CSNI Report 147

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NEA

SYSTEMATIC COLLECTION OF STATISTICAL DATA ON REACTOR SCRAMS

Prepared by the CSNI PWG 1
Operating Experiences and Human Factors

APRIL 1988

COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS
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The NEA Committee on the Safety of Nuclear Installations (CSNI) is an international committee made up of scientists and engineers who have responsibilities for nuclear safety research and nuclear licensing. The Committee was set up in 1973 to develop and co-ordinate the Nuclear Energy Agency's work in nuclear safety matters, replacing the former Committee on Reactor Safety Technology (CREST) with its more limited scope.

The Committee's purpose is to foster international co-operation in nuclear safety amongst the OECD Member countries. This is done in a number of ways. Full use is made of the traditional methods of co-operation, such as information exchanges, establishment of working groups, and organisation of conferences. Some of these arrangements are of immediate benefit to Member countries, for example by enriching the data base available to national regulatory authorities and to the scientific community at large. Other questions may be taken up by the Committee itself with the aim of achieving an international consensus wherever possible. The traditional approach to co-operation is increasingly being reinforced by the creation of co-operative (international) research projects, such as PISC and LOFT, and by a novel form of collaboration known as the international standard problem exercise, for testing the performance of computer codes, test methods, etc. used in safety assessments. These exercises are now being conducted in most sectors of the nuclear safety programme.

The greater part of the CSNI co-operative programme is concerned with safety technology for water reactors. The principal areas covered are operating experience and the human factor, reactor system response during abnormal transients, various aspects of primary circuit integrity, the phenomenology of radioactive releases in reactor accidents, and risk assessment. The Committee also studies the safety of the fuel cycle, conducts periodic surveys of reactor safety research programmes and operates an international mechanism for exchanging reports on power plant incidents.

The Committee has set up a sub-Committee on Licensing which examines a variety of nuclear regulatory problems, provides a forum for the free discussion of licensing questions and reviews the regulatory impact of the conclusions reached by CSNI.

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FOREWARD

A reactor scram can be defined as a manual or automatic actuation of the Reactor Protection System resulting in the most rapid possible insertion of the control rods. In spite of its vital importance as a safety function to bring the plant to a safe and stable condition in case of an emergency, negative side effects of too frequent scrams on plant operations have been a matter of concern for OECD Member countries. Reactor scrams not only challenge the safety systems but also result in undesirable thermal and hydraulic transients and in general are indicative of deficiencies in the operation of the plant. At the same time, unplanned shutdowns of reactors have considerable economical implications for electrical utilities.

Since reactor scrams create a fertile environment for operator error and equipment malfunctions, systematic collection and periodic review of scram records will provide Member countries with a clue to evaluating the safety and reliability of plant operations. By updating the information on a yearly basis, the evolution of scram frequencies can be monitored from various viewpoints, such as type of scram, scram signal, scram context, root cause, initiating system, etc. The scram frequency will thus serve as a performance indicator of the plant, and the information stored in the data base will help regulatory bodies and electrical utilities in promoting their scram reduction programmes.

At the NEA Symposium on Reducing Reactor Scram Frequency held in Tokyo from 14th to 18th April 1986, it was recommended that the collection of statistical data on reactor scrams be continued and updated on a regular basis. PWG 1 delegates discussed this recommendation at their fifth meeting held from 22nd to 24th September 1986. The Committee endorsed the PWG 1 proposal regarding the systematic collection of statistical data on reactor scrams on an annual basis. Following this initiative, efforts have been made to compile the statistical data on reactor scram of 1986.

The next report on data of 1987 will be published during 1989.

QUESTIONNAIRE

1. Objective

Since reactor scrams create a fertile environment for operator error and equipment malfunctions, systematic collection and periodic review of scram records will provide Member countries with a clue to evaluating the safety and reliability of plant operations. By updating the information on a yearly basis, the evolution of scram frequencies can be monitored from various viewpoints, such as type of scram, scram signal, scram context, root cause, initiating system, etc. The scram frequency will thus serve as a performance indicator of the plant, and the information stored in the data base will help regulatory bodies and electrical utilities in promoting their scram reduction programmes.

2. Definition of a Reactor Scram to be Considered

(1) A reactor scram is defined as a manual or automatic actuation of the reactor protection system (RPS) resulting in the most rapid possible insertion of the control rods.

(2) Actuation of the reactor protection system which does not result in any rod motion (e.g. while the reactor is defuelled) is not to be regarded as a reactor scram.

(3) Pre-planned reactor scrams such as plant shutdowns for periodic inspection or refuelling are not to be considered in the statistics.

(4) Only the reactor scrams after the first grid connection are to be included in the statistics.

(5) The statistics should only include the reactor scrams taking place while the reactor is critical and the turbine is on-line**. Therefore, the reactor scrams while the reactor is sub-critical or the turbine is off-line are not to be considered.

3. Plant Types to be Covered

This initiative is intended to cover all types of thermal reactors with more than 100 MWe of net electrical power.

4. Information to be Collected

Once a year Member countries will be invited to contribute the following information for those plants in operation according to the form attached as Tables 1 to 5. Distinction should be made between plant types (e.g. PWR, BWR, GCR, AGR, PHWR, etc.). Breakdowns by specific plant design (e.g. number of loops, power rating, plant vendors etc.) and operating utility are also desirable whenever possible.

