Development and Demonstration of monitoring strategies and technologies for geological disposal

safe solutions for radioactive waste

Modern2020

Methodology for Qualifying the Monitoring Components

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1 -IRSN, 2-VTT, 3-Andra, 4-SKB, 5-SCK-CEN, 6-Univ Mons,7-EDF,8-AMBERG

10 April 201, Cité Universitaire Paris

This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement n° 662177

Methodology for Qualifying MCs

Qualification? *Definition from the NEA glossary on NPP ageing*

Demonstration through testing, analysis or experience of the capability of a Monitoring Component to function within acceptance criteria during specified operating conditions while retaining the ability to perform its safety functions under normal or degraded scenarios.

Objectives

To propose a global methodology for the metrological and functional qualification of the monitoring component (MC)

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Methodology for Qualifying MCs

Outline

- **State of the art** – Analysis of the transferable experience from industrial fields.
- **Lessons learned** - Case studies of long lived components in operation at URLs at conditions close to those expected in a DGR.
- **Development of a qualification process** - i) How to select monitoring components to be tested on testing benches, ii) How to test the selected components with the aim of producing robustness tests and accelerated ageing under harsh conditions.
- To propose a global **methodology** for the metrological and functional qualification of the monitoring component.

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Methodology for Qualifying MCs

Development and Demonstration of monitoring strategies and technologies for geological disposal

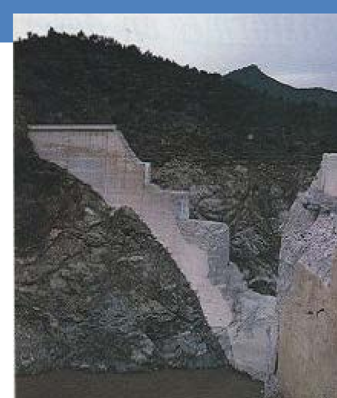
- Experience from the Energy field: EDF (French electricity producer)

Remote long-term quality monitoring for Hydraulic & Nuclear Power Plants

~ 20,000 sensors in 600 civil engineering

innovation

accidentology



pathologies

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Methodology for Qualifying MCs

Experience from the Space field:

- ESA (European Spatial Agency)
- ESCC (European Space Component coordination)

The European organism for space qualification of EEE components in the ESA Member States

ESCC European Space Components Coordination
QPL

Space ≠ Energy and Repository fields

- **Vibrations (strong at the rocket take-off)**
- **Radiations (≠ nuclear energy sector)**
- **Large temperature range (-40°C to +80°C)**
- **High vacuum**

HORIZON 2020
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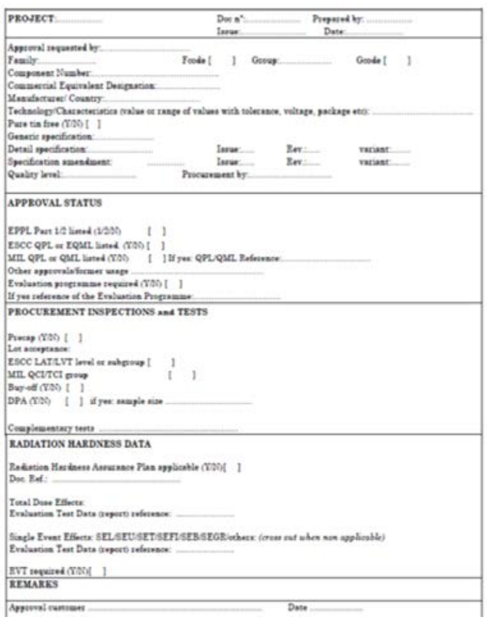
Methodology for Qualifying MCs

Space vs Energy fields

esa

ESCC
European Space Components Coordination
QPL

Part Approval Document (PAD)


PROJECT: .... Doc n°: .... Prepared by: ....
Issue: .... Date: ....

