

上海电气集团核电部 Nuclear Power Dept., Shanghai Electric Group

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上海电气核电产业

2024



NUCLEAR POWER BUSINESS OF SHANGHAI ELECTRIC 上海电气核电产业



上海电气集团聚焦智慧能源、智能制造、智能基础设施三大业务领域,为客户提供工业级的绿色智能系统解决方案。上海电气坚持开放协同、合作共赢,着力推进"智慧能源、智能制造"的双智联动,"产业智能化、服务产业化"的双轮驱动,"能源互联网、工业互联网"的双网互动,以科技赋能全球工业发展,让人类生活更美好。

核电是上海电气关键产业之一。

上世纪70年代发展至今,上海电气已实现了众多首台套的关键主设备业绩突破, 是国内唯一拥有压水堆核岛和常规岛主设备及大型锻件全套供货能力、唯一拥有高温 气冷堆核岛主设备成套供货能力、唯一拥有磁约束可控核聚变主机系统核心设备及关 键材料成套供货能力的高端装备制造集团。

已成功实现了二代加、三代华龙一号、国和一号、AP1000、EPR、VVER及四代高温气冷堆、钠冷快堆、钍基熔盐堆等核电主设备产品的批量化、集成化交付;正在开发和研制一体化供热堆、聚变堆、铅铋快堆、微堆等关键设备。

Shanghai Electric Group focuses on smart energy, intelligent manufacturing and smart infrastructure to provide green and intelligent industrial-grade system solutions. Shanghai Electric upholds the values of open and mutually-beneficial collaboration, advocates smart energy and intelligent manufacturing, promotes the development of smart industry and industrialization of service, and supports the growth of the "Energy Internet" and "Industrial Internet." By facilitating industrial transformation through technological advancement, we promote sustainable human and social progress.

Nuclear Power Business is one of the key businesses of Shanghai Electric.

Since 1970s, Shanghai Electric has achieved many breakthroughs in performance of the first set of key main equipment through years of development. In terms of supply capability, it is the Only high-end equipment manufacturing group in China producing a complete set of main equipment and its large forgings for PWR nuclear island and conventional island, the Only manufacturer of a complete set of nuclear island main equipment for HTR, and the Only one that can supply whole set of magnetic confinement controlled nuclear fusion host system core equipment and core materials.

Shanghai Electric has realized the mass production and integrated delivery of nuclear main equipment with the second generation plus technology, third-generation technologies including HPR1000, CAP1400, AP1000, EPR &VVER and fourth-generation technologies such as HTR, China Fast Reactor (CFR) & Thorium Molten Salt Reactor (TMSR). Furthermore, it is currently actively engaged in the development and manufacturing of key equipment for advanced nuclear technologies such as Integrated Heating Reactor, Fusion Reactor, Lead-bismuth Fast Reactor and micro reactors.

THE LONGEST **DEVELOPMENT HISTORY**

发展历史最久

上海电气核电发展与我国核工业的发展紧密相连。自上世纪70年代我国自行设计制造建设的第一座核电 站——秦山核电站("七二八"工程)开始,上海电气参与了我国多个核电项目的建设,提供了各类的核电关 键设备,由此开始了上海电气核电产业的发展历程。

The development of Shanghai Electric's nuclear power business is closely connected with the development of China's nuclear industry, From Oinshan NPP (the "728" Project) which was China's first NPP designed, manufactured and constructed on our own in the 1970s, Shanghai Electric has participated in the construction of many nuclear power projects in China and provided all kinds of key nuclear power equipment. Thus, the development of Shanghai Electric's nuclear power business was started.

1970年代,参与 "七二八"工程前期 准备和研制工作。

Participated in the preparation and research of the '728' Project in the





1996-1998年,交付了我国首台出口巴 基斯坦恰希玛核电站的堆内构件、控 制棒驱动机构、蒸汽发生器、稳压器 及汽轮发电机组

Supplied RVI, CRDM, SG, PZ and turbinegenerator unit for Chashman NPP in Pakistan. China's first export project, from 1996 to 1998.

2000-2001年,交付了我国首台 600MW核电站——秦山二期核电 站的堆内构件、控制驱动机构、 压力容器、蒸汽发生器及稳压器

Delivered RVI, CRDM, RV, SG and PZ for Qinshan Phase II, China's first 600MW NPP from 2000 to 2001.





1988-1989年, 交付了我 国首个核电站——秦山 核电站的堆内构件、控 制棒驱动机构、蒸汽发 生器、稳压器及汽轮机 发电机组

Supplied RVI, CRDM, SG, PZ and turbine-generator unit for Qinshan NPP, China's first NPP, from 1988 to 1989

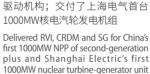






1999-2000年,交付了国内 承制的首台1000MW核电 站——岭澳一期核电站的堆 内构件及控制棒驱动机构

Delivered RVI and CRDM for LingAo Phase I, China's first 1000MW NPP, from 1999 to 2000



2010-2012年,交付了国内承制的 首台二代改进型1000MW核电站 堆内构件、蒸汽发生器、控制棒

1000MW nuclear turbine-generator unit from 2010 to 2012.



2010-2015年,交付了全球首台AP1000三门核电站的安 注箱、堆芯补水箱、稳压器,交付了国内承制的首台 AP1000堆内构件、控制棒驱动机构以及全球首批AP1000 压力容器、蒸汽发生器

Delivered ACC tank, CMT and PZ for Sanmen NPP, the first AP1000 NPP in the world, the first AP1000 RVI & CRDM in China and the first batch of AP1000 RV and SG in the world from 2010 to 2015.









2011-2016年,交付了国内承制的首台EPR台山核电站的堆内构件、控制棒驱动机构、安注箱;交付了国内首批EPR蒸汽发生器

Delivered RVI, CRDM, ACC tank for Taishan NPP, the first EPR NPP in China and the first batch of EPR SG manufactured in China from 2011 to 2016

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2017-2018年,交付了全球首台华龙一号HPR1000暨福清5号机组的堆内构件、人桥吊、辅助吊;我国首台华龙一号海外工程巴基斯坦卡拉奇项目的堆内构件、汽轮发电机组

Delivered the world's first RVI, spent fuel pit cranes & auxiliary cranes for Fuqing Unit 5, the first HPR1000 unit in the world, and the first RVI and turbine-generator unit exported to Karachi NPP in Parkistan from China.









2022年,交付了全球首台国和一号湿绕组电机主泵;自主研制首台1300MW级核电发电机;华龙一号批量化建设首堆首台轴封型主泵。

Delivered the world's first Wet Winding Motor Reactor Coolant Pump RUV for CAP1400 demonstration project, first 1300MW class generator by self-design and self-manufacture and first RSR for HPR1000 Zhangzhou NPP.





2016

2016-2018年,交付了全球首台 200MW高温气冷堆石岛湾核电站 的压力容器、金属堆内构件、控 制棒驱动机构、吸收球装置、汽 轮机、主氦风机、氦气压缩机

Delivered the world's first 200MW HTR RV, RVI, CRDM, absorption sphere device, turbine, helium circulator and helium compressor for Shidao Bay NPP. 2020

2020-2021年,交付了全球首台国和一号蒸汽发生器、堆内构件、控制棒驱动机构;国内首台钍基熔盐堆实验堆堆容器;首批出口南非Koeberg更换蒸汽发生器

Delivered the world's first SG, RVI and CRDM for CAP1400 demonstration project, reactor vessel for the first TMSR in China, and the first batch of replacement SGs for Koeberg NPP in South Africa.









