Profile SFR-6

MSSPD

CHINA

GENERAL INFORMATION

NAME OF THE FACILITY	MSSPD
ACRONYM	Middle Size Sodium Purification Device
COOLANT(S) OF THE FACILITY	Liquid sodium
LOCATION (address):	China Institute of Atomic Energy, Beijing, China
OPERATOR	CIAE
CONTACT PERSON (name, address, institute, function, telephone, email):	XU Chi. P. O. Box 275(34), CIAE, Fun Hill District, Beijing, China 102413. Engineer, Division of Sodium Technology. +86 01069358162 xuchi1008@sina.cn

STATUS OF THE FACILITY In operation

Start of operation (date): 1999

MAIN RESEARCH FIELD(S)

- ☐ Zero power facility for V&V and licensing purposes
- ☐ Design Basis Accidents (DBA) and Design Extended Conditions (DEC)
- ☐ Thermal-hydraulics
- ☒ Coolant chemistry
- ☐ Materials
- ☐ Systems and components
- ☐ Instrumentation & ISI&R

TECHNICAL DESCRIPTION

Description of the facility

MSSPD was constructed in 1999. Its design capacity is to produce 300kg nuclear grade sodium per day. Up to now, it has produced approx. 20 tons of purified sodium for research purpose and civil use of China (mainly for sodium loops). Since the impurities in Chinese industrial sodium whose content exceed the standards of nuclear grade sodium are mainly oxide(O), calcium(Ca), carbide(C), etc., this device had been designed to remove these impurities. After purification, the contents of these impurities will be below the permitted values mentioned in table 1.

Table 1. Permitted contents of impurities in nuclear grade sodium (for CEFR)

Impurities	O	Ca	C	N	Fe	Cl	K
Contents(μg/g)	30	10	50	10	10	30	200

MSSPD consists of the following components:

- *Sodium Transfer Tank*: is a moveable tank connected to the sodium receiver that provides industrial sodium for MSSPD.
- *Sodium Receiver*: is the tank that can receive industrial sodium from the transfer tank and then pump sodium to the reaction tanks for purification.
- *Reaction Tanks*: are the 2 cylindrical containers that remove calcium from sodium. Each one has an effective volume of 311kg sodium. Na_2O_2 is added in from the sodium peroxide feeder on the top of the tank to react with calcium, forming CaO and Na_2O that can be deposited and filtered effectively. Argon gas bubbles from the bottom of the tank to mix the Na_2O_2 and sodium to accelerate reaction velocity. The two tanks work in parallel.
- *Deposition Vessels*: are the first stage deposition vessel and second stage deposition vessel. They work like cold traps. There is a temperature gradient between the upper area and the bottom area of vessel. The upper sodium temperature keeps 120℃～130℃ while the bottom temperature of vessel that is cooled by blowing is lower. Hence, impurities are deposited in the bottom of deposition effectively. The two deposition vessels work in series.
- *Filters*: are placed just after the deposition vessels to remove the remaining impurities. One filter packed with stainless steel mesh is placed after the first stage deposition vessel. Its construction is the same as a cold trap, and the bottom temperature of the filter is 130℃～150℃. Two Dual-stage filters work in parallel are placed after the second stage deposition vessel. One stage is made of three layers of stainless steel mesh (φ=0.2mm), and the other is made of sintered ceramic filter whose filtration aperture diameter is 20μm.
- *Sodium Residual Tank*: is a moveable tank that stores sodium residual from the deposition vessels.
- *Sodium Storage Tank*: stores the final purified sodium and then connect with a transport tank to transfer sodium to anywhere needed.
- *Sodium Vapour Trap*: is to trap sodium vapour.

Argon gas and vacuum pump are two important parts of the device. Argon gas is not only cover gas, but also a mixer and a high pressure provider. By the alternation of high pressure provided by argon gas and low pressure provided by vacuum pump, sodium is transported from one tank or vessel to another. Each tank or vessel has a contact type gauge to indicate the high sodium level and the low sodium level.