Approval requested by: ....
Family: .... Fcode [ ] Group: .... Gcode [ ]
Component Number: ....
Commercial Equivalent Designation: ....
Manufacturer/ Country: ....
Technology/Characteristics (value or range of values with tolerance, voltage, package etc): ....
Pure tin free (Y/N) [ ]
Generic specification: ....
Detail specification: .... Issue: .... Rev.: .... variant: ....
Specification amendment: .... Issue: .... Rev.: .... variant: ....
Quality level: .... Procurement by: ....

APPROVAL STATUS

EPPL Part 1/2 listed (1/2/N) [ ]
ESCC QPL or EQML listed (Y/N) [ ]
MIL QPL or QML listed (Y/N) [ ] If yes: QPL/QML Reference: ....
Other approvals/former usage ....
Evaluation programme required (Y/N) [ ]
If yes reference of the Evaluation Programme: ....

PROCUREMENT INSPECTIONS and TESTS

Precap (Y/N) [ ]
Lot acceptance:
ESCC LAT/LVT level or subgroup [ ]
MIL QCI/TCI group [ ]
Buy-off (Y/N) [ ]
DPA (Y/N) [ ] if yes: sample size ....

Complementary tests ....

RADIATION HARDNESS DATA

Radiation Hardness Assurance Plan applicable (Y/N)[ ]
Doc. Ref.: ....

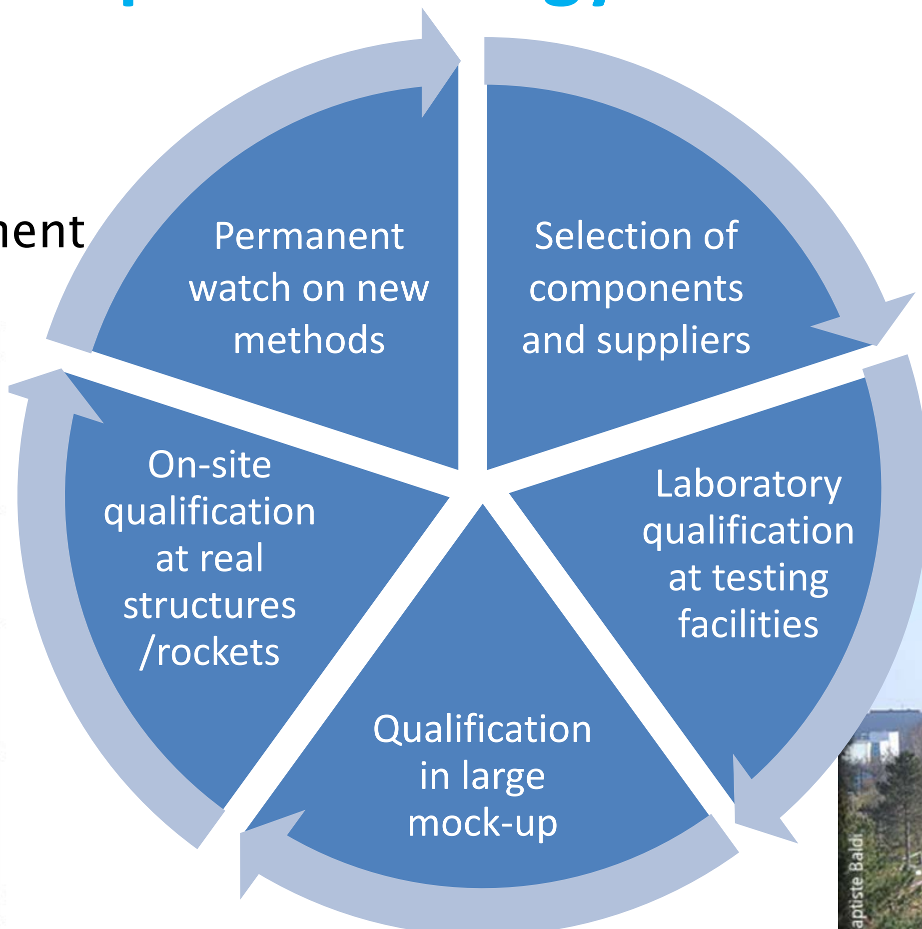
Total Dose Effects:
Evaluation Test Data (report) reference: ....

