Technical Meeting on Research Reactor Ageing Management, Refurbishment and Modernization,

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Experiences at the TRIGA of the University of Pavia in the management of the ageing of a TRIGA Research Reactor

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INTRODUCTION

LENA is located Pavia, Northern Italy, about 25 Km south of Milan

Degrees in English

Degree courses in English are another step towards the University of Pavia's internationalization, which has seen a significant increase in the number of overseas students in recent years

The University of Pavia is one of the world's oldest academic institutions: it was founded in 1361 and until the 20th century it was the only university in the Milan area and the region of Lombardy.

People

23,500 students, **1,500** international students **82%** graduates employed a year after graduation **2,000** professors, lecturers, native language teachers and administrative staff

Degree Programmes

84 Undergraduate and Graduate programmes
17 Doctoral Programmes
42 Professional Master's Programmes

The University of Pavia:

18 Departments
17 Students dorms
30 Libraries
1,250,000 Books and Journals
3,000 scholarships
1 University Language Centre

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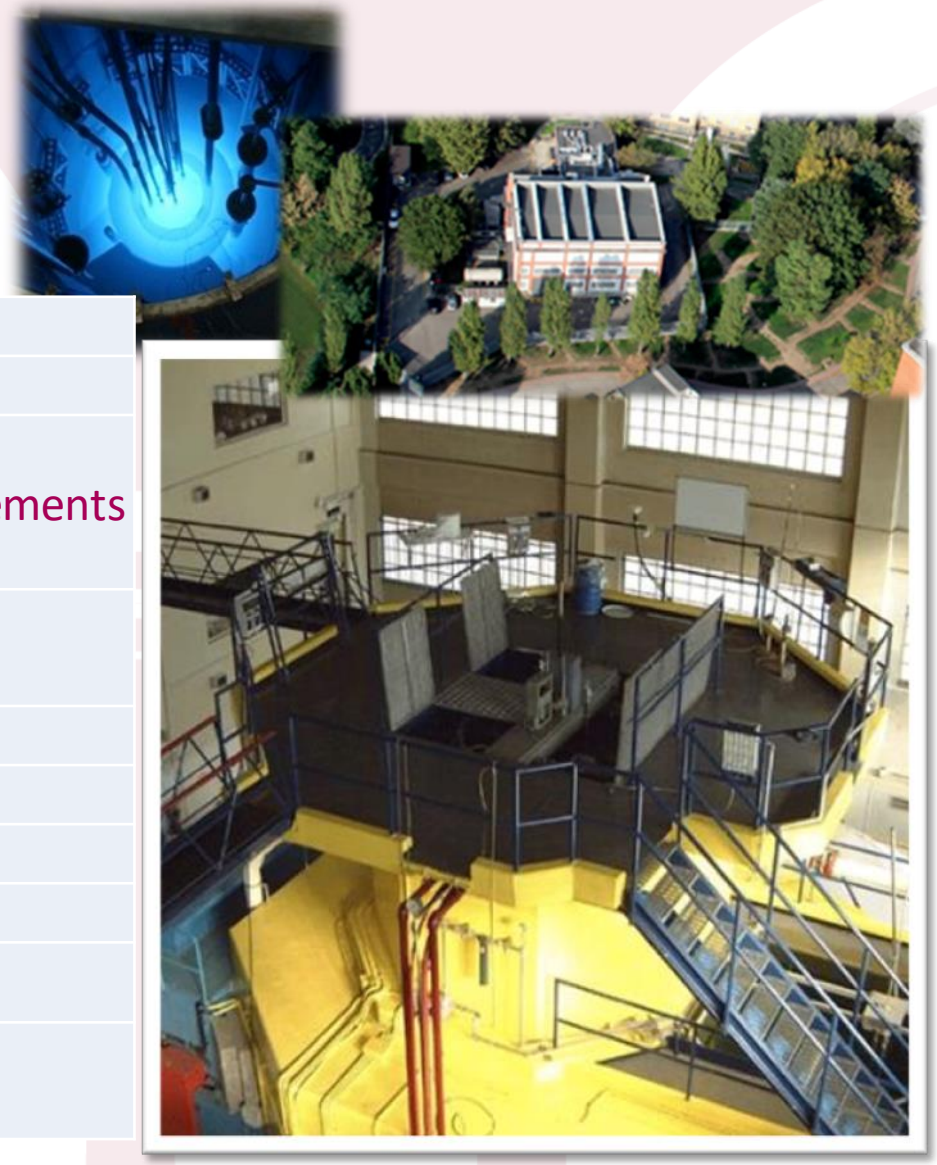
Research Reactor TRIGA Mark II

