Operational Safety Experience at 14 MW TRIGA Research Reactor from INR Pitesti, Romania

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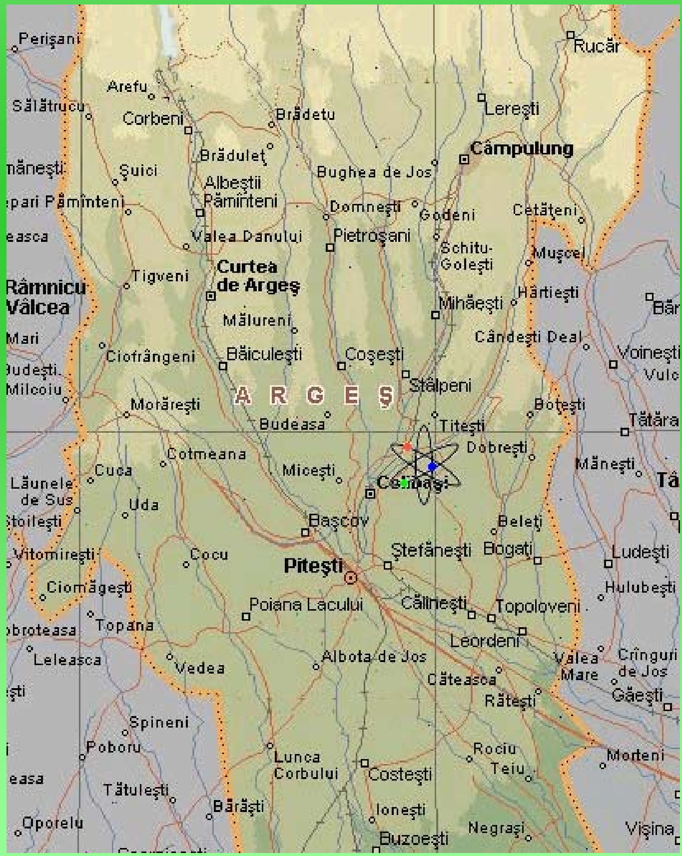
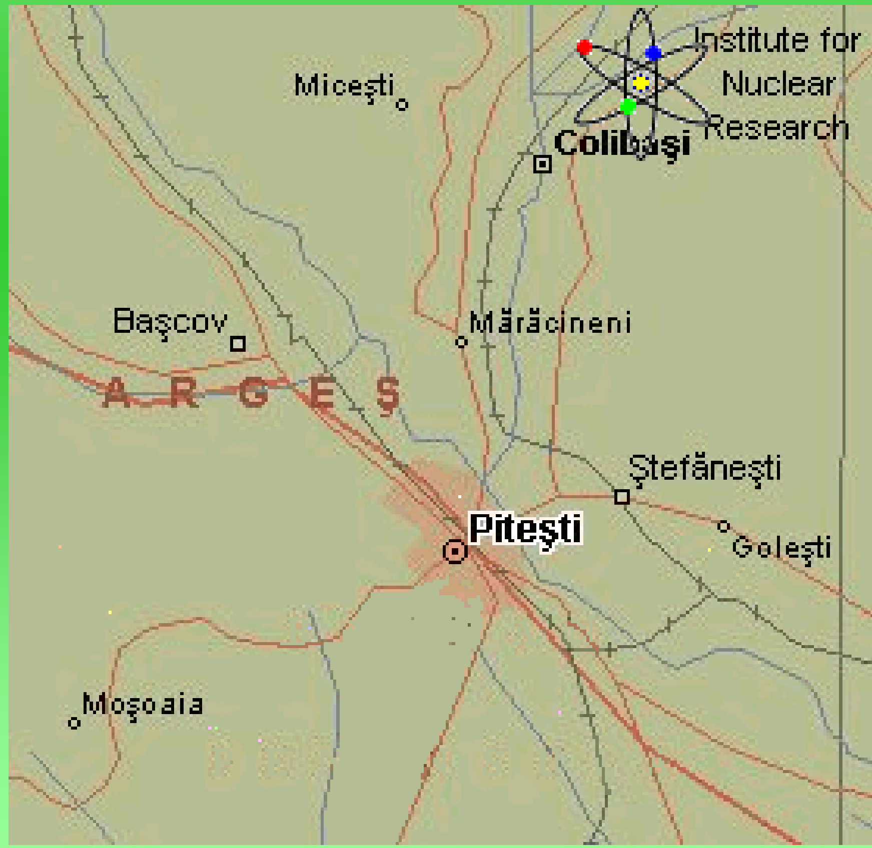
Content:

- Introduction
- Continuous Improvement Of Safety Of Nuclear Installations
- Operational Safety
- Objectives And Types Of Operational Safety Indicators
- 14 MW TRIGA Operation Events
- Data Collection Computerized System for TRIGA Research Reactor
- The Human Factor Analysis for 14 MW TRIGA R.R
- Safety Culture of Operating Organization
- Modernization Programme
- Conclusions
- Acknowledgements