2023

2023年,实现了华龙一号轴封型主 泵100%国产化、自主化;交付了 首台三代WER-1200堆型发电机、 全球首台全高温超导托卡马克装置 HH-70主机系统。

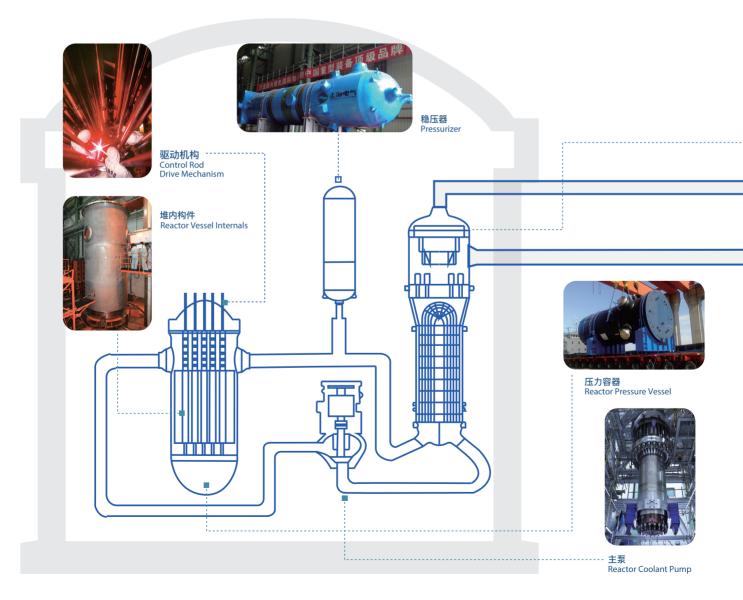
Realized 100% localization of HPR1000 shaft seal type Coolant pump. Delivered the first third-generation VVER-1200 generator and the world's first full high-temperature superconducting Tokamak HH-70 host system.

THE MOST COMPLETE SUPPLY CHAIN

产品配套最全

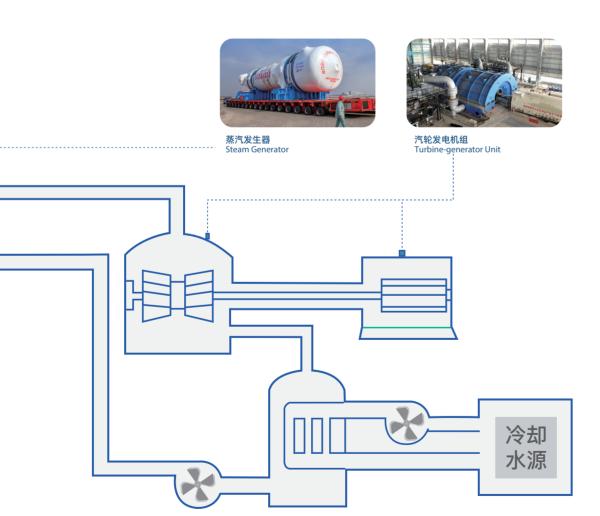
经过50多年的发展,上海电气已形成国内配套最全的核电设备制造产业链,所提供的核电产品包括核岛的反应堆压力容器、蒸汽发生器、堆内构件、控制棒驱动机构、主泵、稳压器、核二、三级泵、核二、三级容器、燃料输送设备、隔膜压缩机、核级阀门,到常规岛的汽轮机、汽轮发电机、辅机、常规泵,以及大型铸锻件、核级风机、配套电机、仪控仪表、厂用电梯、现场服务及备品备件等。

After 50 years of development, Shanghai Electric has formed the most complete nuclear power equipment manufacturing industrial chain in China. It has the capability to supply reactor pressure vessel (RV), steam generator (SG), pressurizer (PZ), reactor vessel internal (RVI), control rod drive mechanism (CRDM), reactor coolant pump (RCP), pumps and vessels of Nuclear Class II & III, fuel handling equipment, diaphragm compressor and nuclear valves in nuclear island, turbine, turbine-generator, auxiliary equipment and pumps in conventional island, large nuclear castings & forgings, nuclear fans, motors, nuclear control & instrumentation, elevator and spare parts & on-site services, etc.





- **5 辅机** Auxiliary Equipment
- ② 核二三级容器 Class || & ||| Vessel
- 3 核级风机 Nuclear Fan
- 4 核二三级泵 Class || & ||| Pump
- 6 核电大锻件 Nuclear Forgings
- **②** 电机 Motor
- 8 核级仪表 Nuclear Instrumentation
- 9 核电阀门 Nuclear Valve



NUCLEAR ISLAND MAIN EQUIPMENT 核岛主设备

REACTOR PRESSURE VESSEL, STEAM GENERATOR, PRESSURIZER

反应堆压力容器、蒸汽发生器、稳压器

上海电气已实现三代AP1000百万千瓦级核岛重型容器——压力容器、蒸汽发生器、稳压器、堆芯补水箱、国和一号蒸汽发生器、稳压器、EPR蒸汽发生器和四代200MW高温气冷堆压力容器、钍基熔盐堆堆容器等设备的交付,标志着上海电气实现了制造能级从60万千瓦到100万千瓦、技术能级从二代加、三代到四代技术的重大突破。

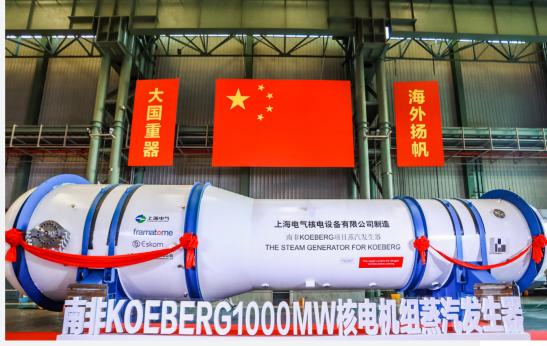
目前在制的核岛重型容器包括我国自主三代技术华龙一号太平岭、三澳、宁德、陆丰、徐圩项目的压力容器、蒸汽发生器,CAP1000三门、海阳、徐大堡等项目的反应堆压力容器、蒸汽发生器、稳压器;及四代高温气冷堆压力容器、蒸汽发生器等项目。

Shanghai Electric has realized the delivery of 1000MW nuclear island heavy components of the third generation, including AP1000 RPV, SG, PZ, CMT & CAP1400 SG & EPR SG, and RPV for 200MW HTR & TMSR vessel of the fourth generation. It marks a great breakthrough of Shanghai Electric from capacity level of 600MW to 1000MW and from technology level of the second generation plus and the third generation to the fourth generation.

At present Shanghai electric is manufacturing heavy NI vessels including reactor pressure vessels, steam generators and pressurizers for domestic independent third-generation technology HPR1000 Taiping Ling, SanAo, Ningde, Lufeng, Xuwei projects, and CAP1000 Sanmen, Haiyang & Xudapu projects, fourth-generation technology HTR600, etc.









REACTOR VESSEL INTERNAL & CONTROL ROD DRIVE MECHANISM

堆内构件和控制棒驱动机构

上海电气已成功实现300MW、600MW、1000MW等级压水 堆及200MW等级高温气冷堆堆内构件及控制棒驱动机构的批量 化、配套化交付,市场占有率国内第一,在设备制造能级及技 术发展方面均迈向了新的台阶。

目前我国自主三代技术华龙一号防城港、太平岭、宁德、三澳、陆丰、金七门项目,CAP1000三门、海阳、徐大堡以及四代快堆、高温气冷堆等项目的堆内构件及控制棒驱动机构正在抓紧制造中。

Shanghai Electric has realized the mass and complete-set delivery of reactor vessel internals and control rod drive mechanisms for 300MW, 600MW and 1000MW PWRs and 200MW HTRs, which marks a new stage of Shanghai Electric in both equipment manufacturing capacity and technology, and holds the highest market share in China.