Acceptance of radioactive material

No

Scheme/diagram

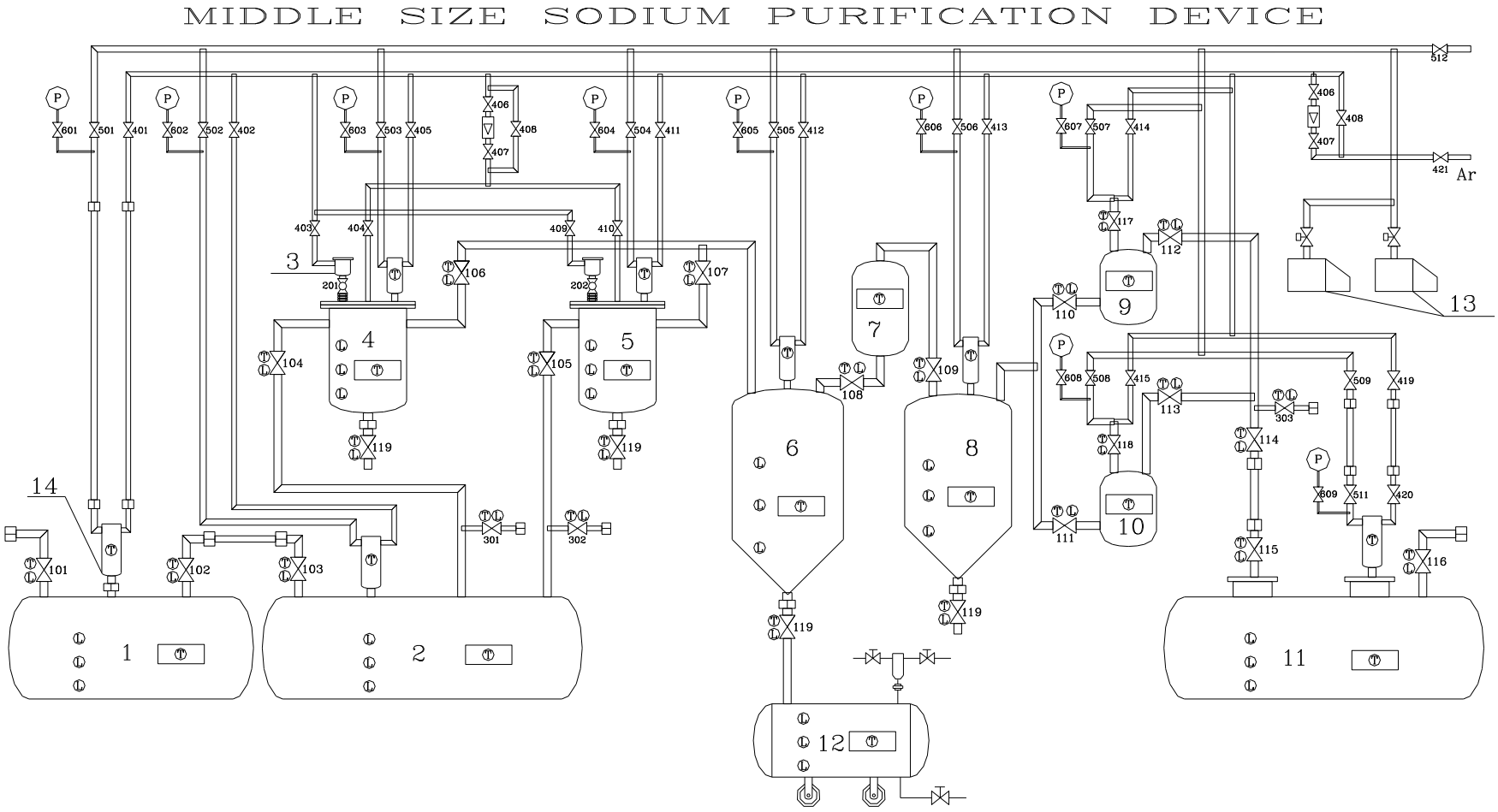

FIG.1. The flow chart of Middle Size Sodium Purification Device (MSSPD)