(1) Evolution of Reactor Scram Frequency (Table 1)

The scram frequencies during the last three years are to be tabulated for respective calendar years. They should be stated in terms of the number of scrams per reactor* and per 1000 hours in which the reactor is critical and the turbine is on line.

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* The number of reactors in operation at the end of the calendar year should be used in calculating the number of scrams per reactor.

** "Generator on the grid" can be regarded as having the same meaning as "turbine on line".

(2) Main Signals Resulting in a Reactor Scram (Table 2)

The scram frequencies should be classified in the following categories according to the types of main signals which caused a reactor scram; they should be stated in a percentage of the total scram frequency in the plant concerned.

(a) Turbine trip.
(b) Other secondary-side signals (not applicable for BWRs).
(c) Primary-side signals (including those from the reactor itself).
(d) Manual scrams.
(e) Other signals (i.e. earthquakes, under-voltage of emergency buses, etc.).

(3) Initiating System (Table 3)

The scram frequencies should be sorted according to the following categories of the plant system in which the root cause of the scram occurred; they should be stated in a percentage of the total scram frequency in the plant concerned.

(a) Condensate/Feedwater System -- (i.e. condensate and feedwater pumps, piping, valves; flow, temperature, pressures, and tank-level instruments; flow control equipment).

(b) Turbine System -- (i.e. turbine piping and valves, electro-hydraulic control (EHC) system, turbine components such as bearings, blades, etc.).

(c) Reactor Coolant System -- (i.e. reactor coolant pumps; recirculating pumps; flow/temperature/pressure/level or other related instruments.

(d) Electrical Systems -- (i.e. transformers, DC power supplies, emergency power supplies and buses, 125-VAC instrument buses).

(e) Reactor Control and Protection System - (i.e. controls; in-core/ex-core detectors; control rod drive assemblies, etc. various input channels monitoring plant processes, signal processing and logic circuitry, etc. Does not include reactor trip breakers).

(f) Main Steam System -- (i.e. steam piping; valves; flow, temperature and pressure instruments; moisture separator/reheaters (MSR); steam drains and relief valves).

(g) Generator -- (i.e. cooling systems; instruments; controls and major components such as excitor, rotor, stator, bearings, etc.).

(h) Others

N.B. Certain scrams can be counted under different items wherever applicable, in which case the total percentage exceeds 100 per cent.

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* The number of reactors in operation at the end of the calendar year should be used in calculating the number of scrams per reactor.

(4) Main Causes (Table 4)

The scram frequencies should be classified according to the following categories. They should be stated as a percentage of the total scram frequency in the plant concerned:

a) due to component failure;
b) due to human error;
c) involving both component failure and human error
d) due to procedural deficiency
e) other cause.

N.B. Certain scrams can be counted under different categories wherever applicable, in which case the total percentage exceeds 100 per cent.

(5) Operational Modes (Table 5)

The scram frequencies should be classified in the following categories according to the plant operational modes when the reactor scrams occurred:

a) during rated power operation
b) during increase to or reduction from rated power operation
c) during surveillance test or periodic inspection
d) other operational modes (i.e. trouble shooting, calibration, maintenance, etc.).

N.B. Certain scrams can be counted under different categories wherever applicable, in which case the total percentage exceeds 100 per cent.

(6) Operational Records (Table 6)

In order to help interpret the differences in scram frequencies, the following information should be provided for individual plants considered:

(a) Total number of hours in which the reactor is critical and the turbine is on line during the calendar year;

(b) Date of first reactor criticality.

5. Data Base

The information contributed in response to the questionnaire will be stored on a computer file at the NEA Data Bank at Saclay near Paris. By request through the NEA-IRS Co-ordinators the contents of the data base will be made available to Member countries in the form of a magnetic tape or through an on-line telephone link, bearing in mind that the information is to be used for official purposes only.

6. Publication

The information collected will be compiled as a restricted report once a year by the NEA and distributed to Member countries. It is preferable that the results of the review of general trends in scram frequencies be included in the report. PWG 1 should discuss such a report before it is published for wider distribution.

TABLES

TABLE 1: EVOLUTION OF REACTOR SCRAM FREQUENCY IN OECD COUNTRIES (1984 - 1986)

Country	Plant Type	1984			1985			1986		
		No. of* Reactors	Scrams per Reactor	Scrams per 1000 critical and turbine on-line hours	No. of* Reactors	Scrams per Reactor	Scrams per 1000 critical and turbine on-line hours	No. of* Reactors	Scrams per Reactor	Scrams per 1000 critical and turbine on-line hours
Belgium	PWR total									
	Doel									
	Tihange									
Canada	PHWR total									
	Pickering A									
	Pickering B									
	Bruce A									
	Bruce B									
	Gentilly 2									
	Pt. Lepreau									
Finland	PWR									
	BWR									
France	PWR total									
	900 MWe									
	1300 MWe									
	GCR									
F.R. of Germany	PWR									
	BWR									
Italy	PWR									
	BWR									
	GCR									

Japan	PWR									
	BWR									
	GCR									
	HWLWR									
Netherlands	PWR									
Spain	PWR total									
	Jose Cabrera									
	Others									
	BWR total									
	S.M. Garona									
	Others									
	GCR									
Sweden	PWR									
	BWR									
Switzerland	PWR									
	BWR									
United Kingdom	GCR total									
	CEGB									
	SSEB									
	BNFL									
	AGR total									
	CEGB									
	SSEB									
United States	PWR total									
	W.									
	C-E									
	B & W									
	BWR total									
	GE									
	AC									
	GCR									

* The number of reactors in operation at the end of the calendar year should be indicated.

