
Modernization of sump filters design on ROVNO NPP

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ABSTRACT: Taking into account the major importance to solve sump plugging in case of primary break, modernization of sump filters design on ROVNO NPP has been engaged. This action has been realized using a «2+2» approach, which had been proposed by the Commission of the European Community (CEC) in 1998, with the purpose of effectiveness increase of activities under realization of TACIS program projects. This paper gives a short summary of the different actions performed by the Technical Support Organization (IRSN, France), the State Scientific and Technical Center for Nuclear and Radiation Safety (SSTC NRS, Ukraine), the State Nuclear Regulatory Committee of Ukraine (SNRCU), the ROVNO NPP, assisted by EDF and the designer (FORTUM and FRAMATOME).

1 INTRODUCTION

Equipment and pipelines of primary and secondary circuits inside of the containment are covered with fiber insulation. Under an accident with coolant loss, steam or water flows can damage insulation. After transportation by the different flows (break flow, spray system flow) to the bottom of the containment, this insulation material can clog ECCS sump filters, increasing risk of circulation loss in ECCS system in conditions of intermediate and large leakages (LOCA). Drawbacks of insulation design affect protection level 1 and under accidents with coolant loss can lead to ECCS general common cause failure due to sump filters and/or ECCS heat exchangers clogging. Considerable risk of circulation loss seriously affects protection level 3. In this situation fulfillment of safety functions is doubted for scenarios included in the list of design basis accidents.

Project U1.01/97A was foreseen in the frame of TACIS technical assistance program, in accordance with which modernization of sump filters should be implemented. The objective of the project was to improve the sump inlet conditions of the Emergency Core Cooling System on ROVNO NPP units 1 and 2.

Two ways of solution of this problem were proposed:

Modernization of sump filters design.

Replacement of equipment insulation.

For ROVNO NPP units 1 and 2, the first way had been chosen.

2 LICENSING PROGRAMME

Licensing of the project is realized using the «2+2» approach, which had been proposed by the Commission of the European Community (CEC) in 1998, with the purpose of effectiveness increase of activities under realization of TACIS program projects.

The «2+2» approach can be presented in the following way.

Operating organization of an EC country, which is permanently at an NPP site, provides support to Ukrainian operating organization on implementation of safety upgrading measures.

Technical Support Organization of an EC country (EC TSO: RISKAUDIT and IRSN) jointly with the Ukrainian State Scientific and Technical Center for Nuclear and Radiation Safety (SSTC NRS) provides support to State Nuclear Regulatory Committee of Ukraine (SNRCU) in assessment of the proposed safety upgrading measures.

EC TSO's use the approach accepted in their countries and their state of the art practices and in parallel, SSTC NRS checks it for compliance with Ukrainian practice. Both parties harmonize their conclusions and recommendations, which are thereupon submitted to SNRCU.

Such approach allows realizing efficient discussion of emerging problems, aimed in the end at agreement of solutions acceptable from the safety point of view, with reduction of work delays.

One of the main tasks of the «2+2» approach is experience upgrading of Ukrainian experts by means of know-how transfer and Western practice used during nuclear and radiation safety assessment.

3 PERFORMED ACTIVITIES

3.1 Design

The design basis report NUCL-1096 from the designer presented the assumption file used for the design of the new sumps.

The design insulation debris filtration capacity was defined according to the principles set in the NRC Regulatory Guide 1.82. The whole amount of the insulation debris is considered as a simple sump design load reflecting the assumption of a single emergency cooling train in operation. Design basis debris load for a single sump was estimated 220 kg within distance of 7 times leak diameter (DN500) including a margin of 10% of additional amount. A transport factor was proposed.

The maximal filter mesh size was defined to be 2x2 mm. The maximum pressure loss over the filter screen was defined to be 20 kPa. The maximal basis flow rate was 1020 m³/h. Temperature for filter testing was chosen to be 50°C.

Moreover, the designer considered that the effect of particles or paints was negligible.