1 sodium transport tank 2 sodium receiver 3 sodium peroxide feeder 4 reaction tank A for removing calcium 5 reaction tank B for removing calcium 6 the first stage deposition vessel 7 stainless steel mesh filter (ϕ =0.2mm) 8 the second stage deposition vessel 9 dual-stage filter A (20 μ m) 10 dual-stage filter B(20 μ m) 11 sodium storage tank 12 sodium residua receiver 13 vacuum pump 14 sodium vapour trap

3D drawing/photo

FIG 2.Tthe MSSPD rig

Parameters table

Coolant inventory	300 kg purified sodium per day
Power	approx. 120KW
Test sections	
TS #1	*Characteristic dimensions* Covering an area of 50m^2, 10m length, 5m width and 4.5m height.
	Static/dynamic experiment dynamic
	Temperature range in the test section (Delta T) 230℃ (reaction tanks 350℃, deposition vessels 120℃)
	Operating pressure and design pressure Operating Pressure →maximum 0.2MPa (gauge) Design pressure → 0.4MPa (gauge)
	Flow range (mass, velocity, etc.) 25L/min velocity of argon gas as a mixer in the reaction tanks. Velocity of sodium is 2m^3/h-4 m^3/h.
Coolant chemistry measurement and control (active or not, measured parameters)	Sodium can be sampled by a moveable sampler at two sampling points, before sodium leaving the receiver and after sodium entering the final sodium storage tank, in the MSSPD. The sampler that can lay 4 samples once is an overflow type. Sodium samples will be sent to chemistry lab to analyse impurities. The analytical methods show as follows: Oxide(O), vacuum distillation-alkali titrated by acid; Carbide(C),

	vacuum distillation-GC; Calcium(Ca),vacuum distillation-AAS; Nitride(N), dissolved by distilled water-UV spectrophotometer; Chloride(Cl), vacuum distillation-IC; iron, vacuum distillation-AAS; Potassium(K), sodium dissolved by ultrasonic humidifier-(F-AES).
Instrumentation	Thermocouples, pressure transducer, flow meter, GC, AAS, IC, F-AES, UV spectrophotometer.

COMPLETED EXPERIMENTAL CAMPAIGNS: MAIN RESULTS AND ACHIEVEMENTS

About 300Kg of industrial sodium can be purified to be nuclear grade sodium by this device in 24hours. In the reaction tank, calcium reacts with proper amount of Na_2O_2 at 350℃ mixed by a 25L/min velocity of argon gas, 24 hours of reaction is well suited. The content of calcium in sodium can be removed from 450μg/g to less than 10μg/g while oxide can be removed from 250μg/g to less than 30μg/g. The total amount of sodium purified by the MSSPD is approx. 20tons.

Reference to the MSSPD, Large Size Sodium Purification Device (LSSPD) with a production of 1.5t/d nuclear grade sodium had been constructed in 2005. All the 337 tons of sodium in CEFR was provided by the LSSPD.

PLANNED EXPERIMENTS (including time schedule)

There has been a plan to upgrade the device in one year or so since the device is ageing. The upgrade design consists of replacing heat insulation, replacing electric accessories and control system, etc. it is an expectation that the device will be operated more friendly after the upgrade.

TRAINING ACTIVITIES

Training activities can be agreed with CIAE for operation and upgrade of the device under the supervision of CIAE qualified staff.

REFERENCES (*specification of availability and language*)

1. XING C.. Purification Technique for Sodium (Chinese). Nuclear Power Engineering, 1989, 10(1): 75-82.

2. XING C., JIA Z.. Calcium Removal Technique for Sodium in LMFBR (Chinese). Nuclear Power Engineering, 1995, 16(5): 476-480.