Appraisal for the Operation Safety of SPRR-300 in Recent Years

CHEN Wei

Institute of Nuclear Physics and Chemistry, China

chenwei_roy@yahoo.com

1. Preface

As showed in figure 1, SPRR-300 is a light-water-cooled swimming-pool reactor. It reached first criticality in 1979. During its 27 years of safe operations, the reactor has never been renovated comprehensively. The most part of its devices are the same type as those used during the stage of the first criticality, which makes the failure rates of the devices increase steadily. The spare parts for those devices are almost used up. So the condition of the devices and the reactor must be analyzed to appraise the safety of the operation.

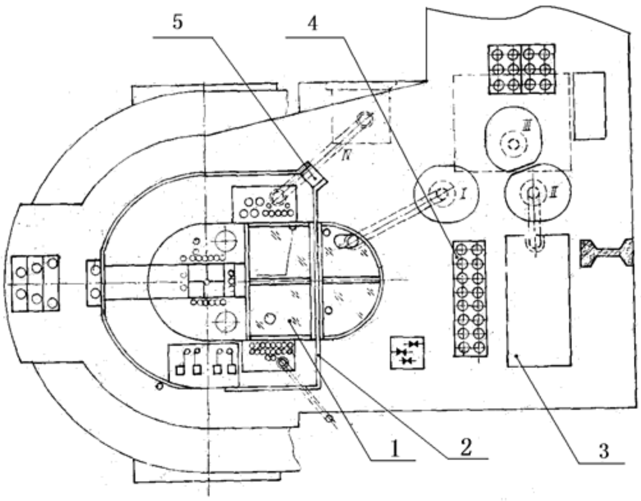

FIG. 1.Plan View of SPRR-300
1-Reactor pool; 2-Shield wall of upper reactor room;
3-Storage pool; 4-Dry well; 5-Peep window

2. Management System

As showed in figure 2, a management networks for the safety and the quality of the reactor operation, which is leaded by the department director, were built within the operation department. The staff is organized regularly to study the law and regulations of nuclear safety. A general outline for quality of SPRR-300 during operation stage went into effect in 2004. A set of files supporting the outline have been written or rewritten to ensure that the outline is operated smoothly. The rules and regulations of the reactor, such as the scheme for report to ratify of operation and experiment, the rule for regular meeting related to safety, the system for routine inspection of the devices, the institution for month report, the regulation for staff training, etc., are insisted on. Now there are six reactor operator leaders, five reactor operators, five radiation inspectors, seven mechanical workers, one coolant loop maintenance workers, three device maintenance workers, and three electric maintenance workers in the operation department.

The emergency scheme and its execution programs had been established around 2002. The first emergency practice was held in 2003, while the second one was organized in 2004, and

