

# The Commissioning of CARR before Fuel Loading

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**Abstract:** The non-nuclear commissioning work for the high performance research reactor CARR before its fuel loading, including commissioning team organization, the management affairs involved, the implementation and problems handling, the experience of commissioning is given in this paper. The conclusion of this paper could be regarded as the assessment and acceptance criterion for a research reactor phase A commissioning.

**Key Words:** research reactor, phase A commissioning, CARR project, management and implementation

## 1. Introduction

The China Advanced Research Reactor (CARR) is a light water cooling, with a sub-moderated compact core surrounded by a high quality heavy water reflector, pool type inverse neutron trap beam research reactor now widely adopted in the world. Its nuclear power designed is 60 MW, the maximum neutron flux unperturbed at the rated power is  $8 \times 10^{14}$  n/cm<sup>2</sup>/s. The main purpose of this reactor is to use its intensive neutron beam extracted to meet the requirements in neutron scattering experimental techniques which has played and will play much more important role in development of many significant fields in national economics such as energy sources, material sciences, IT industry, life science, etc. This reactor is to be a key installation for radio-isotopes production, NAA utilization, NTD silicon production, irradiation tests of nuclear fuel elements and materials and providing a strong R&D platform for science and technology in China.

General speaking, a research reactor will encounter many problems to be resolved coordinately when the project enters the commissioning stage from civil construction and installation phase. These problems include the controversy over project progress and quality on civil construction and equipment installation, the coordination of crossing tasks between different specialities, the common understanding on defects of civil construction and installation, the temporary change to equipment or system due to commissioning requests, the essential design change to equipment or system, etc. All these problems have to be resolved during commissioning stage, especially in non-nuclear or radio-activity free commissioning of the reactor without fuel loading.

The commissioning task is a process to make the structures, systems and components fixed try to run up and to verify their performance and function whether to meet the design requirement and related criterion. The commissioning activity will be divided into two kinds under non-nuclear and nuclear conditions respectively. The non-nuclear commissioning work of CARR before fuel loading has been finished till now and next the nuclear commissioning will be conducted. Some experience on commissioning of research reactor before fuel loading will be given in this paper.

## **2. Organizing commissioning team**

The aims of commissioning work for a research reactor are mainly as follows:

- To demonstrate that the design objectives of the reactor have been achieved, and that the facility can be operated safely;
- To provide assurance that construction and installation have been accomplished in accordance with design and specification;
- To verify the reactor performance assumption and models used in the safety analysis report;
- To familiarize staff with the operation of the facility;
- To verify the adequacy of the operating and emergency procedures.

In order to realize these purposes, organizing a commissioning team and getting involved in the activities in advance for familiarizing systems and facilities with installation is of great importance.

The commissioning team should be formed by persons who are qualified with the basic knowledge and experience on the systems and components to be tested. The commissioning team of CARR is formed by experts who have experienced the whole preliminary and detail design stages of the CARR and are familiar with the CARR systems to be tested.

In order to turn over the reactor after erected to operating unit smoothly and effectively, also favorable to operators training, all persons who are responsible to CARR operation later have to join in the commissioning team and conduct the commissioning job jointly.

## **3. The management of commissioning**

Before the CARR project enters commissioning phase, besides the commissioning team organizing, it is vital important for the project quality and schedule to establish related organizations and management systems. On this account, it is necessary to work out a series management documents mainly including:

- Quality assurance program for commissioning phase
- The program of commissioning
- The organizations and responsibilities of commissioning team
- The management of turning over for responsibility
- The management of interface between installation and commissioning
- Others related on conducting of commissioning work, the treatment on problems and non-conformance occurred, operating regulations of reactor operation, etc.

