Russian Companies' Involvement in CEFR RP (China) Construction

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Abstract. PRC – Russia cooperation in CEFR RP construction commenced in 1992. Since 2002, the cooperation in CEFR has been exercising the granted Status of International one. The design was developed based on technical requirements for CEFR provided by the Chinese part. Defines the main technical characteristics. To validate designing decisions implemented in equipment designs, test facilities were constructed and prototype equipment and core dummy components were tested. Early in 1999, the CIAE obtained permission of the Chinese government and National Nuclear Security Administration (NNSA) to construct CEFR. That enabled in 1999 to commence manufacture and testing of prototypes, RP equipment supply, as well as fuel supply by Russian companies.
Key Words: Fast reactor, CEFR, fabrication, installation

1. Introduction

In 1987, the objective to develop technology of fast reactor, i.e. breeder, was included in PRS's State program on high-tech development. Chinese Institute of Atomic Energy (CIAE) near Beijing was appointed leading organization.
In the period of 1988-1990, CIAE carried out studies and practical activities enabling to include construction of 65 MW(t) experimental fast reactor (CEFR) in the China's State program beginning from 1996.
To minimize CEFR construction expenditures, China decided to involve foreign countries and in the first place Russia that had the most extensive experience of fast reactor development in the world.
PRC – Russia cooperation in CEFR RP construction commenced in 1992.
In 1992 – 1995, specialists from "Experimental Design Bureau of Mechanical Engineering" (OKBM, Nizhny Novgorod), Institute "Atomenergoproekt" (Saint Petersburg), and Institute of Physics and Power Engineering (Obninsk) together with Chinese Institute of Atomic Energy (CIAE) and Beijing Institute of Nuclear Engineering (BINE) developed "CEFR unit concept" and technical requirements for the reactor and its main components.
In 1995 – 1996, Russian companies' specialists developed detailed design of CEFR nuclear power plant. The design was developed based on technical requirements for CEFR provided by the Chinese part.
In March 1995, "RF Ministry of Atomic Energy-CNEIC Inter-Agency Agreement of Cooperation in the Field of Developing the Experimental Sodium-Cooled Fast Reactor in the PRC" was signed.
Since 2002, the cooperation in CEFR has been exercising the granted Status of International one. "Agreement between the Government of the Russian Federation and the Government of People's Republic China on Cooperation in Construction and Operation Experimental Fast Reactor in China" was signed in Beijing on July 18, 2002 (Fig. 1) [1].

Fig. 1 Signing of the RF-PRC Intergovernmental Agreement on Cooperation for Construction and Operation of CEFR (July 18, 2000)

