CONSIDERATIONS ON THE CONCEPT OF REFERENCE PLANT

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Abstract

The concept of the Reference Plant [RP] is mentioned in INSAG-22 and further in INSAG-26 – but is currently not addressed in any of the IAEA Safety Standards. It has primarily been used in two different contexts:

(1) to describe a plant design which has been licensed in an initial country (the vendor country in many cases), which assessment is later relied upon by the regulatory body of another country when licensing that plant design (the ‘Regulatory RP’ concept); and

(2) to describe a plant already constructed, which is used in a commercial new build arrangement between an operator and a contractor to set contractual baselines (the ‘Contractual RP’ concept).

Experience has shown that the ‘Regulatory RP’ concept has been introduced into the regulatory framework of some embarking countries with stringent conditions, which raised difficulties in the practical implementation for specific projects. Equally, there has been some experience of confusion between the ‘Regulatory RP’ concept and the ‘Contractual RP’ concept.

The objectives of the article are to:
— present practical examples where Reference Plants have been used in history;
— seek to clearly define the ‘Regulatory RP’ concept and the ‘Contractual RP’ concept;
— highlight and discuss the impacts of specific conditions in national regulatory frameworks seeking to deploy the Reference Plant concept.

1. INTRODUCTION

The concept of reference plant has been used for long in the safety justification and evaluation files of nuclear power stations as well as for contractual purposes between vendors and future operators.

The paper aims at identifying the different uses of the reference plant concept and will focus on the reference plant concept used for regulatory purposes. In that context, the impact of specific conditions in national regulatory frameworks intending to deploy the reference plant concept for regulatory purposes will be discussed.

2. BACKGROUND AND DEFINITIONS

2.1. Background

The concept of reference plant has been used for long in many countries with the main following objectives:
— To get a guidance in the implementation of a nuclear project based on another coherent nuclear project more advanced in time and that brings experience feedback,
— To get a reference in terms of safety concepts that have been already assessed by a nuclear regulatory body and then maximize the confidence in the level of nuclear safety of a new nuclear project,
— To minimize the risks of a nuclear project schedule by using established plant designs with a background of manufacturing and erection experience and to make savings in capital cost by adhering closely to already established design, manufacturing and erection techniques.

Besides, it must be noticed that a complete adherence to a reference plant is neither always possible nor desirable. Indeed, site specific conditions and respect of national regulations will lead to deviations from the reference plant. Moreover, in some cases the chosen reference plant is still a living project and it is necessary to adopt as a reference a coherent status of the project (e.g. design and plant configuration of the reference plant as submitted for the construction license application) that will be different from the reference plant “as built”. For
this reason a reference plant can only be a starting point for a nuclear project with a number of deviations that will have to be identified, justified and documented.

In the case where a vendor/designer proposes a new reactor design even if the design is innovative and evolutionary it is often based on previous reactor designs that have been, most of the time, modified to improve safety and economics. In that case, the “reference design” of the new nuclear project is derived from one or several nuclear power plant models that can be called “Parent design”.

The following table gives examples of the use of the reference plant concept in France for the national and exporting markets:

<table>
<thead>
<tr>
<th>NPP identification</th>
<th>Operator</th>
<th>NPP type</th>
<th>Reference NPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fessenheim 1, 2</td>
<td>EDF (France)</td>
<td>PWR, 3 loops 2660 MWth</td>
<td>Beaver Valley (Westinghouse design)</td>
</tr>
<tr>
<td>(CP0 reactor fleet type)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bugey 2, 3, 4, 5</td>
<td>EDF (France)</td>
<td>PWR, 3 loops 2785 MWth</td>
<td>Fessenheim 1, 2 &amp; North Anna 1 (Westinghouse design) for the power uprate compared to Fessenheim NPP</td>
</tr>
<tr>
<td>(CP0 reactor fleet type)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tricastin 1, 2, 3, 4</td>
<td>EDF (France)</td>
<td>PWR, 3 loops 2785 MWth</td>
<td>Bugey 4, 5</td>
</tr>
<tr>
<td>(CPY fleet type)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paluel 1, 2, 3, 4</td>
<td>EDF (France)</td>
<td>PWR, 4 loops 3817 MWth</td>
<td>South Texas 1 (4 loops PWR, Westinghouse design)</td>
</tr>
<tr>
<td>(P4 reactor fleet type)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ChoozB 1, 2 &amp; Civaux 1, 2</td>
<td>EDF (France)</td>
<td>PWR, 4 loops 4250 MWth</td>
<td>Previous French 4 loops PWR plants</td>
</tr>
<tr>
<td>(N4 reactor fleet type)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flamanville 3</td>
<td>EDF (France)</td>
<td>PWR, 4 loops 4500 MWth</td>
<td>N4 &amp; Konvoi (Siemens/KWU design)</td>
</tr>
<tr>
<td>(EPR type)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Koeberg 1, 2</td>
<td>ESKOM (Republic of South Africa)</td>
<td>PWR, 3 loops 2785 MWth</td>
<td>Tricastin 1</td>
</tr>
<tr>
<td>Ulchin 1, 2</td>
<td>KEPCO (South Korea)</td>
<td>PWR, 3 loops 2785 MWth</td>
<td>Le Blayais 3, 4 –EDF operator PWR, 3 loops 2785 MWth</td>
</tr>
<tr>
<td>Daya Bay 1, 2</td>
<td>CGN (China)</td>
<td>PWR, 3 loops 2905 MWth</td>
<td>Gravelines 5, 6 PWR, 3 loops 2785 MWth</td>
</tr>
<tr>
<td>Olkiluoto 3</td>
<td>TVO (Finland)</td>
<td>PWR, 4 loops 4300 MWth</td>
<td>N4 &amp; Konvoi (Siemens/KWU design)</td>
</tr>
<tr>
<td>Taishan 1, 2</td>
<td>CGN (China)</td>
<td>PWR, 4 loops 4590 MWth</td>
<td>Flamanville 3</td>
</tr>
</tbody>
</table>

