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Site selection considerations of spent nuclear fuel reprocessing plant in China

Wang Bo^a, Liu Fudong^a, Zhang Chunming^a, Qiao Yahua^a, Liu Yongye^a, Yang Yang^a, Wang Yichuan^a, Shang Zhaorong^a, Shi Qiang^{b*}

^a*Nuclear and Radiation Safety Center, Ministry of Environmental Protection, Beijing 100082, China*

^b*Capital University of Economics and Business, Beijing 100070, China*

Abstract

With conversion of nuclear development strategy from “proper development” to “positive development” in China, the future nuclear power scale and the amount of the spent nuclear fuels will be enormous, the construction of spent nuclear fuel reprocessing plant will be necessary to meet the sustainable development requirement. Because of the huge investment and high environmental sensitivity, the site selection of spent nuclear fuel reprocessing plant has always been the focus of controversy. This article summarizes the site selection considerations from the technical feasibility, safety reliability, environmental compatibility and economic rationality for further discussion about the scientific site selection of spent nuclear fuel reprocessing plant in China.

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1. Introduction

The reprocessing of spent nuclear fuel is very important for the closed cycle of nuclear fuel and sustainable development of nuclear power, as well as the choice of most international states with nuclear power. Especially, the successful operations of UP3 of France and THORP of Britain estimated the feasibility in the technology, management, security and economy of reprocessing performance [1].

* Corresponding author. Tel.: +86-10-82205938; fax: +86-10-82205933.

E-mail address: wangbo@chinansc.cn.

However, the research foundation in China seems to be insufficient, only in 2010 December, thermal debugging test of our first power reactor spent fuel reprocessing plant, 4X4 pilot engineering, met with success, this shows that China has mastered the key techniques, but have not yet reached the industrial scale reprocessing ability [2]. China has set about the site selection of spent nuclear fuel reprocessing plant in Nineties of last century; however, because of the huge investment, long construction period and high environmental sensitivity, the site selection of spent nuclear fuel reprocessing plant has always been the focus of controversy [3]. Aiming for the characteristics of reprocessing plant different from nuclear power plant, this paper took into account key factors relating to the site selection in four aspects, such as the technical feasibility, safety reliability, environmental compatibility and economic rationality, for further discussion about the scientific site selection of spent nuclear fuel reprocessing plant in China.

2. Key factors relating to the site selection

2.1. Safety reliability

The safety reliability evaluation mainly includes external natural accidents and external human accidents. In the site survey stage, the considerations about safety reliability should include the following features:

- The earth's surface fracture: in the regional analysis of high earthquake activity area, the site near to known active faults area should be negated. This could be judged by the distance between candidate site and doubtful active faults area, the site near to the active faults area will be negated, while the site far away enough from the active faults area will be selected prior. This distance is closely related to the size, occurrence and movement rate and so on of active faults area. Only confirming the candidate site doesn't locate in the active faults after investigation and evidence, can we consider the candidate site will be suitable in this aspect.
- Seismic activity: high seismic activity area will be negated normally in the regional analysis. In earthquake zones, screening site could be evaluated by the earthquake intensity, the site influenced less by the earthquake will be selected prior.
- The feasibility of underground rock layer: the data information of underground rock layer maybe can not obtain in the first two steps of site survey, however, the feasibility of candidate sites could be compared by the lithology of the underground rock layer using as the foundation, selecting the proper underground rock layer as the foundation. The foundation failure such as liquefaction, settlement, slippage and collapse under compared influence with earthquake should be researched, when considering the feasibility of underground rock layer.
- Slope stability: if there is a high slope maybe influencing the security (nature or artificial slope), and taking engineering measures still could not guarantee the slope stability, the site will be regarded as unacceptable.
- Volcanic activity: in the regional analysis of active volcanic area, the site near to possible active volcanic area should be negated. The severity influenced by volcanic activity to the candidate site could be a factor of site consideration. The site influenced least by the volcanic activity will be selected prior. According to the factory information of volcanic activity in China, in addition to small part such as Heilongjiang province, Jilin province and Taiwan province, site selection in other region could not consider this aspect.
- Flood routing: in the regional analysis, the site influenced by the high flood level should be negated. The severity influenced by flood to the candidate site could be a factor of site consideration. The site influenced less by the flood will be selected prior. For the candidate site, if taking feasible flood

control measures still could not reach the requirement of the design basis flood level, the site will be regarded as unacceptable.

- Extreme meteorological phenomenon: in the regional analysis, the site influenced frequently and severely by the extreme meteorological phenomenon (tropical cyclone or tornado) should be negated. The severity influenced by the extreme meteorological phenomenon to the candidate site could be a factor of site consideration. The site influenced less by the extreme meteorological phenomenon will be selected prior.
- External human accidents: influencing reprocessing plant from the plane collision or accidents in military installations or huge industry installations for producing, depositing, disposing inflammable, explosive or poisonous materials. In the regional analysis, the site near to large dangerous facilities, huge airport, or transportation routes for mass dangerous materials should be negated. Besides, the distance and influence to the candidate site from the dangerous facilities could be a factor of site consideration. Near to dangerous facilities, the site influenced less with small possibilities by the dangerous facilities will be selected prior.