Maximum power (steady state)	250 kW
Maximum flux (central thimble)	$1.72\ 10^{13}$ cm^{-2} s^{-1}
Fissile mass (235-U)	2.2 kg corresponding to 62 fresh fuel elements (first core loading)
Temperature coefficient of fuel-moderator (negative)	$-1.2x10^{-4}$ Δk/k C° a 50° C
Moderator	HZr, H_2O
Reflector	Grafite
Heat transfer fluid	H_2O
Number of control rods	3
Fuel temperature @ 250 kW	230° C
Heat transfer fluid temperature @ 250 kW	35-40° C



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Introduction

- The University of Pavia is the operator of the nuclear plant TRIGA MKII since its **first criticality** occurred on **November 15th, 1965**
- The Authorization and **License of the TRIGA Mark II** facility are **registered in the legal entity of the University of Pavi**a
- To the **Director of the L.E.N.A**. the Rector of the University of Pavia delegates the tasks, responsibilities and **specific obligations** that can be attributed by law by the Employer **regarding the safety and health of workers in the workplace**.
- To the **Director of the L.E.N.A**. the Rector of the University of Pavia also assigns the tasks, responsibilities and **specific obligations** of the Director **responsible for the plant and the plant operation in the field of nuclear safety and health protection**.

Licence history

1965 – Reactor goes operational
1970 – New licence and operational limits and controls
1976 – Licence extension
1983 – Licence renewal with re-evaluation of:

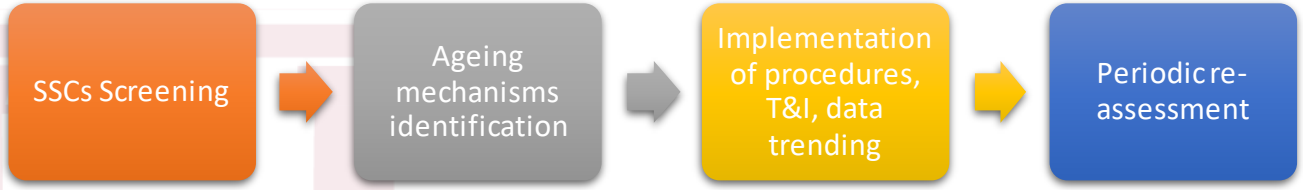
- plant response to design events
- environmental impact in standard operation conditions and in emergency
- technical requirements emergency plan
- evaluation of earthquake events
- evaluation of loss of power supply event
- evaluation of fuel element movement events
- revision of ventilation system
- revision of fire protection system
- revision of power supply systems
- revision of ICS's
- revision of waste management
- revision of radioprotection surveillance
- revision of operational documentation
- revision of the technical plant documentation
- revision of Operating Limits and Conditions (OLC's)

1990 – New licence
2005– New OLC's for the solid waste management
2013 – Code of Conduct implementation

The operation of the facility at present is authorized with the Decree of the Ministry of Economic Development n.VII-285 of May 22, 1990.

