Independent Evaluation by Regulatory Authority of Severe Accident Management Guidelines for Laguna Verde Nuclear Power Plan

Technical Meeting on Verification and Validation of Severe Accident Management Guidelines for Nuclear Power Plants
12-14 Dec, 2016. IAEA, Vienna Austria

Cesar Mugica
National Commission of Nuclear Safety and Safeguards - MEXICO
cesar.mugica@cnsns.gob.mx
Content

• Introduction
• LVNPP Power Uprate
• Background
• Regulatory Requirements
• Severe Accident Analisys
• Example: HCVS Implementation Plan
• Conclusions
Introduction

USA

Pacific Ocean

Gulf of Mexico

MEXICO

Alto Lucero City
State of Veracruz
MEXICO

19.725138, -96.410374
Introduction

MEXICO

Laguna Verde Site:

Units: 2
Technology: BWR-5/Mark II
U1 started operation in: 1990
U2 started operation in: 1995
Power (MWth):
1931 (Original)
2027/+5% (1995 Application, 1999 Authorised)
2317/+20% (2008 Application, 2016 Authorised)
Core: 444 Fuel Assemblies
LVNPP Power Uprate

- **Original**: 675 MWe
- **Power Uprate**: 682 MWe
- **Extended Power Uprate**: 810 MWe
Nuclear & Energy
Background

- CNSNS (Mexican Nuclear Regulatory Authority) concludes as results of Fukushima Accident that new elements must be included as part of measurements to improve the safety in LVNPP:
  - Inspection Plan Revision and Updating
  - Severe Accident Program Implementation
  - Training as part of Severe Accident Program
Background

INSPECTION PLAN

• New elements in inspection plan
  • Inspection of SBO rule (Extended SBO)
  • Inspection of reviewed plan of LV actions

• Updating and improvement of inspection actions
  • Emergency Plan
  • Training Programme
  • Fire Protection System
SEVERE ACCIDENT PROGRAM

• Development and Implementation of SAMG
  • BWR SAMG Generic-Adapted (Utility Proposal)
  • Training Programme

• Review and Evaluation of SAMG
  • Definition of government position
  • Verification and Validation of SAMG
Background

TRAINING PROGRAM

• Training for Reactor Operator (EOP)
  • Role Definition and Responsibilities
  • EOP – SAMG Transition

• Review and Evaluation of SAMG
  • Definition of government position
  • Verification and Validation of SAMG
The results of the inspections under new scheme supported by PSA analysis and simulation of models for progression of several scenarios lead that:

- **Venting (discharging directly to Reactor Building) needs to be modified**
- **Severe Accident Management Programme needs to be implemented**
- **Modification to strategies for BDBA**
Regulatory Requirements

• To develop and implement the Severe Accident Programme for LVNPP
  • NS-G-2.15, SRS-32, SRS-23...

• To develop the proposal of modification for venting system discharge
  • Review and applicability of NRC Order EA-13-109

• To develop guidance and strategies to maintain the core cooling, containment integrity and spent fuel cooling capacity under special events.
  • Review and applicability of NRC Order EA-12-049 and EA-12-051

• To develop the IPEEE (Individual Plant Examinations for External Events)
SAMG are not enclosed in an “Approved/Rejected Process” under Regulatory Authority Actions, but is highly recommended to evaluate that SAMG-S are effective under specific situations.
Regulatory Requirements

What is the purpose of review and evaluate the SAMG-S?

- To verify that strategies specified in the SAMG leads from A to B, where A is a real known state of plant and B is a controlled state (Mitigation/Control)

- To verify that at all times the two basic principles of Nuclear Safety are meet:
  - a) To keep the containment integrity
  - b) To minimize the releases and radiological consequences
Regulatory Requirements

Progression of Scenario

• SBO
• H2 Generation
• Vessel Failure
• Venting (Direct Path)
Regulatory Requirements
Regulatory Requirements

SAMG: Verification and Validation

Regulatory Authority is analyzing the options to perform this task, it is important to define a position about how much the Authority is going to be involved in:

• Development
• Implementation
• Review
• Evaluation
Regulatory Requirements

SAMG: Verification and Validation

**Verification:** QA and development process of SAMG is completely documented and is according and based on the best practices.

