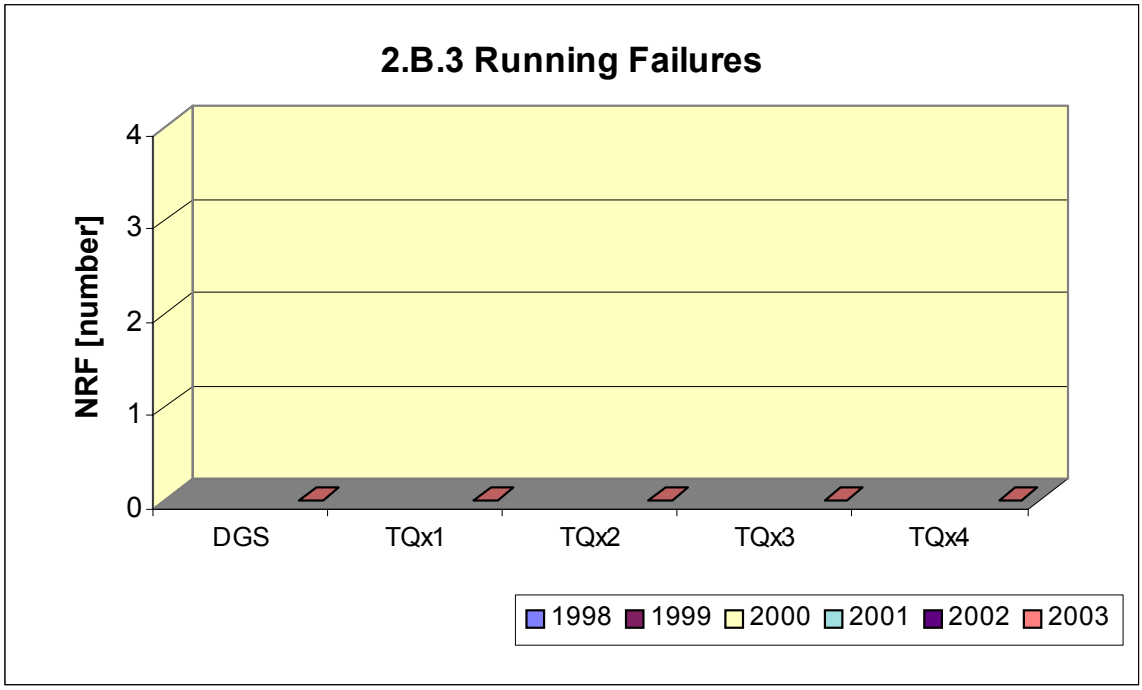



**2.B Failure of safety systems**

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.