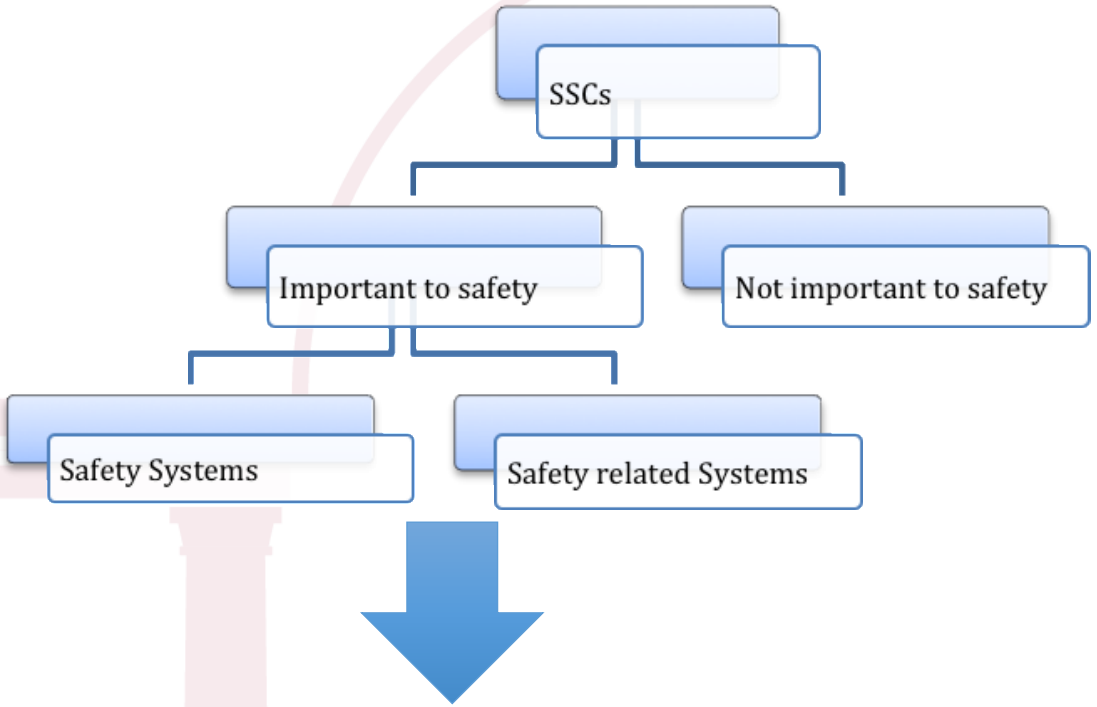
Ageing Management

Ageing Management program was implemented since 2014, complainant to IAEA Safety Standards Series No. SSG-10, Vienna, 2010



SSC	Planned activities
Pool structure and vessel	Visual inspections with underwater camera, development of procedures and definition of acceptance criteria. Assessment of results
Core Structure	
Reflector	
Shielding	
Beam Tubes	
Liner	
Fuel assemblies and storage in reactor pool	
Primary cooling system	Efficiency monitoring by on line data acquisitions and real-time parameters evaluation. Trending of data to assess conditions. Periodic result evaluation.
Biological shield	Efficiency of shielding of gamma and neutron dose to be tested every 5 years
Ventilation: emergency	Improved maintenance and controls on the rotating equipment. Definition of procedures
Control Console (LOG channel, SCRAM loops)	New design for the channel refurbishment. Updating of the documentation, management of spare parts. New calibration procedure
Cabling (control console internals and interconnections)	Step by step cable replacement.
Shielding	Visual inspections. Definition of test to be carried out on periodic base.
Beam tube lines	

Ageing Management

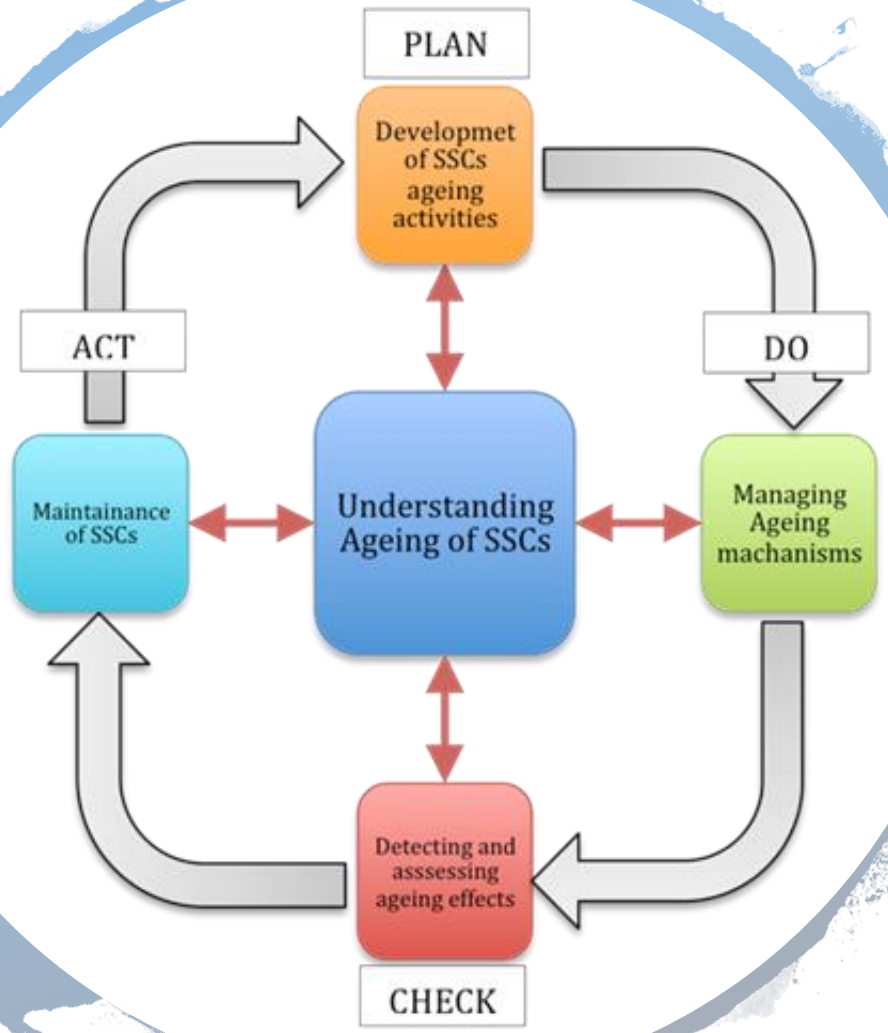


Central role in the definition of the AMP is played by the categorization of relevant structures, systems and components susceptible to ageing played