Introduction

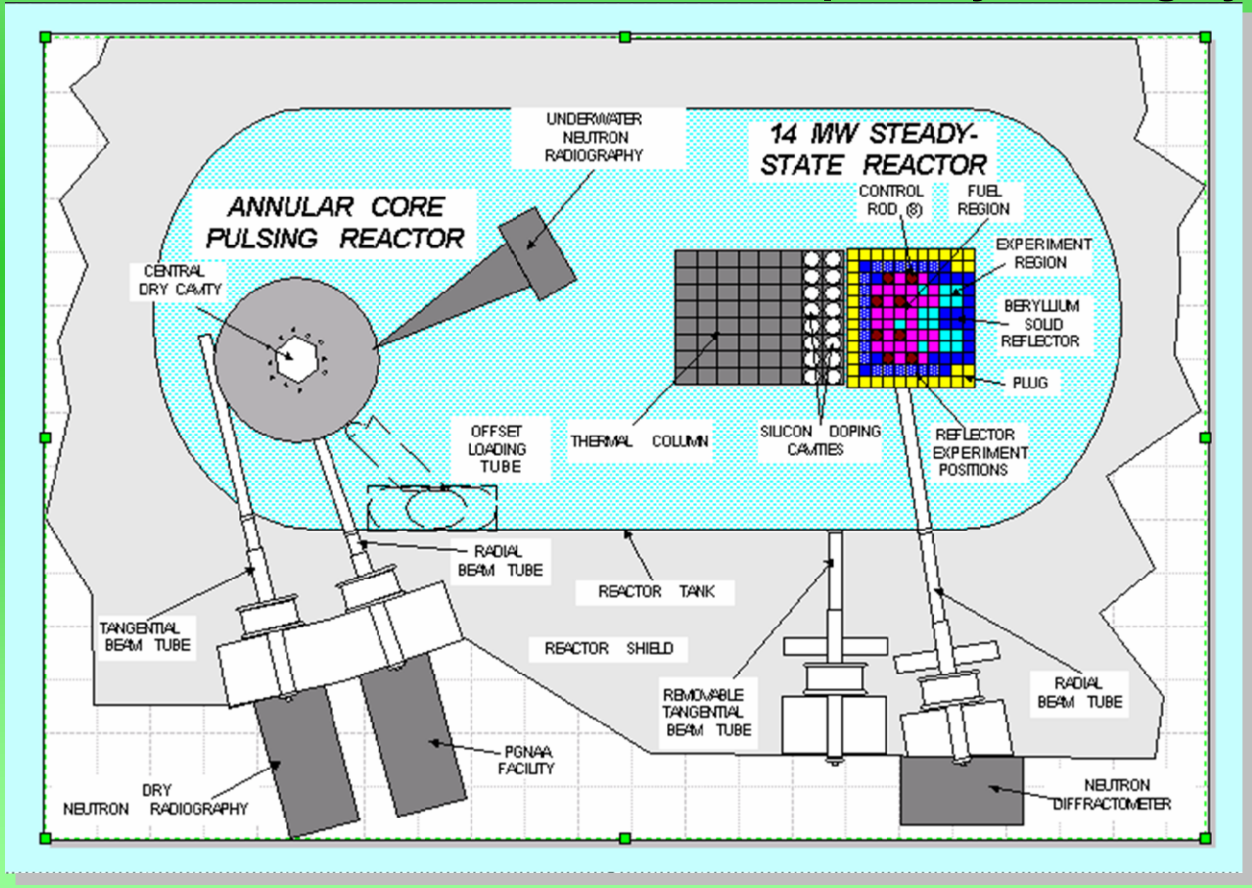
The Institute for Nuclear Research (INR) Pitesti is located at 20 km far from Pitesti city and 5 km from Mioveni (NE). It is the largest Institute in Romania, whose main role is to develop research products and services to ensure technical support for nuclear power in Romania.





Introduction

The Research Reactor facility in Romania is a dual core TRIGA reactor containing a 14MW TRIGA for steady-state operation and an ACPR TRIGA for pulse operation until 20,000 MW pulses. Both reactor cores are installed in a large pool containing 300 m3 of demineralized water, connected to the primary cooling system.



CONTINUOUS IMPROVEMENT OF SAFETY OF NUCLEAR INSTALLATIONS

• Mainly the safety of nuclear power plant is improved by utilization of Probabilistic Safety Assessment (PSA)

• PSA is used to support the system design and configuration decisions and rarely is used to support the operational safety management of plant.

• With respect to plant safety it should be stressed that risk prevention is more appropriate philosophy rather than consequences mitigation procedure.

These ideas are applied to 14MW TRIGA Research Reactor operated by Institute for Nuclear Research Pitesti, Romania.