At present Shanghai Electric is manufacturing reactor vessel internals and control rod drive mechanisms for Fangchenggang, Taiping Ling, Ningde, SanAo, Lufeng & Jinqimen projects of domestic independent third-generation technology HPR1000, Sanmen, Haiyang & Xudapu projects of CAP1000 technology, and fourth-generation technology CFR & HTR600 project, etc.







REACTOR COOLANT PUMP

主泵

上海电气消化吸收德国KSB集团先进的主泵技术,并进行了优化创新, 能够提供具有国际领先技术水平的轴封型主泵(RSR)及湿绕组电机主泵 (RUV)。

为昌江核电站交付的4台RSR主泵已安全运行8年多。用于"华龙一号"批量化建设首堆漳州 1、2号机组的RSR主泵、国家科技重大专项"国和一号"示范工程1号机组的RUV主泵已实现交付。目前正在执行"华龙一号"三澳、三门RSR主泵项目以及CAP1000白龙主泵项目。

上海电气全面推进三代先进核电反应堆冷却剂泵的国产化、自主化。截至2023年,用于华龙一号核电机组的轴封型主泵已实现100%国产化、自主化,机械密封、推力轴承、10kV电机、水力部件等关键部件均完成国产化验证;用于国和一号核电机组的湿绕组电机主泵国产化工作正在稳步推进,大部分关键部件及材料均已完成国产化验证,水润滑推力轴承、湿绕组电缆等关键部件已完成样件研制,将于2024年完成寿命验证。预计2025年湿绕组电机主泵可实现全部国产化。

Shanghai Electric introduced advanced RCP technology from KSB SE & Co. KGaA and has the capability to provide two types of RCPs (RSRs and RUVs) with the international leading technology.

The RSRs supplied for Changjiang NPP have been in safe operation for over 8 years. In addition, it has delivered RSRs for Zhangzhou Unit 1 & 2 and RUVs for CAP1400 Unit 1. At present, it is manufacturing RSRs for HPR1000 San'ao and Sanmen projects and RUVs for CAP1000 Bailong project.

Shanghai Electric has been promoting the localization of 3rd generation RCPs in all respects. In 2023, RCP for HPR1000 has been 100% homemade, and its mechanical seals, thrust bearings, 10kV motor, as well as hydraulic components have went through the localization verification. While the wet winding motor RCP (RUV) for CAP1400 is about to complete the 100% localization. Most key components and materials have completed localization verification. The prototype of key components such as water-lubricated thrust bearings and wet winding cables have been developed and the life verification of those will be completed in 2024. It is expected to achieve 100% localization by 2025.





HELIUM CIRCULATOR

主氦风机

主氦风机是高温、高压、大功率的立式、单级高速、直驱变频压缩机组。转速4000r/min,功率4500kW,国际上尚无相当容量的机组。采用大载荷磁悬浮轴承技术,利用高效的电机腔冷却技术保证氦气环境下电机、电磁轴承的可靠稳定工作。主氦风机的模块化设计具有灵活性高、减少造价、节省工期等优点,为高温气冷堆主氦风机的推广及量产提供技术支撑。

The main helium circulator is a high temperature, high pressure, heavy power, vertical, single-stage high-speed compressor driven by an adjustable-speed motor. The circulator's rotor speed is 4000 r/min and shaft power is 4500kW, and there is no similar capacity unit in the world. Heavy-load magnetic suspension bearing technology was adopted in the unit, and the efficient motor cavity cooling technology was designed to ensure the reliable operation of the motor and electromagnetic bearing under the helium condition. The utilization of a modular design methodology in the circulator design process yields significant benefits such as enhanced flexibility, reduced costs, and improved time efficiency. This approach provides essential technical support for the widespread deployment and large-scale manufacturing of the HTR main helium circulator.



CONVENTIONAL ISLAND MAIN EQUIPMENT

常规岛主设备





汽轮发电机组

上海电气为阳江、防城港、恰希玛、卡拉奇等核 电站提供了10余套汽轮发电机组,均已投运。

阳江核电1号机组于2014年3月投入商业运行,发电负荷达1104MW,目前已投运10年,各项运行指标优异。防城港核电3号机组于2023年3月正式商运,性能出力达到1208.6MW,比合同保证值高出1.77%。

目前,为漳州、防城港、陆丰、田湾和徐大堡核 电站提供的汽轮发电机组正在加紧制造中。2022年6 月,历时6年研制成功的具有自主知识产权的高性能核 电发电机产品——漳州首台1300MW级核电发电机正式 发运。该产品综合了百万千瓦级核电发电机的设计、 制造和运行经验,开展自主设计。采用系列化、模块 化设计理念,按照科学合理的PDP产品开发流程,确 保产品的高性能和开发工作的高质量。







Shanghai Electric has supplied more than 10 sets of Turbine-generation Unit for Yangjiang ,Fang Chenggang, C1-C4 & K2K3 NPP, which were put into commercial operation successfully. Yangjiang unit 1 has been in commercial operation since Mar. 2014. The output power can reach as high as 1104MW. It has operated for over 10 years, all datas show that the turbine-generator unit Shanghai Electric supplied is more efficient than any other same products. Fangchenggang unit 3 has been in commercial operation since Mar. 2023, which output power reaches 1208.6MW. The proportion has achieved 101.77% of contract guarantee value. At present, Shanghai Electric is manufacturing the turbine-generator units for Zhangzhou NPP, Fang Chenggang NPP & Lufeng NPP of HPR1000 technology, and Tianwan NPP& Xudapu NPP of VVER technology.

In June 2022, the first 1300MW nuclear power generator for Zhangzhou NPP was successfully shipped, which has been developed for 6 years with independent intellectual property rights and high performance. The designing, manufacturing and operating experience of million-kw stage nuclear power generators were integrated into the independent design process. Under serialization and modular design concept, scientific and reasonable PDP product development process was adopted to ensure high performance of products and high quality of development work.

WELDED ROTOR 焊接转子

上海电气拥有50余年焊接转子的研究开发和生产应用史,拥有比较完备健全的焊接转子结构设计、强度分析、焊缝设计、焊接工艺和焊接设备、材料技术、无损检测、转子安全性评价等技术体系。2008年上海电气实现了异种钢转子的焊接;2009年实现了超超临界百万等级火电汽轮机低压转子焊接生产制造;2010年实现了华龙一号核电低压试验转子的焊接制造。至今上海电气累计焊接各类转子495根,其中480根已经投入商业运行。目前已完成了巴基斯坦卡拉奇、防城港二期、漳州、田湾、徐大堡等项目的20余根低压转子的制造工作,具备批量化能力。

Shanghai Electric has over fifty years' history in the field of researching and producing of welded rotors, and Shanghai Electric also has a rounded system for welded rotors' structural design and strength analysis, welded joint design, welding technology, welding equipment, welding material technology, nondestructive examination, rotor safety evaluation and so on. In 2008, Shanghai Electric developed dissimilar steel welded rotor. In 2009, welded rotors were manufactured for 1000MW ultra-supercritical thermal turbine. In 2010, a welded rotor was manufactured and test for HPR1000 NNP turbine. So far, there have been 495 rotors of different kinds manufactured, among which 480 rotors have been put into commercial running. More than 20 welded rotors for Karachi, Fangchenggang II, Zhangzhou, Tianwan &Xudapu NPP have been completed until now.











