EVALUATION

of the set of

SAFETY
INDICATORS

CONTENTS:

0. INTRODUCTION 3
1. RESULTS OF THE SAFETY INDICATORS SET EVALUATION FOR THE DUKOVANY NPP 4
1.1 Significant events 4
1.2 Human factor 4
1.3 Safety systems operation 4
1.5 Radiation protection 5
1.6 Miscellaneous 5
3. CONCLUSION 5

0. INTRODUCTION

Evaluation of the nuclear safety of the NPP Dukovany operation for 2000 with the help of safety indicators was performed using the same set as in previous years.

Safety indicators evaluate five specific and one general area of the NPP operation:

1. Significant events,
2. Human factor,
3. Safety systems operation,
4. Tightness of barriers,
5. Radiation protection,
6. Miscellaneous.

Evaluation results are given for a period of six years (years 1995 to 2000), mostly as site values in form of sums or averages of unit values. Only the values for the systems inoperability are given on the system level and the tightness of the barriers on the unit level.

Input data for this evaluation were drawn from the materials provided by the operator, as each year:

- Dukovany NPP operation basic indicators,
- Dukovany NPP failure commission meeting minutes,
- Limits and conditions database,
- Liquid and gaseous effluents reports,
- Primary circuit activity measurements data,
- Collective effective dose spending overview,

and further also from site nuclear safety inspectors monthly reports and protocols and from protocols of events investigations.

In 2000 activities leading to the definition of similar set of safety indicators for Temelín are being pursued. A set of data was agreed, which will be submitted by the operator, and also data filing and acquisition by the site SÚJB workplace was started. The goal is to test it during the first fuel campaign in the unit 1 and to evaluate the year 2001.

1. RESULTS OF THE SAFETY INDICATORS PACKAGE EVALUATION FOR THE DUKOVANY NPP

The years 1999 and 2000 were exceptional, as in most areas best values in the EDU operation history were reached and often the values, which can even never be improved.

Below, evaluation of individual areas of the NPP operation under examination is given, whilst graphic presentation of the indicators is given in the appendix.

1.1 Significant events

The final value for the indicators „Number of INES events ≥ 1“ (Fig. 1.) and „Unscheduled reactor trips (HO-1)“ (Fig. 2.) is one. Continuously increasing operation times of the unit 1 without unscheduled trip is to be noted. In the year 2000 the unit has completed already the ninth year of operation without HO-1. Unit values for both indicators are given in the Figures 1.a) and 2.a).

The results of the indicators „Automatic reactor output reduction initiated by the HO protection type 2 to 4“ are given in the Fig. 3 and the total number of control assemblies drops is given in the Fig. 4.

Indicators „Number of Limits & conditions violations“ (Fig. 5.) and „Number of temporary changes of the Limits & conditions“ (Fig. 6.) have also reached the value one in 2000.

1.2 Human factor

Total number of human errors causing INES events ≥ 1, their percentage of all INES ≥ 1 events, and unit values are given in the figures 7., 7.a) and 7.b).

1.3 Safety systems operation

The area is followed using three main indicators „Safety system unavailability“ (SSU). „Number of SS failures at start-up“, and „ Number of SS failures during operation”.

Site value of the „Safety system unavailability“ (SSU - Fig. 8.) decreased further in 2000 by about 11% compared to the value of the year 1999 so that it is one third of the value of the year 1997, where its abrupt decrease has started. Here it is to be noted that at the beginning of the evaluation, in 1991, the site value of the SSU was 0.01474, this value being almost 10 times higher than the value in the year 2000 (0.00150). The SSU site value decrease is based on a further decrease of most system values for the systems under evaluation (Fig. 8.1 – 7).

The diesel generators (DG) represent an exception, where after years of continuous unavailability value decrease, which started in 1993 from the value of 0.00570, a slight increase of the indicator value occurred in 1999, and in the last year the value has increased stepwise to the value of 0.00461. This deterioration is caused by the ongoing and already partly finished reconstruction of the I&C in these DGs and by the reconstructions carried out in the important service water system.

Emergency and super-emergency SG feeding systems have reached very low unavailability values, at a level of hydroaccumulators passive system.

DG, TJ, TH, and TQ systems failure during the start-up is given in the Fig. 9 and 9 a).

In general, the behavior of the systems in operation is followed using the indicator „DG, TJ, TH and TQ in operation“ (Fig. 10 and 10 a). In the long term no failures of any safety system in operation are filed.

1.4 Tightness of the barriers

The nuclear fuel condition is followed using the indicator „Fuel reliability indicator“ (FRI Fig. 11.). „Number of leaky (inactivated) fuel assemblies“ (Fig. 11.1). Yearly values of the FRI indicator in the units 1 and 3 are low, in the unit 4 the indicator has reached monthly values up to 14 kBq/l. During the refueling in the unit 4, two leaky fuel assemblies were identified, which were transferred to BS. In total six leaky (inactivated) fuel assemblies were unloaded into BS during the whole Dukovany NPP operation time. Mostly they are freely laid into BS, only two of them are located in hermetic enclosures (HP) and only one HP is closed. The indicator "PERIZ results" evaluate the tightness condition of the last barrier – the hermetic rooms (Fig. 12)

1.5 Radiation protection

The indicator „Collective effective dose“ follows the collective effective dose of the JE staff, suppliers and visits per unit. In the year 1999 the operator has performed a change in the collective effective dose filing, where the dose loads lower than 0.1 mSv are neglected and therefore the values are given in accordance with the old methodology in the Fig. 13, and in the Fig. 13.a) the values in accordance with the new methodology. In the year 2000 there was the lowest dose load since 1991.

Additionally the collective effective rate (using values form the Fig. 13.) was expressed in relation to the produced net energy in the indicator „Specific collective effective dose“ (Fig. 13.b).

The indicators „Activity of the liquid effluents from the Dukovany NPP“ and „Activity of the gaseous effluents from the Dukovany NPP“ in the individual charts (14.1-2 and 15.1-3) cover values of the effluents of individual radioactive substances in relation to yearly limit values. Increased values of the iodine activity in the years 1996, 1998 and 2000 are related to the fuel leakage in the units 1 and 4. The same applies also for the rare gases in the year 2000. In 1997 several so-called hot particles were found on the filters in the ventilation chimneys, which has resulted in an aerosol effluents activity increase. All values are, nevertheless, deeply below the limit values for the effluents.

1.6 Miscellaneous

„Unscheduled reactor power reductions factor“ (UCLF, Fig. 16.), using which the so-called technical failure rate of the units is followed has reached the lowest value in the operational history of the Dukovany NPP.

3. CONCLUSION

In the years 1999 and 2000 the NPP Dukovany has reached the best results in the period of safety indicators evaluation (since 1991) and even in the whole period of operation.

Evaluation of the individual selected areas of operation in the Dukovany NPP using the set of safety indicators confirms the safety of the Dukovany NPP with respect to the performed summary of results. Further good results were reached in the area „Significant events“ in the availability of the most safety systems, in the effluents of radioactive substances and in the protection of the staff against the ionizing radiation.

Results of the safety indicators evaluation in 2000

1. Significant events

1. Number of INES ≥ 1 events

The indicator is defined as the number of safety relevant events classified in the respective degree of the international INES scale in the given period of time.