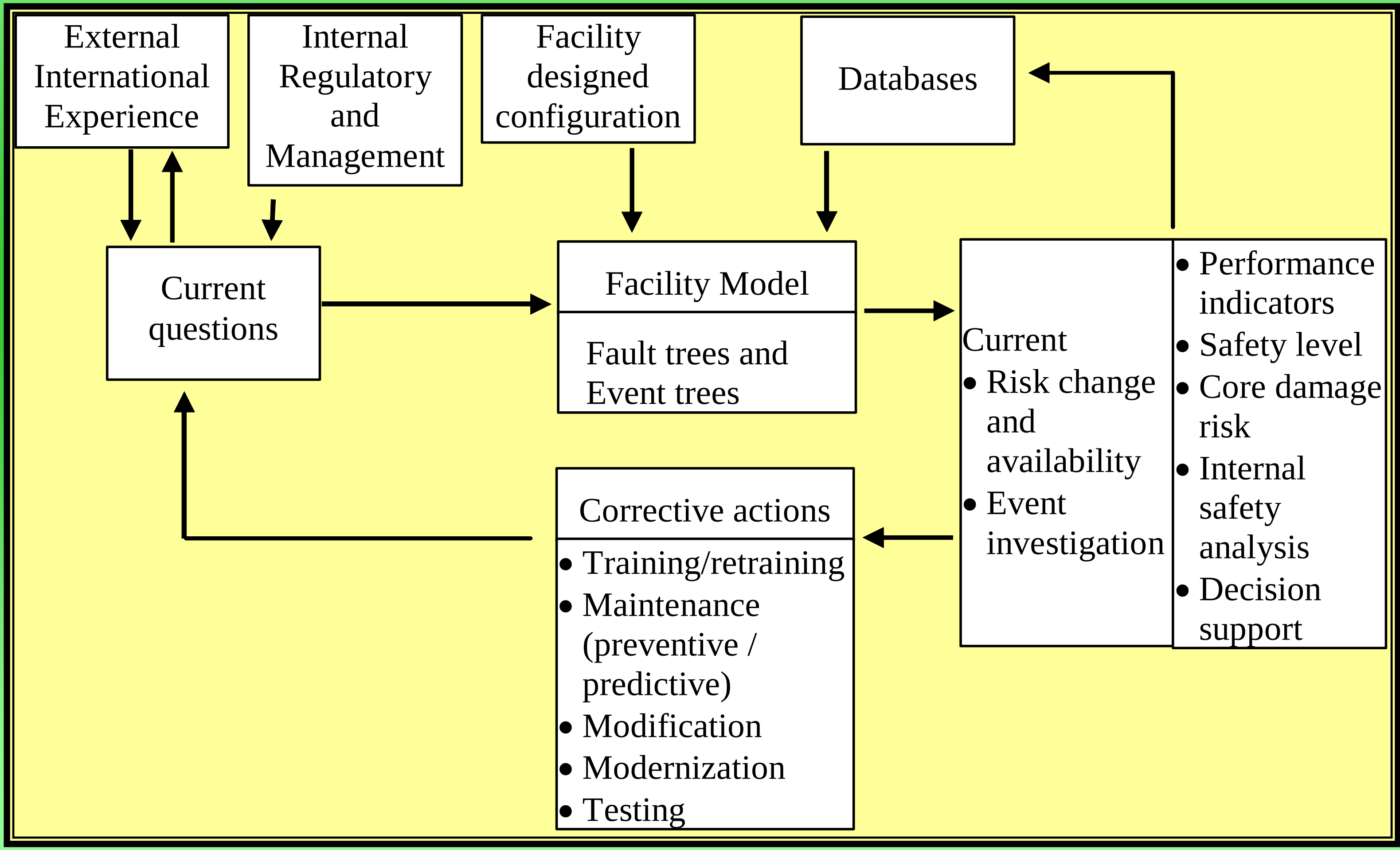
•The initial design of this research reactor were not sustained by results of a specific dedicated PSA, being the result of other 54 TRIGA facilities with smaller power and reduced performances 500 kW to 2000 kW under design construction and operation between 1952 and 1974

•The Safety Report including several Safety Analyses is based mainly on deterministic and qualitative judgements. Each research reactor operate in a changing environment

OPERATIONAL SAFETY

The term Operational Safety

- ***power rectors***
- ***research reactors***



OPERATIONAL SAFETY

The aim of Operational Safety is to minimize or eliminate the risk of injuries or damages to operators, equipment and availability of research reactor utilization.

- should be applied through the entire life of facility

- Performance indicators philosophy

• proposed by IAEA

• proposed through IRSRR (International Reporting System for Research Reactors)

►The analysis of operating experience data based on statistical and deterministic models describe the trends of indicators including human and organizational performances.

- "Unscheduled Shutdown Report"

- Logs Records

The Operational Safety is also correlated with organizational and human performances, safety culture, learning from experience process and research and financial resources.

OBJECTIVES AND TYPES OF OPERATIONAL SAFETY INDICATORS

Operational Safety Indicators

used by Operating Organization, Regulatory Body and international community to evaluate trends of safety of an individual facility, or type of reactor.

