AUTORITÉ
DE SÛRETÉ
NUCLÉAIRE

Direction
des équipements
sous pression nucléaires

RÉPUBLIQUE FRANÇAISE

Letter reference: CODEP-DEP-2022-008741	**For the attention of the Director** Nuclear Operation Division Site Cap Ampère 1, place Pleyel 93282 Saint Denis Cedex
	Dijon 24 février 2022

Subject: Stress corrosion cracks – requests for more in-depth analyses

References: [1] CODEP-DEP-2022-003685 of 1 February 2022
[2] D455022000867 of 11 February 2022
[3] D400822000025 of 14 January 2022 - Situation regarding stress corrosion flaws
[4] D455022000237 ind.0 of 14 January 2022 - Stress corrosion flaws detected at CIV1 and PEN1: data available as at 10/01/22
[5] Order of 7th February 2012 setting the general rules concerning basic nuclear installations

Dear Sir,

At the end of 2021, you informed ASN that cracks resulting from stress corrosion (CSC) had been discovered on the pipes of the safety injection system (RIS) of the main primary systems of the n° 1 reactors at the Civaux and Penly NPPs. The presence of stress corrosion was then confirmed on the other three N4 type reactors and, more recently, indications which could correspond to stress corrosion were detected on the pipes of the residual heat removal system (RRA) for these reactors.

In a letter dated 1 February 2022 [1] ASN sent you requests to which you replied in the letter of 11 February 2022. You presented a report on the stress corrosion phenomenon detected, your analysis of the safety implications and the programme of investigations and inspections you envisage conducting.

With regard to the safety of the reactors in service, you consider that the ability of the RIS lines to withstand the flaws hitherto observed is demonstrated and that reactor emergency shutdown is guaranteed in the event of a failure of an RRA system line.

You observe that the dimensions of the flaws analysed on the removed sections are so far smaller than the height of the first weld pass. In addition your analysis leads you to consider that their propagation would be stopped or significantly slowed owing to a compression zone within the material. Moreover, the analyses carried out so far indicate that the flaws observed on the Penly 1 reactor (1300 MWe) are smaller in scale than on the N4 plant series. Finally, the analyses conducted in other contexts on similar zones have never revealed the presence of stress corrosion cracks, in particular on the 900 MWe reactors.

I note that the mechanical justifications currently only concern two types of reactors and do not cover all the areas liable to be concerned by the stress corrosion phenomenon. In addition, you did not express a position with regard to the envelope nature of the flaws considered in your calculations. These two points require additional work.

A clearer understanding of the factors involved in the appearance and development of stress corrosion is required, notably with regard to the welding processes used. Similarly, identification of the areas that could be affected by stress corrosion is continuing, with upcoming inspections on the pipes of the chemical and volume control system (RCV) and the pressuriser expansion line.

The assessment of the safety implications must also cover situations going beyond those you have envisaged and I consider that the search for operational measures to reinforce prevention or the ability to manage a failure must be continued.

With regard to the programme of inspections, your proposals first of all aim to enhance knowledge of the stress corrosion phenomenon and lift any doubts concerning the welds, for which a review of the previous ultrasonic inspections highlights a risk of stress corrosion being present.

Thus, up until 1 September 2022, you intend to carry out in-depth inspections on the reactors representative of the various models, that is Fessenheim reactor 2, Chinon reactor B3, Penly reactor 1 and Civaux reactor 1. These inspections aim to identify the areas concerned on the various reactor models and to enhance understanding of the stress corrosion phenomenon.

You also plan to carry out inspections on the reactors, for which a review of the previous inspections led you to identify a risk of stress corrosion being present. You prioritised the reactors in service according to the risk of stress corrosion being present. The six priority reactors will be re-inspected during the outages starting between February and April 2022, three of which have been brought forward. The other reactors for which you were unable to rule out the possibility of an indication resulting from stress corrosion will be inspected no later than the end of 2022.

As of 1 September 2022, you intend to adopt a new maintenance programme and a new non-destructive test process capable of identifying and characterising flaws arising from stress corrosion, notably in terms of depth. You will then conduct inspections on the areas identified as sensitive on all of your reactors.

Given the importance of having this process in your strategy, I would ask you to pay particular attention to developing it within the stated time-frame and with the required level of performance.

More generally, you are still working in a number of areas to identify the factors involved in the appearance and development of stress corrosion and to characterise the safety implications. The understanding of this stress corrosion phenomenon should thus be enhanced in the coming weeks by the results of this work and the inspections on the reactors. I would draw your attention to the fact that this strategy will have to be modified whenever necessary, on the basis of any new data obtained.

*   *
*

In the appendix, you will find additional requests as a result of the above points. I would ask you to submit your answers, to the extent possible, by 4 March 2022, such that they can be taken into account during the meeting of the Advisory Committee for Nuclear Pressure Equipment, scheduled for 11 March 2022.