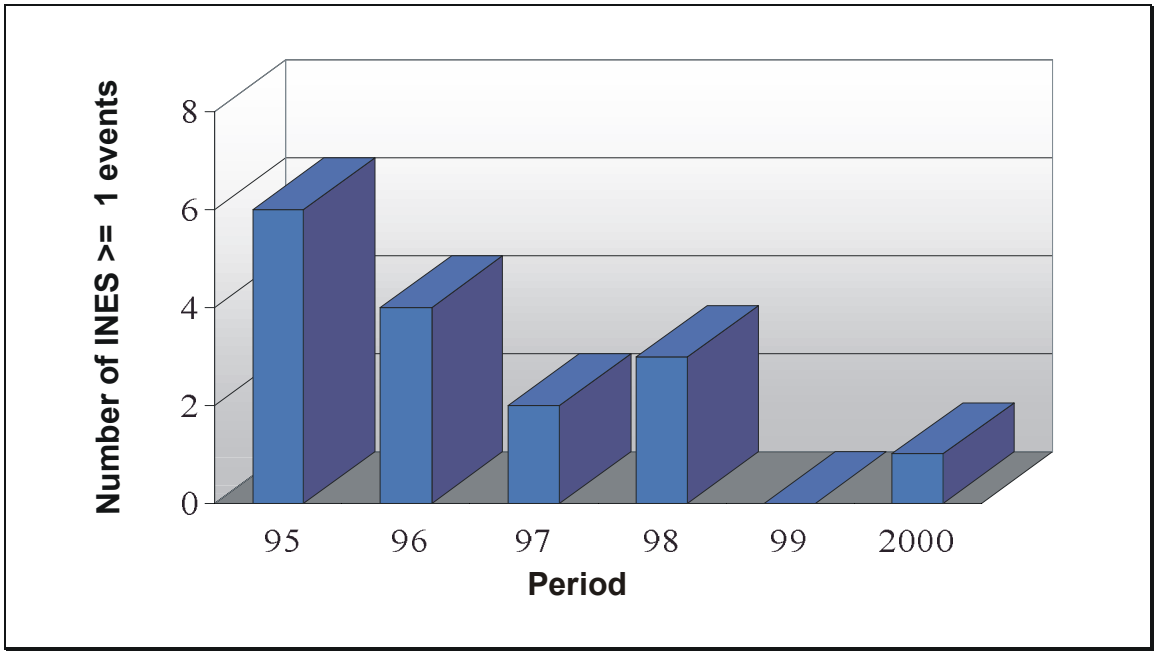

Fig. 1. Number of INES ≥ 1 events

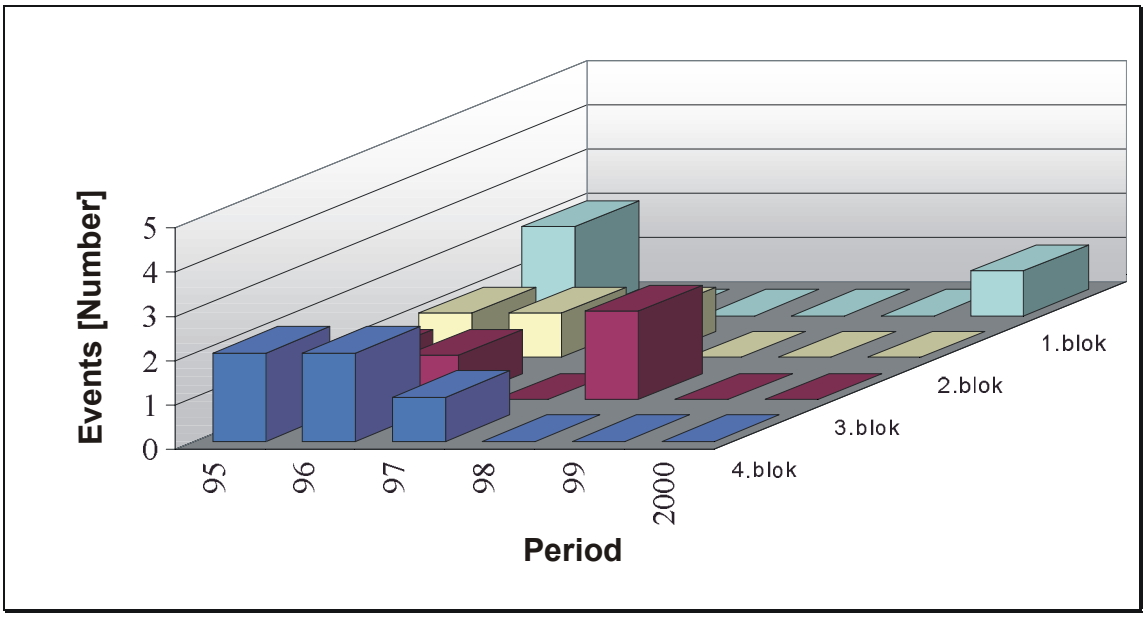

Fig. 1.a) Number of events INES ≥ 1 – unit values (*blok = unit*)

2. Unscheduled reactor trips (HO-1)

The indicator is given by the number of unscheduled reactor trips (reactor in the MODE 1 or 2). Unscheduled means that the trip was not an expected part of a scheduled test. Values for manual trip and automatic actions are given separately.

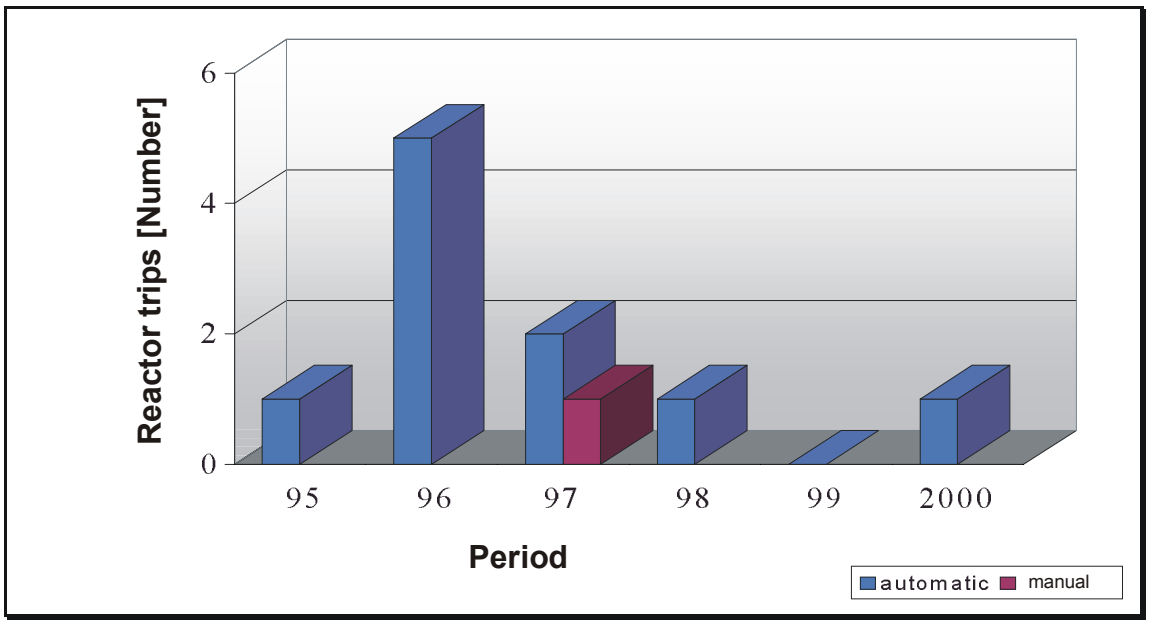

Fig. 2. Unscheduled reactor trips

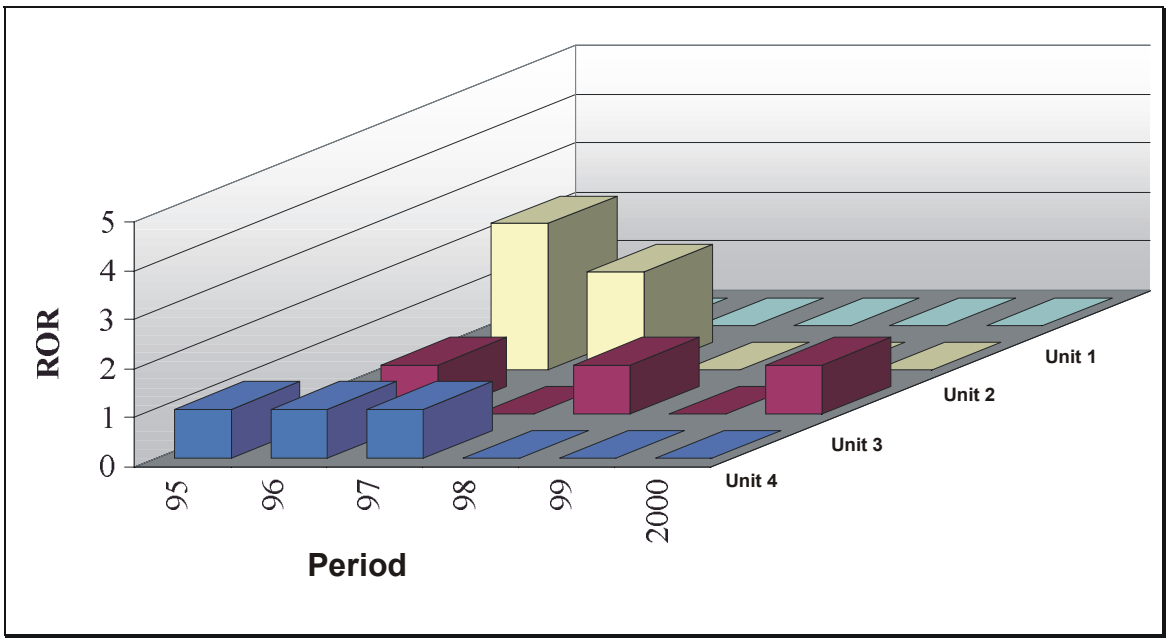

Fig. 2.a) Unscheduled reactor trips – unit values

3. Automatic reactor outputs reductions (HO of type 2 through 4)

The indicator is given by the number of automatic output reductions by action of the correspondent reactor protection.