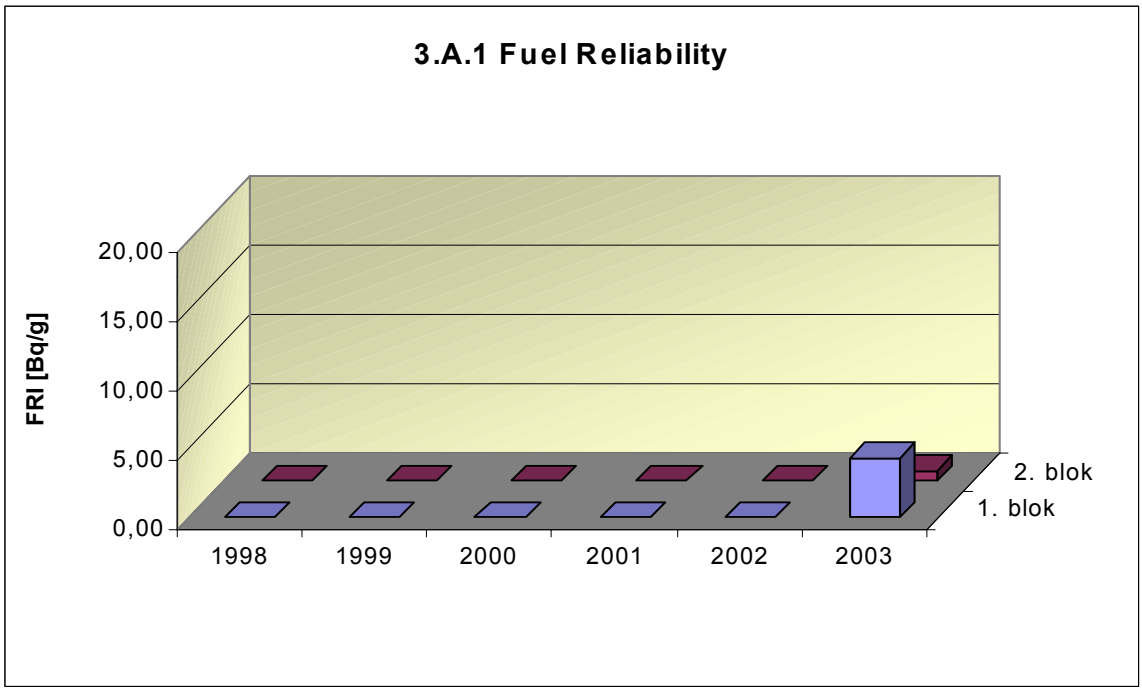

Graph 2.B.3 indicates the number of running failures of safety system (NRF), i.e. the number of states when failure shut down of respective system, drive, possibly set occurs at nominal performance characteristics for the time exceeding 30 minutes since its starting.



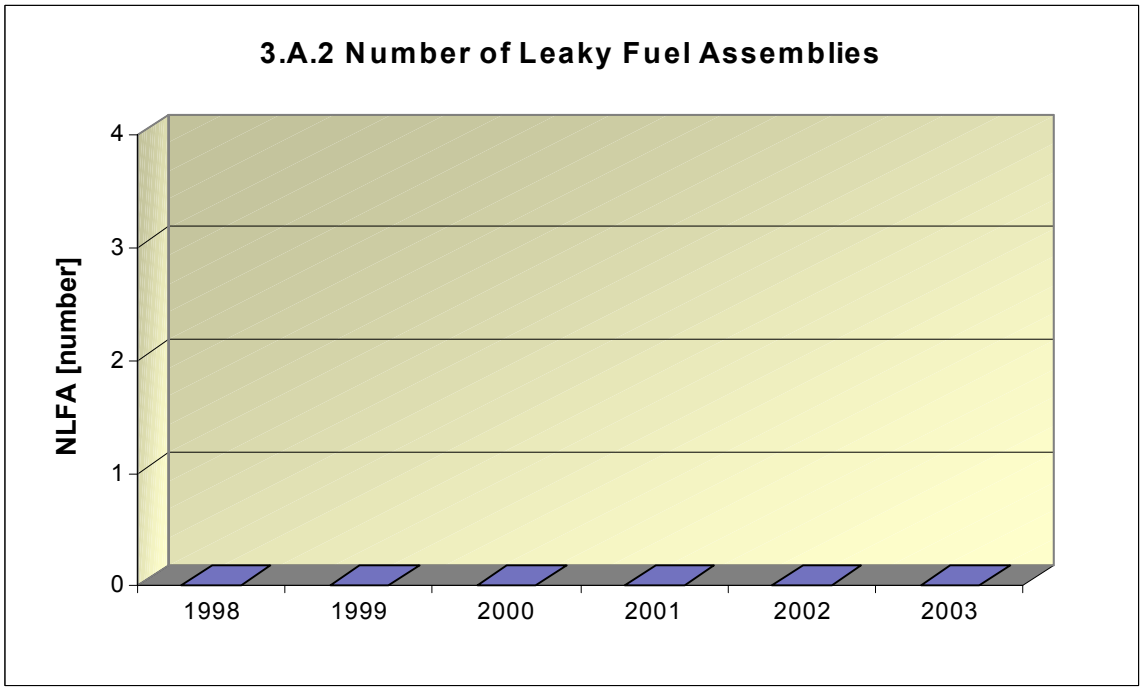
# 3. Barriers integrity

**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.




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.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 with the dwell 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.