LOW PRESSURE LONG BLADE 低压长叶片

上海电气建立了排汽面积按一定比例间隔配置的低压长叶片模块系列,开发了排汽面积为20m2的1420mm高度末叶片、排汽面积为26m2的1710mm高度末叶片以及排汽面积为30m2的1905mm高度末叶片。可满足现有百万级以上压水堆、各种背压机组的配置要求。1710mm末叶片已应用于华龙一号汽轮发电机组。1905mm末叶片是目前世界上开发成功的最长末级叶片。

Shanghai Electric establishes low pressure long blade series whose exhaust areas conform to cetain proportion interval configuration and developed 1420mm blade with exhaust area 20 square meters, the 1710 mm blade with exhaust area of 26 square meters and the 1905 mm blade with exhaust area of 30 square meters, which can meet existing over 1000MW class pressure water reactor, and configuration requirements of various kinds of back pressure units. By now, 1710mm blades have been applied to HPR1000 turbines. And 1905mm blades have been developed and tested, which is the longest low-pressure last stage blade with the largest exhaust area in the world.

OTHER KEY EQUIPMENT 其他关键设备

CLASS II & III PUMPS AND PUMPS FOR CONVENTIONAL ISLAND

核二三级泵及常规岛泵

上海电气自2011年以来,已生产交付了超过260台套的核二三级泵,包括为AP1000三门和海阳依托项目提供的余热排出泵;为华龙一号福清5、6号机组提供的上充泵、余热排出泵、安注安喷泵;为华龙一号防城港3、4号机组提供的立式上充泵等;为华龙一号批量化建设首堆漳州核电1、2号机组提供的余热排出泵、安注安喷泵;为英国欣克利角C核电项目提供立式上充泵等。

同时,上海电气也具备核电常规岛用泵及核级阀门的供货能力,已交付国和一号主给水泵,AP1000海阳1、2号机组凝结水泵,华龙一号防城港3、4号机组凝结水泵等。

Shanghai Electric has manufactured and delivered more than 260 sets of pumps of Nuclear Class II and III since 2011, including residual heat removal pumps for AP1000 Sanmen and Haiyang projects and charging pumps, residual heat removal pumps, safety injection pumps/containment spray pumps for HPR1000 Fuqing Unit 5&6, vertical charging pump for HPR1000 Fangchenggang Unit 3&4, residual heat removal pumps, safety injection pumps/containment spray pumps for HPR1000 Zhangzhou Unit 1&2, and vertical charging pumps for British Hinkley Point C etc..

Meanwhile, it is capable of supplying pumps for conventional islands and nuclear valves. At present, Shanghai Electric had delivered main feed water pumps for CAP1400 project, condensate pump for AP1000 Haiyang Unit 1&2, condensate pump for HPR1000 Fangchenggang Unit 3&4, etc.











FUEL HANDLING MACHINE

燃料输送设备

自秦山核电站开始为国内外多个核电站提供了各类核电专用起重运输机械设备,包括百万千瓦级核电站燃料输送设备,含核燃料装卸料机、转运装置、乏燃料池吊车(人桥吊)、乏燃料容器吊、辅助吊等。2017年至今,已实现华龙一号人桥吊、辅助吊和国和一号燃料输送设备的完工交付。

Shanghai Electric has provided varieties of special nuclear-rated crane equipment for domestic and foreign NPPs since Qinshan NPP, such as 1000MW NPP fuel handling system, including fuel handling machines, transfer devices, spent fuel pit cranes, cask crane and auxiliary cranes, etc. Since 2017, Shanghai Electric has delivered spent fuel pit cranes & auxiliary cranes for HPR1000 and fuel handling machines for CAP1400.

CLASS II & III VESSEL AND HEAT EXCHANGER

核二三级容器及热交换器

能够设计核安全二级设备(压力容器和热交换器),并能够制造核安全一、二、三级设备(压力容器、热交换器、闸门等),包括安注箱、卸压箱、柴油机主贮油罐、余热排出热交换器、安全喷淋热交换器和设备闸门等,其产品几乎覆盖了国内所有的核电站。

Shanghai Electric has the capability to design nuclear safety class II pressure vessels and heat exchangers, and manufacture nuclear safety class I, II & III vessels, heat exchangers and gates, including accumulator tank, pressurizer relief tank, diesel master oil tank, residual heat removal heat exchanger, safe spray heat exchanger and equipment hatch, etc. Our performance almost cover all the domestic NPPs.





DIAPHRAGM COMPRESSOR

隔膜压缩机

正在执行四代核电技术高温气冷堆用隔膜压缩机的设计开发任务,共涉及5种机型,22台套设备。后续,将开发配套压水堆用TEG系统和N2隔膜压缩机。

At present, the design and development task of supporting the fourth generation technology HTR600 is implemented, involving a total of 5 types and 22 sets of equipment. Subsequently, TEG system and N2 diaphragm compressor for pressurized water reactor will be developed.

MOTOR 电机

为压水堆核反应堆主冷却水泵、应急柴油机组 及高温气冷堆氦气风机提供电机配套,可以提供各 类核级、非核级大中型电机,业绩几乎覆盖了国内 所有的核电站。

Shanghai electric supplies reactor cooling pump motor & emergency diesel generator for PWR and primary helium circulator for HTR, and has the capability to design and manufacture 1E Calss and NC Class motor. Our performance almost cover all the domestic NPPs.





AUXILIARY EQUIPMENT

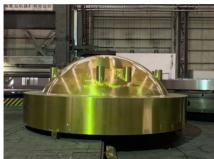
辅机

拥有丰富的核电站常规岛辅助设备供货业绩,能够设计和制造常规岛高压加热器、低压加热器、 凝汽器、除氧器及MSR汽水分离再热器,为岭澳、 阳江、防城港、红沿河、福清、漳州、海阳、田 湾、徐大堡、陆丰等项目提供了大量的辅机产品。

Shanghai electric has rich supply performance of auxiliary equipment and has the capability to design and manufacture high-pressure heater, low-pressure heater, condenser, deaerator and moisture separator reheater in conventional island, and provides a large number of auxiliary equipment for LingAo, Yangjiang, Fangchenggang, Hongyanhe, Fuqing, Zhangzhou, Haiyang, Tianwan, Xudapu and Lufeng project etc.

LARGE NUCLEAR FORGINGS 核电大锻件





上海电气已具备国内最齐全的核岛主设备用锻件配套能力。

已实现了反应堆压力容器、蒸汽发生器、稳压器、主泵、堆芯补水箱、主管道、堆内构件、控制棒驱动机构等锻件的全覆盖。材料包括碳钢、低合金钢、中合金钢、马氏体不锈钢、奥氏体不锈钢和高温合金等。

自2016年至今,先后投制了9个机组压力容器、15个机组蒸汽发生器、5个机组稳压器、6个机组主泵、2个机组主管道、29套堆内构件和3套控制棒驱动机构的配套大锻件,涉及堆型包括华龙一号、国和一号、CAP1000、高温气冷堆及其他专项国家重大项目等。

Shanghai Electric has the most complete supporting capability for nuclear island main equipment heavy forgings in China, achieving full coverage of nuclear reactor pressure vessels, steam generators, pressurizers, reactor coolant pumps, core make-up tanks, main pipes, reactor internals, control rod drive mechanisms, etc. Materials include carbon steel, low alloy steel, medium alloy steel, martensitic stainless steel, austenitic stainless steel, and high-temperature alloys.

Since 2016, following large forgings have been manufactured and delivered: 9 units pressure vessel forgings, 15 units SG forgings, 5 units PRZ forgings, 6 units RCP forgings, 2 units main pipes, 29 sets RVI forgings and 3 sets CRDM forgings, for main types of reactor involved HPR1000, CAP1400, CAP1000, HTR and other national important projects.