To carry out the commissioning activities earlier is favorable to enhance the commissioning quality and training for commissioning group. But it will result in making the job interface not clear or weakening the responsibility of installation team under condition of no final turning over the systems or components to commissioning team. This situation has to be resolved seriously from management of interface and the responsibility about turning over affairs. If simply emphasize that only after final handing over of system and facility from installation team then should begin commissioning job, it would greatly affect the project schedule because of the time consumption for reaching that goal. Therefore it is necessary for commissioning team

to take part in the work in advance and meanwhile to point out the related responsibility of installation team.

After entering the commissioning phase, there are many interface problems to be resolved coordinately within various speciality groups of commissioning team, between the activities performed by installation team and commissioning team, even problems left by civil construction team. So, to establish a commissioning office and to give its full play in commissioning work is very important for the coordinating function of commissioning activities, to work out and carry out the commissioning plan, to ensure the implementation of the commissioning schedule, to write various commissioning management documents, to organize and manage the calibration of special devices and instruments used in commissioning tests, to control the permit of commissioning activities, to manage the qualification training work for persons.

During the commissioning period, it is absolutely necessary to enhance the activities on quality assurance and nuclear safety supervision management. According to the requirement of quality assurance program, these activities include inside undated QA inspection within the utility and outside QA supervision from higher level nuclear safety supervision division. Meanwhile, some quality control witness points for the essential commissioning activities should be set forth and let them approved respectively by the sign of supervisor dispatched. According to the different features of the commissioning items, to raise different QA requirements with individual emphasis, to inspect or supervise the consistence between each commissioning activity and commissioning QA program and related regulations, to reach the aim of controlling commissioning quality effectively. The problems discovered in each QA inspection or supervision have to be closed in written documents.

It is an important work to enhance the training for operators during the commissioning of reactor systems and facilities. For this account, let the candidates who will be the super operators and supervisors for reactor operation later join in actively the commissioning work of various reactor systems so that they can master the features and characteristics of the reactor systems and facilities more solidly, which is favorite to the system operation after the reactor entering the stage of fuel loading operation and to the final turning over of the reactor smoothly to operation team after the whole commissioning work finished.

#### **4. Commissioning implementation and problems handling**

According to the commissioning program, there are 114 commissioning procedures before the fuel loading of CARR. These commissioning test items nearly all are for various systems and facilities, only a few items are dealt with comprehensive performance for whole reactor systems. Certainly for systems involved in instruments, control and electricity specialities, their functions and performance are closely linked with other systems. When drawing up implementation plan for CARR commissioning tests, the items involved in primary cooling system and heavy water loop system have been listed as the main line while the others are conducted in keeping cooperation with the main line. The practicing result indicates that such a commissioning mode is successful to control the commissioning progress and quality effectively.

During the commissioning implementation, some non-conformances would occur due to weak consideration in design and defectiveness in installation. These problems have to be well resolved by commissioning team in order to meet the requirements of design specifications and system functions. For those modifications relating to safety important facility and component performance, it needs approval of the commissioning technical committee of CARR. Nevertheless, for those that though great efforts having been made the requirements of design specifications still not met, the modification and related adjustment can be conducted after getting the approval from safety supervision authority.

Any changes, modifications and adjustments to CARR systems and facilities during commissioning implementation, it is necessary to manage and deal with according to different conditions:

- Modifications and adjustments of adaptability on systems, facilities or components resulted from weak consideration of design stage, which is not favorite to the implementation or to the maintenance and repair in later operation, have to be conducted under the control of related QA procedures;
- Defectiveness of installation discovered during implementation could be corrected after affirming or under the condition of no method to affirm suitable correcting measures could be adopted to prevent the defectiveness from giving rise to any unacceptable serious consequence in later operation;
- In case some commissioning results fail to meet the requirements of design specification, all results and procedures have to be further analyzed. Related accident analyses should be conducted and approved by safety supervision authority if adjustment for the specification was adopted;
- Any temporary change or adjustment adopted for commissioning test implementation on systems and facilities has to be recovery when the commissioning has reached the end of a certain step or completely finished;
- For those slight defectiveness and general abnormal problems occurred in commissioning implementation, their reasonable explanation should be given and be described in related commissioning reports. They are acceptable with no effect on reactor safety.