For the ASN Chairman and by delegation
The Director-General

Olivier GUPTA

Appendix to letter CODEP-DEP-2022-008741
Additional requests

A. Mechanical justification and associated hypotheses

Both the “realistic” studies and those performed with application of the RSE-M code only concern weld A18 on the cold leg of the RIS system of the P’4 type reactors and weld A11 on the cold leg of the RIS system of the N4 type reactors.

Requests X: I would ask you to indicate the extent to which the mechanical studies already provided encompass other welds on the 1300 MWe and N4 type reactors and, as necessary, to supplement them in order to cover all the welds concerned by the stress corrosion phenomenon.

The materials properties data used are not the data codified in the RSE-M. In the realistic studies, you wish to use materials values taken from the literature for the toughness of the base metal (60 kJ/m^2) and you wish to use the work hardening of the material in the tensile strength laws, which is not included in the RSE-M. In the studies with the RSE-M code, you use values that are not yet codified (43 kJ/m^2 at 200°C – point under discussion for development of the RSE-M code).

Request 1: I would ask you to provide data to justify the materials values adopted.

On the basis of the results of “realistic” mechanical studies, you reach a conclusion on the mechanical strength of weld A18 on the cold leg of the RIS system of the P’4 type reactors and weld A11 on the cold leg of the RIS system of the N4 type reactors in the event of an earthquake, or of loadings related to start-up of the safety injection system.

This study is however unable to evaluate the influence of the various parameters (loadings, material properties, etc.) and the corresponding margins. More specifically, with regard to the uncertainties surrounding the height of the flaws that could be present on other reactors, these studies should make it possible to assess the existing margins.

Request 2: I would ask you to conduct a sensitivity study for the main influential parameters, in order to evaluate the existing margins.

B. Safety analysis

The principle of defence in depth requires that you identify measures which would be able to prevent or manage the consequences of any failures of the pipes concerned.

Request 3: I would ask you to analyse the adequacy of the time-frames and required action as set out in the general operating rules (RGE) in the event of unavailability of the equipment needed for prevention or management of potential failures. A specific analysis shall be carried out to identify the transients (normal, incident or accident operation) which generate the greatest loadings on the areas concerned by stress corrosion; you will if necessary identify any necessary changes to operations or to the RGE in order to mitigate them.

Request 4: I would ask you for your position on whether or not it is necessary to make changes to the control of your reactors, such as to reinforce the capacity for and reliability of detecting a loss of primary system integrity.

Your answers to the above requests shall be based on the additional analyses[1] that you will be sending me in order to cover pipe breaks:

- on the RRA system of the 900 MWe reactors;
- on the RIS system for all the reactors.

Your analysis of any such breaks only concerned the 1300 MWe and N4 type reactors, does not cover all the states of these reactors and did not consider a break of an RIS system line. In addition, you only postulated a failure on one train of the RRA system, whereas it is probable that the stress corrosion phenomenon affects both trains in a similar fashion.

You also indicated that inspections are to be conducted on Cattenom NPP reactor 3 and Bugey NPP reactor 4 and these inspections will be carried out with the reactors in the standard "AN/RRA < 90°C" hot shutdown state.

Request 5: I would ask you to justify the standard state adopted for these inspections given the time the reactor is maintained in this state and the measures you will have identified with regard to my previous requests.

[1] similar to those already transmitted, but also postulating the possibility of several flaws breaking.

C. Reactor inspection strategy

i. *Representativeness of the reactors which have undergone in-depth checks*

The strategy proposed until 1 September 2022 is based notably on in-depth inspections on representative reactors. To date, no P4 type reactor has been selected. Similarly, for the reactors of the CPY plant series, there are differences between the even and odd reactors.

There are also reactors for which the austenitic steel of the main or auxiliary piping of the main primary system is of grade 304L and others for which it is 316L.

Finally, the welding processes used are not the same for all the reactors (see point C.iii).

Request 6: I would ask you to justify the representativeness of the reactors selected, taking account of the different designs.

ii. *Choice of zones to be inspected*

You indicated that these reactors will undergo extensive inspections on several austenitic steel welds on the RIS and RRA systems (inspections in progress on reactors n° 1 at Penly and Civaux) but also on the main primary lines, on the pressuriser expansion line and on the RCV system. You did not however specify the welds which are to be inspected.

Moreover, you did not consider the austenitic steel parts of the main primary system containing fluids in vapour phase, notably in the pressuriser.

Request 7: I would ask you to list the austenitic steel zones of the main primary system of the various reactor types and justify the choice of zones to be inspected.

The analyses carried out on Civaux NPP reactor 1 also revealed an indication close to a radiographic inspection plug.