TABLE 2: MAIN SIGNALS RESULTING IN REACTOR SCRAMS (1986)

(in percentage)

Country	Plant Type	Turbine Trip	Other Secondary-Side Signals	Primary-side Signals	Manual Scram	Other Signals
Belgium	PWR total					
	Doel					
	Tihange					
Canada	PHWR total					
	Pickering A					
	Pickering B					
	Bruce A					
	Bruce B					
	Gentilly 2					
	Pt. Lepreau					
Finland	PWR					
	BWR					
France	PWR total					
	900 MWe					
	1300 MWe					
	GCR					
F.R. of Germany	PWR					
	BWR					
Italy	PWR					
	BWR					
	GCR					

Japan	PWR					
	BWR					
	GCR					
	HWLWR					
Netherlands	PWR					
Spain	PWR total					
	Jose Cabrera					
	Others					
	BWR total					
	S.M. Garona					
	Others					
	GCR					
Sweden	PWR					
	BWR					
Switzerland	PWR					
	BWR					
United Kingdom	GCR total					
	CEGB					
	SSEB					
	BNFL					
	AGR total					
	CEGB					
	SSEB					
United States	PWR total					
	W.					
	C-E					
	B & W					
	BWR total					
	GE					
	AC					
	GCR					

* The number of reactors in operation at the end of the calendar year should be indicated.

TABLE 3: INITIATING SYSTEM (1986)

(in percentage)

Country	Plant Type	Condensate/ Feedwater	Turbine	Reactor Coolant	Electrical	Reactor Control & Protection	Main Steam	Generator	Others
Belgium	PWR total								
	Doel								
	Tihange								
Canada	PHWR total								
	Pickering A								
	Pickering B								
	Bruce A								
	Bruce B								
	Gentilly 2								
	Pt. Lepreau								
Finland	PWR								
	BWR								
France	PWR total								
	900 MWe								
	1300 MWe								
	GCR								
F.R. of Germany	PWR								
	BWR								
Italy	PWR								
	BWR								
	GCR								

Japan	PWR								
	BWR								
	GCR								
	HWLWR								
Netherlands	PWR								
Spain	PWR total								
	Jose Cabrera								
	Others								
	BWR total								
	S.M. Garona								
	Others								
	GCR								
Sweden	PWR								
	BWR								
Switzerland	PWR								
	BWR								
United Kingdom	GCR total								
	CEGB								
	SSEB								
	BNFL								
	AGR total								
	CEGB								
	SSEB								
United States	PWR total								
	W.								
	C-E								
	B & W								
	BWR total								
	GE								
	AC								
	GCR								

* The number of reactors in operation at the end of the calendar year should be indicated.

TABLE 4: MAIN CAUSES (1986)

(in percentage)

Country	Plant Type	Component Failures	Human Error	Both Component Failure and Human Error	Procedural Deficiency	Other Cause
Belgium	PWR total					
	Doel					
	Tihange					
Canada	PHWR total					
	Pickering A					
	Pickering B					
	Bruce A					
	Bruce B					
	Gentilly 2					
	Pt. Lepreau					
Finland	PWR					
	BWR					
France	PWR total					
	900 MWe					
	1300 MWe					
	GCR					
F.R. of Germany	PWR					
	BWR					
Italy	PWR					
	BWR					
	GCR					

Japan	PWR					
	BWR					
	GCR					
	HWLWR					
Netherlands	PWR					
Spain	PWR total					
	Jose Cabrera					
	Others					
	BWR total					
	S.M. Garona					
	Others					
	GCR					
Sweden	PWR					
	BWR					
Switzerland	PWR					
	BWR					
United Kingdom	GCR total					
	CEGB					
	SSEB					
	BNFL					
	AGR total					
	CEGB					
	SSEB					
United States	PWR total					
	W.					
	C-E					
	B & W					
	BWR total					
	GE					
	AC					
	GCR					

* The number of reactors in operation at the end of the calendar year should be indicated.

TABLE 5: OPERATIONAL MODES (1986)

(in percentage)

Country	Plant Type	Rated Power Operation	Increase to or Reduction from Rated Power Operation	Surveillance Test or Periodic Inspection	Other Operational Modes
Belgium	PWR total				
	Doel				
	Tihange				
Canada	PHWR total				
	Pickering A				
	Pickering B				
	Bruce A				
	Bruce B				
	Gentilly 2				
	Pt. Lepreau				
Finland	PWR				
	BWR				
France	PWR total				
	900 MWe				
	1300 MWe				
	GCR				
F.R. of Germany	PWR				
	BWR				
Italy	PWR				
	BWR				
	GCR				

Japan	PWR				
	BWR				
	GCR				
	HWLWR				
Netherlands	PWR				
Spain	PWR total				
	Jose Cabrera				
	Others				
	BWR total				
	S.M. Garona				
	Others				
	GCR				
Sweden	PWR				
	BWR				
Switzerland	PWR				
	BWR				
United Kingdom	GCR total				
	CEGB				
	SSEB				
	BNFL				
	AGR total				
	CEGB				
	SSEB				
United States	PWR total				
	W.				
	C-E				
	B & W				
	BWR total				
	GE				
	AC				
	GCR				

* The number of reactors in operation at the end of the calendar year should be indicated.

