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IGNALINA NUCLEAR POWER PLANT

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Outline

- Regulatory Framework
- INPP Decommissioning Strategy
- INPP Final Shutdown and Defueling Phase
- Decommissioning Projects for Unit 1 and 2 Final Shutdown and Defueling Phase
- D&D Activities: Bounding Conditions and Preconditions for Start-up of D&D Activities
- Safety Analysis Report: Goals and Graded Approach
- Licensing Process
- D&D Project Safety Analysis Report Content
- Principles for Selection of D&D Techniques
- Analysis of Separate Aspects Analysed in SAR

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Regulatory Framework

Framework Law → **Law on Nuclear Energy**

- Sets up a basis for the state nuclear energy regulation, competence of state institutions
- Establishes governmental infrastructure for sustainable development of nuclear program
- Establishes status, functions and rights of nuclear safety regulatory authority
- Conditions for nuclear facilities design, construction, operation and decommissioning
- Civil liability in the field of nuclear energy
- Economical and financial conditions for operation of the nuclear facilities
- Employment specifics in the field of nuclear energy

Branch Laws

- Law on Nuclear Safety
- Law on Radioactive Waste Management
- Law on Radiation Protection

Special Laws

- Law on Nuclear Power Plant
- Law on Decommissioning Fund
- Law on decommissioning of INPP

Specific Nuclear Safety Requirements

Nuclear Safety Requirements establishing requirements for specific fields of regulated activity (nuclear, radiation, fire safety, physical protection, emergency preparedness, waste management, decommissioning, etc.)

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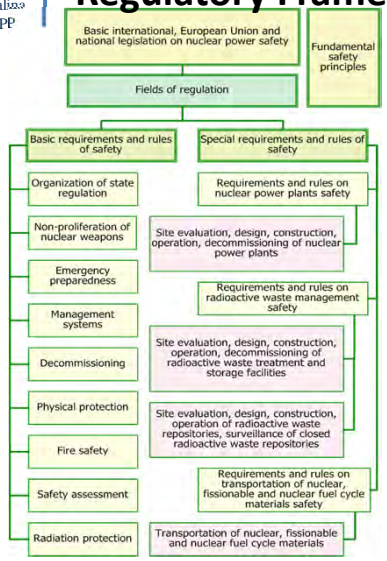
Regulatory Framework (cont.)



- **Consists of the basic requirements and rules, which cover generic safety issues**
- **Special requirements and rules for specific types of facilities and activities**

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Regulatory Requirements Pertaining to Decommissioning

Requirements for Decommissioning of Nuclear Facilities, P-2009-02 (to be replaced by)

Nuclear Safety Regulation BSR-1.5.1-2015 "Decommissioning of Nuclear Facilities"

Establish requirements for nuclear facility decommissioning:

- from the strategy selection to special requirements for dismantling and decontamination activities, removal of structures, systems and components and for safety assessment of decommissioning;
- special requirements for aspects to be analyzed in decommissioning design and safety justifying documents.

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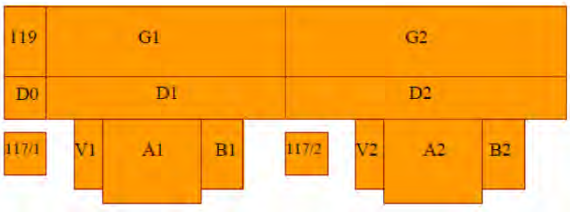
Decommissioning Strategy

Ignalina NPP is being decommissioned following the immediate dismantling strategy adopted by the Government of the Republic of Lithuanian.

INPP systems and equipment dismantling sequence under the INPP Immediate Dismantling Strategy follows "a building after building" approach and is in detail established within Decommissioning Projects for Final Shutdown and Defueling Phase in order to manage and control the radiological risks and also to facilitate the licensing process.

Layout of the INPP Units and its constituent facilities



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INPP Units Status

- For the smooth transition from the operation to decommissioning the **Transition Period** - in accordance with the IAEA terminology, or **Reactor Final Shutdown Process** – based on the national regulator terminology is defined.
- INPP Unit 1 was designated as finally shutdown in 2006 and Unit 2 – in 2012.
- Reactor final shutdown is a process during which the Nuclear Facility power unit is shutdown and the licensee implements measures related to finalisation of the Nuclear Facility operation until the final removal of spent nuclear fuel from the Unit.
- A finally shutdown NPP Unit is considered to be in operation as long as all nuclear fuel is completely removed from it.
- All requirements pertaining to the power unit in operation are applicable during this period.
- Currently the finally shutdown Units are being operated following the existing Units 1 and 2 operational licences conditions.