1

聚变堆超低温超洁净不锈钢材料 Ultra-low temperature and ultraclean stainless-steel materials for fusion reactors

2

乏燃料储运装置3.5Ni材料 3.5Ni material for spent fuel storage and transportation equipment

上海电气持续对核电大型锻件生产关键工序进行技术创新,开发了用于聚变堆、微堆等先进堆型主设备及乏燃料储运装置的关键材料。

As well as, Shanghai Electric has continued to carry out technological innovation in the key processes of large-scale forging production, and developed key materials for advanced reactor such as fusion reactors, micro reactors, and spent fuel storage and transportation equipment.





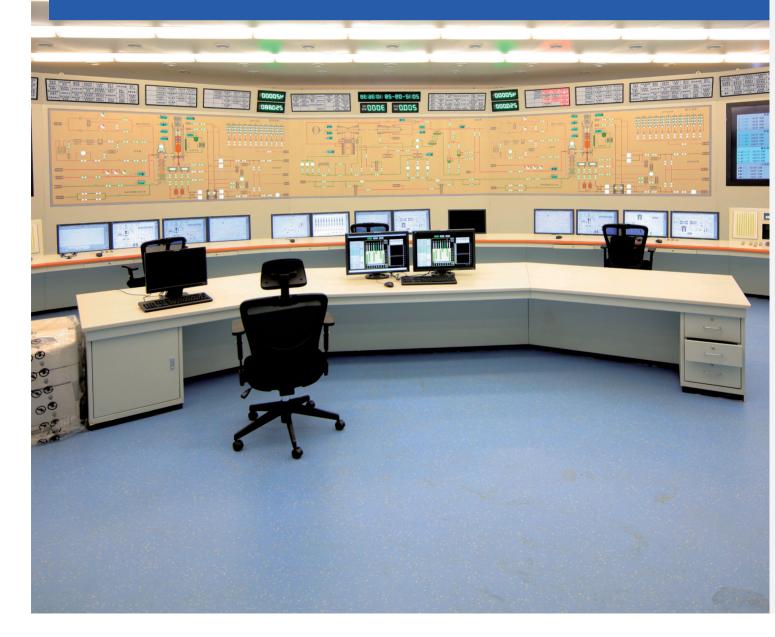




NUCLEAR CLASS I&C 核电仪控仪表

上海电气在核级仪控仪表领域的应用业绩和市场占有率长期处于行业领先,为国内及国外巴基斯坦的民用核电站、试验堆提供了各类核电产品,包括核电仪表如压力变送器、关键调节阀及辅助仪表等设备和各类核电系统装置如一体化专用装置等。

Shanghai Electric takes the leading position in market share and product performance of nuclear class control and instrumentation industry. Shanghai Electric has provided various nuclear power products for all commercial NPP and test reactors built by China, both domestically and internationally, including nuclear power instruments such as pressure transmitters, key control valves, and auxiliary instruments, as well as various nuclear power system devices such as Integrated Special Purpose Device.



NUCLEAR VALVE AND INTEGRATED SPECIAL PURPOSE DEVICE

核级阀门和一体化专用装置

核级阀门

主要产品有核 1、2、3 级气动、电动调节阀、阀门定位器、电-气转换器、阀位变送器、限位开关及电磁阀等,产品广泛应用在国内各个核电站以及出口巴基斯坦等核电项目。

Nuclear valve

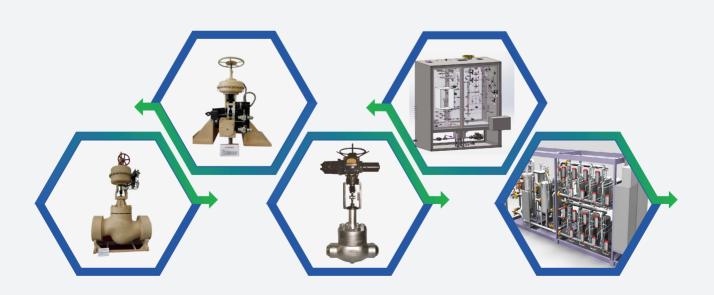
The main products are nuclear level 1, 2 and 3 pneumatic and electric control valves, valve positioners, electric-pneumatic converters, valve position transmitters, limit switches and solenoid valves, etc. The products are widely used in various domestic nuclear power plants and nuclear power projects exported to Pakistan.

一体化专用装置

主要有除盐水贮箱(DWST)脱气装置与凝结水贮箱(CST)脱气装置(MS08)、一回路取样系统手动取样装置(MS20)、电离除盐装置(MS22)、WGS取样装置(MS27)等。用于国和一号以及AP1000项目。

Integrated special purpose device

DWST and CST (MS08), manual sampling device of primary sampling system (MS20), ionization desalination device (MS22), WGS sampling device (MS27), etc. are mainly used in CAP1400 projects and AP1000 projects.



OTHER PRODUCTS AND SERVICE 其他产品与服务

ELEVATOR 电梯

上海电气旗下的上海三菱电梯有限公司是中日合资大型电梯企业,在中国电梯行业中名列前茅,连续第11年蝉联中国房地产500强首选供应商(电梯类)评选的电梯首选率第一名,年产量达到10万台。

近年来,上海电气承担了福清、昌江、霞浦、漳州、田湾、大亚湾等多个核电项目厂用电梯的供货任务。

Shanghai Mitsubishi Elevator Co., Ltd., a subsidiary of Shanghai Electric, is a large Sino Japanese joint venture elevator enterprise that ranks among the top in the Chinese elevator industry. For the 11th consecutive year, it has been ranked first in the elevator preference rate of China's top 500 real estate suppliers (elevator category), with an annual output of 100000 units. In recent years, Shanghai Electric has supplied elevators for Fuqing, Changjiang, Xiapu, Zhangzhou, Tianwan, and Daya Bay Projects.



CABLES

电缆

上海电气可提供各类电缆,包括高低压电缆、PP绝缘电缆、直流电缆、电缆附件。 Shanghai Electric has the capability of supply HV/LV Cables, PP Insu-lated Cables, DC Cables, Cable Accessories.



35kV 交联聚乙烯电力电缆 35kV XLPE Cable



10kV 架空线 10kV Overhead Line



10kV 柔性电力电缆 10kV Flexible Cable



35kV 海底电缆 35kV Submarine Cable

SWITCH COMPONENTS 开关元器件

作为开关元器件领域的先导者,已积淀了百年以上开关元器件制造 经验,新型智能产品具有完善的在线状态监测、诊断功能、可靠的智能 保护管理系统,快速精确的智能决策系统,坚强的自诊,自愈,自恢复 系统、通讯数据记录功能,可用于智能控制系统。实现遥控、遥测、各 类保护功能和系统能量、运行、寿命管理。

As a leader in the switch components market, Shanghai Electric has over a hundred years of history in switchcomponent manufacturing. The new smart products have perfect on-line condition monitoring and diagnosis functions, reliable intelligent protection management system, fast and precise intelligent decision-making system, strong selfdiagnosis, self-healing, self-recovery system and communication datarecording function, which can be used in intelligent control systems. And the products have realized remote control, remote metering, various protective functions and system energy, operation and lifemanagement.





TECHNICAL SURVICE

技术服务

在不同场景下提供相应工具及台架的设计、制造、改造及相关定制服务,设计并制造维修过程中所需检修平台及辅助装置,同时可向业主提供定制化的解决方案。

Provide design, manufacturing, modification, and related customization services for tools and platforms in different scenarios, design and manufacture maintenance platforms and auxiliary devices required during the maintenance process, and provide customized solutions to costomers.