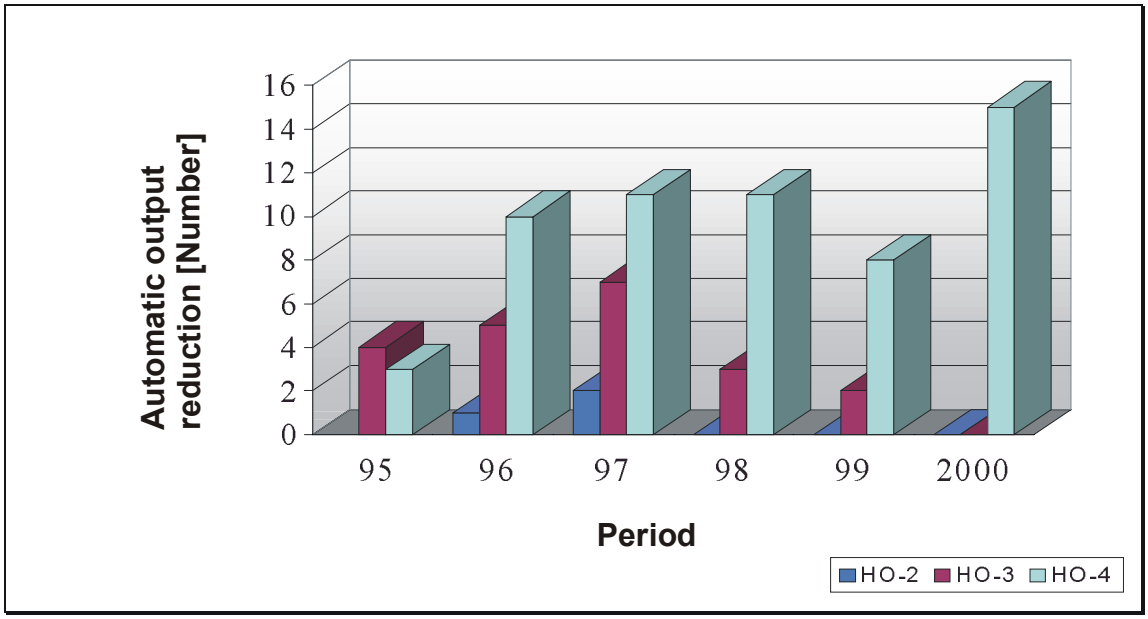

Fig. 3 Automatic rector output reductions

Fig. 4 Number of control assemblies drops

The indicator is given by the number of control assemblies drops in the whole NPP.

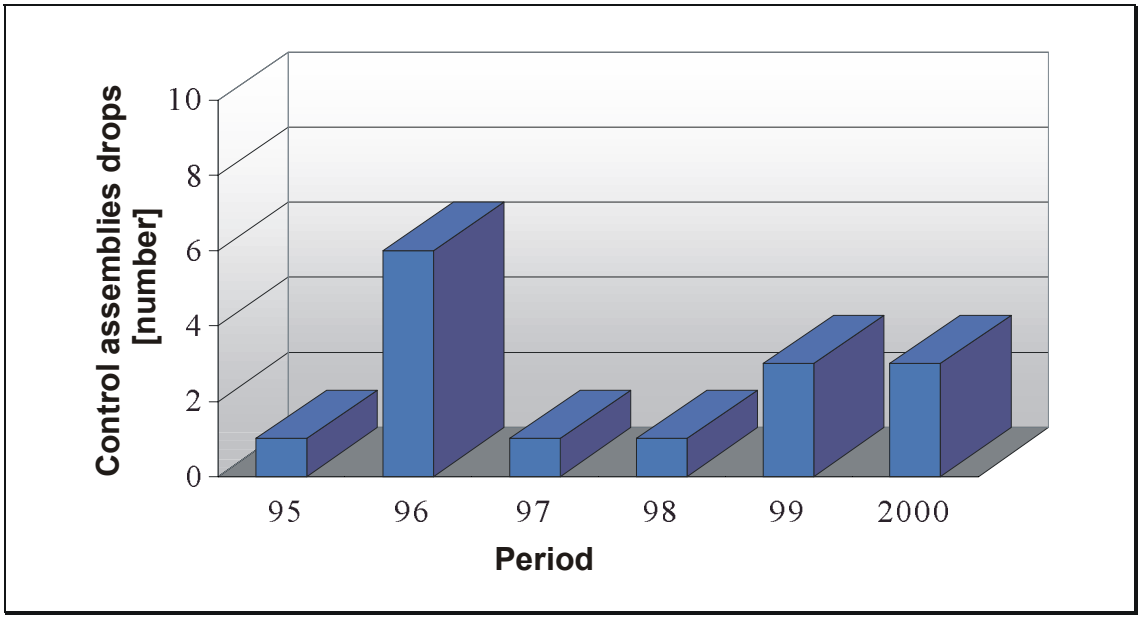

Fig. 4 Number of control assemblies drops

5. Limits & Conditions violations

The indicator is given as the number of Limits & Conditions violations, discovered by the regulatory body or reported to the regulatory body by the plant operator.

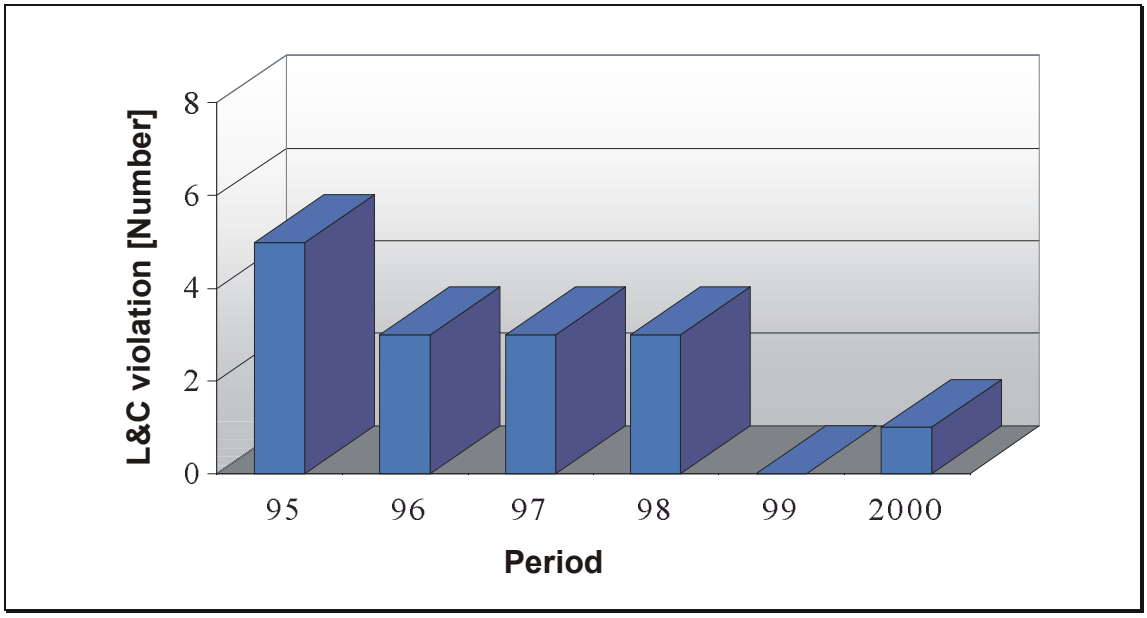

Fig. 5. Number of Technical specifications violations

6. Number of temporary changes of Limits & conditions

The indicator is defined as the number of temporary modifications of Limits & conditions, used in the NPP operation, but also of those ones, which were required, approved by the regulatory body, but not used.

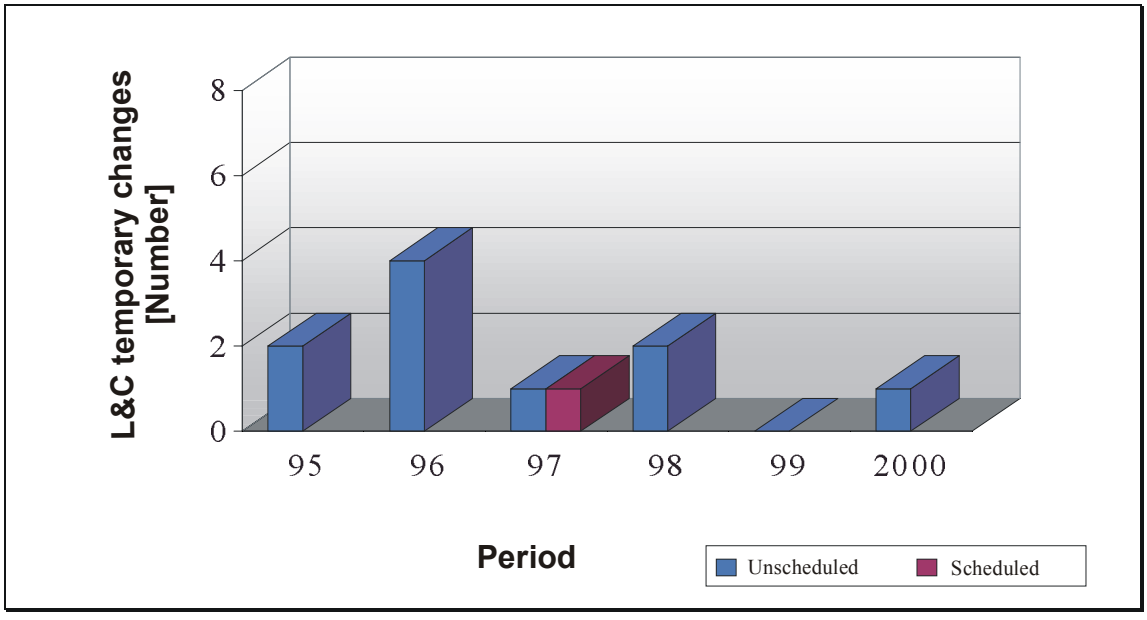

Fig. 6. Number of temporary changes of Limits & Conditions

2. Human Factor

7. Number of human errors INES ≥ 1

This indicator indicates how many INES events greater than one were caused by the human factor error.

