IAEA Training Course on Safety Assessment of NPPs to Assist Decision Making

Overview of Risk Informed Inspection

Lecturer
Lesson IV 3_11.11

Workshop Information

IAEA Workshop

City , Country
XX - XX Month, Year

Outline of Presentation

- General Focus and types of NPP inspections
- Risk-informing inspection process
- Safety cornerstone-based inspections
- Assessing inspection findings
- Tools development for risk-informed inspection (RII)
- Summary

NPP Inspections to Ensure Public Health and Safety

- Collect information on licensee performance
- Inspect licensee programs, processes, and performance
- Assess the information for safety significance
- Provide regulatory response and assure appropriate corrective action by the licensee

NPP Inspections

- Generic Safety Inspections
  - Inspection needed for resolution of generic safety issues; assuring adequate safety improvements
- Event Response
  - Inspections in response to operational events when deemed necessary
- Supplemental/special inspections
  - Additional inspections as deemed necessary or when declining performance is noted in particular aspects

NPP Inspections (Cont’d)

– Baseline Inspection

- Minimum level of Inspection conducted at plants regardless of performance

– Risk-Informed baseline inspection

- Focus inspection activities where potential risks are greater

Objectives in a Risk Informed Inspection

- Maintain safety
  - regulatory inspection to ensure continued safe operation
- Improve Effectiveness, Efficiency, and Realism
  - focus resources on risk-significant aspects
- Reduce Unnecessary Regulatory Burden
  - minimize regulatory and licensee resources on aspects with minimal safety implication
- Enhance Public Confidence
  - clear and understandable process for inspection and enforcement

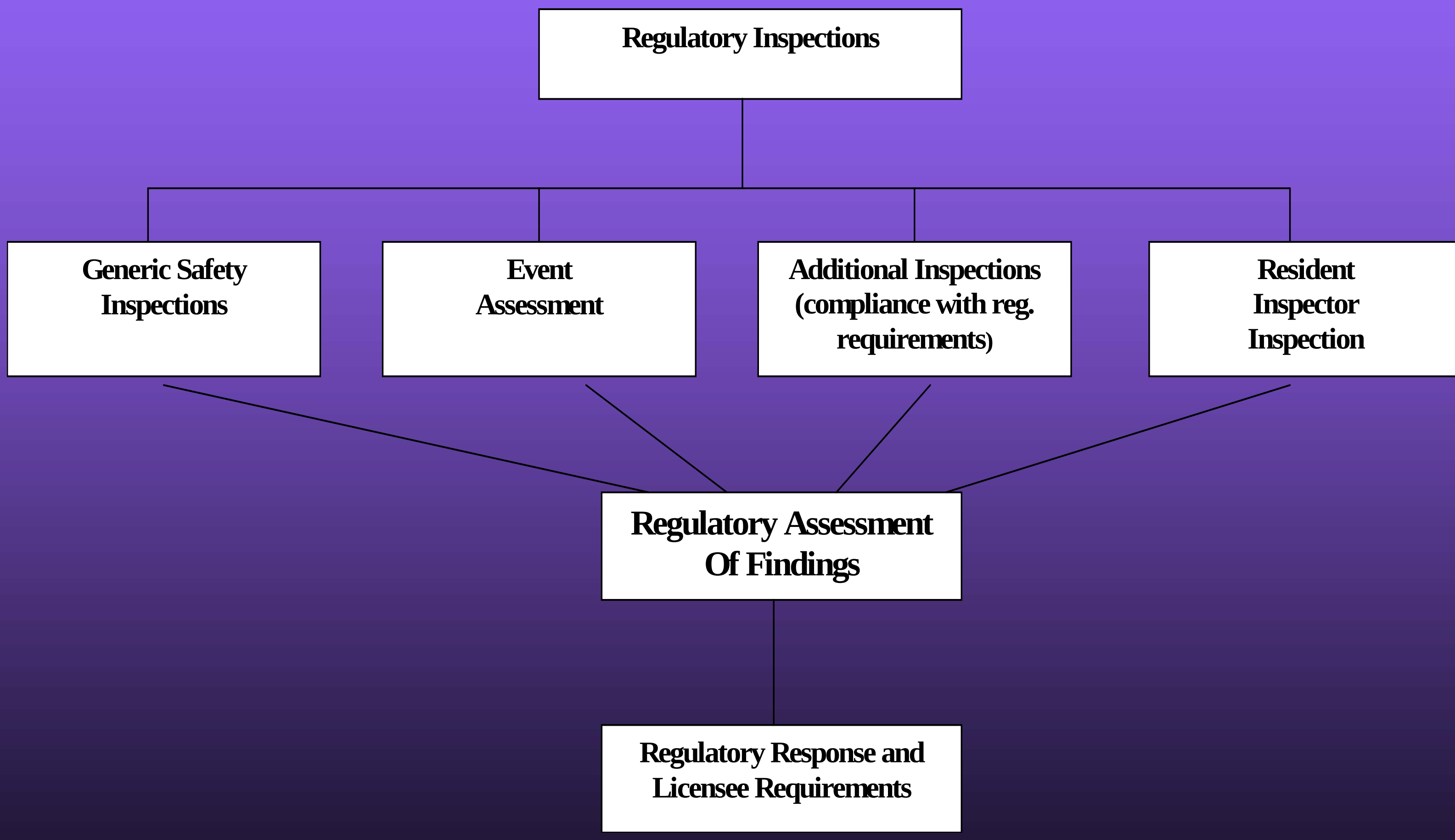
Features in a Risk Informed Inspection Program