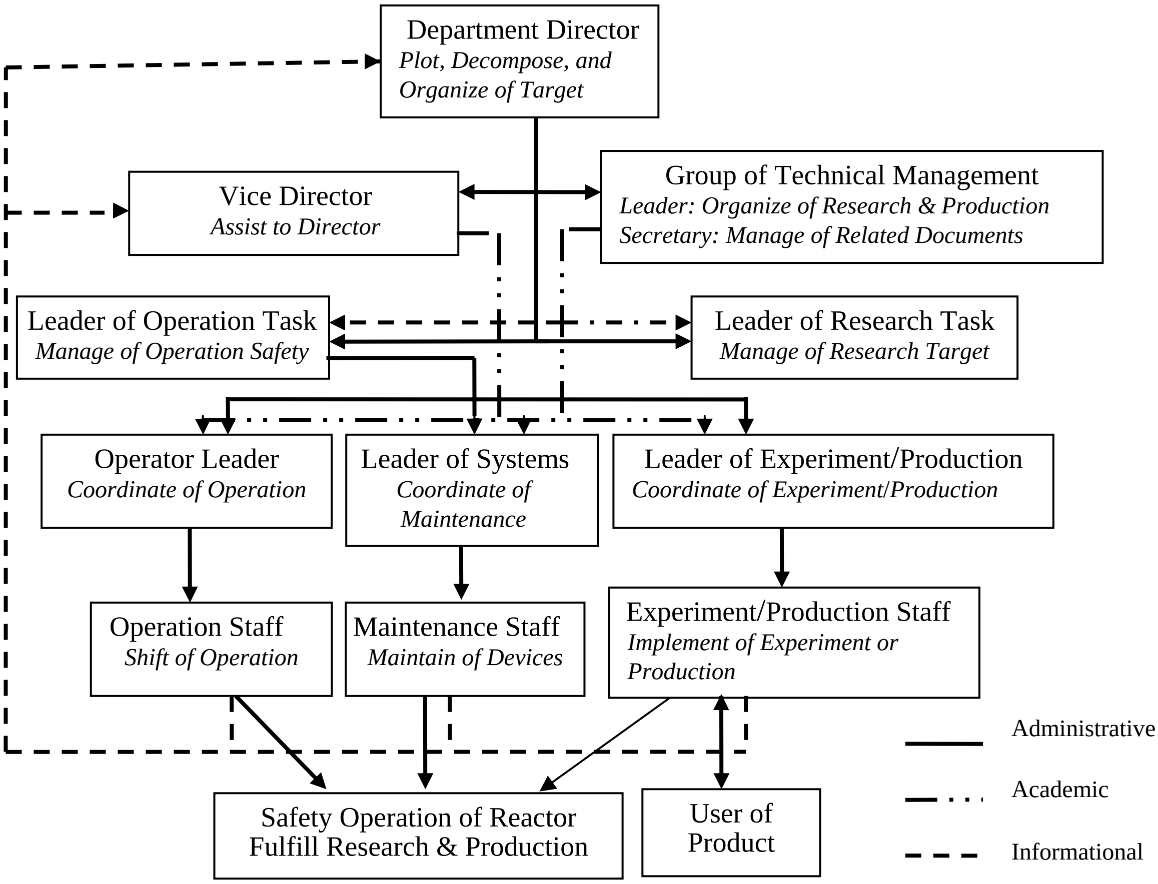

FIG. 2. Management Structure of Operation & Experiment in SPRR-300

the third one was staged in 2006. Through this series of practices, the abilities for emergency treatment of the staff have been boosted continually.

3. Technical Transformation

The minimalist technical transformation of the reactor had only been done once around the year of 2002[1]:

a) The ceaseless power system is composed of three kinds of direct-current power systems , which are 110V, 48V, and 24V. It had been renovated in 2001 and 2002. Their lead acid cells were replaced by maintenance-free storage cells.

b) Technical transformation of the spent fuel transport system and the storage pool purifying system had been finished in 2001[2]. First, spent fuel assemblies can now be transferred from the reactor pool to the storage pool with much lower exposure. Second, the quality of the storage pool water can be ensured. So the safety of spent fuel assemblies in storage can be guaranteed.

c) The cantilever crane in the upper reactor cubicle and the bridge crane in the reactor hall had been complete overhauled.

d) The feed cables from the power transformer station of the institute managing the reactor to the reactor building and from the reactor building to the coolant towers had all been replaced in 2002.

e) A new set of XH-3021 gamma survey system was installed in 2002 to ensure that the exposures of the staff are really under control.

f) Meter systems of the secondary coolant loop flow rate, primary coolant loop pressure, and primary coolant loop temperature had been renewed in 2002.

g) Six new sets of power supply for ionization chamber had been developed and used in 2002 to replace those old ones which made in 1965.
h) Two new sets of digit power protection instruments, whose preferment are better than those old ones, had been developed. They had been grouped with old ones to form “four choice one” logic in the power protection system while two sets of ionization chambers had been added for them in 2002[3].
i) The heat exchanger had been cleaned in 2003. The efficiency of heat exchanger rose obviously. The gauging of temperature had been verified at the same time. So the safety of cladding temperature for fuel elements is ensured.

4. Events Related to Nuclear Safety

4.1 Reactor Scram

TABLE I: Statistic Data of Operation

Year	Operation Times	Energy Released MWd	Scrams	Failure Ratio %
2001	76	4.300	8	10.526
2002	151	21.269	23	15.232
2003	535	145.849	27	5.047
2004	460	127.969	5	1.087
2005	318	96.664	9	2.830
2006	100	45.851	0	0.0

As showed in table 1 and figure 3, the failure ratio of the reactor goes down year by year[4]. Before 2002, 22 out of the 31 scrams occurred without even one warning signal showed at the same time, while others were mainly caused by staff faults. Since the minimalist technical transformation mentioned in the third section finished, scram without any warning signal has not occurred any more.