The indicators can be used for:

✓***Definition of goals and targets;***

✓***Follow-up of effectiveness of corrective actions including changes and modernization/ refurbishment;***

✓***Identification of improved performances in a specific area;***

✓***Transfer of knowledge and experience;***

✓***Acceptance and appreciation of operation of facility by public and organizations/stakeholders.***

OBJECTIVES AND TYPES OF OPERATIONAL SAFETY INDICATORS

Safety performances indicators of research reactors as proposed by IAEA – IRSRR

1. availability
2. unscheduled shutdowns
3. radiation doses
4. radioactivity released
5. adequacy of man power and personnel turnover
6. emergency preparedness
7. maintenance of safety systems
8. safety review
9. safety culture
10. completeness of safety documentation
11. quality assurance
12. fuel integrity
13. utilization
14. unusual events records

14 MW TRIGA OPERATION EVENTS

• The reactor operation is performed following the approved procedures in agreement with irradiation facilities and programs.

• A large experience of operation during 27 years was acquired in terms of events which produced unscheduled scrams concerning 14 MW TRIGA R.R.

• A systematic collections of recorded data from Control Room logs allow to compute the reactor operation time and availability. The data tables contain:

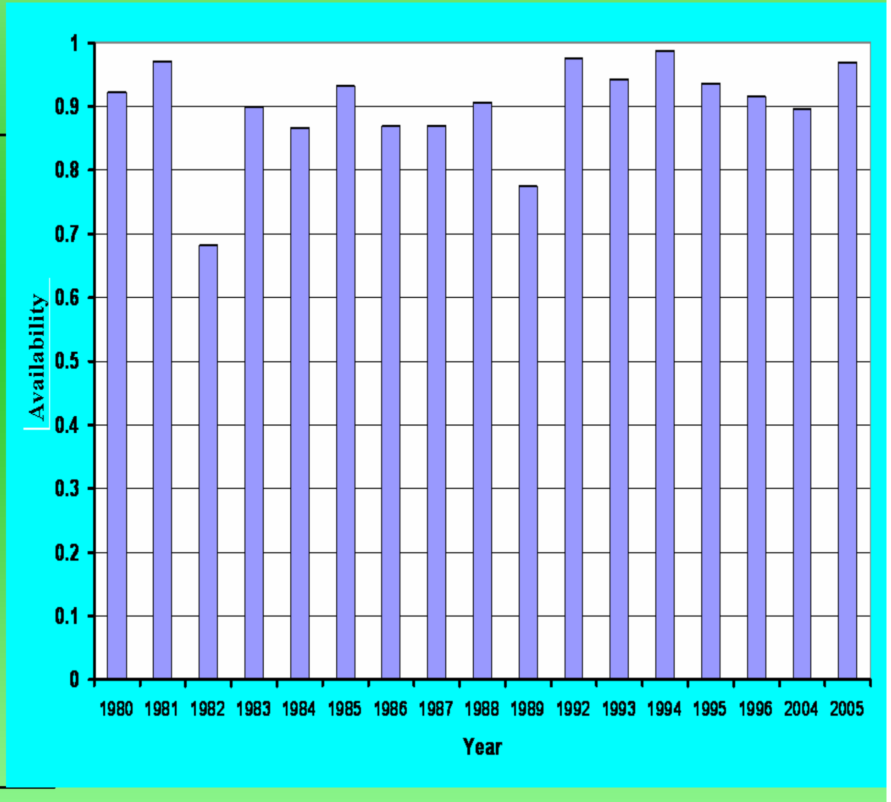
- *equipment or component that caused failure;*
- *failure type (mechanical, electrical, irradiation device, human failure);*
- *scram cause;*
- *scram mode.*

14 MW TRIGA OPERATION EVENTS

Data collected from the reactor operation log books

YEAR	Scrams Number	Operating Time(hours)	Outage Time (hours)	Average Outage Time (hours)	Reactor Availability
1980	8	144	12.1	1.51	0.9224
1981	7	216	8.4	0.91	0.9712
1982	206	2940.2	471.55	2.27	0.6817
1983	100	2187.8	245.0	2.45	0.899
1984	58	3014.0	462.5	7.97	0.8669
1985	43	5980.0	435.7	10.13	0.932
1986	46	4401.0	663.5	14.42	0.8689
1987	49	5149.0	767.0	15.85	0.8703
1988	76	6720.0	893.25	9.12	0.9064
1989	47	1807	524.25	11.15	0.7751
1992	40	3923	97.0	2.425	0.9758
1993	21	3208	196.25	9.3	0.9423