- Focus inspection on activities where potential risks are greater
  - identify important risk contributors in a plant
  - define inspectable areas using risk insights
- Focus greater regulatory attention to plants with performance problems
  - define inspection program where plants with performance problems receive more emphasis
  - minimum baseline inspection for all plants

Features in a Risk Informed Inspection Program (Cont'd)

- Avoid unnecessary regulatory burden
  - use risk analyses to identify or delineate inspection findings with minimal risk implications
  - minimize use of resources for such findings
- Respond to violations commensurate with safety implications
  - use risk analyses to obtain an objective measure for the inspection finding
  - define regulatory action requirement based on the safety impact of the violation

Inspection Process



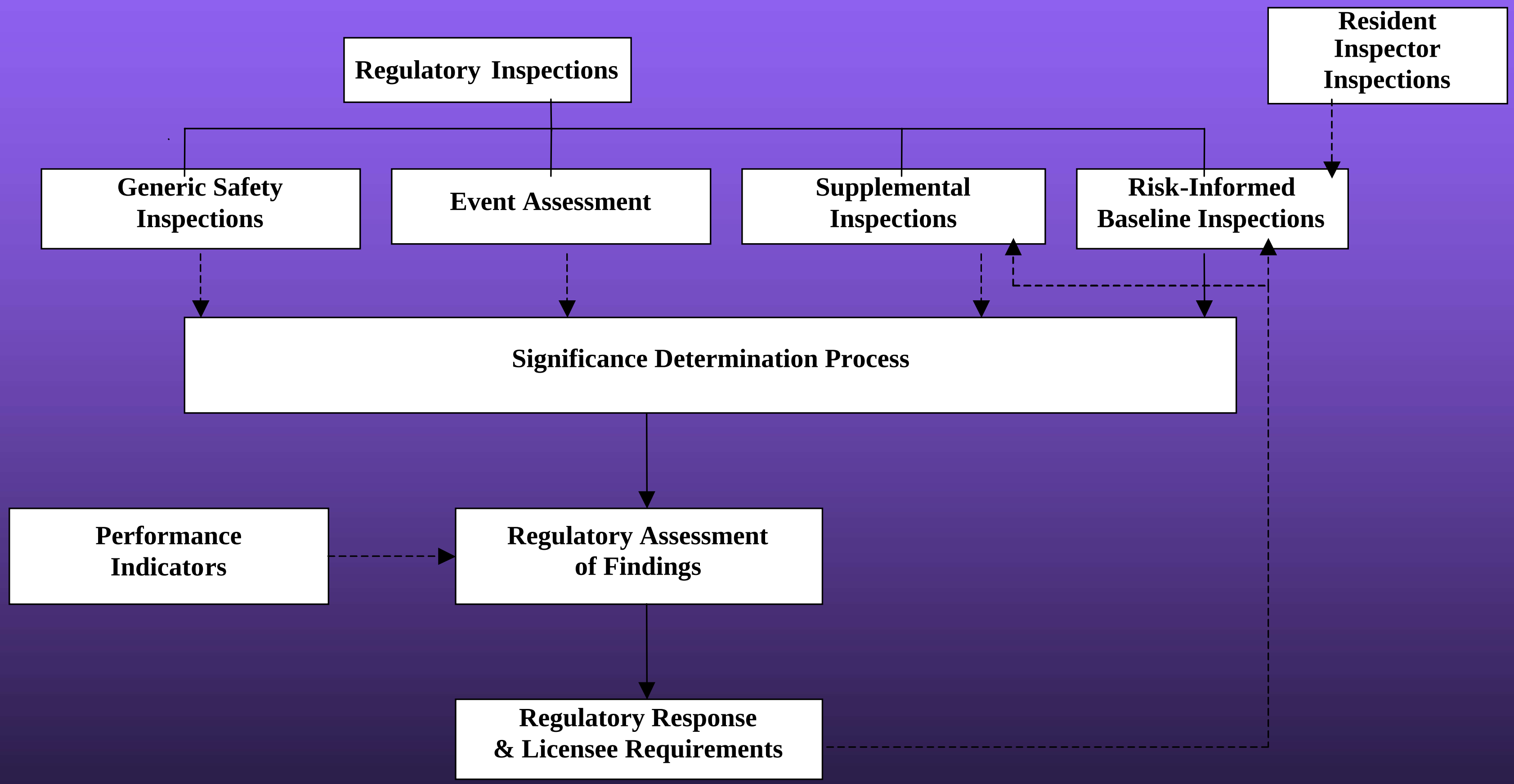
Risk-Informed Inspection Program

- Complements the current inspection activity with risk-informed baseline inspection
- Maintain current inspections relating to generic safety issues, event responses, and special issues
- Risk-informed inspection program to focus on risk-significant aspects and define needs for supplemental inspections when performance degradations are identified;
- Baseline inspections to include teams consisting of different technical areas to address all relevant issues

Features of Risk-Informed Inspection Program

- To assess plant performance, focus inspection on cornerstones of safe operation
- Define inspectable areas to address each of the cornerstones of safe operation
- Define inspection guidance and provide plant-specific risk information for specific inspection to focus on risk-significant aspects
- Use risk-assessment methodology to assess inspection findings
- Define licensee corrective actions and regulatory actions consistent with the risk-significance of inspection findings