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INPP Final Shutdown and Defueling Phase

The final shutdown and defueling phase was subdivided into 2 stages:

- Stage 1 starts after the reactor final shutdown:
  - reactor is cooldown,
  - fuel is unloaded from the core,
  - transferred for storage in the spent fuel storage pools,
  - ends after complete fuel removal for the reactor core;
- Stage 2 starts after the stage 1 and ends after the fuel removal to the Spent Fuel Storage Facility from the Unit, including damaged fuel assemblies, i.e. after complete Unit defueling.

Both stages are associated with isolation, preparation for dismantling and actual dismantling of systems and equipment not needed any more to ensure safety and safe operation of the remaining in operation safety systems and equipment.

In order to be able to proceed with isolation and modification of some of the redundant systems during each stage, the INPP safety systems analysis was performed to determine their status (safety class) during separate fuel removal stages by comparing their performed corresponding functions prior to shutdown and the need of these functions to be performed after the reactor shutdown.

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INPP Final Shutdown and Defueling Phase

- Decommissioning Projects (DP) for Unit 1 and Unit 2 Final Shutdown and Defueling Phase;
- Safety Justification (Safety Analysis Report (SAR));
- Environmental Impact Assessment (EIA) Report developed in advance;
- Affirmative decision regarding the possibility to carry out the proposed economic activity under consideration taken by the competent state authority.

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Decommissioning Projects for Unit 1 and 2 Final Shutdown and Defueling Phase

DPs provide descriptions:

- INPP Unit 1 and Unit 2 systems that may be **modified and isolated** as a consequence of **losing their functions** to ensure safe operation of other remaining in operation safety systems and normal operation functions at each stage.

Safety of Unit 1 and Unit 2 decommissioning during defueling phase was justified in the Safety Analysis Reports (SAR) providing:

- engineering assessment of each safety system during each defueling stage,
- demonstrating that decommissioning activities covered in the corresponding Unit 1 and Unit 2 DPs can be safely executed.

DPs and SARs did not include any D&D activities for implementation of which separate design and safety justifying documents must be developed.

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Bounding Conditions Set in Regulations

- Safety related systems and equipment may be decontaminated and dismantled only after the spent fuel removal from the Unit.
- Non-safety related systems and equipment can be decontaminated and dismantled prior to fuel removal from the Unit.
- In some cases, after agreement with VATESI, non-contaminated systems and equipment can be dismantled following the modifications management procedure.
- Prior to fuel removal from Units, currently implemented equipment D&D projects are being performed following the modifications procedures.

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Preconditions for Start-up of D&D Activities

- Technological Design and the Safety Justification documents;
- Environmental Impact Assessment Report
- Affirmative decision of the competent state authority regarding possibility to carry out the proposed economic activity;
- Amendment of the Operating Licence conditions authorising to start D&D activities;
- Equipment must be shutdown and taken out of operation and isolated;
- No further operation of this equipment is predicted;
- A very clear definition of equipment dismantling boundaries;
- Preparatory works must be preformed dedicated for ensuring:
  - waste transportation conditions and routes;
  - sites for dismantled equipment preliminary decontamination, fragmentation;
  - temporary waste storage and packaging sites for different classes of waste;
  - preparation of building systems for performance of D&D works, including preparation of equipment for dismantling (taking down pipe insulation, arrangement of working areas, fencing), modification of utility systems (ventilation, power, water, compressed air supply, lighting), implementation of fire protection technical means, lifting devices, temporary sanitary locks, dose rate metering devices.

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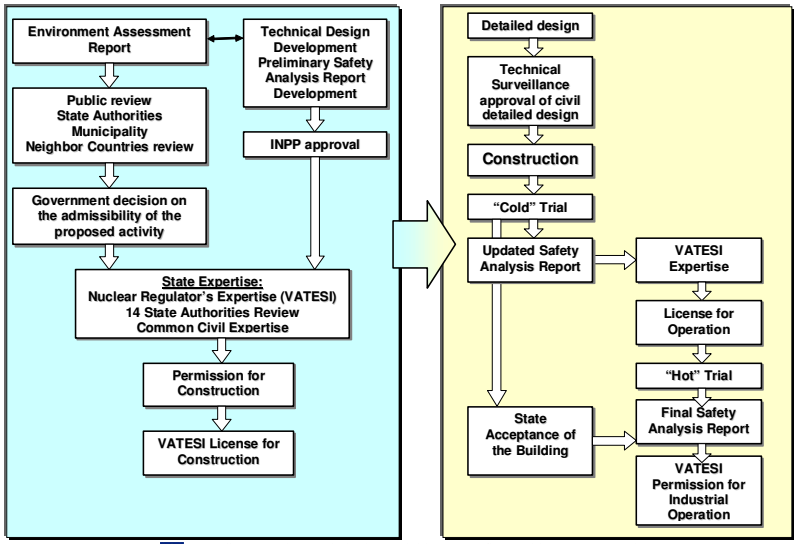
New Nuclear Facilities - Licensing Process