**Validation:** Evaluation of Effectiveness for proposed strategies (from A to B, where A is a real known state and B a controlled/mitigated state).
Severe Accident Analysis

- Scenarios for CNLV modelled in MELCOR code
- Source Term availability
- Trends for Core Damage
- HCVS already implemented
- Results are not detailed for venting pipe (interest parameters)
  - Alternative analyses needed (CFD for Hydrogen Behaviour)
    - Performed by Research Organisation Support (ININ-MEXICO)
Severe Accident Analysis

CNSNS has been performing and analyzing the modelling and simulation of scenarios for severe accident sequences, including:

• SBO with injection and SBO with no injection
• Small Break LOCA, Medium Break LOCA and Large Break LOCA (no injection)
• Reflooding
• Containment Failure Analysis
• Venting Strategies
• Hydrogen Generation and Stratification Analysis
Severe Accident Analysis
Severe Accident Analysis

GRAFICAL INTERFACE
Severe Accident Analysis

1) After the Fukushima accident, nuclear safety around the world was even more committed to control and cope with the accident progression in order to minimize the radiological consequences by improving the strategies and equipment implementation in facilities.

2) Modelling of systems, components must be adequate in accordance with features of utilities configuration, this is in order to model with more accuracy the progression of a severe accident (Severe Accident Modelling has a very wide window of uncertainties).

3) By modelling it is possible to analyze the best strategies to control, cope and mitigate the progression of a severe accident and to implement the most convenient improvements to hardware or administrative procedures.
Severe Accident Analysis
Severe Accident Analysis

Containment Failure Predicted by MELCOR for Laguna Verde NPP
a) No venting action
Severe Accident Analysis
Severe Accident Modelling

**Scenario:**

Station Blackout with injection of RCIC System for 4 hrs

**Details:**

After total lost of electrical power (out-site and in-site), reactor scrams automatically, MSIV’s close automatically because of lost of energy in valves, SRV’s start to cycle once they reach the setpoint, those valve are operating in relief mode until either electrical or emergency pneumatic supply is exhausted, at this point SRV’s begin to operate in safety mode (spring actuation) and there is no more chances to open SRV’s to depressurize or actuate the ADS or even vent the containment, which leads to a failure in primary containment.
Severe Accident Modelling
Severe Accident Modelling

Mass Flow Rate [Kg/s] vs time [sec]
Severe Accident Modelling

Containment Failure
Predicted by MELCOR for Laguna Verde NPP
a) No venting action
Severe Accident Modelling

- Containment Venting
  - $<4.5 \text{ kg/cm}^2$
  - for Laguna Verde NPP
- Venting action
Example: HCVS Implementation Plan

Current venting configuration:
Designed to release pressure from the containment to reactor building

• Leads severe environment inside the reactor building.
• Leads failure of different safety systems.

• In case of SBO the electrical power supply is limited to 4hrs.
Proposed venting configuration:
Designed to released pressure from the containment to outside of reactor building

- It does not lead severe environment inside the reactor building.
- It does not lead failure of safety systems.
- In case of SBO it is possible to open the venting valves (alternative modes).
Example: HCVS Implementation Plan
Example: HCVS Implementation Plan

What about?

• Progression of Conditions inside the Venting Pipe
• Impact on Structure and Hardware due to explosions
• Releases in case of Failure or Piping Damage
• Filtering or not?
Example: HCVS Implementation Plan

CHANGES ON:

- Hardware and System Configuration
- Procedures and Strategies

IMPACT ON:

- Risk
- Safety

Outside

H₂
FP
H₂O
N₂
Etc..

Inside
Example: HCVS Implementation Plan
Example: HCVS Implementation Plan

HCVS for Laguna Verde is already implemented in MELCOR Model, this allow to compute the concentration and possible (not detailed) hydrogen explosions in path (by using an intermediate control volume), however in order to compute the stratification, the detailed progression of conditions inside pipe and releases to environment, the use of a CFD code to simulate the flow path, filter or rupture disk is a very powerful tool.

This analysis was developed using GASFLOW code by Mexican Nuclear Research Institute (ININ).
Conclusions

• A government position about the evaluation (V&V) of SAMG must be defined.
• Training Programme implementation for Utility Staff and Role Definition.
• Inspection Programme for SAM has to be completed in accordance with high quality standards.
• Analyses for Low Power and Shutdown have to be completed.
• CNSNS-SA Model is ready for analysis (improvements could be implemented as needed), several scenarios were performed and documented.
• Current version of SAMG for LVNPP are in V.b1, Regulatory Authority checked the general requirements about the SAMG but not the development process neither effectiveness.
• Some results related to HCVS needs a more detailed analysis because of danger of deflagrations or explosions inside venting pipe for proposed configuration.
Independent Evaluation by Regulatory Authority of Severe Accident Management Guidelines for Laguna Verde Nuclear Power Plan

Technical Meeting on Verification and Validation of Severe Accident Management Guidelines for Nuclear Power Plants
12-14 Dec, 2016. IAEA, Vienna Austria

Cesar Mugica
National Commission of Nuclear Safety and Safeguards - MEXICO
cesar.mugica@cnsns.gob.mx