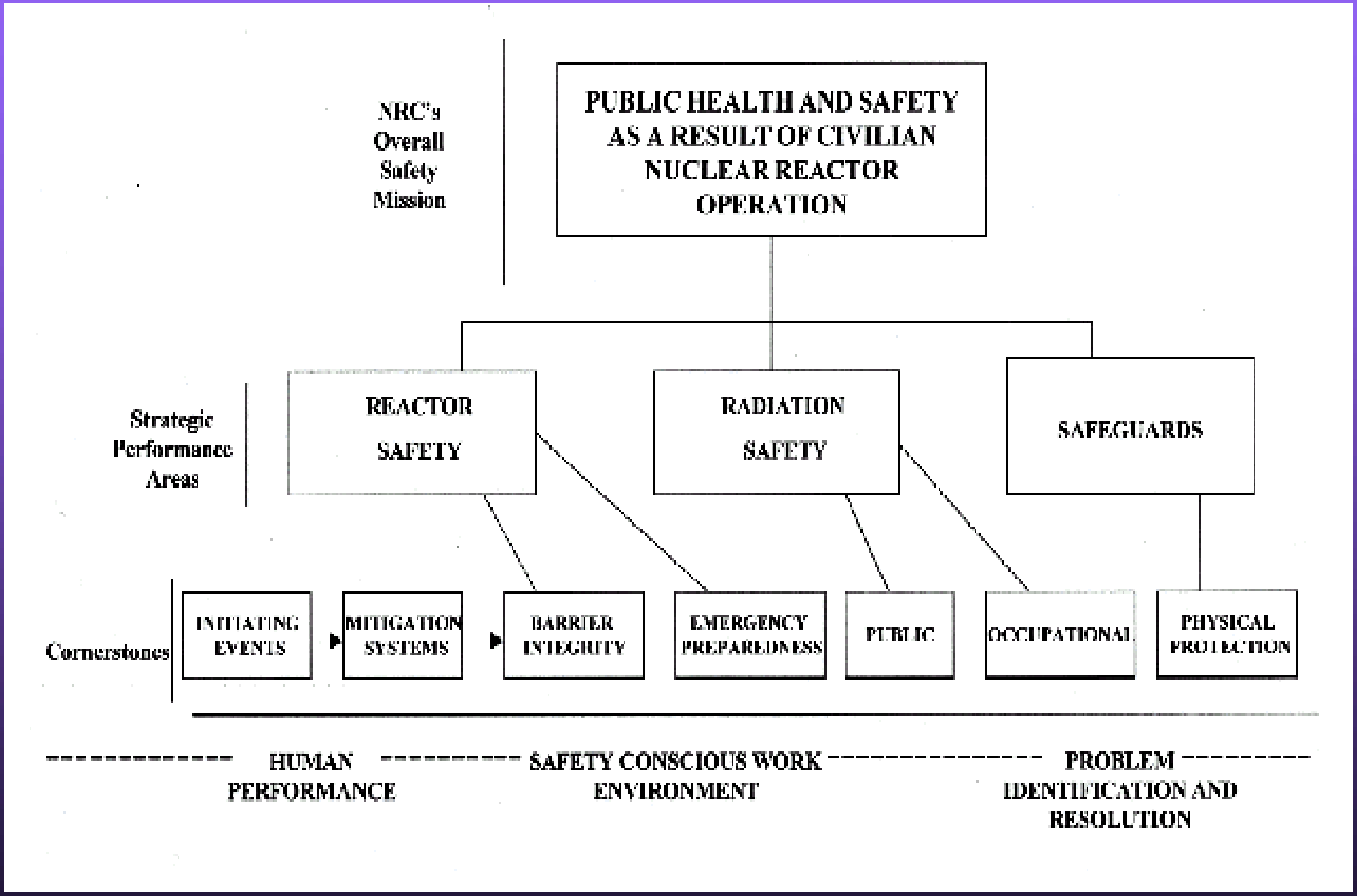
Conceptual Framework for the Risk-informed Inspection Process



Implications of Risk-Informed Inspection Program

- A base level regulatory attention to all plants focussing on aspects which support the safety of plant operations
- Greater regulatory attention to plants where performance problems are identified as part of the baseline inspection
- Use of objective measures of plant performance through use of risk implications of identified findings
- Licensee corrective action requirements and regulatory response to violations reflect safety impact of the violation
- Regulatory burden of inspection is defined and focussed

Framework for Risk-informed Inspection (USNRC's Reactor Oversight process)



Cornerstones of safety

Reactor safety Cornerstone	Radiation Safety Cornerstone	Safeguard Cornerstone
Initiating Events	Worker Safety	Physical protection of the plant
Mitigating Systems	Public Safety	Control of the nuclear fuel
Barrier Integrity		
Emergency Preparedness		

Human Performance ---- Safety Conscious Work Environment --- Problem Identification & Resolution

