AREVA support to nuclear power plants' long-term operation

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Total electrical production capacity of nuclear power worldwide continues to grow. IAEA latest scenarios predict an increase in nuclear production capacity of between 17% and 95% by 2030. While this growth will be fed up by major nuclear programs launched in Asia, the Middle-East as well as in Europe, in mature countries the growth will be bolstered by significant life extension programs. Two-thirds of today's nuclear reactors are over 25 years old and over the next ten years, no less than 150 reactors will be operated following a license renewal. There is thus a high demand for plants' service life extension across the whole nuclear fleet worldwide. To support these initiatives, AREVA launched the "Forward Alliance" program to help utilities ensure the safe long-term operation of their existing nuclear fleet.

La capacidad de producción eléctrica mundial continúa creciendo. Los últimos escenarios de la AIEA predicen un incremento de la capacidad de producción nuclear entre un 17% y un 95% en 2030. Mientras que este crecimiento está alimentado por los grandes programas nucleares lanzados en Asia, Oriente Medio y también en Europa, en muchos países el crecimiento se verá impulsado por importantes programas de extensión de vida. Dps tercios de los reactores actuales tienen más de 25 años de operación y durante la próxima década no menos de 150 reactores seguirán un proceso de renovación de licencia. Hay, por lo tanto, una gran demanda para la extensión de vida de las plantas en la flota mundial nuclear. Para dar respuesta a estas iniciativas, AREVA lanzó el programa 'Forward Alliance' con el fin de trabajar conjuntamente con las compañías eléctricas para asegurar la operación segura a largo plazo de la flota nuclear existente.

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HIGH EXPECTATIONS FROM A GROWING REACTOR FLEET WORLDWIDE

The total electrical production capacity of nuclear power worldwide continues to grow, with almost 371 GWe currently produced by 434 reactors in operation across the globe and 69 reactors under construction[1]. The Fukushima Daiichi accident in March 2011 certainly slowed this growth, but the need for innovative services for existing reactors continues to grow.

The latest IAEA scenarios predict an increase in nuclear production capacity of between 17% and 95% by 2030[2], and the demands of the global market are growing.

Thanks to its integrated model, spanning the complete nuclear cycle from the uranium mines to the recycling of used fuel, taking in reactor design and maintenance, AREVA supplies services to more than 360 reactors of all technology types across the world.

[1]IAEA September 2013.
[2]IAEA-RDS-1/33: Energy, Electricity and Nuclear Power Estimates for the Period up to 2050, 2013 Edition, August 2013.

These services respond to three major challenges:

- Ensuring optimum safety of facilities, notably meeting all post-Fukushima criteria
- Guaranteeing long-term operability for each plant
- Optimizing operation

ENSURING MAXIMUM SAFETY

Constantly improving the safety of nuclear installations depends on technological innovation and the returns on experience and lessons learned from major accidents: Three Mile Island, Chernobyl and Fukushima. The systematic application of the most advanced technology at nuclear power plants, with support and supervision from the safety authorities, is the only way to guarantee the future of our industry.

The solutions demanded by nuclear power plant operators in this field meet three essential safety requirements[3]:

- Resistance to major natural hazards: earthquakes and floods.
- Resistance to the consequences of these hazards or other major natural hazards: loss of power supply, loss of cooling source or loss of both simultaneously.
- Resistance to serious accidents: loss of core cooling, loss of used fuel pool cooling and loss of integrity of facility's containment.

[3]European stress test specifications, ENSREG.

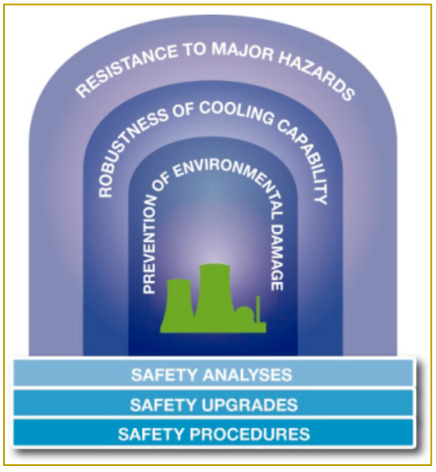

Figura 1. Programa AREVA Safety Alliance.