TABLE 6: OPERATIONAL RECORDS (1986)

COUNTRY NAME:

Plant Type	Plant Name	Critical and Turbine on-line Hours (h) during the Year	Date of First Reactor Criticality
PWR			
	Total		
BWR			
	Total		
GCR			
	Total		
AGR			
	Total		
PHWR			
	Total		
TOTAL			

STATISTICAL DATA ON REACTOR SCRAM

EVOLUTION OF REACTOR SCRAM FREQUENCY IN OECD COUNTRIES (1984-1986)

NR84 : Number of Reactors in 1984
PR84 : Scrams Per Reactor in 1984
CT84 : Scrams per 1000 Critical and Turbine on-line hours in 1984

		NR84	PR84	CT84	NR85	PR85	CT85	NR86	PR86	CT86
Belgium	PWR total	5	3.80	0.50	5	3.40	0.50	7	5.30	0.74
	Doel	3	2.30	0.30	3	3.70	0.50	4	3.70	0.52
	Tihange	2	6.00	0.80	2	3.00	0.40	3	7.30	1.06
Canada	PHWR total	13	2.75	-	16	2.19	-	17	1.59	-
	Pickering A	4	0.50	0.14	4	0.25	0.09	4	0.00	-
	Pickering B	2	6.00	0.76	4	2.50	0.56	4	0.25	-
	Bruce A	4	1.00	0.12	4	2.00	0.35	4	1.50	-
	Bruce B	1	6.00	0.92	2	3.00	0.08	3	1.67	-
	Gentilly 2	1	8.00	-	1	8.00	-	1	1.00	-
	Pt. Lepreau	1	3.00	0.38	1	2.00	0.24	1	2.00	-
Finland	PWR	2	0.00	0.00	2	0.00	0.00	2	0.00	0.00
	BWR	2	0.50	0.06	2	1.00	0.12	2	0.00	0.00
France	PWR total	31	-	-	36	-	-	43	3.60	0.53
	900 MWe	31	4.50	0.60	34	3.20	0.44	34	3.30	0.45
	1300 MWe	0	-	-	2	-	-	9	9.10	1.01
	GCR	4	-	-	4	-	-	4	-	-
FRG	PWR	-	-	-	-	-	-	10	1.00	0.15
	BWR	-	-	-	-	-	-	7	1.90	0.25
Italy	PWR	1	6.00	0.77	1	5.00	0.87	1	7.00	0.83
	BWR	1	4.00	0.52	1	10.00	0.30	1	4.00	0.60
	GCR	1	1.00	0.16	1	4.00	0.48	1	0.00	0.00
Japan	PWR	14	0.07	0.01	15	0.07	0.01	15	0.07	0.01
	BWR	15	0.13	0.02	16	0.31	0.05	16	0.13	0.02
	GCR	1	0.00	0.00	1	0.00	0.00	1	1.00	0.15
	HWLWR	1	0.00	0.00	1	0.00	0.00	1	0.00	0.00
Nether.	PWR	1	0.00	0.00	1	0.00	0.00	1	1.00	0.12
Spain	PWR total	4	9.00	1.40	5	2.60	0.60	5	5.20	0.80
	Jose Cabrera	1	5.00	0.80	1	1.00	0.40	1	1.00	0.10
	Others	3	10.30	1.60	4	3.00	0.60	4	6.25	0.90
	BWR total	2	8.50	2.10	2	9.00	1.60	2	4.50	0.60
	S.M. Garona	1	4.00	0.60	1	1.00	0.20	1	5.00	0.60
	Others	1	13.00	10.90	1	17.00	2.30	1	4.00	0.50
	GCR	1	8.00	1.00	1	7.00	0.88	1	10.00	1.25
Sweden	PWR	3	3.00	0.44	3	2.67	0.36	3	3.67	0.53
	BWR	7	2.72	0.35	9	10.00	1.36	9	2.67	0.33
Switz.	PWR	3	0.66	0.08	3	1.66	0.21	3	0.33	0.04
	BWR	1	2.00	0.25	2	3.50	0.46	2	1.00	0.14
UK	GCR total	-	-	-	-	-	-	-	-	-
	CEGB	-	-	-	-	-	-	-	-	-
	SSEB	-	-	-	-	-	-	-	-	-
	BNFL	-	-	-	-	-	-	-	-	-
	AGR total	-	-	-	-	-	-	-	-	-
	CEGB	-	-	-	-	-	-	-	-	-
	SSEB	-	-	-	-	-	-	-	-	-
USA	PWR total	53	4.15	0.70	60	4.97	0.80	60	4.20	0.66
	W.	35	4.51	0.80	39	4.97	0.77	39	4.28	0.66
	C-E	11	3.82	0.62	13	5.38	0.93	14	5.00	0.76
	B & W	7	2.86	0.41	8	3.75	0.74	7	2.14	0.41
	BWR total	28	3.93	0.83	30	3.77	0.71	31	2.74	0.52
	GE	-	-	-	-	-	-	-	-	-
	AC	-	-	-	-	-	-	-	-	-
	GCR	-	-	-	-	-	-	-	-	-

MAIN SIGNALS RESULTING IN REACTOR SCRAMS (1986)

SSTT : Turbine Trip
SSOS : Other Secondary-side Signals
SSPS : Primary-side Signals
SSMS : Manual Scram
SSOT : Other Signals