Inspectable Areas: Examples

Initiating Events

Protection Against External factors	Flood hazard Fire Switchyard activity Loss of heat sink	<u>Inspectable Areas</u> Adverse weather preparation Heat sink performance Maintenance work prioritization
Human Performance	Human Errors	<u>Inspectable Areas</u> Nonroutine evolutions
Configuration Control	Operating equipment lineup Shutdown equipment lineup	<u>Inspectable Areas</u> Equipment alignment Emergent work

Conducting Inspections Using Inspectable Areas

- Inspectable areas are based on safety cornerstones and are defined to address all important aspects of safety cornerstones
- Inspection frequency, number of activities to inspect, and resources used (time for inspection) are defined
- Selection of activities to inspect is risk-informed, using plant-specific risk insights (summary risk insights and risk-information matrix)
- Inspectors are trained in using risk information

Risk Insights for Selecting Inspection Activities

- Summary risk contributors based on PSA results
  - major risk contributors and reasons for their risk contributions
  - risk-important components and human actions
  - inspection implications
- Risk-Information Matrix (RIM)
  - information presented by systems
  - features of system, components within the system, and failure modes dominating risk contributions
  - important human actions and hardware needed to complete the actions
  - connection to safety cornerstones

Example RIM

Systems in Shearon Harris That Are *Risk Important* and Reasons for Importance				
Important Systems from IPEs	**Reasons for Importance**	**Cornerstones**		
		Initiating Events	**Mitigation Systems**	**Barri**
Systems Selected Based on CDF and LERF Contributions from the Shearon Harris IPE				
Low Head Safety Injection (LHSI)	Failure of LHSI system in the Shearon Harris plant is important because it results in loss of recirculation mode. The loss of recirculation mode is an important contributor for small LOCA sequences. Upon depletion of the refueling water storage tank (RWST), the pump suction is semi-automatically transferred to the containment recirculation sumps. The containment sump isolation valves (two per pump) automatically open to provide a flow path from the sump to the residual heat removal (RHR) pump suction. The operator is directed by procedures to complete the switch over by closing the RWST supply valves to the RHR's pump suction thereby placing the RHR system in recirculation. The operator will also manually align the CSIP suction from the RWST to the RHR pump discharge. The containment spray pump will automatically be realigned from the RWST to the containment sump without operator action. 1 of 2 RHR pump is required for success. The pumps receive power from 480 V vital buses. The two hot leg suction valves for each pump are powered from separate trains; the capability to cross-power one valve in each RHR train is provided. The pumps are cooled by CCW trains; the swing CCW can provide the cooling, if aligned. The RHR pumps are susceptible to CCFs; beta factor for failure to start is 0.1, and for failure to run is 4.1E-2. The relevant operator action includes establishing recirculation alignment or as an alternative to recirculation makeup to the RWST. In general, an important issue related to the LHSI system deals with a LOCA due to failure of high and low pressure interface. A series of interface check valves isolate the RCS from the LHSI system. Large back-leakages through a pair of these interface check valves result in an interfacing ("V" sequence) LOCA. In Shearon Harris, the relevant pathways are: cold leg safety injection line; RHR suction line, and hot leg low head safety injection line. Interfacing system loss of coolant accident (ISLOCA) is not a dominant CDF or LERF contributor.		X (SSPI)	X

Assessing Inspection Findings

– Termed “Significance determination process (SDP)”

– Provides a methodology for relating inspection findings to its risk implications

– Assigns risk values to inspection findings in terms of colors (red, yellow, white, and green); order of magnitude determination

– Risk values for inspection findings in different cornerstones are addressed similarly; differences in details

Significance Determination Process (SDP)

– Plant-specific PSAs are used to develop SDPs as a screening tool to discriminate between risk-significant and low risk-significant inspection findings

– SDPs are developed in engineering terminology and in a manner that facilitates use by inspectors

– SDPs can be used by inspectors directly to obtain a quick assessment of inspection findings during an inspection