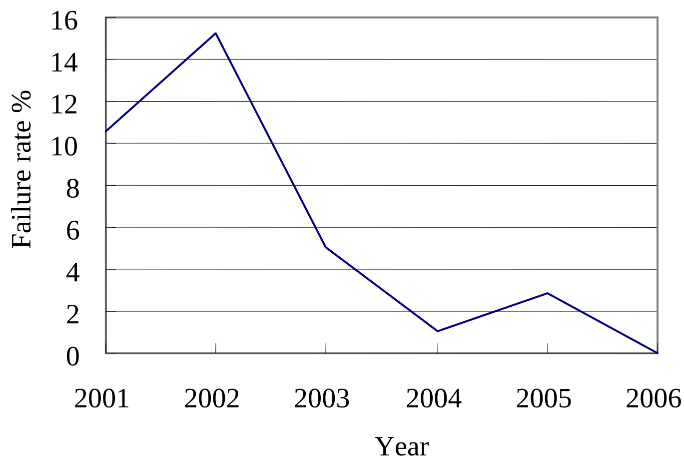

FIG. 3. Failure Ratio in Recent Years

The reactor resumed normal operation in 2003. In this year, there were 27 scrams, in which nine were caused by staff faults. As showed in the third section, two new sets of digit power protection instruments had been grouped with old ones to form “four choice one” logic in the power protection system during the technical transformation. Occasionally the operator would forget to adjust or readjust one of those instruments that are located beyond the old positions, which were the main sources of the staff faults. Other 18 scrams in 2003 were cause by devices breakdowns, while most of them were originated from malfunctions of the old sets of power protection instruments. Those old instruments are difficult to be fixed for lack of spare parts.
There were 14 scrams in 2004 and 2005. Five of them were caused by staff faults in which most were still due to forgetting to adjust or readjust one of the power protection instruments. More than half of the nine scrams caused by devices breakdowns were related to the

electricity net lapse while the others were mainly related to malfunctions of the power protection instruments.
Because the personnel in the reactor move in and out very frequently, it is reasonable that there are small quantities of manual failure. Every time before and after operation, the group of technical management would organize some kind of meeting to discuss the problem that may appear or have appeared. With the continued fostering of safety culture, the operation quality of the staff is enhanced constantly.
To those old reactors like SPRR-300, devices are the key of the reactor safety although some suitable modifications have already been done. In this period, usually some new kinds of device failure would turn up. So it is a must that the quality of the staff should be enhanced steadily to solve every accident correctly and resolutely.
Owing to the enhancing of the quality of those two kinds of staff in the reactor, recently the scrams are kept in lower level. And there is no scram in 2006.

4.2 Other Events

There were 12 cases in 2003 that the power supplies for ionization chambers gave alarms of lower voltage because the voltage of local power grid was too low, while at the same time a series of warning signal for the power protection instruments and the power regulate instruments were triggered. The reactor was removed of automatic operation afterwards because of malfunction of the power regulate system. The reactor could only be re-putted into automatic operation later after the voltage of local power grid rose to normal level. To solve this kind of hidden peril, the institute managing the reactor began to work together with local power supply bureau to stabilize the voltage during every period of operation. There is no similar case appear after August, 2003.
Also in 2003, the second regulate rod system worked abnormal two times. Its lifting speed was much lower than that of normal. In the first case, the reason was that the contact of its speed-adjust electric resistance was poor. The system returned to normal after the resistance had been repaired. In another case, the reason was short-circuit between the turns of the stator coil of the servo motor. The system returned to normal after the old motor had been replaced by a new one.
Once in 2004 the drop-fuse of one transformer outside the reactor building struck arc. The reactor was forced to be shut down temporarily so the transformer could be disconnected to be repaired later.
The bad installation of the second motor for the ventilation of the coolant tower was one of the inherent defects in SPRR-300. Six times during the maintenances in 2004 and 2005 the ground bolts and elasticity jointer between retarder and the motor were found broken. The retarder lapsed eventually in September, 2005. Thorough repair of the retarder had been accomplished in November, 2005. Then its condition went back into normal.
Twice the seal rings of the second pump in the secondary coolant system were mangled in 2004 and 2005. The seal ring was changed always in time. Every time the system returned to normal shortly after the running-in time finished.

5． Conclusion

The most of threats to the normal operation of the reactor come from instability of power grids outside the reactor building. Because the inherent safety of the reactor and the developing of the ability for accident treatment within the reactor staff, instability of power grids can only influences the usages of the reactor to a certain extent. It will not produce an effect on the safety of the reactor.
One of the main inherent defects in the coolant system of SPRR-300 is bad installation of the second motor for the ventilation of the coolant tower. This defect disappeared after the thorough repair of the motor system had been done.

Through maintaining and repairing in accordance with certain cases apart from overhauling at regular intervals for the devices, all systems of the reactor are kept in good condition, which meets the demand to guarantee the safety of the reactor. So long as the regulations are abided by, the training of the staff is strengthened over and over, and the safety culture is fostered continually, the safety and the quality of the operation can be ensured.

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