The design of the new sump is provided on FIGURE. The sump is made by a channel on which are connected a large amount of filtering elements. The critical factors are the filtering area and the distance between the filtering surfaces, for which validation tests were foreseen.

3.2 Assessment of the design

The assessment of the improved design led to the following comments:

- first at all, the assumptions of the assessed document to be used for defining the loadings in relation with the design of a new filtering system took into account specifications defined in a previous document. Consequently, in the worst case, it was required to be kept in mind that the results of the corresponding studies to be performed could lead to identify deficiency and in fact to conclude to the need to submit an alternative solution,
 - taking into account the fact that the Containment Spray System is in operation during a LOCA and consequently able to washdown all, or a part, of thermal insulation located on the loops, the amount of thermal insulation dislodged could be strongly higher than when it is just considered a steam/water jet effects and the design of new filters. A review was required,
 - a spherical model was used to estimate the amount of thermal insulation destroyed. A ratio of 7 was proposed by the designer which led to an amount of 200 kg to be considered to design the filters. The L/D ratio to be considered is full of uncertainties and the value can vary from 10 (US studies) to 40 (VATTENFALL and SKI estimation). Also, a second approach considering a ratio of 12 was proposed and a mass of about 800 kg was reviewed. Moreover, the transported fraction was discussed,
 - the assumption coming from studies performed for other VVER plants leading to consider that the quantity of particles is negligible was considered as questionable. Consequently, it was required that the assumptions and the results of the corresponding studies will have to be presented and commented,
 - consideration about new filters resistance against the jet effects and earthquake was required. The designer proposed to justify it in the detailed design,
 - consideration about mechanical behavior of the screens under maximal head loss was required. The designer proposed to justify it in the detailed design,
 - consideration about profile temperature was required to investigate the possibility to have an increase of the head loss during medium term. The contractor accepted to test this parameter in a separated test,
 - consideration about the maximal values of the flow rates of ECCS and CSS was required,
 - consideration on the efficiency of the new sump (filtering area, distance between filtering surfaces) was required,
 - consideration on the test program was required. It concerned:
 - the calculations and justifications of the maximal velocity including those at the junction between flow channel and filtering element,
 - the capacity of the test facility to reproduce the maximal velocities,
 - the detailed procedure of test to be submitted before performing the test.The designer has answered to these comments.
 - consideration about the procedure of test for the passive cleaning system was required for defining the strategy for the operator to use the cleaning system in emergency situation. The designer has considered this item and will provide the strategy in the PSAR.
- In conclusion, the designer considered the different remarks for the design and for the experimental program of validation.

3.3 Assessment of the validation programme

Under performance of modernization, normative documents require performance of equipment tests for confirmation of its parameters and characteristics. Since it was not possible to perform the full-scale tests of sump filters, it had been decided to perform model tests and to demonstrate that obtained results are adequate to actual conditions.

With this purpose, Licensee submitted for evaluation a document titled «Assumption File» containing necessary input data, which was the basis for sump filters design, and also a program of filter model test.

Joint assessment of these documents demonstrated, that a number of input data required revision and additional substantiation. First of all, taking into account results of IRSN studies that led to disagree recommendations of the RG 1.82 revision 2, investigations on temperature values, duration of the test planned and amount of insulation have been required. Consequently, new conditions have been defined to perform tests, calculation of which had been performed on the basis of drafts of documents.

Moreover, results of tests performed by IRSN in Slovakia and in Russia in particular on a full-scale model for French reactors pointed out the necessity of revision of documents.

Absence of active system for sump filters cleaning was also of concern for experts.

According to experts' recommendations, designer of filters carried out additional model tests under temperature 80° C and duration 96 hours in comparison with the 24 hours recommended in the RG 1.82. Changes concerning assurance of required flow rate under operation of filters had been introduced into design.