Single Event Effects: SEL/SEU/SET/SEFI/SEB/SEGR/others: *(cross out when non applicable)*
Evaluation Test Data (report) reference: ....

EVT required (Y/N)[ ]

REMARKS

Approval customer .... Date ....



EDF

Vercors: 1/3 scale mock up of a NPP reactor containment building at Moret sur Loing

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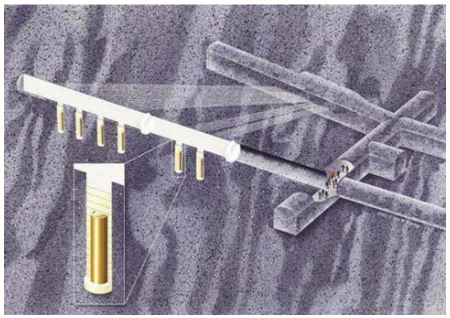
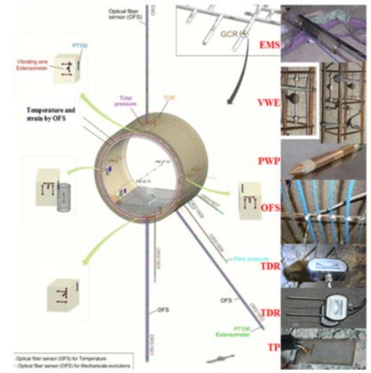
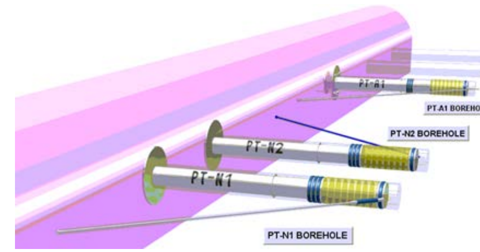
Selection of long-term experiments



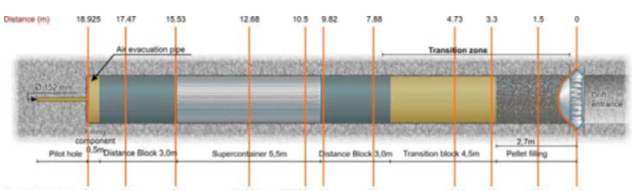
SKB – LT - Prototype Repository "in-situ" (8y) /Äspö URL



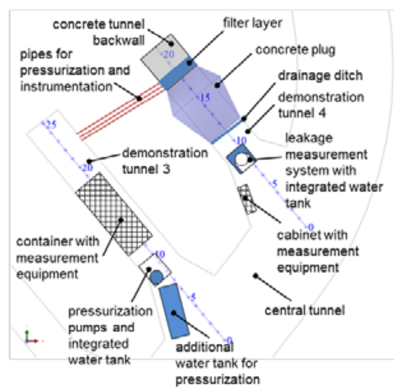
Andra – Dem - GCR (6y) / CMHM URL



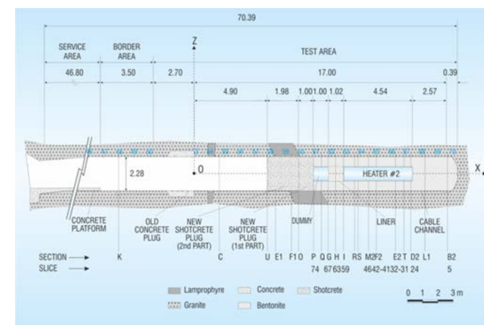
IRSN – LT – SEALEX (6y) / Tournemire URL



SKB – LT - MPT "in-situ" (5y) /Äspö URL



VTT – LT - POPLU (5y) / ONKALO URF



NAGRA/AMBERG – Dem - FEBEX "in-situ" (18y) /GTS URL

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Methodology for Qualifying MCs