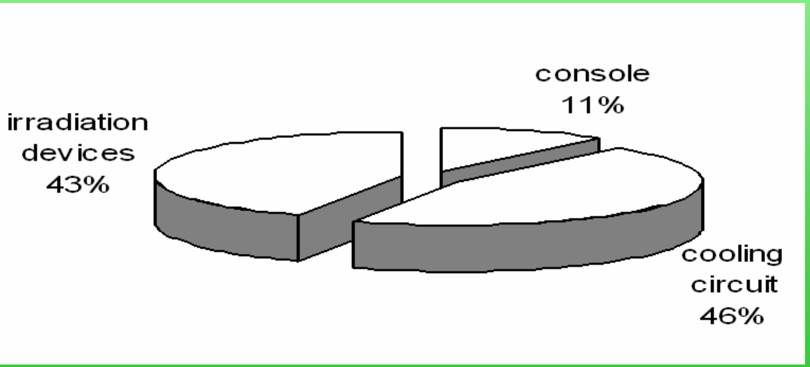
The 14 MW TRIGA Research Reactor availability



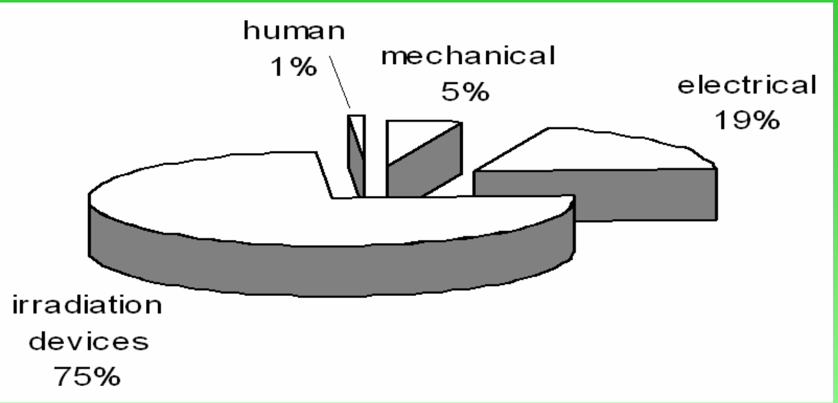
14 MW TRIGA OPERATION EVENTS

The classification of events which impaired the reactor availability

Scram Cause	Scrams number	Total outage time (hours)	Average outage time (hours)
electrical	344	949.0	2.76
mechanical	19	158.0	8.36
irradiation devices	273	3168.25	11.61
human error	7	5.0	0.76
Total	**643**	**4282.25**	**6.84**



Main causes of unavailability of reactor



Main causes of reactor outages

DATA COLLECTION COMPUTERIZED SYSTEM FOR TRIGA RESEARCH REACTOR

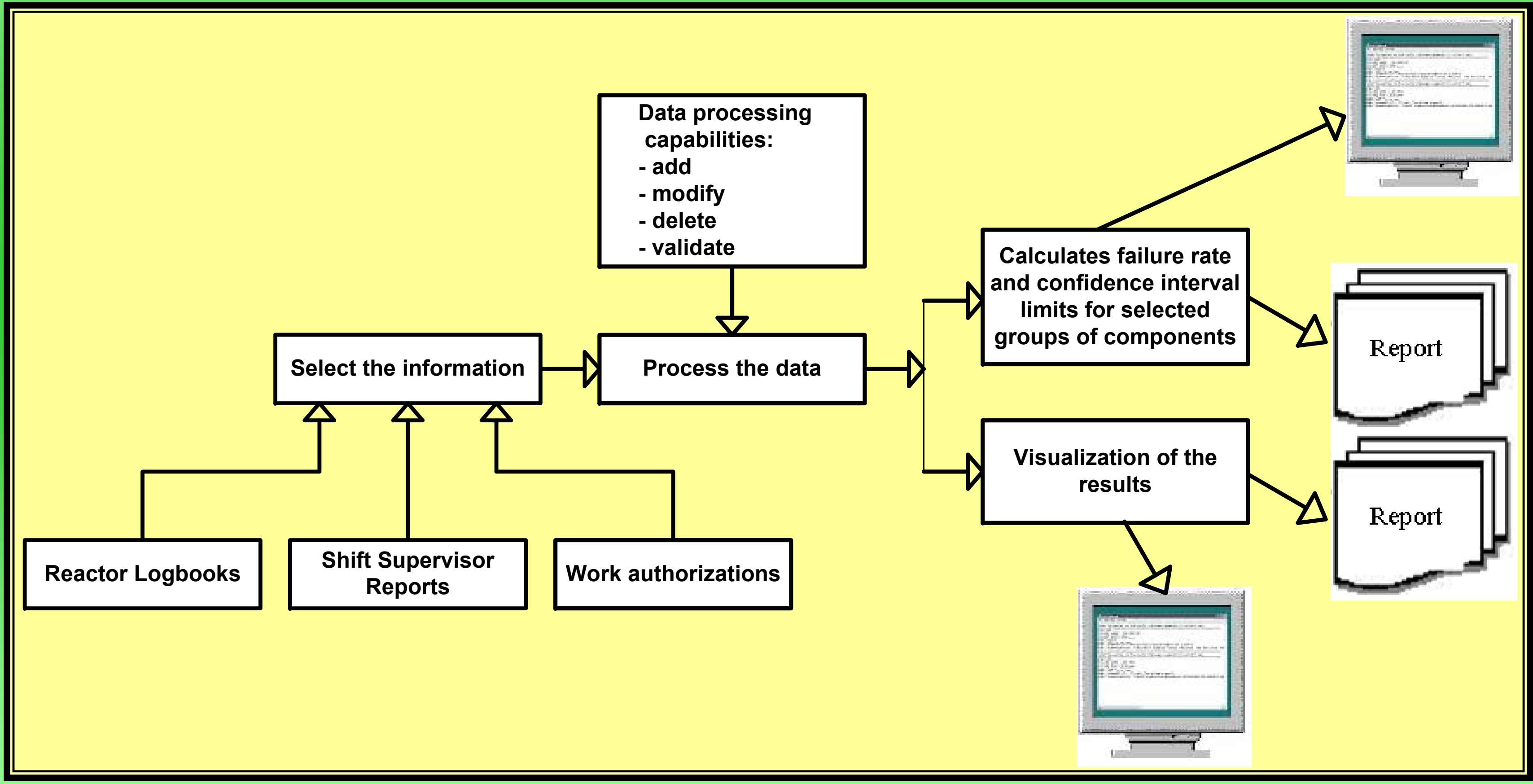
The necessity to develop a raw data collection and processing computerized system