		SSTT	SSOS	SSPS	SSMS	SSOT
Belgium	PWR total	11.0	51.0	32.0	5.0	0.0
	Doel	20.0	40.0	40.0	0.0	0.0
	Tihange	5.0	59.0	27.0	9.0	0.0
Canada	PHWR total	7.4	3.7	48.2	3.7	37.0
	Pickering A	0.0	0.0	0.0	0.0	0.0
	Pickering B	10.0	0.0	30.0	0.0	60.0
	Bruce A	0.0	0.0	83.0	0.0	17.0
	Bruce B	12.5	0.0	50.0	12.5	25.0
	Gentilly 2	0.0	100.0	0.0	0.0	0.0
	Pt. Lepreau	0.0	0.0	50.0	0.0	50.0
Finland	PWR	0.0	0.0	0.0	0.0	0.0
	BWR	0.0	=	0.0	0.0	0.0
France	PWR total	36.0	-	-	0.0	-
	900 MWe	30.0	-	-	0.0	-
	1300 MWe	30.0	-	-	0.0	-
	GCR	-	-	-	-	-
FRG	PWR	-	-	-	-	-
	BWR	-	-	-	-	-
Italy	PWR	0.0	0.0	57.0	28.0	15.0
	BWR	0.0	25.0	50.0	25.0	0.0
	GCR	0.0	0.0	0.0	0.0	0.0
Japan	PWR	100.0	0.0	0.0	0.0	0.0
	BWR	50.0	=	50.0	0.0	0.0
	GCR	0.0	0.0	100.0	0.0	0.0
	HWLWR	0.0	0.0	0.0	0.0	0.0
Nether.	PWR	0.0	100.0	0.0	0.0	0.0
Spain	PWR total	38.5	23.1	34.6	3.9	0.0
	Jose Cabrera	0.0	0.0	100.0	0.0	0.0
	Others	40.0	24.0	32.0	4.0	0.0
	BWR total	35.0	=	45.0	0.0	20.0
	S.M. Garona	20.0	=	40.0	0.0	40.0
	Others	50.0	=	50.0	0.0	0.0
	GCR	0.0	0.0	40.0	10.0	50.0
Sweden	PWR	9.0	45.0	37.0	0.0	9.0
	BWR	17.0	13.0	58.0	4.0	8.0
Switz.	PWR	100.0	0.0	0.0	0.0	0.0
	BWR	0.0	=	100.0	0.0	0.0
UK	GCR total	-	-	-	-	-
	CEGB	-	-	-	-	-
	SSEB	-	-	-	-	-
	BNFL	-	-	-	-	-
	AGR total	-	-	-	-	-
	CEGB	-	-	-	-	-
	SSEB	-	-	-	-	-
USA	PWR total	-	-	-	-	-
	W.	22.8	33.5	19.2	10.8	13.8
	C-E	18.6	20.0	42.9	11.4	7.1
	B & W	53.3	6.7	33.3	6.7	0.0
	BWR total	29.0	=	53.5	7.0	10.5
	GE	-	-	-	-	-
	AC	-	-	-	-	-
	GCR	-	-	-	-	-

INITIATING SYSTEM (1986)

SICF : Condensate/Feedwater   SITB : Turbine
SIRC : Reactor Coolant   SIEL : Electrical
SICP : Reactor Control & Protection
SIMS : Main Steam   SIGN : Generator   SIOT : Others

		SICF	SITB	SIRC	SIEL	SICP	SIMS	SIGN	SIOT
Belgium	PWR total	54.0	8.0	5.0	0.0	27.0	5.0	0.0	0.0
	Doel	40.0	13.0	7.0	0.0	27.0	13.0	0.0	0.0
	Tihange	64.0	5.0	5.0	0.0	27.0	0.0	0.0	0.0
Canada	PHWR total	14.8	3.7	0.0	7.4	44.5	3.7	0.0	25.9
	Pickering A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pickering B	20.0	0.0	0.0	10.0	30.0	0.0	0.0	40.0
	Bruce A	0.0	0.0	0.0	0.0	83.3	0.0	0.0	16.7
	Bruce B	25.0	12.5	0.0	0.0	37.5	0.0	25.0	0.0
	Gentilly 2	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
	Pt. Lepreau	0.0	0.0	0.0	50.0	50.0	0.0	0.0	0.0
Finland	PWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
France	PWR total	30.0	12.0	5.0	12.0	21.0	3.5	9.0	9.0
	900 MWe	36.0	11.0	6.0	11.0	19.0	4.0	4.0	9.0
	1300 MWe	11.0	15.0	0.0	14.0	35.0	1.0	21.0	4.0
	GCR	-	-	-	-	-	-	-	-
FRG	PWR	-	-	-	-	-	-	-	-
	BWR	-	-	-	-	-	-	-	-
Italy	PWR	0.0	28.0	44.0	14.0	14.0	0.0	0.0	0.0
	BWR	0.0	0.0	0.0	0.0	50.0	25.0	25.0	0.0
	GCR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Japan	PWR	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
	BWR	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	GCR	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
	HWLWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nether.	PWR	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spain	PWR total	23.1	3.9	3.9	30.8	3.9	0.0	7.7	26.9
	Jose Cabrera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
	Others	24.0	4.0	4.0	32.0	4.0	0.0	8.0	24.0
	BWR total	10.0	0.0	0.0	10.0	45.0	0.0	35.0	0.0
	S.M. Garona	20.0	0.0	0.0	20.0	40.0	0.0	20.0	0.0
	Others	0.0	0.0	0.0	0.0	50.0	0.0	50.0	0.0
	GCR	0.0	10.0	0.0	20.0	30.0	0.0	0.0	40.0
Sweden	PWR	9.0	0.0	9.0	0.0	27.0	0.0	55.0	0.0
	BWR	4.0	25.0	29.0	13.0	17.0	0.0	0.0	12.0
Switz.	PWR	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BWR	50.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0
UK	GCR total	-	-	-	-	-	-	-	-
	CEGB	-	-	-	-	-	-	-	-
	SSEB	-	-	-	-	-	-	-	-
	BNFL	-	-	-	-	-	-	-	-
	AGR total	-	-	-	-	-	-	-	-
	CEGB	-	-	-	-	-	-	-	-
	SSEB	-	-	-	-	-	-	-	-
USA	PWR total	-	-	-	-	-	-	-	-
	W.	37.1	12.6	2.4	12.0	19.8	4.2	6.0	6.0
	C-E	28.6	8.6	4.3	14.3	22.9	8.6	11.4	1.4
	B & W	46.7	20.0	6.7	13.3	6.7	0.0	6.7	0.0
	BWR total	23.3	19.8	5.8	15.1	14.0	8.1	8.1	3.5
	GE	-	-	-	-	-	-	-	-
	AC	-	-	-	-	-	-	-	-
	GCR	-	-	-	-	-	-	-	-