AREVA's global Safety Alliance program (Figure 1) was launched in Spring 2011 to provide a global response to these needs[4].

Responding to this need means above all providing solutions: passive hydrogen recombiners (PAR), filtered containment venting systems (FCVS) (Figure 2), improved and more diverse cooling systems, diesel backups, new approaches to spent fuel management to free up space in unloading pools, among others.

Finally, new demands arise from the installation of shared emergency response centers. AREVA, alongside PEICo (Pooled Equipment Inventory Company), has developed a complete solution that guarantees the availability of equipment and skills for emergency centers (FLEX Emergency Response Centers) in the United States.

By making the most advanced tried-and-tested technologies available across the industry and sharing knowledge and best practices, our industry can sustainably reach a higher level of safety.

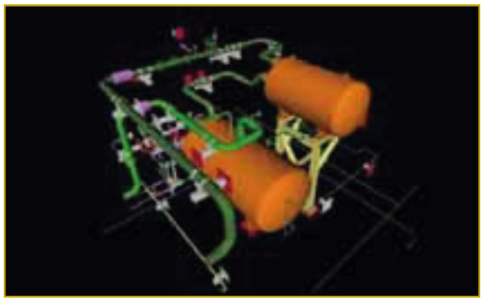

Figura 2. Sistema de Venteo Filtrado de Contención (SVFC).

Figura 3. Sistema de I&C digital Teleperm XS.

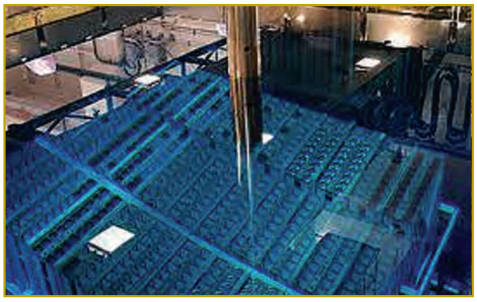

Figura 4. Gestión de combustible usado.

GUARANTEEING OPERABILITY UNTIL THE END OF PLANT SERVICE LIFE

In order to meet CO_2 and greenhouse gas emission reduction targets, it is vital to maintain a basic source of nuclear power to compensate for the intermittent nature of solar and wind power contributions to the grid.

The fact that 80% of reactors currently in service are more than 20 years old, with half of these over 30 years old[5], means there is high demand for service life extension across the global nuclear fleet.

Meeting market demand in this area means, first of all, supporting global operators in their own work to extend plants' service life. This involves helping them optimize investment in much-needed fleet modernization work, thereby enabling them to take advantage of the value of current assets in the most effective way.

Renewal of operating licenses, periodic safety reviews, service life extension, etc., different approaches are taken depending on the country or continent concerned. However, the end goal is the same: to guarantee the safe operation of plants over the long term. Measures are introduced at major milestones set in consultation with safety authorities: 10-year inspections in Spain as well as in France, generally 30-year inspections for VVER-type reactors and 40-year or even "beyond 60-year" inspections for US reactors.

These processes correspond to the main steps recommended by the IAEA:

- Preliminary studies.
- Scoping and screening of components.
- Ageing management reviews by component.
- Implementation of solutions and new procedures.

Responding to needs also means proposing an ageing management approach based on the component: vessel, vessel internals, pressurizer, steam generator and primary and secondary pumps, to name just the main systems of the nuclear island.

Since the start of 2013, these services have been offered by AREVA as part of its "Forward Alliance" approach.

They include a wide range of skills and experience in material physics and the management of mechanical fatigue, as well as a precise understanding of the behavior of a wide range of components, whether or not they are AREVA-designed.

Solutions including sensors to measure transients and the use of historical evaluation to back up component ageing management methods are also available.