- ***Store all the information regarding the events produced in the operation of TRIGA SSR reactor, whether these are systems or components failures, events due to test or maintenance or information about reactor power, time intervals, number of scrams, etc.***
- ***Identify, retrieve, select and group information from raw data sources in a time interval period***
- ***Calculate reliability data, failure data and confidence interval limits, which are used as input data in the Probabilistic Safety Analysis for TRIGA Research Reactor.***

The computerized system includes operation events for TRIGA SSR 14 MW reactor during 1979 – 2000, covering three data sources: Shift Supervisor Reports, Reactor Logbooks, Work Authorizations.

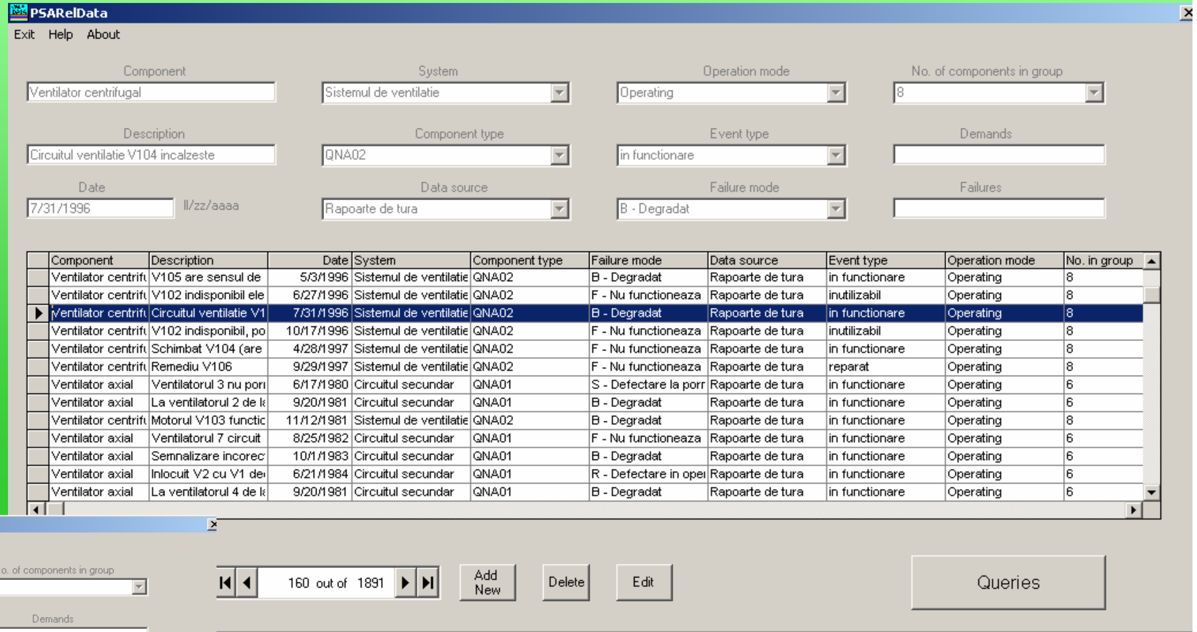
DATA COLLECTION COMPUTERIZED SYSTEM FOR TRIGA RESEARCH REACTOR

Computerized System called "PSARelData"