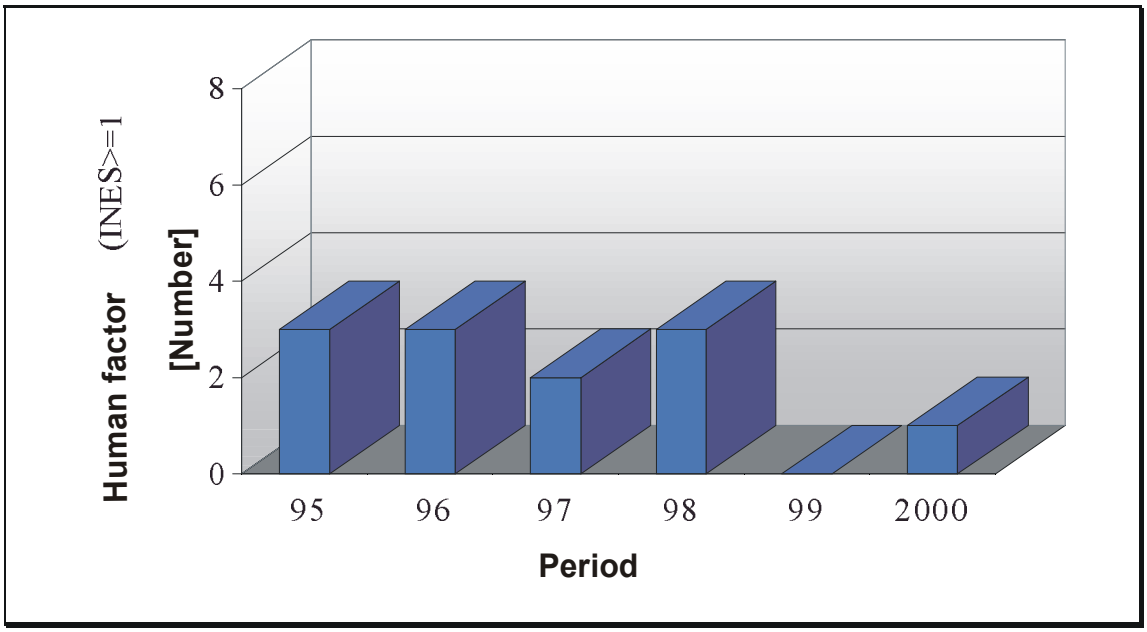

Fig. 7. Number of human errors INES ≥ 1

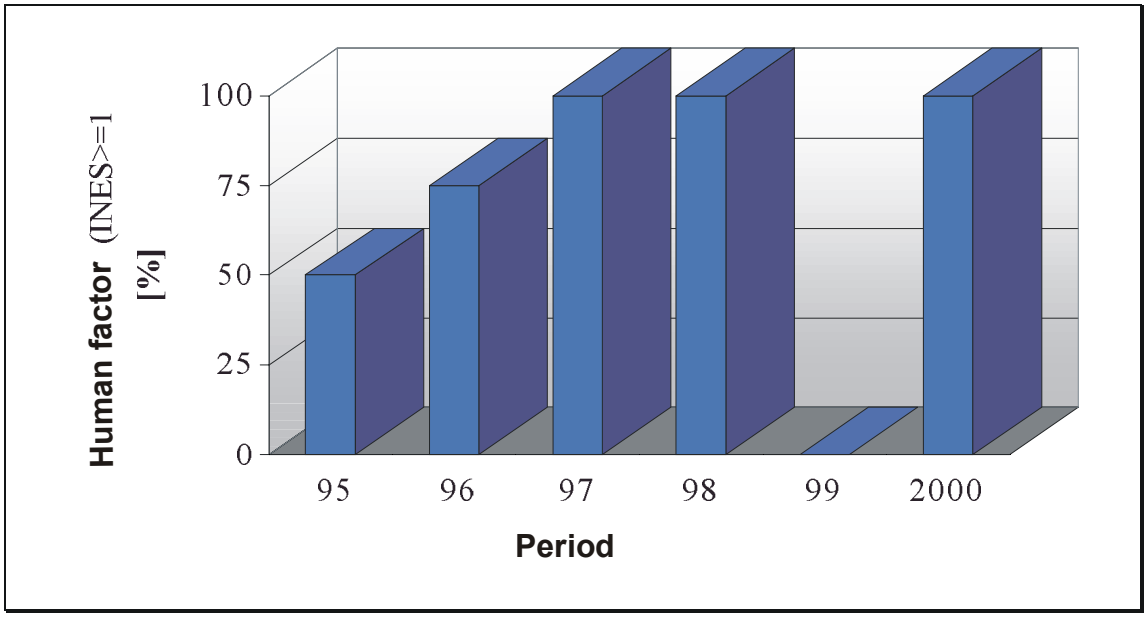

Fig. 7.a) Number of human errors INES ≥ 1 in relation to the total number of INES ≥ 1 events

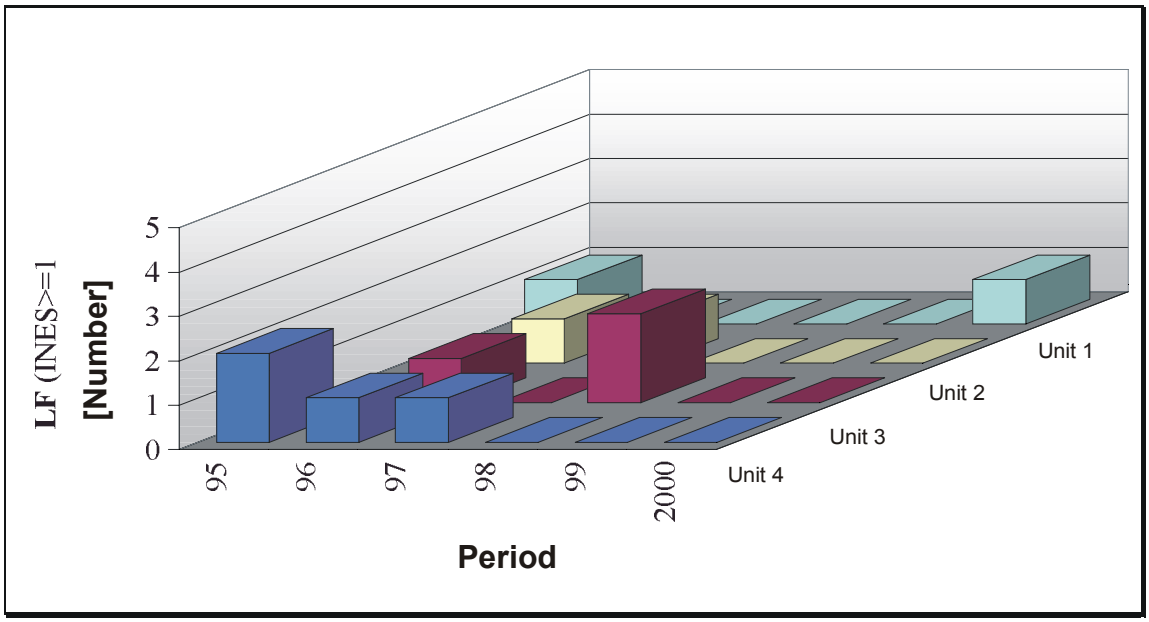

Fig. 7.b Number of human errors INES ≥ 1 – unit values

3. Safety systems operation

Availability of these safety systems is followed using the following safety systems:

- Diesel generators	**DG**
- High pressure emergency core make-up system	**TJ**
- Low pressure emergency core make-up system	**TH**
- Spraying system	**TQ**
- Hydroaccumulators	**HA**
- Steam generators emergency feeding system	**HN PG**
- Steam generators super emergency feeding system	**SHN PG**

and failure at start-up and during operation of DG, TJ, TH and TQ.

8. Unavailability of the safety systems = SSU =

The indicator is defined as the ratio of the cumulative unavailability duration of the individual safety systems and the total time, when their availability was required in one safety system train. Site value is given by the average value of the individual system values.

