The Nitrogen Threat

1. Why nitrogen is a risky threat to our reactors?
2. Current strategies to deal with it.
3. The new Valve ASVAD. Advantages.
4. Conclusion & questions.

by Arnaldo Laborda
www.asvad-nuclear.com
The Main objective

TO MAKE OUR NUCLEAR PLANTS SAFER

Revealing the inner enemy that can lead us to disaster, stabbing our cooling systems directly from its inside.

Introducing ASVAD, the new valve that will protect us from the nitrogen injection threat.
Some studies were done in the past about the gas effects in the ECCS systems. The amount of gas considered were limited to small quantities.

After the NRC GL-2008-1, plants evaluated its potential affectation, also considering small quantities of gas.

After Fukushima, plants developed actions to avoid the nitrogen injection from the accumulators, mainly based in FLEX equipment.

Neither plants nor regulators took further actions after that. It seems a “CLOSED ITEM”.

In this presentation, we will discuss this issue, because it seems underestimated. Is there a big (and hidden) enemy inside our plants?
A hard Fukushima lesson:

One of the worst nuclear accidents is the ELAP (Extended Loss of AC Power) accident, also known as LTSBO (Long Term Station Black-Out).

In this accident, all the electrical energy is lost during long time. The plant control is fully lost.

This accident also leads us to other serious accident: the LOCA (Loss Of Coolant Accident). It will jeopardize the core cooling.
ELAP: The accident worsens (45h - 60h)

The RCP seals continue leaking. Without enough steam, the AFW turbine stops.

The nitrogen reaches the top of SG’s tubes. Natural circulation is stopped.

When the water ends, nitrogen gets into the RCS.

Nitrogen will remain inside RCS disturbing the long term cooling and threatening the core integrity.

If FLEX Equipment can’t maintain the RCS pressure then…
Each accumulator has 14 m³ (~650 Kg) of nitrogen (@ 45 Bar @ 35ºC).

This nitrogen follows the ideal gas laws.

During the accident, the gas temperature will rise.

And LOCA will depressurize RCS.

This means the nitrogen will expand. It can reach 585 m³ (@ 1 Bar @ 35ºC).

The total RCS volume is around 340 m³ (@ 4 loop plants).

Just one accumulator has enough nitrogen to fill the whole RCS volume.

And there is one accumulator in each loop.

Then, the problem IS THREE OR FOUR TIMES BIGGER !!!
The ELAP accident in brief

Passive Safety

RCP’s low leakage seals
Accumulators

ASVAD

Active Safety

ELAP → LOCA → ACCUM. INJECTION → GAS INJECTION → LOSS OF COOLING → CORE MELTS

RESIDUAL HEAT REMOVAL

RCS FLEX injection (FSG-1) → Auxiliary Feedwater (turbine) → SG’s FLEX injection (FSG-3) → Accum. Isolation (FSG-10) → RCS Feed & Bleed (FSG-14)
Current strategies

Close the outlet isolation valves
- Closing the valves one by one using a FLEX AC generator. **Time critical action.** But even closed, the valves can leak nitrogen to RCS during all the time. All are active elements.

Open the nitrogen relief valves
- Using a FLEX air compressor to open these valves. The air distribution has to be operable, but it is not designed to withstand accidents. **Time critical action.** Alternative strategy.

Keeping high the RCS pressure
- While the RCS pressure is higher than the nitrogen pressure, there is no injection. A Flex pump is needed. Just to get time trying to close the valves. **Temporary strategy.**
Current strategies weakness

Current strategies rely on:

- Knowing the correct moment to perform it.
- Having enough time to perform it.
- The deployment of some ACTIVE elements and its proper actuation.
  - The Flex AC Power Generator availability.
  - The cabling deployment to the valves.
  - The valve’s ability to isolate the accumulators.
- The proper organization actuation.
  - Their capabilities to perform the work.
  - The adequate operator’s training.

This is a long chain of active elements!
Just one failure, it means nitrogen injection.

Do you still rely on it?
The ASVAD safety valve

The SIMPLE SOLUTION to the nitrogen injection problem.

AUTOMATIC  SAFETY  VALVE FOR  ACUMULATOR DEPRESSURIZATION
How ASVAD is installed?

ASVAD is installed in the nitrogen side of the accumulator.

It only needs a manual isolation valve and few feet of pipe.
What is inside ASVAD?