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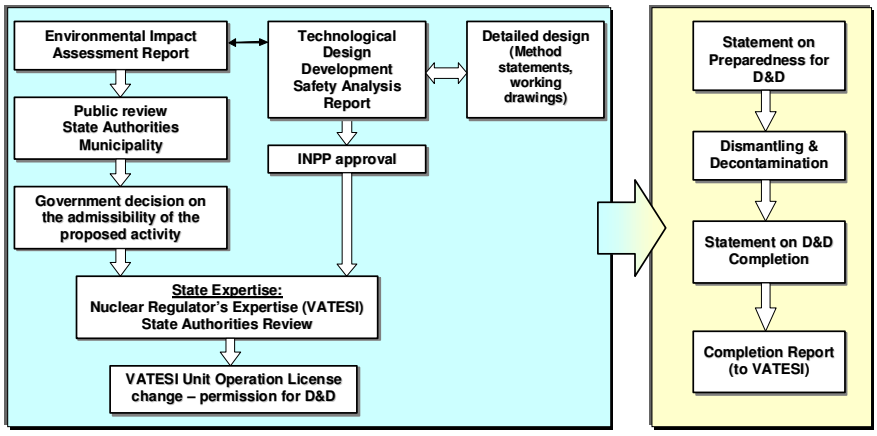
D&D Projects - Licensing Process



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Dismantling and Decontamination Projects - Safety Analysis Report

- Since TDD and SAR for D&D projects are developed by the INPP staff, an internal document was drafted establishing:
  - the procedure and sequence of SAR development,
  - requirements for the scope, content and level of detail of separate SAR chapters,
  - safety aspects to be analysed and substantiated within the scope of SAR.

  The document was agreed with the regulatory body in order to ensure common approach towards D&D licensing documents for the regulator to assess the safety and make a conclusion regarding completeness and safety of engineering solutions and procedures accepted in D&D TDD and justified in SAR and their compliance with the safety requirements set in the normative documents.

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D&D Project Safety Analysis Report Content

INTRODUCTION	• Definition of the D&D project • Goals of the Safety Analysis
TECHNICAL DESCRIPTION	• Description of systems to be dismantled • Systems remaining in operation • Description of D&D technological process • Occupational safety measures • Main indicators of the D&D project • Application of existing experience in D&D
RADIATION SAFETY	• Radiological conditions within D&D performance areas • Assessment of individual and collective doses • Compliance to ALARA principle • Radiation monitoring • Radioactive releases to environment
RADIOACTIVE WASTE MANAGEMENT	• Summary of radioactive waste to be generated during D&D project implementation (classification, quantity, physical state, etc.) • Radioactive waste handling (main principles, packages, routes, destination places, accounting system, free release waste) • Non-radioactive waste handling

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D&D Project Safety Analysis Report Content (cont.)

FIRE SAFETY	• Overall fire safety measures • Load carrying structures • Fire safety measure during D&D activities • Fire risk assessment
PHYSICAL SECURITY	• Impact of D&D to physical security, if any
ENGINEERING ASSESSMENT	• Impact of D&D process to linked systems • Analysis of functional requirements
INCIDENTS AND DESIGN BASIS ACCIDENTS ANALYSIS	• Method of risk analysis • Postulated initiating events • Incidents analysis • Acceptance criteria for incidents related to radiological impact • Design basis accidents analysis
PLANNING AND QUALITY ASSURANCE MEASYRES	• Main stages of D&D project implementation • Application of INPP management procedures
COMPLIANCE OF THE PROJECT TO NORMATIVE DOCUMENTS	• Demonstration of compliance
CONCLUSIONS	• Conclusions in accordance with the D&D project goals declared

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Safety Analysis Goals

- The overall objective of each D&D project is safe and efficient performance of equipment dismantling, fragmentation, decontamination, packaging of waste and its transportation from the Units to corresponding waste processing, storage or free release facilities and provision of safe operation conditions for systems remaining in operation needed for subsequent stages of decommissioning.