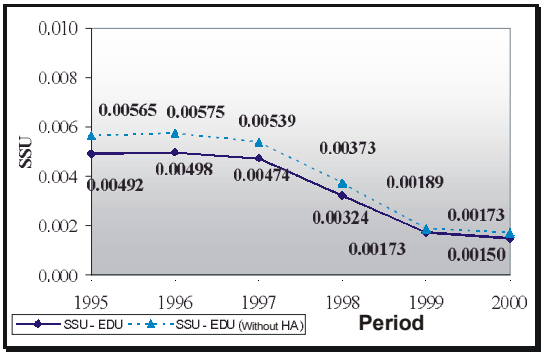

Fig. 8. SS unavailability site value

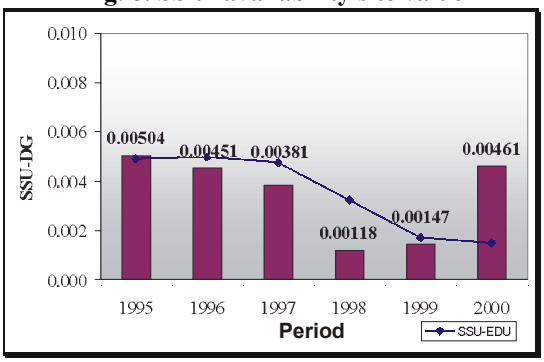

Fig. 8.1 DG Unavailability

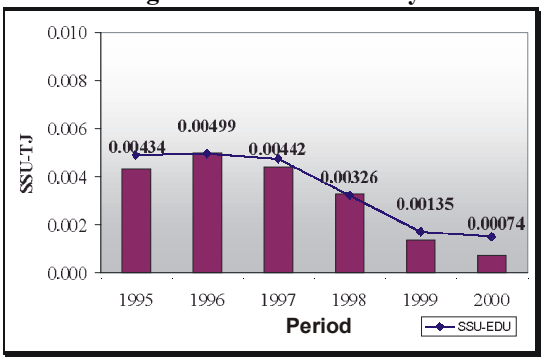

Fig. 8.2 TJ unavailability

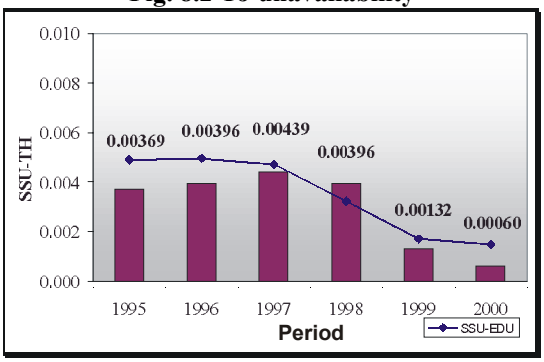

Fig. 8.3 TH unavailability

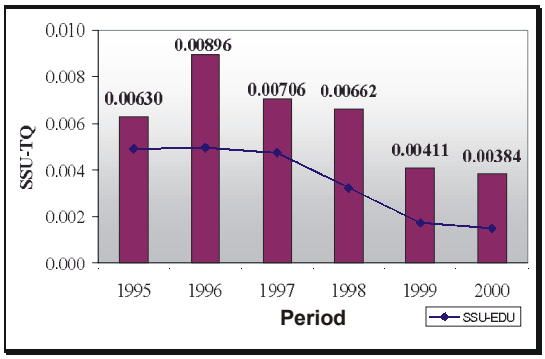

Fig. 8.4 TQ unavailability

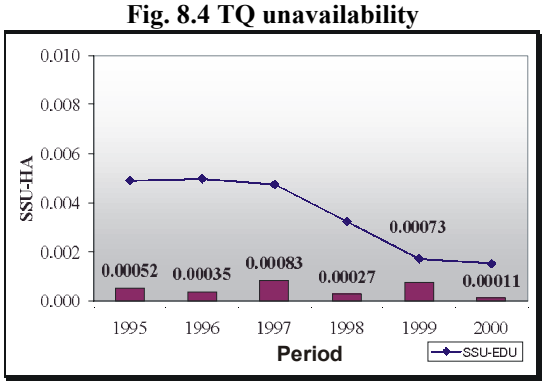

Fig. 8.5 HA unavailability

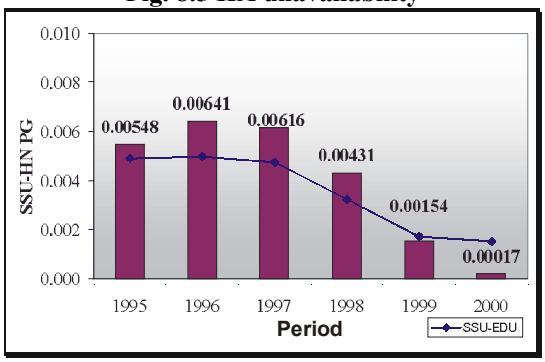

Fig. 8.6 HN PG unavailability

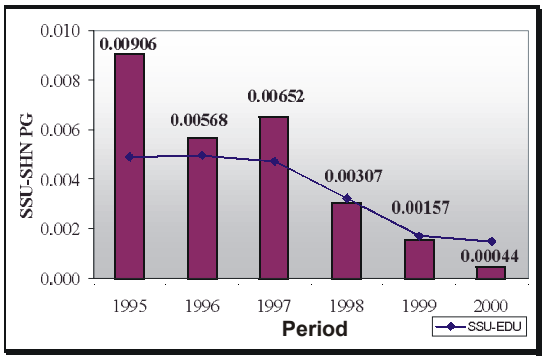

Fig. 8.7 SHN PG unavailability

9. DG, TJ, TH, and TQ failure at start-up

The indicator is defined as the number of states, in which the corresponding system or unit does not reach operational characteristics, or its shutdown occurs within 30 minutes after its start-up.

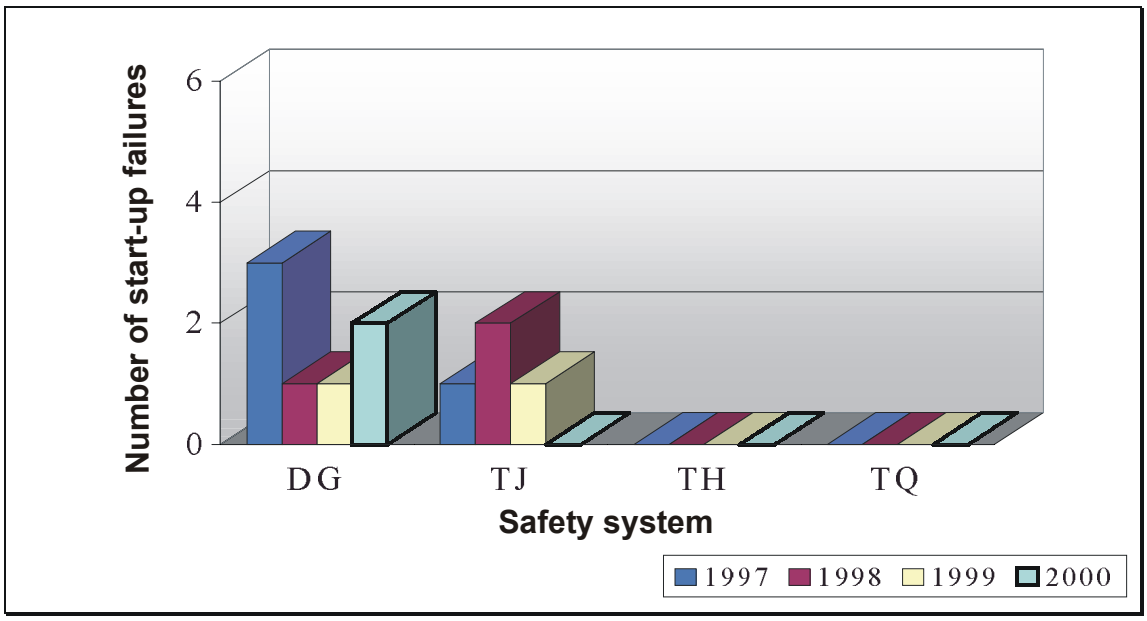

Fig. 9. SS failures at start-up

It is also possible to express it as the ratio of the number of failures to the total number of safety systems in the given period (so-called unreliability at start-up).

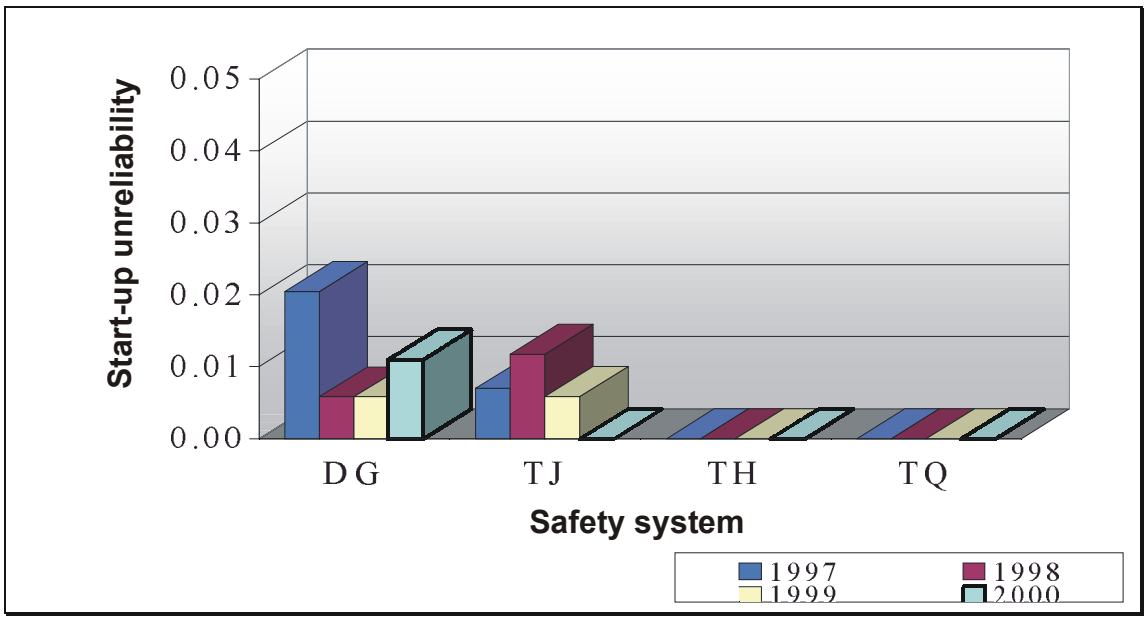

Fig. 9.a) Safety systems start-up unreliability

10. DG, TJ, TH, and TQ in operation

The indicator is defined as the number of states, in which the corresponding system, drive, or unit is tripped at normal operating characteristics for the time longer than 30 minutes after its start-up. It is also given as the ratio of the total failures and the total number of hours of operation, when its availability is required.