– SDPs are used in USNRC’s reactor oversight process

– Detailed risk analysis, as needed, is done using detailed PSA models

Levels of Significance Associated with Inspection Findings

- Green - very low risk significance
- White - low to moderate risk significance
- Yellow - substantive risk significance
- Red - high risk significance

$\Delta CDF < 1E\text{-}6$	Green
$1E\text{-}6 < \Delta CDF < 1E\text{-}5$	White
$1E\text{-}5 < \Delta CDF < 1E\text{-}4$	Yellow
$\Delta CDF > 1E\text{-}4$	Red

Example SDP Worksheet Transient w/o PCS (TPCS)

Estimated Frequency (Table 1 Row) __________ Exposure Time __________ Table 1 Result (circle): A B C D E F G H

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Secondary Heat Removal (AFW)	1/2 MDAFW trains (1 multi-train system) or 1/1 TDAFW train (1 ASD train) through 1/3 SGs and associated 1/1 ADVs or 1 of safety relief valve
Early Inventory, High Pressure Injection (EIHP)	1/2 Charging pump trains (3 pumps) (1 multi-train system)
Primary Heat Removal, Feed/Bleed (FB)	1/2 PORVs open for Feed/Bleed (operator action = 2) (1)
High Pressure Recirculation (HPR) (2)	1/2 charging pump trains with 1/2 LHSI pumps (1 multi-train system)
Recirculation Spray (RS)	1/2 Inside RS (1A or 1B) pumps or 1/2 Outside RS (2A or 2B) pumps (2 multi-train systems) (3)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 TPCS - AFW - RS (3)			
2 TPCS - AFW - HPR (4)			
3 TPCS - AFW - FB (5)			
4 TPCS - AFW - EIHP (6)			

Assessment

– Inspection findings are combined to obtain overall assessment of plant performance

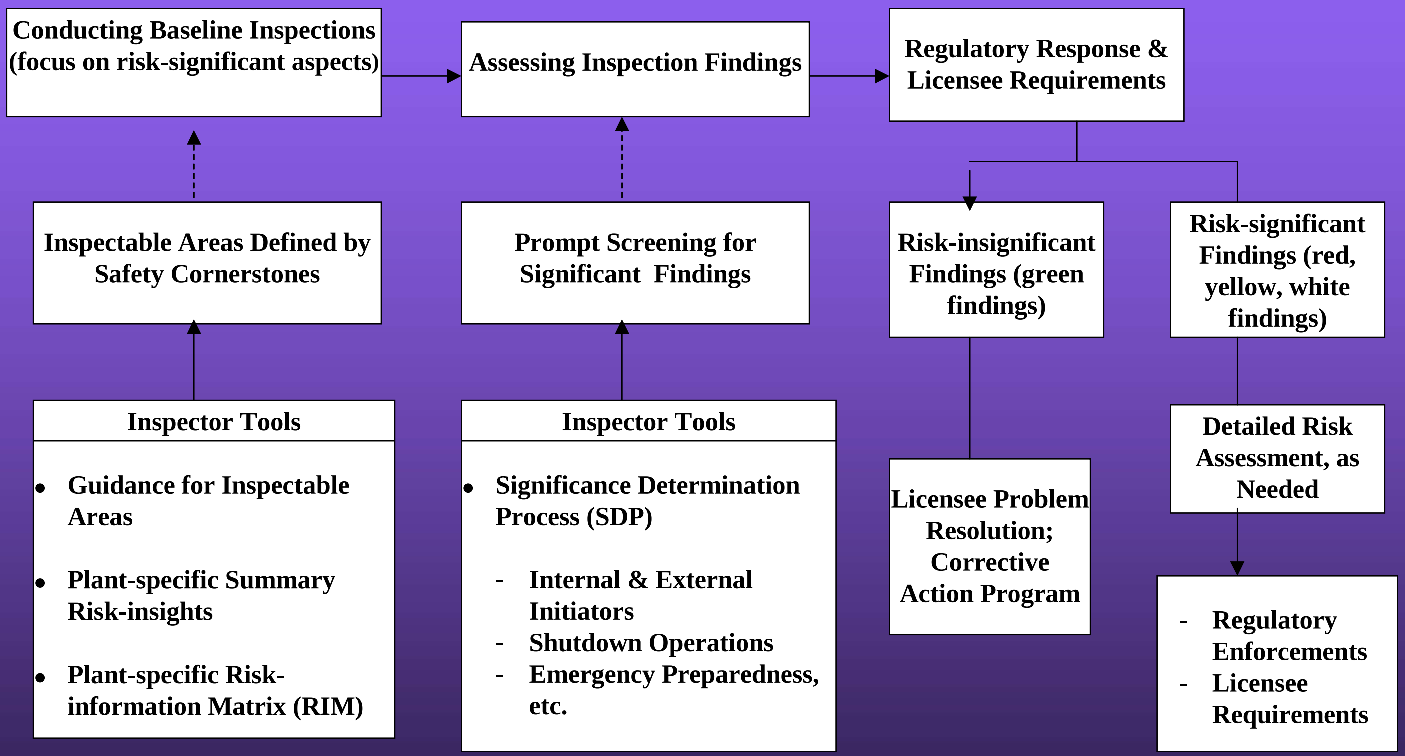
– SDP assessed violations:

  - low risk significant violations are entered into corrective action programs
  - higher risk significant violations obtain additional regulatory attention (to be defined)
  - Other violations not addressed by SDPs are treated as before

Tools Development for Implementation of RII

- Inspectable areas and guidance for conducting inspections
- Plant-specific risk-information matrix and summary risk insights for inspection focus on risk-significant aspects
- plant-specific model for significant determination process (SDP)
- Plant-specific notebooks for supporting risk-informed inspections

Risk-informed Baseline Inspections



Experience with Risk Informed inspection

- Significant differences with the previous inspection process
  - a different process
  - consistent use of risk insights
  - use of different tools
- Better understanding and appreciation of the inspection process
  - licensee's have better understanding of the process
  - easier to focus on risk-significant issues
- Need for tools and training for inspectors
  - plant-specific tools need to be developed
  - training in using the new process and tools
  - feedback from the inspectors

Experience with Risk Informed inspection (Cont'd)

- Step-wise implementation
  - inspection process is broad, changes can be implemented in incremental steps
  - risk-informed inspection process can be implemented in all aspects over time
- USNRC Implementation
  - used for all plants
  - plant-specific SDP tools developed; benchmarking being conducted
  - Tools being developed for some aspects

CSN's regulatory inspection

- CSN's Current inspection programme
  - CSN has a well organised inspection programme
  - Dozens of elements addressed by the inspection program
  - Regular and ad hoc inspections, focused inspections
  - The program is comprehensive, but not always fully focused
- Transition between existing and RII inspection process

  Objective *not to replace existing processes, rather to bring focus on risk significant aspects*

  - Review of current inspection process to identify its elements and embed those in risk-informed process
  - Define changes to the process & support needed by inspectors
  - Training for CSN inspectors

Risk informed inspection

– Conducting Risk-Informed Inspections
  - Risk-insights to be developed to facilitate inspector's use
  - Types of risk-information needed by inspectors:
    - General risk insights which help selecting important SSCs, op. actions, maintenance activities, other basic elements, etc.
    - Specific inspection requirements and guidance for the inspectable areas relating to each cornerstone
    - Development of plant-specific risk-informed inspection notebooks for supporting risk-informed inspections

Risk informed inspection

- Risk-Informed Inspections-developments needed
  - Developing plant-specific risk insights
  - Establishing Risk-Information Matrix (RIM)
  - Selection of Inspectable Areas
  - Actual plant inspection related issues
  - Plant-Specific Inspection Notebooks for performing inspections
  - System for evaluating inspection findings (SDP)