Feedback from long-term experiments: main conclusions

Partner	ANDRA	NAGRA AMBERG	IRSN	SKB	VTT	SKB
URL/LAB (country)	LMHM (F)	GTS (CH)	Tournemire (F)	Äspö (S)	Onkalo (FIN)	Äspö (S)
Dismantled long-term and demonstrator experiments	GCR	FEBEX in situ				
Long-term experiments			SEALEX	MPT	POPLU	PROTOTYPE
Duration (y)	6	18	6	5	5	8
Total number of sensors						
Wired/Wireless	-	176/0	149/105	194/33	132/0	328/0
Total/Survival	134/9	176/108	149/113	227/99	132/20	328/125
% survival rate	93%	39%	24%	56%	85%	61%

- **Short duration and no 100% survival rate**
- **Highest survival rate attributed to the massive use of high TRL MC and to passive measuring methods → need for a longer acquisition time**
- **Lowest survival rate are due to experiments using « new » technologies (eg wireless) and/or to problems occuring during the swelling of the bentonite-based seals → need for a better isolation/reinforcement and improve the transmitter/receiver exchange**

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Development of a qualification process

- 1 - Selecting the Monitoring Components

1. Verification of metrological characteristics and performances
2. Sensitivity to influence parameters.
3. Verification of functional and ergonomic characteristics and design.
4. Verification of compliance with current standards.
5. Operation: input/output power, operating temperatures, wavelength, modulation, consumption, end of life, etc.
6. Testing: evaluation and qualification plan, test methods, screening definition.
7. Quality and Product Assurance (focus on reliability and traceability): define the customers’ reviews, the list of documents, the hardware acceptance.
8. Verification of the Technology Readiness Level (TRL).

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Methodology for Qualifying MCs

- 2 - Testing at laboratories (*in situ*, off-site)

1. Define the list of physical quantities to be tested. Define the main influence parameters.
2. Define the list of functionalities to be tested: same as 1. but wrt to the functional aspect of the operator interface, the dialogue with the PC or the central datalogger, the associated software.
3. List the tests to be carried out: **robustness, ageing**.
4. Select the laboratories, preferentially accredited.
5. Establish the test conditions.
6. Prioritize the tests (laboratory or on-site).

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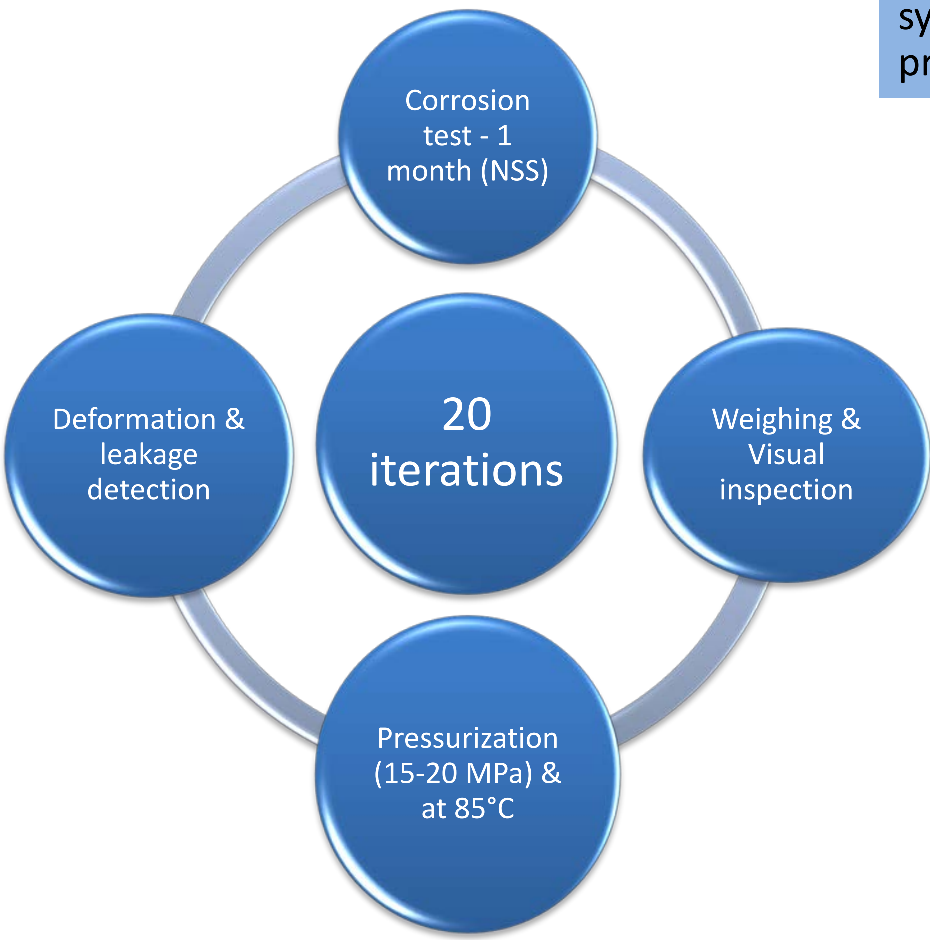
Methodology for Qualifying MCs