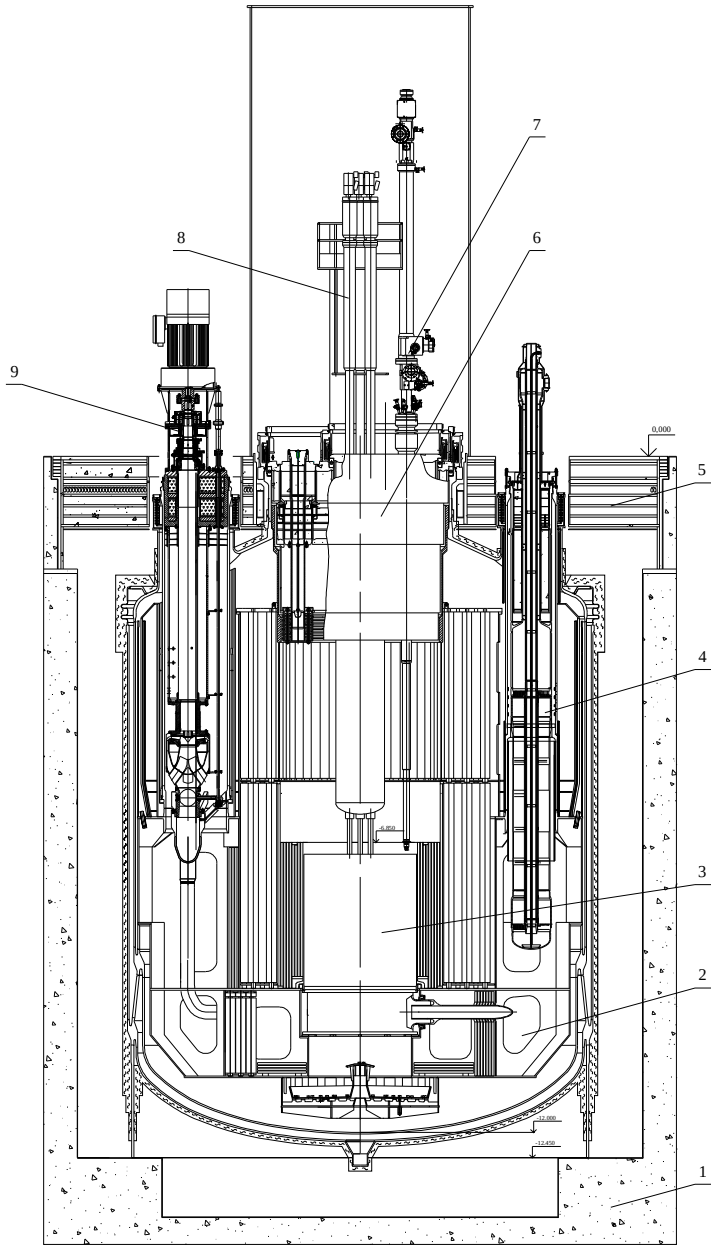
2. CEFR basic technical characteristics

CEFR basic technical characteristics and reactor components are given in Table 1 and Figure 2.

Main technical characteristics

Table 1.

Parameter	Value
Thermal (electrical) power, MW	65.5 (25)
Coolant	sodium
Number of circuits	3
Number of heat exchange loops	2
Reactor type	integral
Reactor vessel diameter	7.96
Primary sodium temperature, 0C - at core inlet - at core outlet	360 530 480
Steam temperature at steam generator outlet, 0C	190
Feed water temperature, 0C	14.0
Steam pressure at SG outlet, MPa	30
Service life, years	8 points according to MSK-64 scale
Seismic resistance	



1 – reactor cavity;
2 – supporting skirt;
3 - core;
4 – intermediate heat exchanger;
5 – upper stationary shielding;
6 – rotating plugs;
7 – refueling mechanism;
8 - CRDMs;
9 – main circulation pump

Fig.2. CEFR

3. Experimental validation

To validate designing decisions implemented in equipment designs, test facilities were constructed and prototype equipment and core dummy components were tested (Table 2).

Experimental stands

Table 2.

Purpose of test facility	Test location
1. Hydraulic tests of core dummy FSAs	OKBM
2. Bending stiffness studies of DFSA wrapper tube	OKBM
3. Vibration resistance studies of CDFSAs	OKBM
4. Stability and tensile studies of CDFSAs	OKBM
5. Impact resistance studies of DFSAs	OKBM
6. Core studies using BFS large physical test facility	SSC RF-IPPE
7. Full-scale tests of primary and secondary MCPs using water test facility	OKBM
8. Tests of oil seals in the upper bearing unit of MCP	OKBM
9. Tests of the MCP flow path	OKBM
10. Flushing of the flow meter flow path in the primary MCP	OKBM
11. Full-scale tests of CRDMs	OKBM
12. Seismic stability tests of prototype CRDMs (as for shim rods, control rods, and safety rods)	“Atom-Dinamik” (Vyborg), OKBM
13. Full-scale tests of the refueling mechanism	OKBM
14. Tests of the refueling mechanism gripping device	OKBM
15. Tests of the force sensor	OKBM
16. Tests of the leaktight torque transfer for refueling equipments drives	OKBM
17. Full-scale tests of loading/unloading elevators	OKBM
18. Full-scale tests of the FSA flow meter	OKBM
19. Flushing of the flow meter flow path for FSAs with magnets using sodium test facility	SSC RF-IPPE
20. Full-scale sodium EMP tests	НИИЭФА
21. Full-scale irradiation ICS tests	МИФИ, OKBM
22. Sensor tests: - for sodium - for sodium pressure	JSC “Piramida” (Smolensk), JSC “NII Teplopribor”, OKBM
23. Studies of the emergency cool-down system	SSC RF-IPPE, OKBM
24. Tests of absorbing components based on boron carbide	ГНЦ РФ НИИАР
25. Tests of sodium devices (level meters, flow meters, monitors of hydrogen in sodium).	SSC RF-IPPE, JSC “Piramida” (Smolensk), OKBM