Some commissioning items could not completed before applying for and getting the fuel loading permission of the reactor due to certain conditions limited. However, these items should not belong to safety important system or safety related auxiliary system involved in preventing and mitigating the accident consequence, their incompleteness should neither affect the implementation of reactor fuel loading followed nor bring any unfavorable effect or interruption to the test results of later items conducted, otherwise it would be unsuitable to apply for reactor fuel loading.

Before the reactor entering commissioning stage, persons who are responsible to run the reactor later have already worked out the operating procedures for various systems and facilities according to their design documents. These procedures have to be verified and corrected during commissioning related. This is an important job

during commissioning stage and a key link of turning over from commissioning to operation. The verifying and correcting work for operating procedures should be performed under the joint efforts of commissioning team and operating group.

One very important test before the reactor entering fuel loading stage is integral performance of reactor when finishing the main single systems commissioning and all meet the design specifications. The condition of the CARR core is loaded with dummy fuel assemblies. When conducting the test, each fluid system is put into normal operation and so do the ventilation of main process systems, the reactor monitoring and control system, protection system, ATWS mitigating system, radiation protection system, control rod driven system, etc. To draw the safety rods up to top position and other control rods to certain level, all systems then run steadily several hours. The test should indicate that each system of the reactor run with steady parameters, the power supply in normal condition, all possessing continuous running ability.

In order to check the safe response properties of reactor safety protection system to the occur of certain event, a test of total offsite power supply loss has been conducted in CARR based on integral performance test of the reactor mentioned above. The test indicates that all signals on accident alarming and ATWS alarming are on, the accident horn sounds, all control rods drop down automatically, the main cooling pumps coast down, heavy water pumps, blowers and the second cooling water pumps all stop, heavy water emergency discharging valves open automatically and heavy water discharged from heavy water tank to its storage tank, UPS A, B and C work continuously in discharging condition, emergency pumps A and B smoothly transfer to function of core residual heat removal mode, and so on.

## **5. Conclusion**

The completion of CARR project phase A commissioning has provided the necessary condition for CARR's fuel loading and phase B commissioning and its power operation later. The assessment of phase A commissioning for CARR is given below.

- The organization of commissioning is well set, each unit and personnel has definite duty and responsibility to meet the requirement of commissioning. The commissioning personnel have got their correspondent training and authorization according to regulation, the personnel qualification and number meet the requirement.
- Various management programs for commissioning have been worked out and they meet the commissioning test requirement. These programs are strictly implemented during the commissioning period.
- All commissioning test programs have been checked, reviewed and approved under definite procedure. The change of commissioning test program has been reviewed and approved strictly, the change dealt with safety important system or component has been reviewed and approved by the technical committee of CARR project division. The collection and record of test data are reliable and complete. The final test reports have got reviewed and meet the requirement of design specifications.

- The instruments involved in commissioning have been calibrated and identified according to national measuring standards and within their effective periods throughout the commissioning period.
- Whole commissioning activities are under QA supervision, all nuclear safety related test items are confirmed by supervisor's witness, the test results are reliable and convincing.
- The results of phase A commissioning shows that the performance of CARR systems and components meets the requirements of design and relative norms. The performance of safety important systems involved meets the requirements of related safety norms.
- The questions and problems raised by nuclear safety supervision group, which have to be completed before fuel loading, have been fixed and closed one by one. Related inspections and tests for systems have been conducted and assured that their design function verified could be kept.
- The results of pre-operation integral performance test indicate that the systems and components could work normally, continuously and steadily with long period operating ability. It shows that the design aim for CARR has been reached.
- Those not yet finished tests will not give rise to any unfavorable effect on fuel loading followed and phases B, C commissioning conducting.