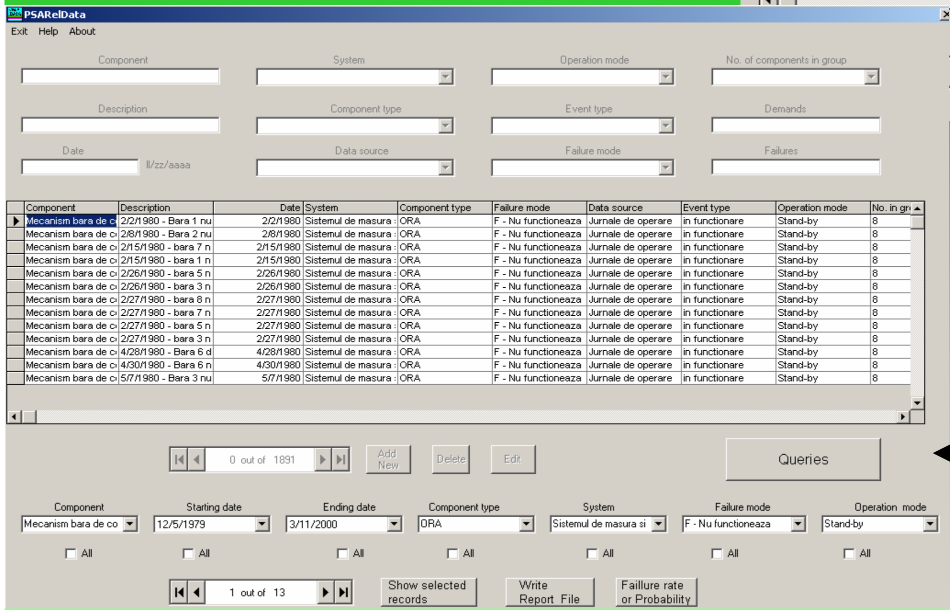


Logic diagram for data computerized system

DATA COLLECTION COMPUTERIZED SYSTEM FOR TRIGA RESEARCH REACTOR

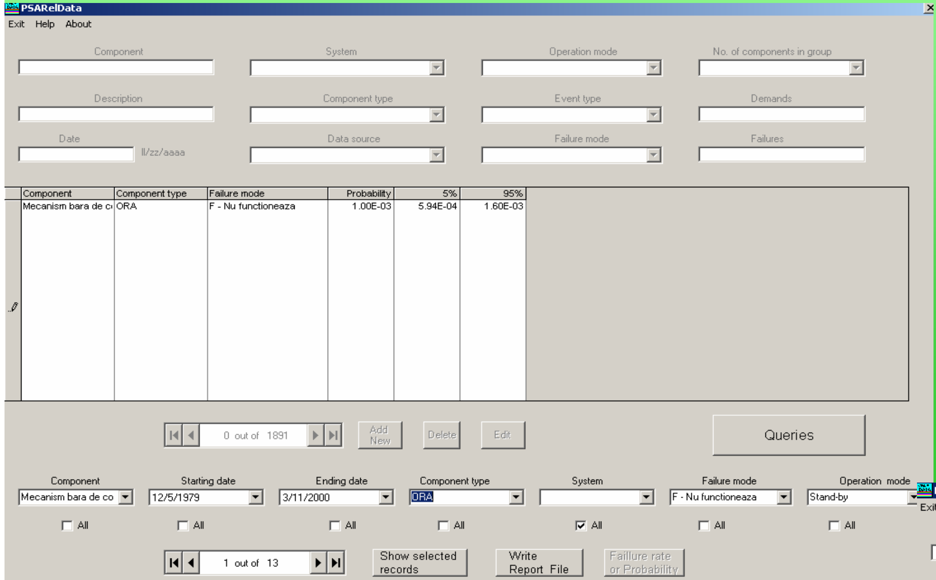


Main form of the application

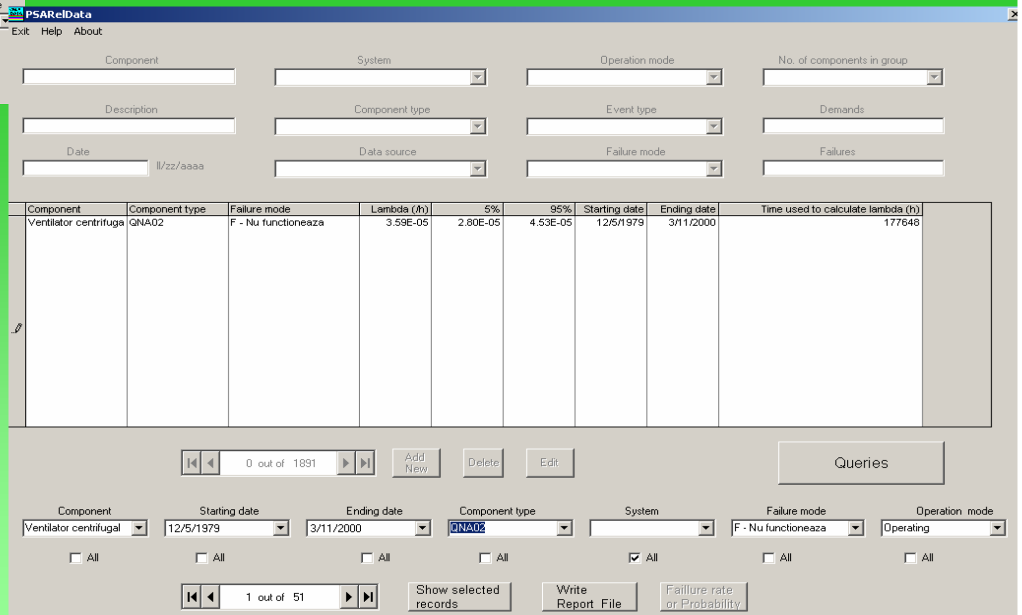


Selection process results for a component in stand-by (control rod drive) in scope of failure rate calculation

DATA COLLECTION COMPUTERIZED SYSTEM FOR TRIGA RESEARCH REACTOR



Calculation results of failure rate and confidence interval limits for the centrifugal fan



Results of calculation of failure rate and confidence interval limits for control rod drive

The Human Factor Analysis for 14 MW TRIGA R.R.

The types of human errors:

➢***errors of omissions (omits entire task or omits a step in a task) in the cases when operators uses the procedures;***

➢***errors of commission;***

selection errors on the equipments as keyboards, switches (manual control) and readings of information.

Effect of Performance Shaping Factors are relative low and are determined from a list of activities concerning performance of:

❖***written procedures,***

❖***administrative control,***

❖***communication,***

❖***training,***

❖***characteristics of personnel and***

❖***stress.***

The Human Factor Analysis for 14 MW TRIGA R.R.

Failure probabilities of activities by operating staff of TRIGA reactor range between 0.033 for reactor start-up and 0.027 for normal reactor shutdown

Probabilistic human errors data will be used within Probabilistic Safety Assessment of TRIGA safety in order to provide:

- **a complete description of the human contribution to risk**
- **to identify ways to reduce that risk and to perform corrective actions such as**
  - ✓ ***reduce the number of manual actions***
  - ✓ ***reduce the dependence between manual control and display***
  - ✓ ***reduce oral instructions***
  - ✓ ***verification of human actions by Senior Reactor Operator***

Safety Culture of Operating Organization

Safety Culture of Operating Organization is appreciated in regards of:

- ❖ ***actions oriented to foster responsible behaviour***
- ❖ ***the manner in which conditions and resources for safety are allotted***

The main challenges identified in TRIGA Research Reactor operated in Institute for Nuclear Research in Pitesti, Romania:

- ✓ ***Ageing of work forces and knowledge management;***
- ✓ ***Maintaining an enhanced technical and scientific competences;***
- ✓ ***Ensuring adequate financial and human resources;***
- ✓ ***Enhancing excellence in management;***
- ✓ ***Ensuring confidence of stakeholders and public;***