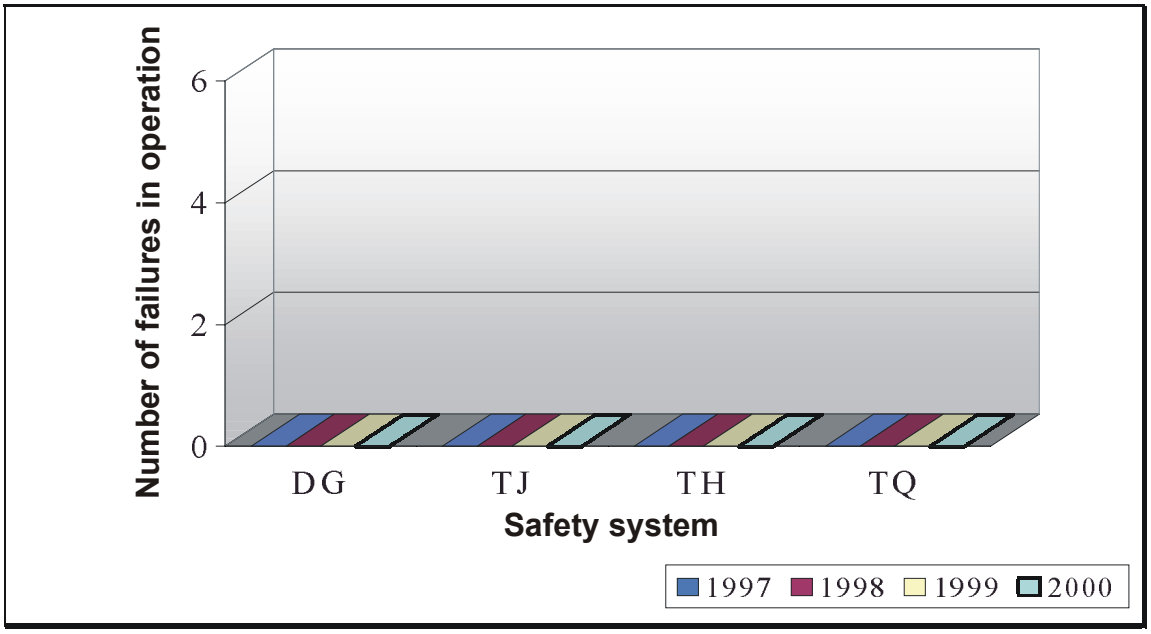

Fig. 10. Number of SS failures in operation

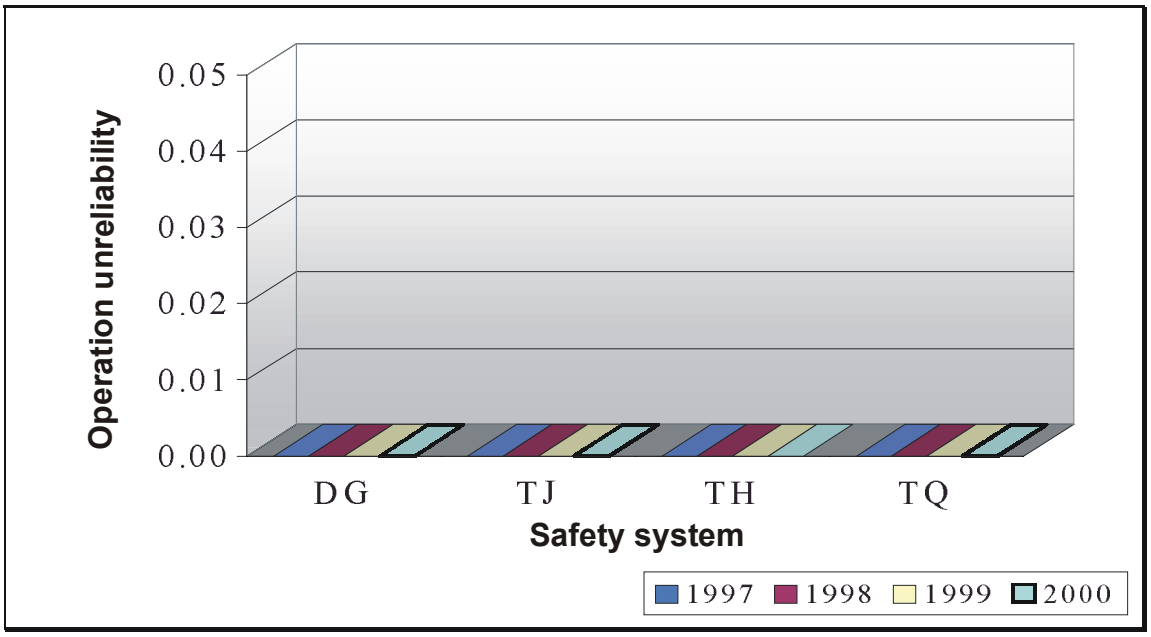

Fig. 10.a) SS operation unreliability

4. Tightness of barriers

11. Fuel reliability = FRI =

The indicator is defined as the steady state activity of the primary circuit given by the activity of ^{131}I and corrected by uranium contribution and normalized by the fuel purification speed.

The steady state is defined as continuous operation at the given output level with deviations ± 5% for a period of time of at least three days.

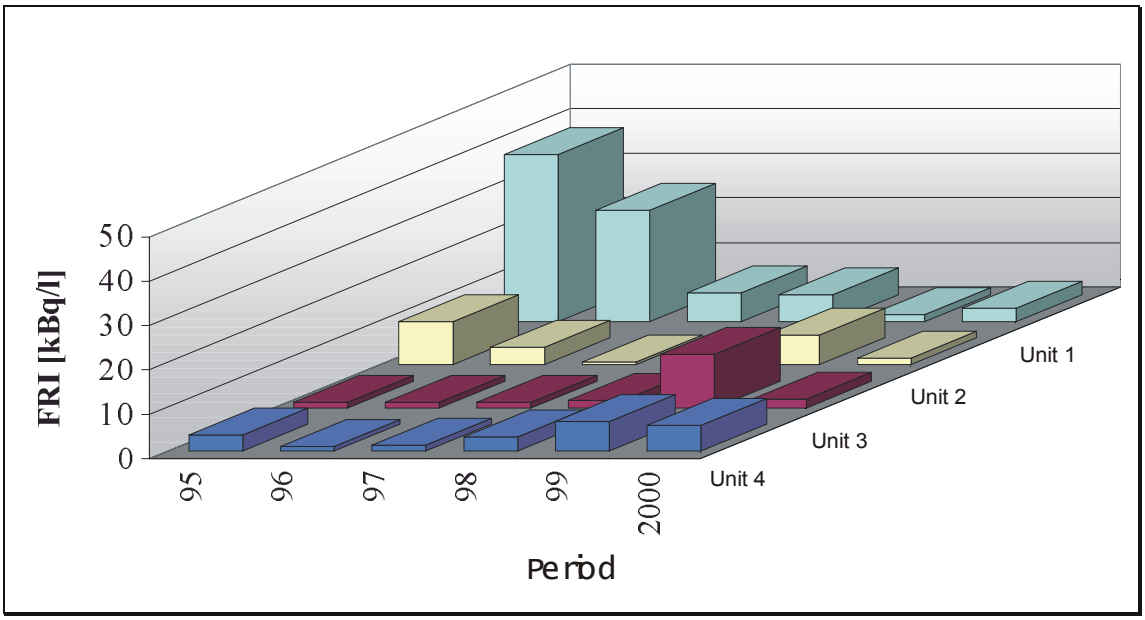

Fig. 11. Fuel reliability

11.1 Number of leaky (inactivated) fuel assemblies

The indicator is given by the number of fuel assemblies, which had to be put out of operation for their unacceptable leakage.