LIST OF SSCs relevant for ageing considrations

USE OF Failure Mode and Effect Analysis METHOD

Steps in the process
Failure modes (What could go wrong?)
Failure causes (Why would the failure happen?)
Failure effects (What would be the consequences of each failure?)



Deming (PDCA) cycle

Periodically, through the safety review committee, is carried out a continuous review of the safety of the Plant and the state of preservation and its use.

Any change of the technical equipment of the installation relevant from the point of view of nuclear safety and radiation protection are documented, communicated and placed in approvals in accordance with the approved Management Mode.

Each activity is regularly documented and reported to the Regulatory body.

Ageing Management

2006 – Area Radiation Monitoring system

2007 – Reactor I&C refurbishment

2008 – Reactor cooling system

2010 – Ion and fission chambers positioning system

2011 – Water demineralization system

2011 – DAQ for I&C

2012 – DAQ Cooling system

2014 – Periodic Reactor Safety Review

2016 – Building Seismic evaluation

2016 – New particulate monitor

2016 – New UNIT 300

2017 – New Logarithmic channel in comparative operation

2017 - Topical Peer Review Ageing Management National Assessment Report

2018 –SC rewiring

2019 - Regulatory body approvation

Extract of ageing menagement program

SSC	Replacement complexity	Ageing mechanism	Periodic checks, preventative or mitigating actions	Frequency	Recording
Liner and inner Reactor structures					
Tank structure, liner	A	1,5	Video inspection, ordinary cleaning	Each 3 years	MPEG files on USB storage
Core structure	A	1,5	Video inspection, ordinary cleaning	Each 3 years	MPEG files on USB storage
Riflector	A	1,5	Video inspection, ordinary cleaning	Each 3 years	MPEG files on USB storage
Control rods	A	1,5	Video inspection, ordinary cleaning	Each 3 years	MPEG files on USB storage
Handling of control rods					
Cabling	B	2,4	Visual Inspection, Regular Cleaning, Greasing, Screw Clamping and Connections	Six moth	MD SMESICS
Electrical components	B	2,4		Six moth	MD SMESICS
Mechanical components, leak inspections, wear, tightening connections and joints	B	2		Six moth	MD SMESICS
Rods guide	B	2		Monthly	Reg EC Module SDM (Fall Time / Extraction Time)
Experimental Channels (A, B, C, D, CT, thermalisation column)	A	1,5,7	Video inspection, ordinary cleaning	Each 3 years	MPEG files on USB storage

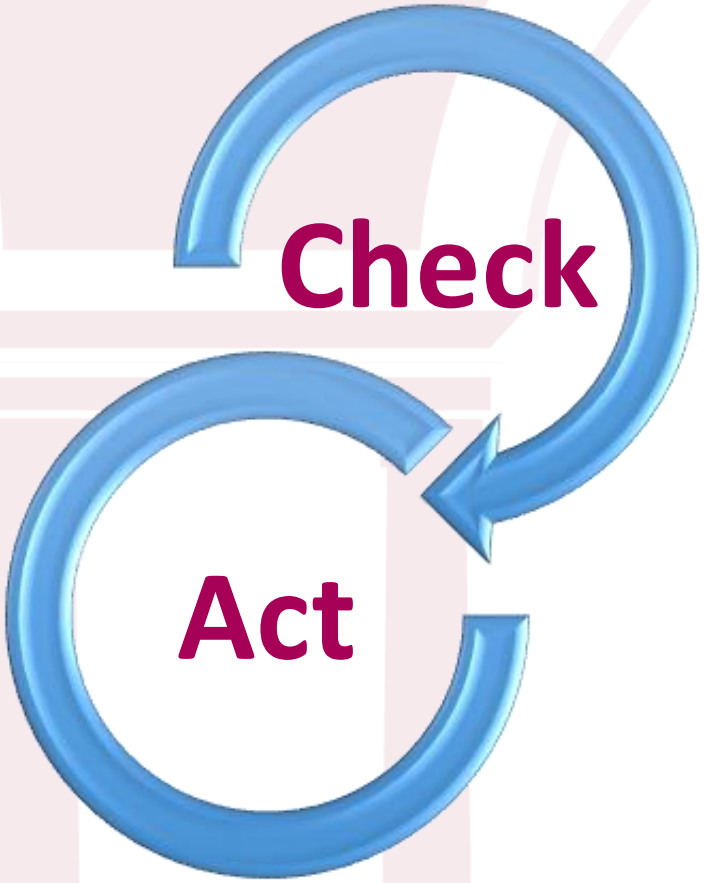
Aging Mechanisms (coding according to IAEA SSG10)
1. Change of properties (physical, chemical, mechanical) due to neutron irradiation
2. Change of properties (physical, chemical, mechanical) of materials due to operating temperatures
3. Mechanical stresses or cracks due to temperature / or operating pressure
4. Fatigue phenomena, material consumption due to thermal cycles, mechanical load, flow, induced vibrations
5. Corrosion
6. Chemical processes
7. Erosion
8. Technology change
9. Regulatory changes, regulations, prescriptions, etc.
10. Documentation obsolescence
Replacement difficulty
A = high
B= medium C= low