2.2. The concept of reference plant in IAEA safety publications

In 2008, INSAG 22 [1] introduced the reference plant concept to encourage new entrant countries to base their first construction on this concept: “Many mature nuclear countries used a so-called “reference plant” concept for their first nuclear units. Under this approach, an imported plant has the same design and safety features as a plant already licensed by the regulatory body of the exporting country. However, care should be taken to ensure that the selected site and the reference plant site have similar characteristics or that any significant differences have been taken into account…. Also any construction by a new entrant will likely be based on the well proven technologies of an exporting country. It might be expected that the design has been licensed by the regulatory body in the exporting country, perhaps with the benefit of analysis by other regulatory bodies… It is highly recommended that the regulatory body in the importing country establish and maintain a knowledge transfer relationship with the regulatory body in the exporting country…. “. Then, in 2012 INSAG 26 [2] indicated that, whenever possible, when a new entrant country chooses as its first nuclear power plant a power plant that would have essentially the same design as a nuclear power plant already licensed by an experienced regulator, the use of the reference plant concept would be desirable : “…During the design safety review process for issuance of the construction licence for the first nuclear power plant, use of the design safety
review conducted earlier by an experienced regulator for the reference plant could be appropriately made. However, it is essential that the regulatory body has a good understanding of the design and due attention is paid to the design differences on account of factors such as site related parameters, plant layout and incorporation of new design features based on operating experience and advancement in technology. This strategy is proposed primarily to ensure a high level of safety which incidentally, may also help expediting the licensing process”.


2.3. Tentative definitions

2.3.1. The reference plant concept used for contractual purposes

The reference plant concept used for contractual purposes can be defined as a plant of same or similar design as that of the nuclear project to be built, having readily a level of detailed design sufficient to secure the project and limit the provisions for industrial risk. Experience of the vendor and of the buyer as well as the maturity of the proposed technology are important factors to limit industrial risks.

2.3.2. The reference plant concept used for regulatory purposes

The reference plant concept used for regulatory purposes can be defined as a plant of same or similar design and safety features as that of the nuclear project to be built, having already been licensed or certified in the vendor country or possibly in another country. In that case the concept of reference plant is used to help securing the licensing process and minimizing the risk of dead ends during safety evaluation process. Indeed, one can suppose that a reactor design that has gone through a thorough safety evaluation by an experienced regulatory body will comfort the feasibility in a reasonable time frame of the licensing of the same or of a similar design in another country. Especially in new entrant countries, the existence of a reference plant would facilitate the licencing process as the regulatory body (which has never licensed a nuclear power plant before) could learn considerably from the existing safety evaluation reports (SER) written as part of the licensing process of the reference plant and could obtain important insights from the results of various safety analyses that were carried out for the reference plant. The concept of reference plant could also be extended to a reference design at the level of a detailed design having strong technical similarities with an existing model using proven technologies and safety concepts already assessed by an experienced regulatory body.

3. IMPACT OF SPECIFIC CONDITIONS IN THE REGULATORY FRAMEWORK OF THE REFERENCE PLANT CONCEPT

Up to now, specific conditions related to the use of a reference plant concept in national regulatory frameworks is very seldom. Certain countries are currently revising their requirements to allow for more flexibility and to facilitate the completion and the submission of the safety case to be provided along with the chosen reference plant for regulatory purposes.

Even if such requirements, mainly for new entrant countries, are intended to bring more confidence about the new projects to be built in terms of support brought by an experienced regulatory body it could also lead to undue or unexpected difficulties. Indeed, imposing for example that the reference plant for regulatory purposes be already a plant in operation or under construction could considerably limit the number of potential adapted nuclear power plant models and associated vendors. Moreover, the requirement linked to the transmission of the entire licensing case could pose intellectual property issues. Finally, it must be also kept in mind that a new entrant regulatory body will also have to go through a rigorous licensing process that will ensure:

— Full endorsement of the safety case by the operator and the regulatory body,
— Full understanding of the safety case for the complete life of the plant,
— Full consideration of the national regulations.

4. CONCLUSION

The use of the reference plant concept for licensing purposes has proven its efficiency in terms of transferring knowledge between regulatory bodies and ease of the licensing process through a close collaboration between the regulatory body of the new entrant country and the regulatory body of the country of origin. Nevertheless, the experience shows that introducing requirements, if any, in the national regulatory framework about a reference plant for regulatory purposes should be done in a manner that leaves sufficient flexibility not to unduly limit the potential choice of reactor models acceptable in the recipient country.

As a matter of fact, the concept of reference plant could also be extended to a reference design at the level of a detailed design having strong technical similarities with an existing model using proven technologies and safety concepts already assessed by an experienced regulatory body.

It should be noted that the licensing process is not limited to the granting of the construction license and the concept of reference plant is also intended to provide insights to the regulatory body in the recipient country regarding the oversight of the construction and commissioning phases of the nuclear power plant to be built. This aspect was intentionally not developed in this article and further discussion should be planned to better explain it.

REFERENCES

[1] INSAG 22, Nuclear Safety Infrastructure for a National Nuclear Power Programme supported by the IAEA Fundamental Safety Principles,
[2] INSAG 26, Licensing the First Nuclear Power Plant,