- 2-1 – Robustness tests

A testing process to verify the degree to which a system or component can function correctly in the presence of stressful environmental conditions



(VTT) Cyclic tests to simulate the long-term behaviour of MC in **EBS** environment as for the Nordic repository case

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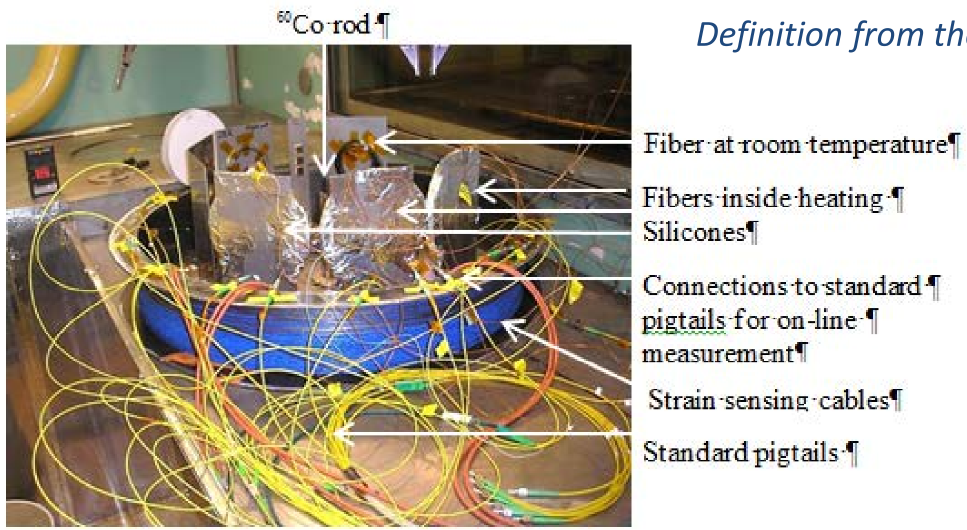
Methodology for Qualifying MCs

- ## 2-2 – Ageing tests

Irradiation = the only real time-quantifiable test

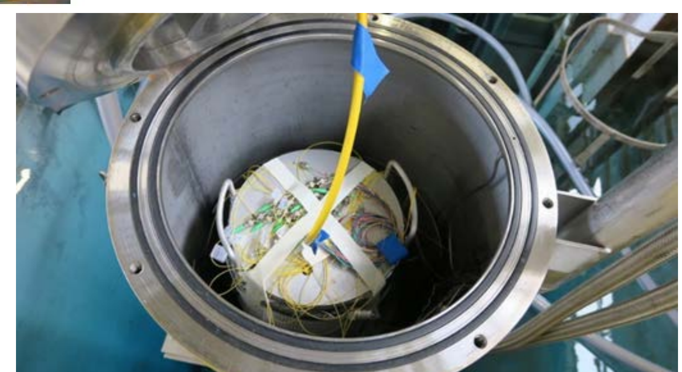
A testing process to accelerate artificially the normal degradation of a monitoring component (**MC**) with time of use

Definition from the NEA glossary on NPP ageing



IRMA/IRSN irradiation tests Nov. 2017 – Dose rate 3kGy/h - TID 1MGy

RITA/CEN irradiation tests Oct. 2017 – Dose rate 0.41-0.66 kGy/h, TID < 10kGy



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Methodology for Qualifying MCs