Another element is helping utilities combat obsolescence via reverse engineering or replacement with new components, a major success factor in extending service life. Modernizing instrumentation and control systems (I&C) is without doubt the most relevant example, with digital systems (Figure 3) able to deal with obsolescence issues in analog systems whose maintenance cost becomes too high.

Finally, it involves providing nuclear operators with fuel cycle management solutions that are effective until the end of plant service life. This can be done by implementing management solutions for unloading pools, dry storage and spent fuel recycling (Figure 4).

These efforts to extend operating licenses are accompanied by a growing demand for assistance in staff training. Managing and anticipating the age and skill distribution of the workforce, as well as guaranteeing the quality of personnel, are vital elements in such an approach.

By sharing experience, these projects can be managed in an optimum manner, minimizing investments through wise choices and controlling project costs by maximizing the value of existing assets through service life extension.

OPTIMIZING OPERATION

Increasing and improving production, in a more flexible way and optimizing the associated operating expenses. While these demands are expressed by the vast majority of operators, their motivations and the means for achieving these optimizations have recently seen some diversification. Market conditions and laws governing the energy mix and access to the grid involve trade-offs which can lead to radically different optimization and operation requests. This in turn results in demand for ever more innovative services.

[4]Safety Alliance has more than 100 projects in 19 countries for 49 clients as of July 2013.
[5]IAEA/PRIS September 2013.

Figura 5. Programa AREVA Safety Alliance.

INCREASING AND IMPROVING PRODUCTION

For a long time, lengthening operating cycles has been the preferred way to improve the capacity factor. This consists in reducing the duration of refueling outages by switching from 12-month to 18- or even 24-month periods, which is made possible by higher fuel enrichment levels and the reorganization of maintenance work. However, a reverse trend has also been noted in certain areas, such as in the United States for example, which saw a drop of more than 73% in the price of gas combined with the lowest level of seasonal electricity demand since 2009[6] due to the financial crisis, with grid priority being given to renewable energies in certain states.

In any case, optimizing the work done during outages and reducing the operating losses associated with unscheduled shutdowns remain a significant progress factor in this area.

Improved production also means optimizing fuel cycle management. Optimizing fuel stocks and the associated logistics, and being able to access better spent fuel management solutions are determining factors in achieving this aim.

[6]Reference: Week of July 5, 2013. Bloomberg - Christine Harvey July 17, 2013

Finally, we are increasingly asked to contribute to reducing the doses received during maintenance operations and reducing the accident rate in a major, sustainable way, by applying ever stricter safety rules and reinforcing supervision at all sub-contracting levels. These approaches, whose effectiveness can be measured by improvement of the INPO composite index for example, contribute to "improved production", a vital element in optimizing operation of the global nuclear fleet.

OPERATIONAL FLEXIBILITY: A NEW REQUEST FOR CERTAIN COUNTRIES

Already used in France for decades, load-following in nuclear production, which makes it possible to adapt power supply to the level of demand, is beginning to interest a growing number of countries where this flexibility is becoming attractive in the face of new market requirements.

Approaches to flexible operation must firstly take into account the new needs of the grid operator: daily demand monitoring, management of slight variations in real time, and production and long-term consumption forecasts.

In first place, responding to the demands of the market in this area involves helping the operator select the flexibility measures that are most appropriate for the specific new model to which they must respond. Load-following, frequency control and spinning reserve have specific fields of application and various associated operating restrictions, which depend on the reactor type and the requirements of the grid operator.

Introducing these techniques can also require the installation of new devices (modifications to control rod drive, monitoring of component fatigue, etc.) as well as major changes to the instrumentation and control system. These changes are performed under the regulatory framework of the country concerned, via safety analysis reports (SAR), design transient files or primary and secondary overpressure protection files.

In conclusion, the demand for global installed base services for nuclear reactors has never been so high, so varied or required so much innovation. More than ever before, the future of our industry is bound up in its capacity to guarantee the highest level of safety, ensure that investments are for long term and optimize production levels. These are the challenges we are rising to meet by providing an ever-increasing range of best practices and key knowledge to nuclear operators worldwide.