Safety Analysis Goals

The safety analysis of D&D project pursues the following goals:

- to demonstrate compliance of the D&D design solutions and technologies to the carried out D&D activity goal;
- to demonstrate that the D&D design solutions and technologies are optimized from the radiation protection point of view and are in compliance with the ALARA principle;
- to demonstrate that the impact limits to workers, general public and the environment set by the laws and other normative documents of the Republic of Lithuania are not exceeded;
- to demonstrate that the D&D project solutions and technologies could be safely integrated into the existing INPP conditions during the implementation of the project and the absence of the negative impact on the integrity and normal operation of other INPP systems remaining in operation.

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Graded Approach

IAEA recommends (No. WS-G-5.2) to apply a graded approach for performance of the safety assessment taking into consideration that the scope, extent and level of detail of safety assessment of the specific D&D project is commensurate with the types of hazards and their potential consequences.

The graded approach is applied in such a way that it does not compromise safety but ensures compliance with all relevant safety requirements and criteria.

In case of D&D projects application of the graded approach is expressed by:

- applying to the maximum extent the results and materials of the safety analysis earlier performed for analogous D&D projects already realised in Unit 1, including used D&D technologies;
- the scope of engineering assessment, risk assessment analysis, selection of initiating events, incidents and accidents analysis, including fire hazard analysis shall comply with the complexity of the D&D technological process, assessed radiological conditions and fire risk conditions in the D&D work performance areas, extent of impact to the operation of related systems remaining in operation;
- the scope of work related to justification of the waste final disposal ways shall comply with the quantities and characteristics of to be generated waste.

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Principles for Selection of D&D Techniques

Principles for selection of D&D techniques and organisation of D&D process to be justified in SAR:

- provision of worker safety;
- provision of operational integrity of equipment remaining in operation;
- the entire D&D process must follow the ALARA principle;
- the specific dismantling sequence „dismantling from radionuclide non-contaminated equipment towards radionuclide contaminated equipment“ shall be followed;
- use of experience gained during implementation of other D&D projects;
- use of available equipment and devices obtained for implementation of other D&D projects;
- apply such D&D techniques that lead to generation of minimum quantities of secondary waste and releases into the environment;
- selection of dismantling techniques (mechanical, thermal, electrical cutting) depends on equipment configuration, size, material composition (stainless steel – plasma cutting; carbon steel – acetylene-oxygen cutting);

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Principles for Selection of D&D Techniques (cont.)

- due to minimisation of dismantled equipment fragmentation at the dismantling sites, equipment is dismantled in as large as possible pieces depending on the load carrying capacity of lifting devices, sizes of openings made for waste transportation and capacity of fragmentation facilities;
- confinement of gases and aerosols during flame cutting and plasma cutting within welding areas by using mobile filtering devices;
- provision of separate transportation routes for different activity waste, i.e. free released waste and very low level waste routes are separated to prevent spread of contamination;
- decontamination of very low level waste is carried out to allow their subsequent categorisation as conditionally non-radioactive waste leading to minimisation of final disposal costs and environmental impact;
- subdivision of the entire scope of to be dismantled equipment into several working areas depending on the equipment location. At a time only the same type of equipment will be dismantled.

Justification of such principles and subsequent implementation during D&D work ensures safe performance of D&D Project.

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Radiation Protection Aspects

The SAR goal in this field is:

- to analyse radioalogical conditions at the work performance areas;
- to identify radioactive contamination sources on the basis of performed radiological characterization, surveys and measurements;
- to determine sufficiency of measures for radiation protection of personnel during D&D performance provided in TDD and their compliance with the ALARA principle;
- to prove that personnel exposure during D&D performance shall not exceed the set normative limits;
- releases into the air and water due to D&D activity do not exceed the set limits.

Based on the number of performed analysis for already implemented D&D projects and D&D projects in progress it is determined that actual dose rates for personnel performing D&D activities are much lower than the estimated due to:

- Conservative approach to dose rate calculation by assuming the maximum equivalent dose rate values at the dismantling area;
- The work is performed by trained, certified and experienced staff who has sufficient experience in performing similar D&D operations;
- Half life of Co-60 as a key radionuclide (which is equal to 5,3 years) since the radiological characterisation of to be dismantled equipment being performed much earlier than the actual performance of works, thus leading to equivalent dose rate significant decrease at the working areas;
- Prior to start of actual dismantling radioactive contamination sources impacting the major equivalent dose rates are removed from the dismantling areas and the areas with the greater surface contamination are decontaminated; Based on radiological measurements
- In areas with high equivalent dose rate values biological shielding is used during work performance.

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Radiation Protection Aspects (cont.)