From experience gained over these years, a revision phase has begun to identify difficulties in applying the plan and integrate changes to make it more practical and effective in its application

LENA is going through a phase of generational change of human resources.

On-the-job training are basis of correct management of human resources, nevertheless it is important that reference documentation is exhaustive and understandable.

LENA aging management document was created on a voluntary basis in support of operation of the Reactor, after submission to Italian control body it is now part of LENA's prescriptive documentation.

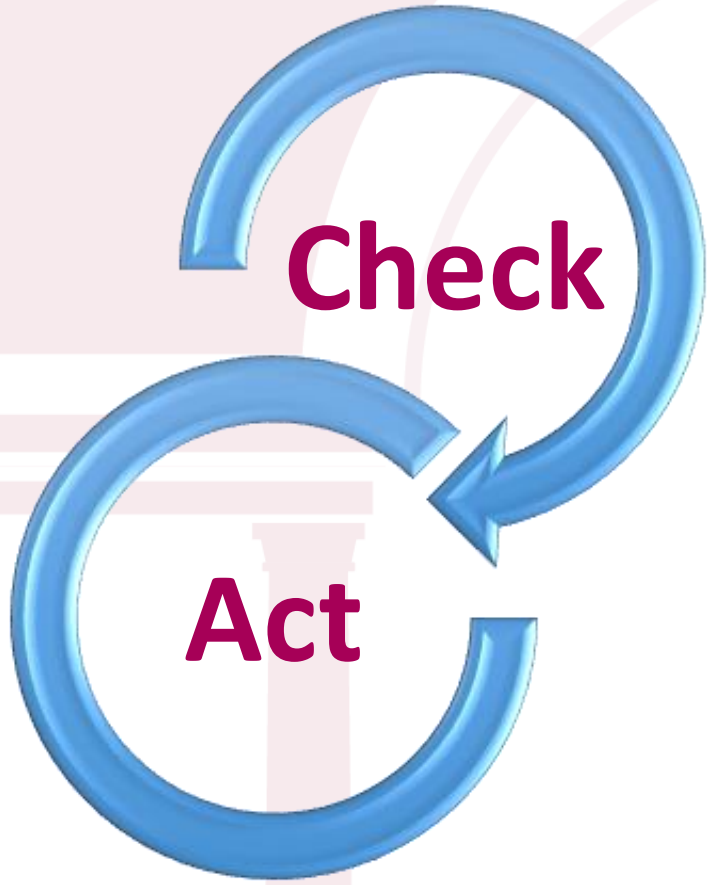


Deming PDCA cycle

Verification of implementation of ageing management system, made through internal audits, highlighted difficulty of inserting actions of the plan within the routine checks with their own clear and univocal registration.

Ageing plan was still found to be as a separate prescriptive documentation and not homogeneous with the other references.

For new maintenance personnel it was found necessary to better define the systems and their parts subject to the actions of the aging plan



Deming PDCA cycle

Maintenance managers and operators will be strongly involved in revision phase of the AMP

Quality service is dealing with revision of the verification registration system

Revision of AMP foresees a revision of initial selection of the SSCs on basis of the experience gained

Best identification in detail of components of systems subject to verification

Deming PDCA cycle

Conclusion and lessons learned

AMP has brought positive implications to the operation of the Laboratory by reducing non-conformities in the provision of the irradiation service due to system malfunctions

AMP and consequent planning of interventions was included in the process by optimizing the definition of the facility budget

General state of conservation of the reactor systems are generally better if compared to before the implementation of the AMP

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