- ✓ ***Ageing of equipments and systems.***

MODERNIZATION PROGRAMME

A large refurbishment and modernization programme was undertaking by management of institute concerning:

- *modernization of reactor control and safety systems,*
- *primary cooling system instrumentation,*
- *radiation protection and releases monitoring with new spectrometric computerized abilities,*
- *ventilation filtering system*
- *cooling towers*

MODERNIZATION PROGRAMME

✓First step - to achieve the complete conversion of core for utilization of LEU fuel trough an international cooperative effort.

✓Second step concern the equipment and systems of reactor to reduce the consequences of ageing, obsolescence and technological development.

✓The reactor control and safety system will be replaced with a new computer assisted system.

✓The original control rods of reactor will be completely replaced with new more reliable designed ones, considering the root causes of failure of the old ones.

✓The radiation protection monitoring system will be replaced with modern integrated computer system using online gamma spectrometry for potential releases or for exposure of staff and contamination of environment.

✓The heating and ventilation system and emergency ventilation will be equipped with new more efficient and available HEPA and charcoal filters.

✓The secondary cooling system was pre-constructed with modern equipments allowing the increase of reactor power with a factor of 1.5 – 2.0.

✓Some of irradiation devices will be also refurbished through new control system.

The expected life extension of 14MW TRIGA Research Reacto will be about 15 years

CONCLUSIONS

✓The operational safety experience for 14MW TRIGA Research Reactor is relative new. The systematic approach of requirements, methods and objectives of nuclear safety, is a continuous activity developed by the management and other entities or organizations. The role of operating organization is to predict, detect and manage all the situations challenging the safety and availability of facility.

✓Learning from the past events analysis and from the other events communications, the predictive function is accomplished.

✓The long term trends of performance indicators associated with analysis methods will contribute to the prevention of recurrences.

✓The international cooperation fostered by International Atomic Energy Agency in the field of nuclear safety is very useful, ensuring the exchange of experience in the framework of technical cooperation oriented to continuous safety of nuclear installations improvement.

ACKNOWLEDGEMENTS

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