可集成供货设备备件,满足电厂常规备件、应急备件、事故备件和大修备件等需求。

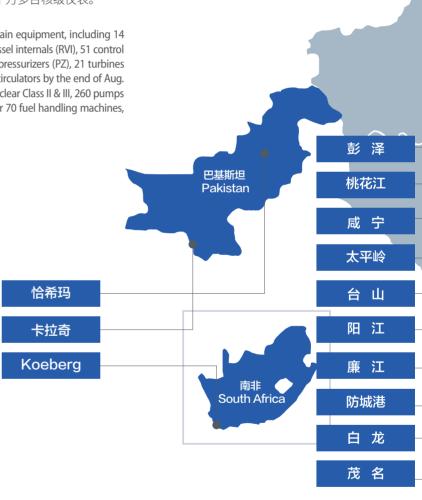
Integrate and supply spare parts to meet the needs of power plant conventional spare parts, emergency spare parts, accident spare parts, and repair spare parts.



THE MOST MANUFACTURING DELIVERIES 交付业绩最多

截止2024年8月,上海电气已累计交付270台套核电主设备,包括14台反应堆压力容器、72台蒸汽发生器、58套堆内构件、51套控制棒驱动机构、11台稳压器、17台主泵、21台汽轮机及22台发电机、2套吸收球停堆装置、2台主氦风机。此外,上海电气还提供了2400多台核二三级容器、260多台核二三级泵、近150台常规岛辅机、70多台燃料输送设备、400多台配套电机及十万多台核级仪表。

Shanghai Electric has already delivered 270 sets of nuclear power main equipment, including 14 reactor pressure vessels (RV), 72 steam generators (SG), 58 reactor vessel internals (RVI), 51 control rod drive mechanisms (CRDM), 17 reactor coolant pumps (RCP), 11 pressurizers (PZ), 21 turbines and 22 generators, 2 sets of absorption sphere device and 2 helium circulators by the end of Aug. 2024. Besides, Shanghai Electric has supplied over 2400 vessels of Nuclear Class II & III, 260 pumps of Nuclear Class II & III, nearly 150 sets of CI auxiliary equipment, over 70 fuel handling machines, 400 motors and more than 100,000 nuclear instruments.



14 压力容器 Reactor Pressure Vess 72 蒸汽发生器

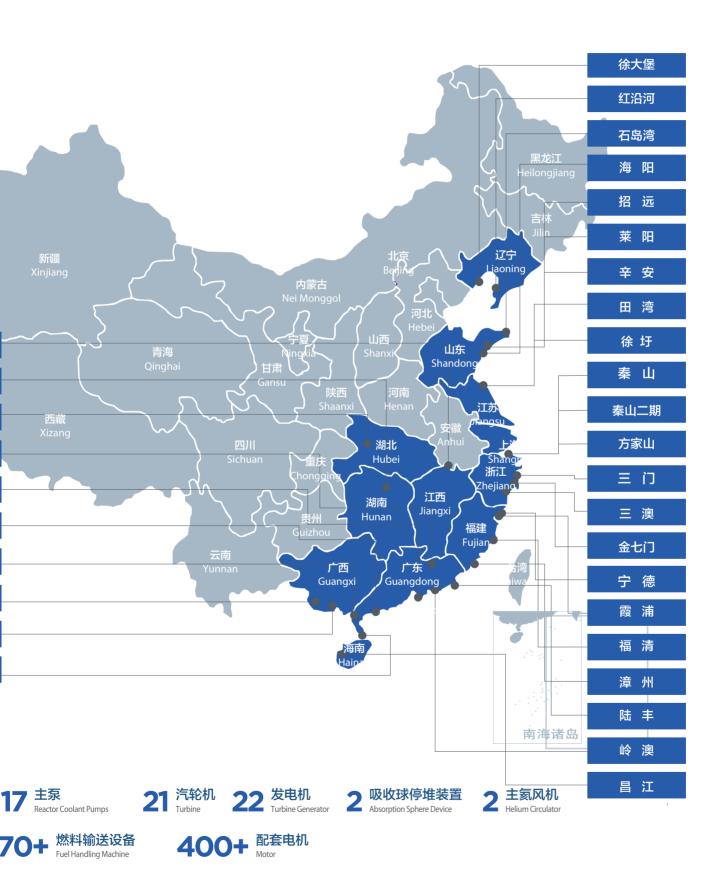
58 堆内构件 Reactor Vessel Internal 51 控制棒驱动机构

11 稳压器

2400+ 核二三级容器 Class II & III Vessels

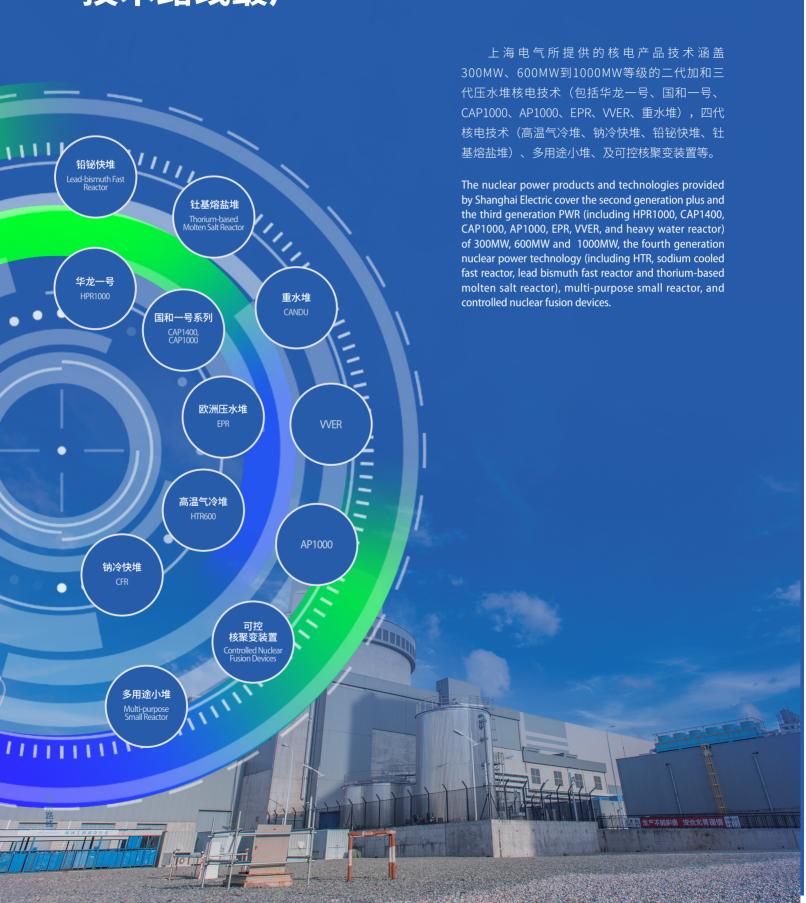
260+ 核二三级泵 CLASS II & III Pumps

150 常规岛辅机 Auxiliary Equipment



25

THE MOST WIDELY APPLIED MANUFACTURING TECHNOLOGY 技术路线最广



上海电气将坚持创新驱动发展,不断完善科技创新体系,着力深化对外合作,进一步补齐核电装备制造技术短板,提升核电装备的核心竞争力。

Shanghai Electric adheres to an innovation-driven development approach, continuously enhance the scientific and technological innovation system, prioritize deepening external collaborations, and further focuses on nuclear power equipment manufacturing technology to strengthen the core competitiveness of nuclear power equipment.