- 3 – On-site testing *of the whole MC system under realistic conditions*
  - At site-specific URLs (when radiation is not involved)
  - In large surface mockups (optional)
  - At DGR in dedicated disposal cells with real radioactive waste packages (obviously the most representative conditions)

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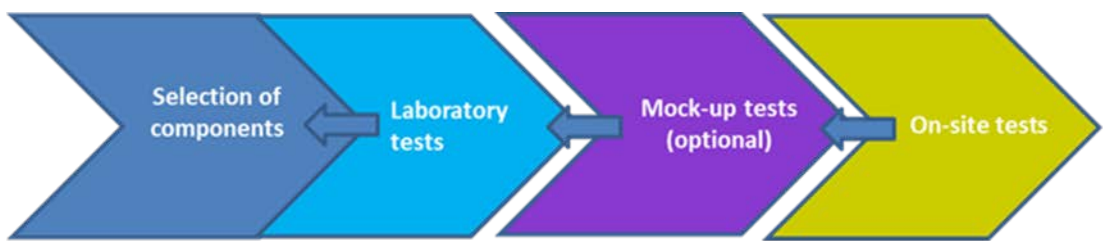
Main conclusions

- Strong synergy between Energy, Space fields and DGR needs with a qualification process in 3 stages: i) Selection of components, ii) The laboratory qualification and iii) On-site qualification.
- Despite a strict selection of the best technical solution of the moment, in situ and long-term experiments performed at URLs or at large mock-ups suggest improvements to be checked in situ.
- The Initiatives for the development of a generalized qualification procedure must combine robustness, ageing and on-site tests with an optional mock-up off-site test.



Global sketch for the qualification of monitoring components in DGRs

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Methodology for Qualifying MCs

Proposal of an Approval DOCument (ADOC) for a monitoring component qualification

Study reported in D36

Receive: ___/___/______

ADOC - Approval DOCument for a monitoring component qualification

Project:	**Doc n°:**
Prepared by:	**Date:**
Approval requested by:	
Family:	**Component:**
Technology Detail specification:	

Approval status:

Evaluation programme required:	☐ Yes	☐ Not

Component selection

TRL:	Procurement by:	
Influence parameters with measurement range and sensitivity:		
Sensitivity to influence parameters	☐ Ok	☐ Not Ok
Verification of functional and ergonomic characteristics	☒ Ok	☐ Not Ok
Verification of metrological characteristics	☐ Ok	☐ Not Ok
Verification of compliance with current standards	☐ Ok	☐ Not Ok
Requirement for additional tests (in case not ok)	☐ Yes	☐ No
If yes, test required Lab - Robustness	☐ Yes	☐ No
Lab - Ageing tests	☐ Yes	☐ No
In situ – Long-term	☐ Yes	☐ No
In situ – demonstration	☐ Yes	☐ No

Laboratory test (testing of components/combined components under adverse conditions)

1. Test of robustness:	☐ Yes	☐ No
Laboratory name:	Certification/accreditation number:	
Detailed Specifications: (type of test, steps, iterations…):		
Reporting:	Number	Date
Results:	☐ Ok	☐ Not Ok
2. Ageing tests	☐ Yes	☐ No
Laboratory name:	Certification/accreditation number:	
Detailed Specifications: (type of test, steps, iterations…):		
Reporting:	Number	Date
Results:	☐ Ok	☐ Not Ok

On-site test (testing of the whole components under realistic conditions)

1. Tests at URLS:	☐ Yes	☐ No
URL:	Certification/accreditation number:	
Detailed Specifications: (type of test, steps, iterations…):		
Reporting:	Number	Date
Results:	☐ Ok	☐ Not Ok
2. Testing at witness structure/cells at DGR	☐ Yes	☐ No
DGR:	Certification/accreditation number:	
Detailed Specifications: (type of test, steps, iterations…):		
Reporting:	Number	Date
Results:	☐ Ok	☐ Not Ok

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Thank you for your attention

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