Request 8: I would ask you for your position regarding the performance of inspections close to radiographic inspection plugs and other geometrical discontinuities.

iii. Influence of manufacturing conditions on determination of the zones to be inspected

You indicated that the influential parameters for initiation and propagation of stress corrosion include the manufacturing conditions, in particular the welding process and how it is implemented (welding mode, pass height, characteristics of filler materials, etc.), as well as the surface preparations before and after welding. You indicate that you have completed the review of the end of manufacturing reports (EOMR) for the 1300 MWe reactors and intend to review those of the 900 MWe reactors by 28 February 2022.

Request 9: On the basis of the information contained in the EOMR and current knowledge, I would ask you for your position on the link between the manufacturing conditions and the stress corrosion phenomenon observed. In particular, you will transmit a detailed analysis of your review of the EOMR and the consequences you consider this will have for the inspection programme.

You also indicate that residual compression stresses are present in the welds, which would lead to a slowing down or even a cessation of the propagation of the cracks observed. The residual stresses are liable to be significantly modified when the weld has been repaired.

Request 10: For all the reactors concerned, I would ask you to identify the austenitic steel welds situated in the zones liable to be affected by the stress corrosion phenomenon and which have been repaired. You will analyse the influence of these repairs and, as necessary, you will propose a specific inspection programme for these welds.

iv. Results of the review of the previous inspections

Under the preventive maintenance basic plan (PBMP), certain RIS pipe welds undergo radiographic and then ultrasonic inspection in order to detect the appearance of thermal fatigue cracks. For the reactors which underwent ultrasonic inspection, you reviewed the corresponding indications tracking sheets (FSI) and identified 18 indications that could correspond to a stress corrosion phenomenon. You classified these indications according to their characteristics and on this basis identified six reactors that you consider should be re-inspected in the short term.

For these reactors, if the indication is confirmed, you envisage expanding the inspections to the adjacent welds, in accordance with the usual PBMP rules, whereas this process is not necessarily one that would be able to optimise the collection of information of use for management of this deviation.

Request 11: I would ask you to justify the strategy that consists in limiting the extension of the inspections solely to the welds adjacent to those with indications.

D. Laboratory analysis programme

In order to characterise the indications detected, you removed sections of the piping concerned for destructive analysis in the laboratory to confirm the nature and characteristics of the cracks.

I would note that the analyses envisaged at this stage primarily concern the N4 type reactors. These analyses will allow the acquisition of generic knowledge on the stress corrosion phenomenon, but will only make a limited contribution to characterising the situation of the reactors still in service.

To date, you have conducted a number of inspections on the RIS and RRA systems of Penly NPP reactor 1, which detected stress corrosion indications. However, you only conducted an analysis of two A18 welds and one A17 weld on the RIS system.

I consider that the small number of flaws characterised so far means that that there is not a sufficient statistical sample for evaluating the dimension of the flaws that could be present on this type of reactor and for ruling out the presence of a flaw that is higher than 3mm and possibly axisymmetrical. So far you only plan to conduct only a single analysis of one A19 weld on a removed elbow.

Request 12: I would ask you to supplement your analysis programme in order to reinforce the robustness of your conclusions regarding the size of the flaws potentially present on the 1300 MWe reactors.

You have also undertaken to conduct an analysis of one RIS weld on Chooz reactor B1 and to remove one RIS line from Civaux reactor 1. You envisage removing one RRA weld from an N4 type reactor and one RRA weld and one RIS weld from a 1300 MWe reactor.

Request 13: I would ask you to clarify the time-frames for these analyses.

E. Other points

Management of the flaws observed could lead to a prolonged shutdown of several reactors. This could in particular be the case of all the N4 type reactors. **I would draw your attention to the need to take steps to guarantee the conservation of the equipment and structures for the entire duration of this period, taking account of their environment.**

These prolonged shutdowns have an impact on the activities of the teams in charge of operating these sites. More specifically, the activities involved in managing transients, periodic tests, system lock-outs, alignment and local or control room monitoring of the facility will be considerably reduced. These day-to-day activities are necessary so that the personnel undergoing qualification can acquire the required skills and they also help to maintain the level of expertise of those teams already qualified.

Special measures will therefore need to be taken to guarantee the continued expertise of the teams and the acquisition of skills by the personnel undergoing qualification during these outage periods, so that they are able to operate the reactors once restart is authorised.

Request 14: I would ask you to inform me of the measures envisaged for maintaining the skills of the teams in charge of operating the reactors subject to prolonged outage.

On 10 January 2022, you sent me your strategy concerning the management of the problem [3] along with the state of your knowledge of the flaws and the stress corrosion phenomenon observed [4]. Your strategy and the available knowledge have changed considerably since then.

Request 15: I would ask you to update these two notices. As necessary, you will take account of the answers to the requests in this letter.