4. Equipment supply

Early in 1999, the CIAE obtained permission of the Chinese government and National Nuclear Security Administration (NNSA) to construct CEFR. That enabled in 1999 to commence manufacture and testing of prototypes, RP equipment supply, as well as fuel supply by Russian companies including:
- supply of fuel (JSC “TVEL”, Elemach, OKBM);
- supply of components for reactor vessel and rotating plugs (OKBM);
- supply of primary and secondary pumps (OKBM);
- supply of CRDMs (OKBM);
- supply of intermediate heat exchangers (OKBM);
- supply of refueling mechanism (OKBM);
- supply of fuel loading/unloading elevators (OKBM);
- supply of steam generators (JSC “ZIOMAR”, Podolsk);
- supply of devices (NII Teplopribor, OKBM);
- supply of FSA flow meter (OKBM);
- supply of steam generator emergency protection (IPPE);
- supply of level meter (OKBM, NII Teplopribor);
- supply of electromagnetic pumps (OKBM, NIIEFA);
- supply of ionization chamber suspensions (OKBM, STC Elegiya);

In all, Russian companies supplied more than 100 units of equipment.
Also, detailed designs were developed for:
- control and protection system (SPbAEP, OKBM, IPPE);
- special devices for equipment dismounting/mounting (OKBM);
- special devices for gas heating (OKBM);
- and several other designs.

Simultaneously, CEFR operating personnel was trained using test facilities at OKBM, IPPE, and NIIAR Training center.
In that stage, consulting cervices were rendered by specialists from OKBM, IPPE, and SPb AEP, lectures on BN reactors were delivered, practical trainings for CIAE specialists were prepared using OKBM and IPPE (large physical test facility) test facilities, training for CNI-23 installation company’s specialists and technical briefing for operating repair personnel were conducted in OKBM, CIAE operating personnel (operators) were trained in RIAR Training center using BOR-60.
Beginning from 2000, be the decision of the parties, Russia-China Coordinating working group for CEFR construction has been functioning. [2]

5. Main stages of the CEFR construction and startup (Table 3).

Main Stages of the CEFR construction

Table 3.

Phase	Year	Main works
1	1992-1995	Development of the CEFR concept (Russian and Chinese companies)
2	March 2001	Start of plant construction
	August 2002	Completion of reactor building construction
	2003-2005	Completion of detailed design for major process systems and equipment. Completion of turbine room and plant service building construction, installation of plant-shared equipment.
3	2003-2004	RP equipment supply by Russian and Chinese companies
	July 2004	Fuel supply (Russia)
	2003-2008	Installation of reactor vessel, rotating plugs, in-vessel equipment (involvement of Russian companies). Completion of RP installation.
4	2009-2011	RP startup and adjustment, reactor heating up and filling with sodium, fuel loading
	2011-2014	Physical startup, experiment and research performance
	2015	RP power startup, power startup research performance

Currently, Russian companies are continuing to cooperate with China in the following areas.
JSC “Afrikantov OKBM” – SPTA supply for CEFR equipment and provision of consulting services for repair technology development for equipment of Russian origin:
JSC “RF SSC RIAR” – training of CEFR operating personnel;
JSC “Rusatom Service” – provision of consulting cervices in the RP operation stage;
JSC “TVEL” – fuel supply;
JSC “SSC RF-IPPE” – studies and model analyses of the CEFR core using the large physical test facility.

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