同时,上海电气开展多层次、多场景的智能制造实践,创建"数字孪生+""人工智能+""大数据+"等智能场景,建设智能车间、智能工厂,打造数据互联互通、信息可信交互、生产深度协同、资源柔性配置的智慧供应链。

Meanwhile, Shanghai Electric implements intelligent manufacturing practices at multiple levels and scenarios, creating intelligent scenarios such as "digital twin +", "artificial intelligence +" and "big data +". It establishes smart workshops and factories while building a smart supply chain with interconnected data, reliable information interaction, deep production collaboration, and flexible resource allocation.

TECHNOLOGY EXTENSION 技术延伸

TECHNOLOGY INNOVATION PLATFORM

科技创新平台

全力打造建设核能及高端装备科技创新平台,通过多年努力, 目前拥有:

We are fully committed to building a technology innovation platform for nuclear energy and high-end equipment. After years of hard work, we currently have.

- 2家国家级技术中心
- 2 National Level Technology Centers
- 2家国家专精特新小巨人企业
- 2 National Specialized, Refined, Unique, and New Small Giant Enterprise
- 1家国家知识产权优势企业
- 1 National Intellectual Property Advantage Enterprise
- 4家上海市企业技术中心
- 4 Shanghai Enterprise Technology Centers
- 5家上海市专精特新企业
- 5 Shanghai Specialized, Refined, Unique, and New Enterprise
- 2家院士工作站
- 2 Academician Workstations
- 1家博士后科研工作站
- 1 Post-Doctoral Research Center
- 3家CNAS认可实验室
- 3 CNAS Accredited Laboratories
- 4家上海市临港智能工厂
- 4 Shanghai Lingang Intelligent Factories

COLLABORATIVE RESEARCH AND DEVELOPMENT MECHANISM

协同攻关机制

通过多层次交流合作建立互信,推动产品联合研发、协同攻关 工作机制,主要包括:

Establishing mutual trust through multi-level communication and cooperation, promoting joint product research and development, and collaborative problem-solving mechanisms, mainly including:

产学研合作模式

Industry University Research Cooperation Mode

研供一体模式

Integrated Research and Supply Mode

研发试验设施开放共享模式

Open Sharing Mode of R&D Experimental Facilities

平台共建模式

Platform Co-Construction Mode

CORE TECHNICAL CAPABILITIES

聚焦五大核心技术能力, 不断提升竞争力:

全力打造建设核能及高端装备科技创新平台,通过多年努力,目前拥有:

Focus on the five core technological capabilities and continuously enhance competitiveness.

专业设计与集成

Professional Design and Integration

超纯净材料开发

Ultra Pure Material Development

精密与极限制造

Precision and Extreme Manufacturing

专业化试验测试 Specialized Testing

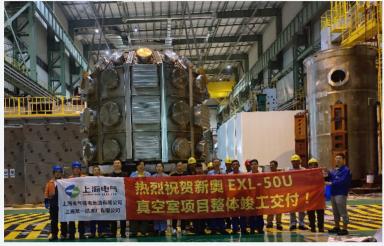
数字化与智能化

Digitization and Intelligence



CONTROLLED NUCLEAR FUSION DEVICE

可控核聚变装置



EXL-50U 真空室 Vacuum Vessel for EXL-50U Device



HH-70 杜瓦 Dewar for HH-70 Device



80mm厚度双边激光打底焊 Double Sides Laser Backing Welding with 80mm Thickness

上海电气在核聚变装备制造领域已有二十多年历程,是国内核聚变主机系统核心设备供货业绩最全面的装备制造企业之一。

上海电气研制并供货聚变主机系统核心设备真空室、杜瓦、冷屏、线圈盒、测试杜瓦等相关装备,参与了国内首个燃烧等离子体聚变能装置BEST;世界上最大的磁约束托克马克聚变实验反应堆装置国际ITER项目;全球首个全超导非圆截面托卡马克实验装置EAST"东方超环";国家可控核聚变重大科技基础设施CRAFT项目;全球目前唯一建成运行全高温超导托卡马克HH70装置;紧凑球形环氢硼聚变物理实验装置EXL-50U。

上海电气依托上述项目经验积累,在特种材料、精密焊接、精密装配、极限尺寸加工四方面形成核心制造能力,开发了聚变用超低温性能等级316LN、316LN-Mn、N50大锻件,超大壁厚锻件焊接的激光打底焊接系统,实时视觉传感的自动氩弧焊焊接系统,N50焊接工艺等,相关技术指标已达到国际先进水平。

Shanghai Electric has more than 20 years of experience in the field of nuclear fusion equipment manufacturing, and is one of the manufacturers with the most comprehensive supply performance of core equipment for nuclear fusion host systems in China. Shanghai Electric has developed and supplied core equipment for fusion host systems, including vacuum vessel, Dewar, thermal shield, coil boxes, Cryostat, etc, participated in following devices: the first domestic plasma burning experimental device, BEST; the world's largest magnetic confinement tokamak fusion experimental reactor device, ITER; The world's first fully superconducting non-circular cross-section tokamak experimental device, EAST, known as the "Oriental Super Ring"; CRAFT, a major scientific and technological infrastructure for controllable nuclear fusion in China; the world's only fully high-temperature superconducting tokamak HH70 device currently in operation; the compact spherical experimental hydrogen boron fusion device, EXL-50U Shanghai Electric has developed core manufacturing capabilities in special materials, precision welding, precision assembly, and extreme size processing based on the experience accumulated in the above-mentioned projects. It has developed fusion devices used ultra-low temperature large forgings material with 316LN, 316LN-Mn and N50, laser backing welding systems for and ultra-thick forgings, real-time visual sensing automatic argon arc welding systems, N50 material welding processes, etc. The relevant technical parameters have reached the international advanced level.

THORIUM MOLTEN SALT REACTOR

针基熔盐堆

钍基熔盐堆核能系统是第四代先进核能系统6种堆型之 一。熔盐堆输出的700℃以上高温核热可用干发电,也可用 于工业热应用、高温制氢以及氢吸收二氧化碳制甲醇等, 可以有力缓解碳排放和环境污染问题。

2018年,完成了钍基熔盐仿真堆(TMSR-SF0)设备的制造。 2019-2021年,完成了2MWt钍基熔盐实验堆反应堆 (TMSR-LF1)设备的主设备研制和配套系统供货。

2023年,与中科院上海高等研究院联合研发的国内首 套"卧式10MWt氦气轮机"完成总装并发运。

Thorium molten salt reactor is one of the six candidates for the fourth generation of advanced nuclear energy system. The high temperature nuclear heat above 700 output from molten salt reactors can be used for power generation, industrial thermal applications, high temperature hydrogen production, hydrogen absorption carbon dioxide production of methanol, etc., which can effectively alleviate carbon emissions and environmental pollution.

Shanghai Electric constructed simulation reactor equipment(TMSR-SF0) in 2018.

Shanghai Electric has completed the main equipment development and supporting system supply of 2MWt experimental reactor equipment (TMSR-LF1) from 2019 to 2021.

The first set of horizontal 10MWt helium turbine in China developed by Shanghai Electric was completed in 2023 through collaboration with Shanghai Advanced Research Institute, Chinese Academy of Sciences.