- Pressure chamber.
- Upper container.
- Locking cylinder.
- Closing piston.
- Fixing cylinder.
- Shut-off plug.
- Opening spring.
- Spring container.
- Fixing screws.
- Opening piston.
- Upper cover.
The ASVAD operating principle is the imbalance of forces: The force done by the accumulator pressure against the spring force.

During the injection, the nitrogen expands, and its pressure drops. When the pressure is low enough, the spring overcomes the pressure force.

Then, the shut-off plug are suddenly displaced to the bottom. This provides an open path to exhaust all the residual nitrogen in the accumulator.
Manual operation mode

ASVAD can be opened, applying pressurized air to the “open” inlet.

This pushes the opening piston downwards, until the plug opens.

ASVAD can be closed, applying air to the “close” inlet.

The air pressure pushes the closing piston upwards, closing the shut-off plug. Now, the accumulator can be refilled again.

When the air is exhausted, the piston returns to their initial position, and ASVAD remains armed.
Main advantages of ASVAD

⭐ It is **ALL TIME AVAILABLE** from the first moment.
⭐ It **FULLY AVOIDS** the nitrogen injection problem.
⭐ **NO EXTERNAL ENERGY** is needed.
⭐ **NO OPERATOR** assistance is required.
⭐ It acts at the **CORRECT MOMENT** and over **ALL** the accumulators.
⭐ It acts **AUTOMATICALLY** sensing the accumulator pressure.
⭐ Once it actuates, it vents **COMPLETELY** the accumulator. No further nitrogen injections are possible.
⭐ Its action **CAN BE VERIFIED** by the available instruments.
⭐ It will **SAVE ORGANIZATION EFFORTS**, allowing to focus on other recovering tasks.
More advantages of ASVAD

- **HIGH RELIABILITY** due to its robust and simple design.
- **HARD ENOUGH** to bear the post-Loca environment.
- **EASY TO BE INSTALLED** in the accumulator system.
- **EASY TO BE LICENSED**. Does not add a new failure mode.
- **INTRINSICALLY SAFE**. No EMC. No software. Cyber-attack proof.
- **QUALIFIED** for nuclear use. It’s a nuclear class 2 valve.
- **EASY TO BE OPERATED**. It can be remotely actuated if needed.
- **EASY TO BE MAINTAINED**. No wear in the valve. Few spares needed. With minimal maintenance cost.
- **EASY TO BE TESTED**. It can be functional and leak tested.
- **EASY TO BE ADJUSTED** to the desired pressure actuation.
- **CHEAP**. No expensive modification is needed.
- **HIGH QUALIFIED LIFE**. No further investments required.
1. **RESPONSIBILITY:** The license retains the prime responsibility for safety throughout the life time of facilities and activities.

2. **GOVERNMENT ROLE:** The Government authorities have to ensure that arrangements are made for preparing action programs to reduce radiation risks.

8. **PREVENTION OF ACCIDENTS:** All practical efforts must be made to prevent and mitigate accidents. The primary means to prevent and mitigate the consequences of accidents is ‘defense in depth’.

9. **EMERGENCY PREPAREDNESS AND RESPONSE:** Arrangements must be made for emergency preparedness and response for nuclear or radiation incidents.
Nitrogen is like a missile that goes right to our RCS “veins”

Now, we only have weak strategies to avoid its effects. This is like a giant with feet of clay…

Fortunately, now we could install ASVAD… the best passive defense.
The nitrogen injection to RCS is a **REAL THREAT** to the core integrity, and the current strategies to avoid it are **TOO WEAK** to rely on them.

Applying the Defense in Depth concept, ASVAD is the **FIRST** and the **STRONGEST SAFETY BARRIER** to avoid the nitrogen injection. It will be available all the time, protecting our RCS from nitrogen.

Nuclear community **HAVE TO REEVALUATE** this issue. It’s **OUR RESPONSIBILITY** to definitely solve this threat taking actions. **Nitrogen IS NOT a closed item.**
The stair of the (nuclear) professional behavior.

I'm not aware of the reality
Is not my work...
I’m not aware of the reality
I can’t do anything...
Someone will fix it...
I recognize the reality
I take the responsibility
I find a solution
I make it happen

We’re here now.... trying to make it happen.
We found a solution and have developed it.
We started on seeking solutions.
We’re aware of the nitrogen problem.

Where are you?
Where do you want to be?
Can we DO it NOW?
Questions

Now is your time to ask... (or to act)

More information at:

info@asvad-nuclear.com or
www.asvad-nuclear.com
Thanks!