Risk informed inspection

– Risk informed inspection implementation plan:
  - CSN’s inspection program reviewed, and compared with cornerstone inspection areas
  - Risk informed matrix development, ASCO selected for the pilot plant
  - Training and clarification to be provide for inspectors
  - Pilot inspections on selected areas to be performed after tools are established

CSN's risk informed inspection Development tasks

1. Review of CSN Inspection Process at CSN

1.1 Review the current inspection practices at CSN to identify how different elements can be embedded in the risk-informed process

1.2 Define the changes to the process and the needs

1.3 Training needs for the CSN and the inspectors

2. Utilisation of performance indicators

3. Conducting Risk-Informed Inspections

3.1 Developing plant-specific risk-insights for use in a RII

3.2 Risk-Information Matrix (RIM)

3.3 Incorporate risk insights in Inspection Manuals

3.4 Plant Inspection Issues

3.5 Plant-specific inspection notebooks for conducting inspections

CSN's risk informed inspection
Development tasks

4. Assessing Inspection Findings

4.1 Development of SDP model for a plant for at power

4.2 Benchmarking the SDP model

4.3 Shutdown operations SDP

4.4 Fire Protection SDP

4.5 Description of the SDP process for use in plant-specific evaluations

4.6 Plant-specific SDP notebooks

5. Response or Action Requirements

5.1 Development of an Action Matrix defining CSN requirements

5.2 Defining Plant Issues Matrix

5.3 Assessment of Plant's Corrective Action Program

6. Training and Co-ordination

CSN's risk informed inspection
RII pilot

– Objective

- Aim is to establish parameters needed for supporting CSN management decision on adoption of new oversight process
- Aim is to identify conditions, elements and tasks needed to support the evaluation to new process
- The pilot shall determine the appropriateness and applicability of methods and tools for specific Spanish conditions

CSN's risk informed inspection
RII pilot

- Development of RII tools to be used in RII pilot completed (*draft versions-could be updated or enhanced later*)
- Areas for pilot inspection selected
    - Evaluation of Changes, Tests and Experiments
    - Fire Protection
    - Safety System Design and Performance Capability
    - Identification and resolution of Problems.
- Procedures to be used in inspection to be adopted from USNRC inspection manual
- Risk information relevant for those procedures to be extracted from ASCO's RIM
- Specific and focused training to be provided to participating inspectors

CSN's risk informed inspection
RII pilot

- Pilot inspection conduced as one-off regulatory inspection at ASCO plant
- For the inspection, support from USNRC inspectors with specific experience in areas selected
- Preparation for the inspection, a seminar to discuss in details the tools available and their use
- The Seminar also to address practical, hands-on experience accumulated by the USNRC in oversight process
- Attendance at the seminar-inspectors participating in the pilot
- PSA information system available for preparation and identification of risk significance

CSN's risk informed inspection RII pilot

- Pilot inspection implemented in April 2002
- Seminar for inspectors provided before the actual inspection
- Inspection conducted by CSN staff with participation of resident inspectors
- The inspection not to be considered a regulatory inspection
- ASCO plant informed that this is a pilot program
- Report to be prepared documenting the experience including
  - Tools used
  - Results achieved
  - Comparison with current inspection practices on similar areas

CSN's risk informed inspection
Transition process

- Pilot inspection and reports on findings to be used for establishing action plan for (*gradual*) introduction of RII
- Determine the needs for an extended pilot RII
  - Application to other plants
  - Extension to other inspectable areas
- Elements of action plan depends on experience from pilot
  - The approach and its application at CSN
  - Tools and methods provided
  - Training needs
  - Transition schedule
- Comparison with USNRC experience and lessons learned
- Presentation of the plan and its review throughout CSN

Conclusions

- A risk-informed inspection focuses inspection activities where risks are greater and applies greater regulatory attention for risk-significant findings and for plants with performance problems
- CSN's risk-informed inspection plan will enhance/balance the current process by adding a risk-informed minimum baseline inspection and complement the need for other types of inspection
- Transferring to a risk-informed inspection process is a significant change which can be effectively implemented in a step-wise process