LEAD BASED FAST REACTOR

铅基快堆







CiADS主容器原理样机 The principle prototype of Main Vessel

CiADS堆内构件原理样机 The principle prototype of Internals

铅基快堆核能系统是第四代先进核能系统6种堆型之 一。它是采用铅或铅铋合金作为冷却剂的快中子反应堆, 可用于舰艇动力、海洋电站、移动电源、嬗变乏废料、核 燃料增殖等。上海电气布局多条技术路线铅基快堆关键设 备研发。

2020-2023年,上海电气成功完成了国家重大科技基 础设施中国加速器驱动嬗变研究装置(CiADS)关键主设备原 理样机和散裂靶集成测试样机研制。

散裂靶LBE换热器集成测试样机,已经完成项目交付 和现场安装调试工作。

反应堆主设备原理样机,包括主容器、主换热器、堆 内构件、铅铋泵、熔料罐、储料罐等,已完成制造。

The lead based fast reactor nuclear energy system is one of the six candidates for the fourth generation of advanced nuclear energy system. It is a fast neutron reactor that uses lead or lead bismuth alloy as a coolant, which can be used for naval power, marine power plants, portable power source, transmutation of nuclear waste, nuclear fuel proliferation, etc. Shanghai Electric has laid out multiple technical routes for the research and development of key equipments for lead based fast reactors.

From 2020 to 2023, Shanghai Electric successfully completed the development of key main equipment prototypes and spallation target integrated testing prototype for the China Accelerator Driven Transmutation Research Device (CiADS), a national major scientific and technological infrastructure.

Integrated Test Prototype of LBE Heat Exchanger for Spallation Target. Project delivery and on-site installation and commissioning have been completed.

The principle prototype of reactor main equipments, including Main Vessel, Main Heat Exchanger, Main Vessel Internals, Lead-Bismuth Pump, Lead-Melting Tank and Lead-Storage Tank, have been manufactured.

SPENT FUEL & NUCLEAR WASTE TREATMENT EQUIPMENT

核三废及后处理装备

与国内设计院、业主单位开展广泛合作,进行乏燃料、 核三废处理装备及系统研制,积累了乏燃料以及放射性废物 的取样、收集、贮存、转运、处理等相关装备的制造技术、 系统集成技术。

2020年起,上海电气与国家电投上海核工程研究设计院有限公司联合开展高燃耗乏燃料干式贮存系统关键设备样机研制,完成了SA-350 Gr.LF3 Cl.2锻件研制、燃料格架研制以及密封容器、转运容器、贮存容器研制,掌握了高燃耗乏燃料干式贮存设备材料及关键制造技术。

Shanghai Electric has carried out extensive cooperation with domestic design institutes and owner units to develop spent fuel and nuclear waste treatment equipment and systems, and has accumulated manufacturing technology and system integration technology of spent fuel and radioactive waste sampling, collection, storage, transfer, treatment equipment.

Since 2020, Shanghai Electric and SNERDI have jointly developed key equipment prototypes for high burnup spent fuel dry storage systems. They have completed the development of SA-350 Gr.LF3 Cl.2 forgings, fuel grids, sealed containers, transfer containers, and storage containers, and have mastered the materials and key manufacturing technologies for high burnup spent fuel dry storage equipment.



贮存容器 Storage container



燃料格架 Fuel grid



转运容器 Transfer container



密封容器 Sealed container



THE MAXIMUM EQUIPMENT CAPACITY 装备能力最强

上海电气已投资72亿元建成临港基地及改造完成闵行基地,拥有机加工、焊接、冶炼、锻造、热处理、成型、起重、检测和试验等各类设备2500余台套,其中世界级的高端设备40多台,能够满足核电规模化发展需要。

通过临港和闵行两大基地的建设,已具备年产10台/套百万千瓦级堆内构件和控制棒驱动机构、6套核岛重型容器(压力容器、蒸汽发生器、稳压器等)、12台核主泵、6套汽轮发电机组的制造能力,并已形成最大钢锭600吨、最大铸件450吨、最大锻件350吨的核电配套大型锻件的配套加工能力。

Shanghai Electric has built Lingang Base and modified Minhang Base with an investment of 7.2 billion yuan, having more than 2,500 sets of machining, welding, smelting, forging, heat treatment, forming, lifting, detection and testing equipment, including more than 40 sets of world-class advanced equipment to meet the large-scale development of nuclear power industry.

Thanks to the construction of Lingang Base and Minhang Base, it has formed the annual manufacturing capability of 10 sets of 1000MW reactor vessel internals and control rod drive mechanisms, 6 sets of heavy NI vessels (reactor pressure vessel, steam generator and pressurizer, etc), 12 sets of RCPs and 6 sets of turbine-generator units, and it has large nuclear power large forging manufacturing capacity to supply the largest steel ingot of 600 tons, the largest casting of 450 tons and the largest forging of 350 tons.













THE BROADEST INTERNATIONAL COOPERATION

全球合作最深





COMPANY LIST 涉核企业

Shanghai Electric Nuclear Power

上海电气核电集团有限公司

上海第一机床厂有限公司 Shanghai No.1 Machine Tool Works Co., Ltd.

上海电气核电设备有限公司

Shanghai Electric Nuclear Power Equipment Co., Ltd.

上海电气凯士比核电泵阀有限公司 Shanghai Electric-KSB Nuclear Pump & Valve Co., Ltd.

上海电气上重铸锻有限公司 Shanghai Electric SHMP Casting & Forging Co., Ltd.

上海核电技术装备有限公司

Shanghai Nuclear Power Technology & Equipment Co., Ltd.

上海电气电站设备有限公司汽轮机厂

Shanghai Electric Power Generation Equipment Co., Ltd., Shanghai Turbine Works

上海电气电站设备有限公司发电机厂

Shanghai Electric Power Generation Equipment Co., Ltd., Shanghai Generator Works

上海电气电站设备有限公司电站辅机厂

Shanghai Electric Power Generation Equipment Co., Ltd., Power Station Auxiliary **Equipment Works**

上海电气集团上海电机厂有限公司

SEC Shanghai Electric Machinery Co. Ltd.

上海电气电站服务公司

Shanghai Electric Power Generation Service Co., Ltd.

上海电气鼓风机厂有限公司 Shanghai Electric Blower Works., Ltd.

上海电气集团 SHANGHAI ELECTRIC **GROUP**

> 上海电气电站集团 Shanghai Electric Power Generation Group

上海自动化仪表有限公司

Shanghai Automation Instrumentation Co., ltd.

上海电气输配电集团

Shanghai Electric Power Transmission Distribution Group

上海三菱电梯有限公司 Shanghai Mitsubishi Elevator Co., Ltd

堆内构件、控制棒驱动机构、燃料输送设备等 Reactor Vessel Internals, Control Rod and Driver Mechanism, Fuel Handling Devices 压力容器、蒸汽发生器、稳压器、堆芯补水箱等 Reactor Vessel, Steam Generator, Pressurizer, Core Makeup Tank etc. 核主泵、核二三级泵阀 Reactor Coolant Pump, Class II & III Pump & Valve 核电大型铸锻件、主管道等 Nuclear Casting & Forging, Main Pipe 非标设备集成及系统集成、备品备件及专用工具、核电技术服务 Non-nuclear Equipment/System Integration Service, Spare Part, Special Tools & Service 汽轮机、BOP设备、隔膜压缩机 Turbine, BOP Engineering, Diaphragm Compressor 发电机 Generator 核二三级容器及热交换器、常规岛辅机 Class II & III Vessel & Heat Exchanger, Auxiliary Equipment 核电用配套电机 Motor 现场服务及备品备件 Site Service & Spare Part 核电用风机 Nuclear Fan 核电仪表、关键调节阀、辅助仪表、各类核电系统装置 Nuclear instruments, key control valves, auxiliary instruments, various nuclear system devices 变压器、开关柜、电缆 Transformer, switch cabinet, cable 电梯及其备件 Elevator and its spare parts