Besides the measures provided in TDD and proved in SAR in order to minimize exposure doses of the staff performing D&D works a number of general personnel radiation protection measures are followed:

- Preliminary assessment of individual and collective doses on the basis of radiological characterization reports, radiological measurements prior to start of works, during the work and after their completion and application of specific measures for normalization of radiological situation;
- Minimizing the exposure time (by correct selection of equipment, establishment of optimum working conditions, optimization of work performance sequence, defined requirements for staff experience, training);
- Performance of preliminary decontamination;
- Using mobile shielding;
- Monitoring of individual and collective doses;
- Monitoring of working places;
- Monitoring of air contamination;
- Use of appropriate personal protective means.

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Engineering Assessment

The goal of engineering assessment is:

- to prove that systems required for D&D purposes perform their functions;
- to demonstrate absence of negative impact of D&D process on INPP systems remaining in operation.

For this purpose the following algorithm is applied:

- a list of related INPP systems required for D&D technological process is drafted (including, as for instance: service water supply system; fire fighting system; power supply system; compressed air system; heating systems; ventilation system; water supply and sewerage system; lighting system; communications system; radiation monitoring system; load carrying and transportation system);
- functions of each of the system from the list are identified with the indication of their relation to safety;
- functional requirements for these systems are identified and the analysis is made by proving that each system performs its functional requirements;
- analysis of impact of D&D technological process on INPP systems remaining in operation is performed.

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Risk Assessment

Based on the graded approach and justification of similarity of conditions from the technological, radiological contamination point of view, results and materials of the earlier performed safety analysis for analogous already realised D&D projects are applied.

The HAZOP (hazard and operability study) methodology is applied for risk identification, selection of postulated initiating events related to D&D process which enables to perform comprehensive assessment of risks posing potential hazard to personnel, general public and operability of systems remaining in operation and compile the list of postulated initiating events related to D&D process:

- incidents related to radiological impact to personnel and general public due to process equipment failures, human error, fire, drop of load, etc.;
- incidents not related to radiological impact to personnel and general public due to process equipment failures, human error, fire, etc.

Safety analysis of selected initiating events is performed in the following sequence:

- acceptance criteria for each of the identified incident are set;
- probable (assessed based on the conservative approach) impact is determined including (if any) organizational and technical measures preventing or mitigating the impact consequences.

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Risk Assessment

For incidents related to radiological impact to personnel and general public, dose limits set in the normative documents serve as acceptance criteria:

- effective dose limit for the 5-year period – 100 mSv and annual effective dose limit for “A” category worker – 50 mSv;
- annual effective dose constrain for general public – 0.2 mSv;
- dose limits for general public: annual effective dose – 1 mSv; annual effective dose in special cases – 5 mSv, under condition that the average dose shall not exceed 1 mSv per year during the subsequent 5-year period;
- annual effective dose constrain for general public due to separate radionuclide release streams into the air and water shall not exceed 0.1 mSv per year.

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Risk Assessment

The performed analysis of initiating events related to D&D process of separate INPP systems and equipment (within the scope of different D&D projects) with the most severe consequences to personnel and general public from the radiological point of view show that in no case the limits

set in the normative documents of the Republic of Lithuania will be exceeded.

Incident	Effective dose, μSv	
	Personnel	General public
Drop of radioactive waste package due to failure of lifting device or human error during load lifting operations	14,90	0,0222
Leakage of liquid radioactive waste during dismantled equipment surface wet decontamination	38,90	0,0217

Besides analysis of initiating events classified as initiating events leading to design basis accidents and beyond design basis accidents during D&D process (if any) is performed.
So far, initiating events neither for design basis accidents nor beyond design basis accidents were identified requiring additional safety systems ensuring impact limitation bellow the set acceptance criteria.

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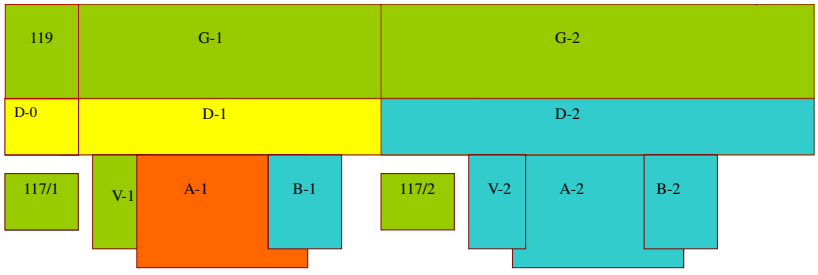
SAR Development Status



- SAR already developed and agreed with regulator, D&D is in progress or already completed;
- Final stage of agreement with Regulator;
- In progress, completion of development in beg. 2016;
- To be developed in future.

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Thank You for Your Attention

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