MAIN CAUSES (1986)

SMCF : Component Failures   SMHE : Human Error
SMBT : Both Component Failure and Human Error
SMPD : Procedural Deficiency   SMOT : Other Cause

		SMCF	SMHE	SMBT	SMPD	SMOT
Belgium	PWR total	51.0	32.0	5.0	0.0	8.0
	Doel	60.0	20.0	0.0	0.0	0.0
	Tihange	45.0	41.0	13.0	0.0	14.0
Canada	PHWR total	55.6	7.4	0.0	14.8	22.2
	Pickering A	0.0	0.0	0.0	0.0	0.0
	Pickering B	50.0	10.0	0.0	10.0	30.0
	Bruce A	83.3	0.0	0.0	16.7	0.0
	Bruce B	62.5	12.5	0.0	12.5	12.5
	Gentilly 2	0.0	0.0	0.0	0.0	100.0
	Pt. Lepreau	0.0	0.0	0.0	50.0	50.0
Finland	PWR	0.0	0.0	0.0	0.0	0.0
	BWR	0.0	0.0	0.0	0.0	0.0
France	PWR total	61.0	39.0	-	-	-
	900 MWe	62.0	38.0	-	-	-
	1300 MWe	58.0	42.0	-	-	-
	GCR	-	-	-	-	-
FRG	PWR	-	-	-	-	-
	BWR	-	-	-	-	-
Italy	PWR	57.0	15.0	28.0	0.0	0.0
	BWR	75.0	25.0	0.0	0.0	0.0
	GCR	0.0	0.0	0.0	0.0	0.0
Japan	PWR	50.0	50.0	0.0	0.0	0.0
	BWR	50.0	50.0	0.0	0.0	0.0
	GCR	100.0	0.0	0.0	0.0	0.0
	HWLWR	0.0	0.0	0.0	0.0	0.0
Nether.	PWR	100.0	0.0	0.0	0.0	0.0
Spain	PWR total	65.4	3.9	0.0	0.0	30.8
	Jose Cabrera	0.0	0.0	0.0	0.0	100.0
	Others	68.0	4.0	0.0	0.0	28.0
	BWR total	77.5	0.0	10.0	0.0	12.5
	S.M. Garona	80.0	0.0	20.0	0.0	0.0
	Others	75.0	0.0	0.0	0.0	25.0
	GCR	50.0	0.0	10.0	0.0	40.0
Sweden	PWR	73.0	9.0	9.0	0.0	9.0
	BWR	50.0	13.0	21.0	12.0	4.0
Switz.	PWR	0.0	100.0	0.0	0.0	0.0
	BWR	0.0	100.0	0.0	0.0	0.0
UK	GCR total	-	-	-	-	-
	CEGB	-	-	-	-	-
	SSEB	-	-	-	-	-
	BNFL	-	-	-	-	-
	AGR total	-	-	-	-	-
	CEGB	-	-	-	-	-
	SSEB	-	-	-	-	-
USA	PWR total	-	-	-	-	-
	W.	57.5	28.7	=	6.0	7.8
	C-E	70.0	18.5	=	5.7	5.7
	B & W	73.3	13.3	=	6.7	6.7
	BWR total	67.4	20.9	=	8.1	3.5
	GE	-	-	-	-	-
	AC	-	-	-	-	-
	GCR	-	-	-	-	-

OPERATIONAL MODES (1986)

SORP : Rated Power Operation
SOIR : Increase to or Reduction from Rated Power Operation
SOSP : Surveillance Test or Periodic Inspection
SOOT : Other Operational Modes