2.2. Technical feasibility

For the candidate site, if after design or taking engineering measures, requirements still could not achieve or extremely difficult to achieve, this site must be regarded as unacceptable. The technical feasibility evaluation includes construction conditions, transportation conditions, operation conditions and wastes management. The considerations about technical feasibility should include the following features:

- Topographic conditions: the suitability of topographic conditions depends on the site leveling workload analyzed by the topographic map, as well as the engineering technical problems due to the levee and drainage condition, and the site secure problems causing from large excavation or big fill.
- Power grid conditions: the candidate site should be close to the power grid, as well as the load center, and have necessary compatibility with the connecting grid guaranteeing the operation stability under various conditions; the power grid should be able to provide the offsite power for normal operation and secure, including start, overhaul, and standby power and so on.
- Water conditions: The requirements of cooling water are the appropriate water quality and enough water recharge. The conflict for water between industry and agriculture should be considered as well. If after taking engineering measures, the cooling water source still could not be guaranteed, this site must be regarded as unacceptable. For the coastal site, the fresh water supply should be guaranteed.
- Transportation routes: the transportation routes for the candidate site must be suitable to transport the superheavy or overranging equipments. The emergency requirements for transporting reprocessing equipments (size and weight), spent nuclear fuels and solid wastes from estimated manufacturing center or entry port by existing or proposed highway, waterway and railway should be researched.
- Distance from industry center: for convenience of operation, maintenance and some routine check in the plant, the reprocessing plant site closing to the permanent industrial base is available for maintenance socialization. However, if the candidate site has been got through by a big industry base (for instance, in the specified planning restricted zone), the conventional security problems causing from the nuclear accident emergency will need to be considered either.

2.3. Environmental compatibility

With enhancement of public participation in recent years, the environmental compatibility is becoming an important factor in site selection consideration. Referring the nuclear power plant site proposal, for the reprocessing plant, it is more important to consider the emergency plan execution conditions and the

opinions of local public, government and owners. If the environment surrounding the candidate site can not compatible with the construction or operation of reprocessing plant, the site should be negated. In the site survey stage, the considerations about environment compatibility should include the following features:

- Atmospheric diffusion conditions: in the region analysis, the site near to the area with long-term adverse atmospheric conditions should be negated; this could be compared and selected according to the wind direction and other atmospheric characteristics.
- Water diffusion conditions: including surface water and underground water diffusion conditions. It should be considered more cautiously, when the candidate site located in the upstream of drinking water sources from surface water or underground water. The relative position between selected site and important drinking water sources could be a factor of site consideration. In the comparing and selecting candidate sites, the site influencing less to the drinking water resources under accidents will be selected prior.
- Population distribution: in the region analysis, the site near to the area with high-density population should be negated. It should be compared and sequenced for the candidate sites according to method suggested by the HAF 0100 (91) on the basis of population [4], or in accordance with the characteristics of population distribution (for instance, the distance to the large, middle, and small towns).
- Land utilization: the land utilization in the region could influence the site selection. In the region analysis of land utilization, it supposed to be considered the future development and regional planning, for instance, the farmland, the scenery protectorate, wild animals and plants, nature reserve, rest place, tourist zone, etc.
- Emergency plan: in the last two steps of site survey, it supposed to be considered the possibility executing effective emergency action, for instance, the conditions of communication, access control, evacuation, and transportation.
- Nonradioactive influence: in the site selection, it supposed to be considered the adverse nonradioactive influence by the construction and operation of reprocessing plant to the aquatic animals, plants, and crops in environment, as well as the climate or microclimate influence by the operation of cooling tower to the surrounding region, such as the changing site characteristics in the humidity, cloud and mist, freezing, shadow screen effect, visibility, and diffusion features, etc., however, the considerations in this stage are supposed to be cursory.
- Economic development planning: the influence to the existing and proposed economic development plan should be considered, as well as the acceptance of local government and public to the selected site.

2.4. Economic rationality

When the conditions in technical feasibility, safety reliability and environmental compatibility are similar for the candidate sites, the comparison in investment will be an indispensable link and an important factor for evaluation. In the considerations of economic rationality, additional engineering cost and operation cost causing from the site characteristics should be included:

- Engineering cost: in comparing and selecting the candidate sites, the following cost of engineering and maintenance should be considered: land expropriation, compensation, immigrants and remove; site leveling and earthwork; the foundation treatment of construction; construction of levee and drainage engineering; construction of protecting slope and wall; the additional anti-seismic cost; the transportation connection between plant and outside; supporting facilities of region grid for transmission and distribution of power; water supply and drainage facilities, etc.[5]

- Transmission cost: in selecting and sequencing the candidate sites, the cost from power lost in the transmission should be considered.
- Water supply cost: in selecting and sequencing the candidate sites, the cost influenced by the water temperature, quality and the carry level and distance should be estimated.
- Transportation cost: in selecting and sequencing the candidate sites, the factors influencing transportation of spent nuclear fuel and solid waste should be considered, and the transportation cost according to the planning transportation proposal should be estimated. [6]

3. Conclusion

Since the Fukushima accident, the public put more and more attention to the nuclear safety, for this reason, the weight of the above four aspects by descending order is the safety reliability, technical feasibility, environmental compatibility and economic rationality. Firstly, the selected site must be safe and reliable, if there is a major potential security hazard, the candidate site should be negated; and then, the candidate site must be feasible in technology, this including two aspects: for one, the site has the conditions for construction safety reliability for itself, for another, taking necessary technical measures (improvement of designed technology) could make it to meet the safety conditions; based on the above two requirements, the candidate site need to be compatible with the surrounding environment, can not conflict with the national or regional environmental policies and standards; last, with similarity of the above requirement, the investment for the reprocessing plant is an important factor for decision maker.

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