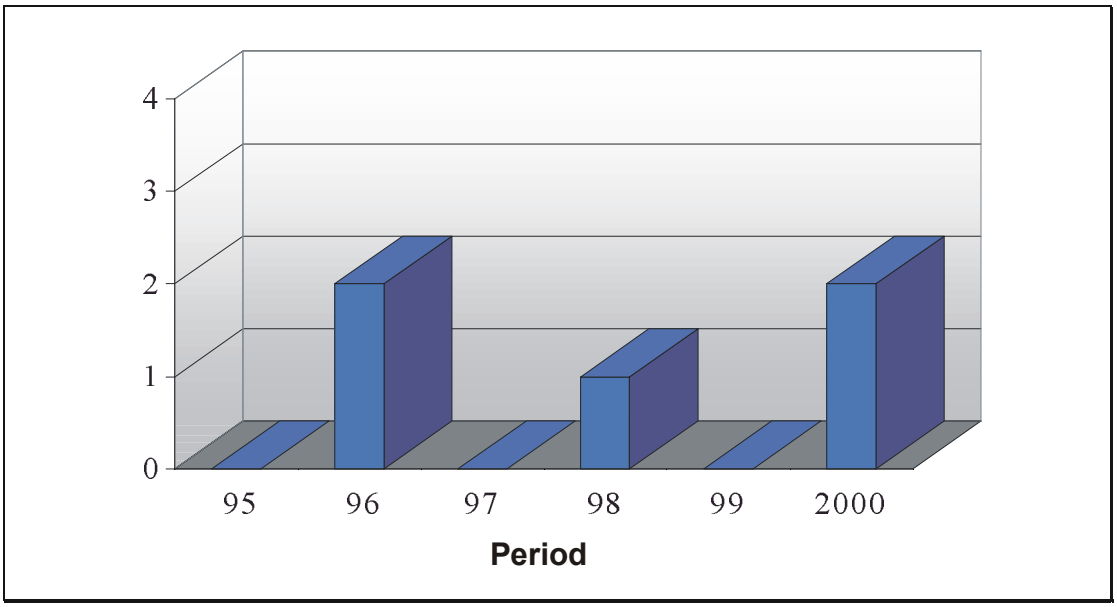

Fig. 11.1 Number of leaky (inactivated) fuel assemblies

12. PERIZ units results

In this indicator, results of the tightness tests of the hermetic rooms performed using the overpressure of 150 kPa for 24 hours are filed. For tests at lower pressure and shorter duration extrapolated results are included.

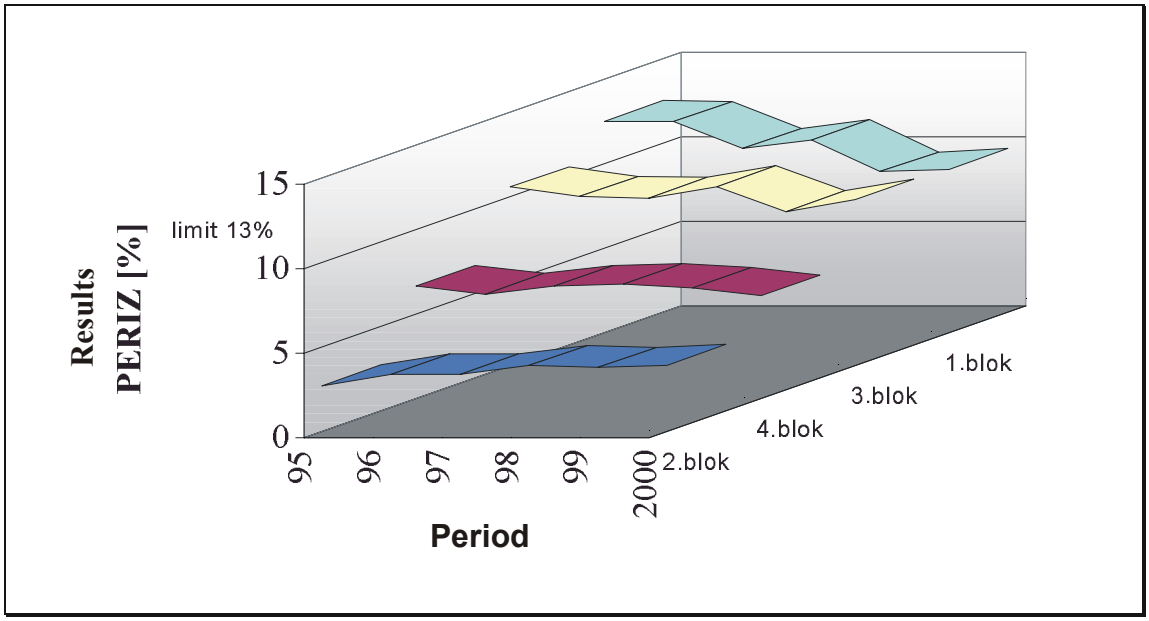

Fig. 12. PERIZ results for the units

5. Radiation protection

13. Collective effective dose (KED)

Collective effective dose is the total external whole-body dose incurred by the NPP personnel (including the suppliers and visitors) during the period of observation, measured with film dosimeters, expressed as value per unit.

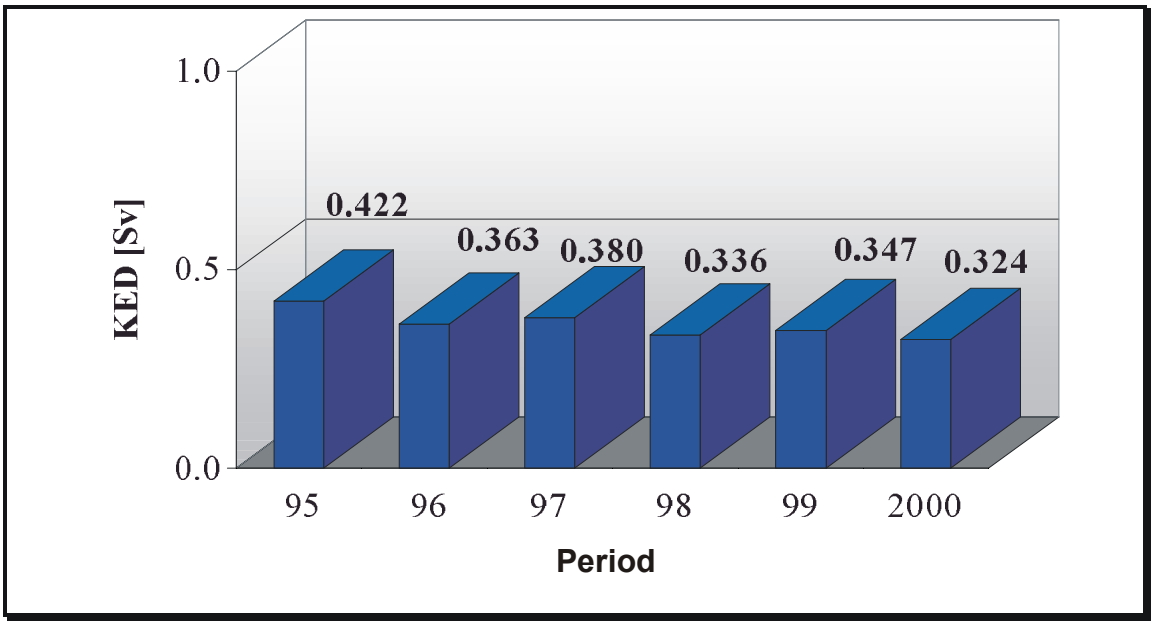

Fig. 13. Collective effective dose

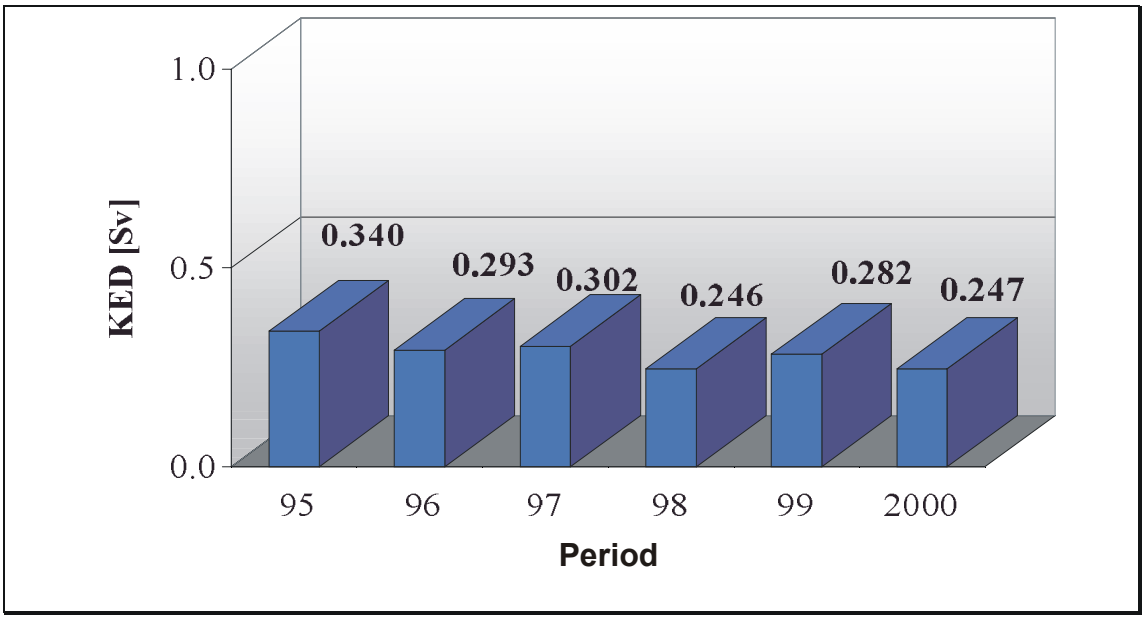

Fig. 13.a) Collective effective dose (records > 0.1 mSv)

13.b) Specific collective effective dose (KEDM)

Specific collective effective dose is the total external whole-body dose incurred by the NPP personnel (including the suppliers and visitors) during the period of observation, measured with film dosimeters, expressed as value per produced net energy output.