		SORP	SOIR	SOSP	SOOT
Belgium	PWR total	41.0	19.0	41.0	0.0
	Doel	40.0	13.0	47.0	0.0
	Tihange	41.0	23.0	36.0	0.0
Canada	PHWR total	100.0	0.0	0.0	0.0
	Pickering A	0.0	0.0	0.0	0.0
	Pickering B	100.0	0.0	0.0	0.0
	Bruce A	100.0	0.0	0.0	0.0
	Bruce B	100.0	0.0	0.0	0.0
	Gentilly 2	100.0	0.0	0.0	0.0
	Pt. Lepreau	100.0	0.0	0.0	0.0
Finland	PWR	0.0	0.0	0.0	0.0
	BWR	0.0	0.0	0.0	0.0
France	PWR total	-	-	18.0	-
	900 MWe	-	-	19.0	-
	1300 MWe	-	-	11.0	-
	GCR	-	-	-	-
FRG	PWR	-	-	-	-
	BWR	-	-	-	-
Italy	PWR	43.0	43.0	14.0	0.0
	BWR	75.0	0.0	25.0	0.0
	GCR	0.0	0.0	0.0	0.0
Japan	PWR	0.0	100.0	100.0	0.0
	BWR	0.0	100.0	50.0	0.0
	GCR	0.0	100.0	100.0	0.0
	HWLWR	0.0	0.0	0.0	0.0
Nether.	PWR	0.0	100.0	0.0	0.0
Spain	PWR total	69.2	26.9	3.9	0.0
	Jose Cabrera	100.0	0.0	0.0	0.0
	Others	68.0	28.0	4.0	0.0
	BWR total	70.0	0.0	30.0	0.0
	S.M. Garona	40.0	0.0	60.0	0.0
	Others	100.0	0.0	0.0	0.0
	GCR	70.5	21.6	4.7	3.2
Sweden	PWR	45.0	55.0	36.0	0.0
	BWR	38.0	62.0	13.0	0.0
Switz.	PWR	0.0	100.0	0.0	0.0
	BWR	100.0	0.0	0.0	0.0
UK	GCR total	-	-	-	-
	CEGB	-	-	-	-
	SSEB	-	-	-	-
	BNFL	-	-	-	-
	AGR total	-	-	-	-
	CEGB	-	-	-	-
	SSEB	-	-	-	-
USA	PWR total	-	-	-	-
	W.	41.9	17.4	21.0	19.7
	C-E	55.7	12.9	20.0	11.4
	B & W	46.7	20.0	13.3	20.0
	BWR total	41.9	5.9	30.2	22.1
	GE	-	-	-	-
	AC	-	-	-	-
	GCR	-	-	-	-

OPERATIONAL RECORDS (1986)

***** OPERATIONAL RECORDS (1986) ****

----- COUNTRY NAME: Belgium

TYPE	PLANT NAME		OPHOUR	OPDATE
PWR				
	DOEL-1		6971	740716
	DOEL-2		5913	750804
	DOEL-3		8009	820614
	DOEL-4		7972	850331
	TIHANGE-1		5384	750221
	TIHANGE-2		7508	821005
	TIHANGE-3		7732	850614
		Sub Total	49489	
BWR				
GCR				
AGR				
PHWR				
		TOTAL	49489	

***** OPERATIONAL RECORDS (1986) ****
----- COUNTRY NAME: Finland

TYPE	PLANT NAME		OPHOUR	OPDATE
PWR				
	LOVIISA-1		8093	770121
	LOVIISA-2		7273	801017
		Sub Total	15366	
BWR				
	TVO-1		8008	780721
	TVO-2		8437	791013
		Sub Total	16445	
GCR				
AGR				
PHWR				
		TOTAL	31811	

***** OPERATIONAL RECORDS (1986) ****
----- COUNTRY NAME: Italy

TYPE	PLANT NAME		OPHOUR	OPDATE
PWR				
BWR				
	CAORSO		6647	771231
		Sub Total	6647	
GCR				
	LATINA		7663	621200
		Sub Total	7663	
AGR				
PHWR				
		TOTAL	14310	

***** OPERATIONAL RECORDS (1986) ****
----- COUNTRY NAME: Japan

TYPE	PLANT NAME	OPHOUR	OPDATE
PWR			
	GENKAI-1	5425	750128
	GENKAI-2	8760	800521
	IKATA-1	7044	770129
	IKATA-2	8760	810731
	MIHAMA-1	8482	700729
	MIHAMA-2	7100	720410
	MIHAMA-3	8760	760128
	OHI-1	4664	771202
	OHI-2	8760	780914
	SENDAI-1	7224	830825
	SENDAI-2	7112	850318
	TAKAHAMA-1	6507	740314
	TAKAHAMA-2	5183	741220
	TAKAHAMA-3	8215	840417
	TAKAHAMA-4	7073	841011
	Sub Total	109069	
BWR			
	FUKUSHIMA I-1	5836	701001
	FUKUSHIMA I-2	7478	730510
	FUKUSHIMA I-3	5621	740906
	FUKUSHIMA I-4	5733	780128
	FUKUSHIMA I-5	5622	770826
	FUKUSHIMA I-6	7390	790309
	FUKUSHIMA II-1	7404	810617
	FUKUSHIMA II-2	6727	830426
	FUKUSHIMA II-3	6559	841018
	HAMAOKA-1	5804	740620
	HAMAOKA-2	6145	780328
	KASHIWAZAKI-1	6463	841212
	ONAGAWA-1	6871	831018
	SHIMANE-1	4903	730601
	TOKAI-2	5508	780118
	TSURUGA-1	6863	691003
	Sub Total	100927	
GCR			
	TOKAI-1	6826	650504
	Sub Total	6826	
AGR			
PHWR			
	TOTAL	216822	

***** OPERATIONAL RECORDS (1986) ****
----- COUNTRY NAME: Netherlands

TYPE	PLANT NAME		OPHOUR	OPDATE
PWR				
	BORSSELE		8066	730000
		Sub Total	8066	
BWR				
GCR				
AGR				
PHWR				
		TOTAL	8066	