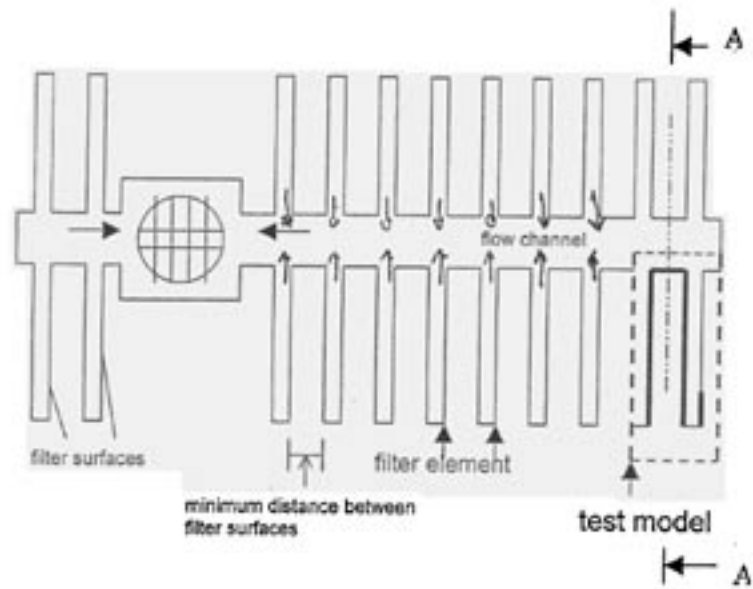
Results of these tests are presented in the APPENDIX.

The experts had recommended improving the test programs in order to take into account all phenomena.

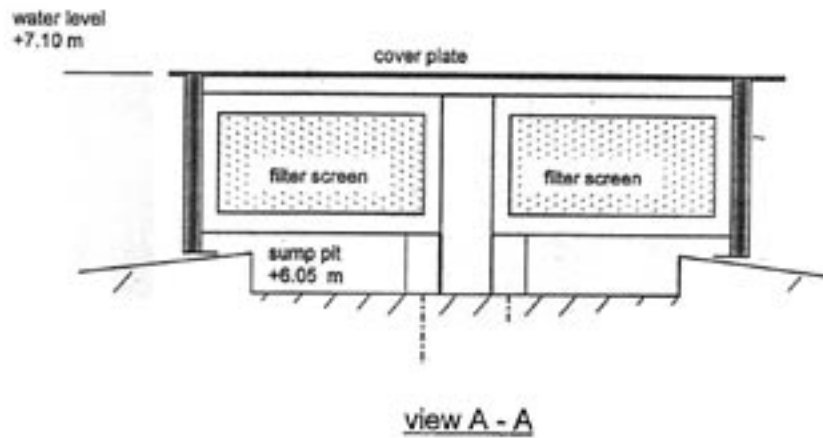
According to the revised program, tests had been performed at the designer's site, which confirmed acceptability of the used model for development of sump filters design. These documents had been jointly reviewed by the experts and recommended for approval by SNRCU.

4 CONCLUSION

Results presented in this report demonstrate efficiency and appropriateness of «2+2» approach used in the assessment of the proposed safety upgrading measures, and also vividly demonstrate the efficiency of the transfer of know-how and Western practice used under performance of nuclear and radiation safety assessment for experience upgrading of Ukrainian specialists.



Tested section of the filter system



Filter element principle

APPENDIX

RESULTS FOR THE TESTING IN HIGH TEMPERATURE DURING LONG TERM.

- No effects of higher pressure loss development during long term was observed,
- The chemistry resulted low ph-values from 7,84 to 7,78 during the higher temperatures
- The surface of the fiber bed "hardened" during the long term
- No air was inside the suction box at the end of the test

- The fiber bed was broken at the end of the test during the phase when temperature was lowered from 80 to 50 C. This was a result of the forces from higher pressure loss (effect of water viscosity changes), which forced the two fiber bed surfaces apart from each other. This created a new flowpath for the water inside the center of the filter, reducing the pressure loss approximately 3 kPa. This was a result of special test arrangement.