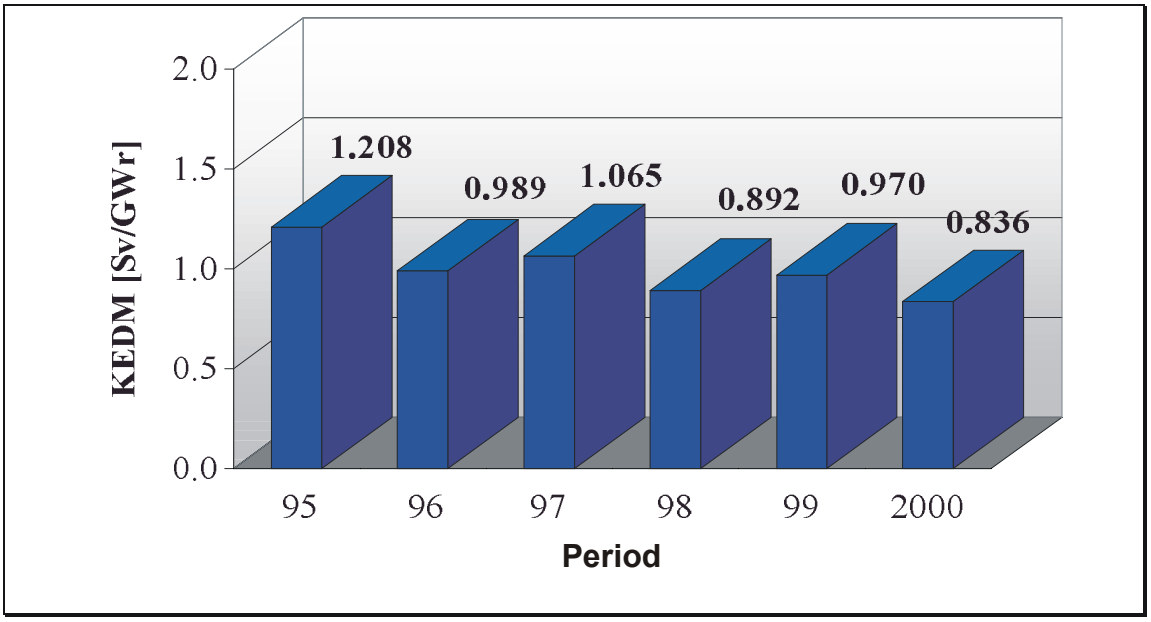

Fig. 13.b) Specific collective effective dose (KEDM)

14. Activity of Liquid effluents from EDU

Activity of the liquid effluents is the summary value of activation and fission products and tritium, released into watercourses. It is expressed as ratio to limit values.

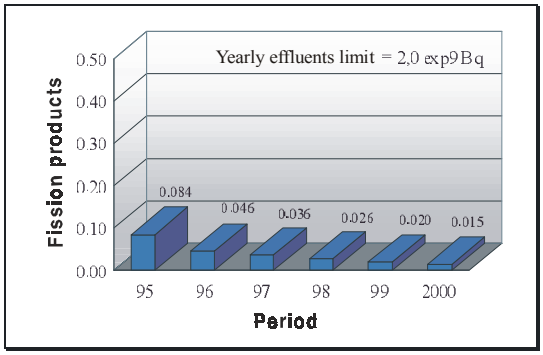

Fig. 14.1 Fission products activity

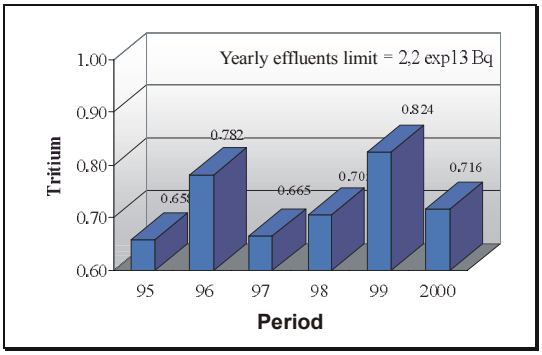

Fig. 14.2 Tritium activity

15. Activity of gaseous effluents from EDU

Activity of gaseous effluents is a summary activity value of three basic radioactive substances, released into atmosphere. It is expressed as ratio to limit values.

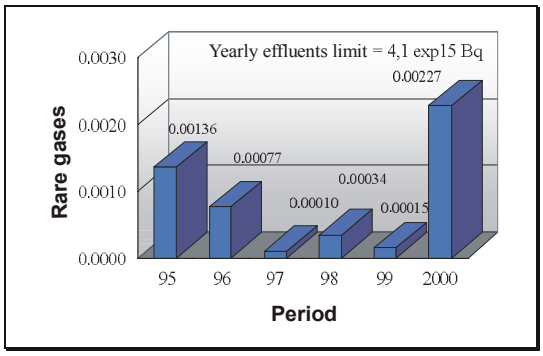

Fig. 15.1 Rare gases activity

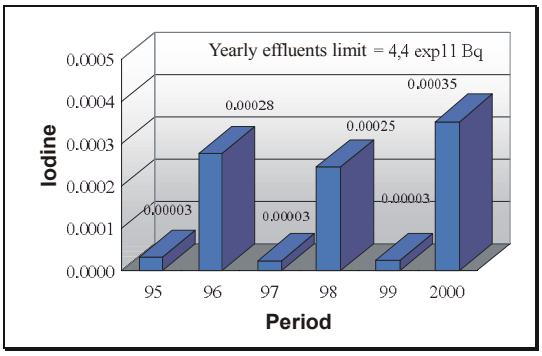

Fig. 15.2 Iodine activity

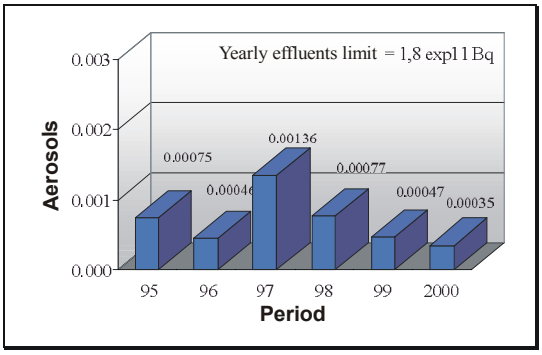

Fig.15.3 Aerosols activity

6. Miscellaneous

16. Unscheduled output reductions factor

The indicator is defined as the ratio of average unscheduled output reductions value (technical failure rate) and the reference output at the given period of time.

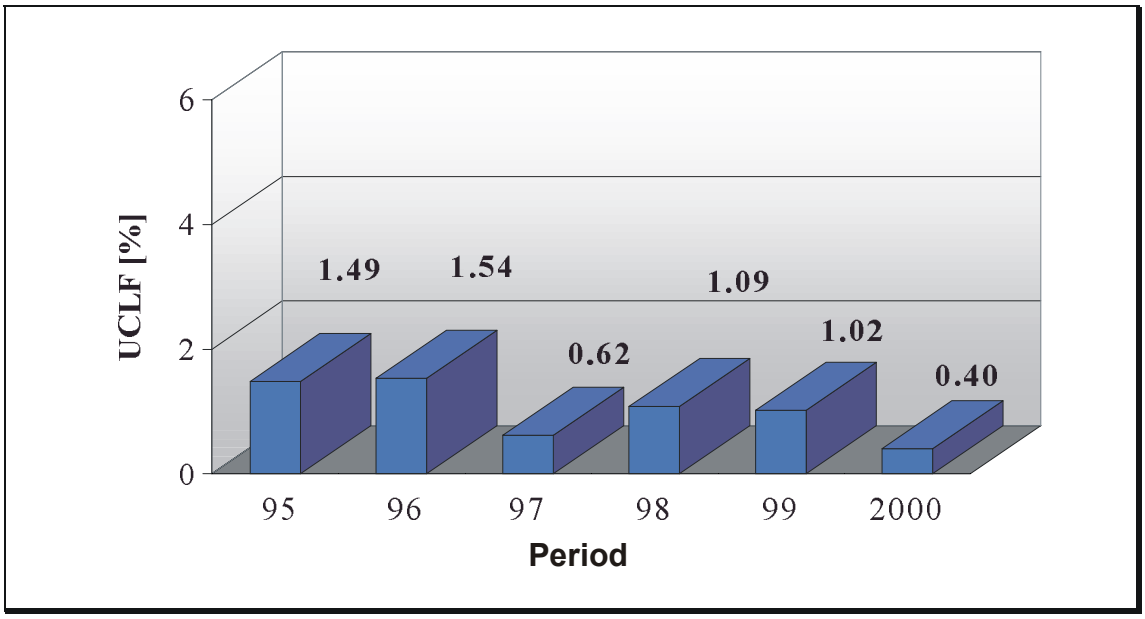

Fig. 16. Unscheduled output reductions factor