***** OPERATIONAL RECORDS (1986) ****
----- COUNTRY NAME: Spain

TYPE	PLANT NAME	OPHOUR	OPDATE
PWR			
	ALMARAZ-1	6417	810405
	ALMARAZ-2	7098	830919
	ASCO-1	6208	830617
	ASCO-2	6639	850911
	Sub Total	26362	
BWR			
	COFRENTES	7490	840822
	SANTA MARIA DE GARONA	8174	701105
	Sub Total	15664	
GCR			
AGR			
PHWR			
	TOTAL	42026	

***** OPERATIONAL RECORDS (1986) ****
----- COUNTRY NAME: Sweden

TYPE	PLANT NAME		OPHOUR	OPDATE
PWR				
	RINGHALS-2		6720	740800
	RINGHALS-3		7210	800900
	RINGHALS-4		6940	820600
		Sub Total	20870	
BWR				
	BARSEBAECK-1		8040	750500
	BARSEBAECK-2		7630	770300
	FORSMARK-1		8380	800600
	FORSMARK-2		8380	810100
	FORSMARK-3		8180	850300
	OSKARSHAMN-1		7630	710800
	OSKARSHAMN-2		7890	741000
	OSKARSHAMN-3		8250	850300
	RINGHALS-1		7360	741000
		Sub Total	71740	
GCR				
AGR				
PHWR				
		TOTAL	92610	

***** OPERATIONAL RECORDS (1986) ****
----- COUNTRY NAME: Switzerland

TYPE	PLANT NAME		OPHOUR	OPDATE
PWR				
	BEZNAU-1		7403	690000
	BEZNAU-2		7983	710000
	GOESGEN		7386	790000
		Sub Total	22772	
BWR				
	LEIBSTADT		7670	840000
	MUEHLEBERG		6645	710000
		Sub Total	14315	
GCR				
AGR				
PHWR				
		TOTAL	37087	

***** OPERATIONAL RECORDS (1986) ****
----- COUNTRY NAME: USA

TYPE	PLANT NAME	OPHOUR	OPDATE
PWR			
	BEAVER VALLEY-1	6244	760510
	BYRON-1	7821	850202
	CALLAWAY-1	7308	841002
	CALVERT CLIFFS-1	6906	741007
	CALVERT CLIFFS-2	8442	761130
	CATAWBA-1	5425	850107
	CATAWBA-2	2678	860805
	CRYSTAL RIVER-3	3691	770114
	DIABLO CANYON-1	5967	840429
	DIABLO CANYON-2	7296	850819
	DONALD COOK-1	7536	750118
	DONALD COOK-2	5561	780310
	FARLEY-1	7276	770809
	FARLEY-2	7550	810505
	FORT CALHOUN-1	8485	730806
	H.B. ROBINSON-2	7119	700920
	HADDAM NECK	5061	670724
	INDIAN POINT-2	5102	730522
	INDIAN POINT-3	6582	760406
	KEWAUNEE	7584	740307
	MAINE YANKEE	7791	721023
	MCGUIRE-1	5022	810808
	MCGUIRE-2	5770	830508
	MILLSTONE-2	6600	751017
	MILLSTONE-3	6201	860123
	NORTH ANNA-1	7560	780405
	NORTH ANNA-2	7301	800612
	OCONEE-1	5949	730419
	OCONEE-2	7254	731111
	OCONEE-3	7835	740905
	PALISADES	1491	710524
	PALO VERDE-1	5498	850525
	PALO VERDE-2	3803	860418
	POINT BEACH-1	7905	701102
	POINT BEACH-2	7263	720530
	PRAIRIE ISLAND-1	7898	731201
	PRAIRIE ISLAND-2	7972	741217
	SALEM-1	7097	761211
	SALEM-2	5629	800808
	SAN ONOFRE-1	2975	670614
	SAN ONOFRE-2	6480	820726
	SAN ONOFRE-3	7422	830829
	ST. LUCIE-1	8424	760422
	ST. LUCIE-2	7327	830602
	SURRY-1	6233	720701
	SURRY-2	6171	730307
	THREE MILE ISLAND-1	6269	740605
	TROJAN	7064	751215
	TURKEY POINT-3	6988	721020
	TURKEY POINT-4	3048	730611
	WATERFORD-3	7012	850304
	WOLF CREEK	6524	850522

	ZION-1	5491	730619
	ZION-2	7784	731224
	Sub Total	346685	
BWR			
	BRUNSWICK-1	8318	761008
	BRUNSWICK-2	4233	750320
	COOPER	6570	740221
	DRESDEN-2	7110	700107
	DRESDEN-3	2766	710131
	DUANE ARNOLD-1	7348	740323
	ENRICO FERMI-2	1403	850621
	FITZPATRICK	8076	741117
	GRAND GULF-1	5625	820818
	HATCH-1	5521	740912
	HATCH-2	6452	780704
	HOPE CREEK-1	2670	860628
	LASALLE-1	2396	820621
	LASALLE-2	6614	840310
	LIMERICK-1	7146	841222
	MILLSTONE-1	8277	701026
	MONTICELLO	6985	701210
	NINE MILE POINT-1	5824	690905
	PEACH BOTTOM-2	7273	730916
	PEACH BOTTOM-3	5919	740807
	PERRY-1	1430	860606
	QUAD CITIES-1	6151	711018
	QUAD CITIES-2	5728	720426
	RIVER BEND-1	5309	851031
	SHOREHAM	1300	850215
	SUSQUEHANNA-1	6196	820910
	SUSQUEHANNA-2	5947	840508
	VERMONT YANKEE	4360	720324
	Sub Total	152947	
GCR			
AGR			
PHWR			
	TOTAL	499632	