Update on Framatome

Jan Langenberger

Baden, February 28, 2023

CONTENT

5 min. Safety

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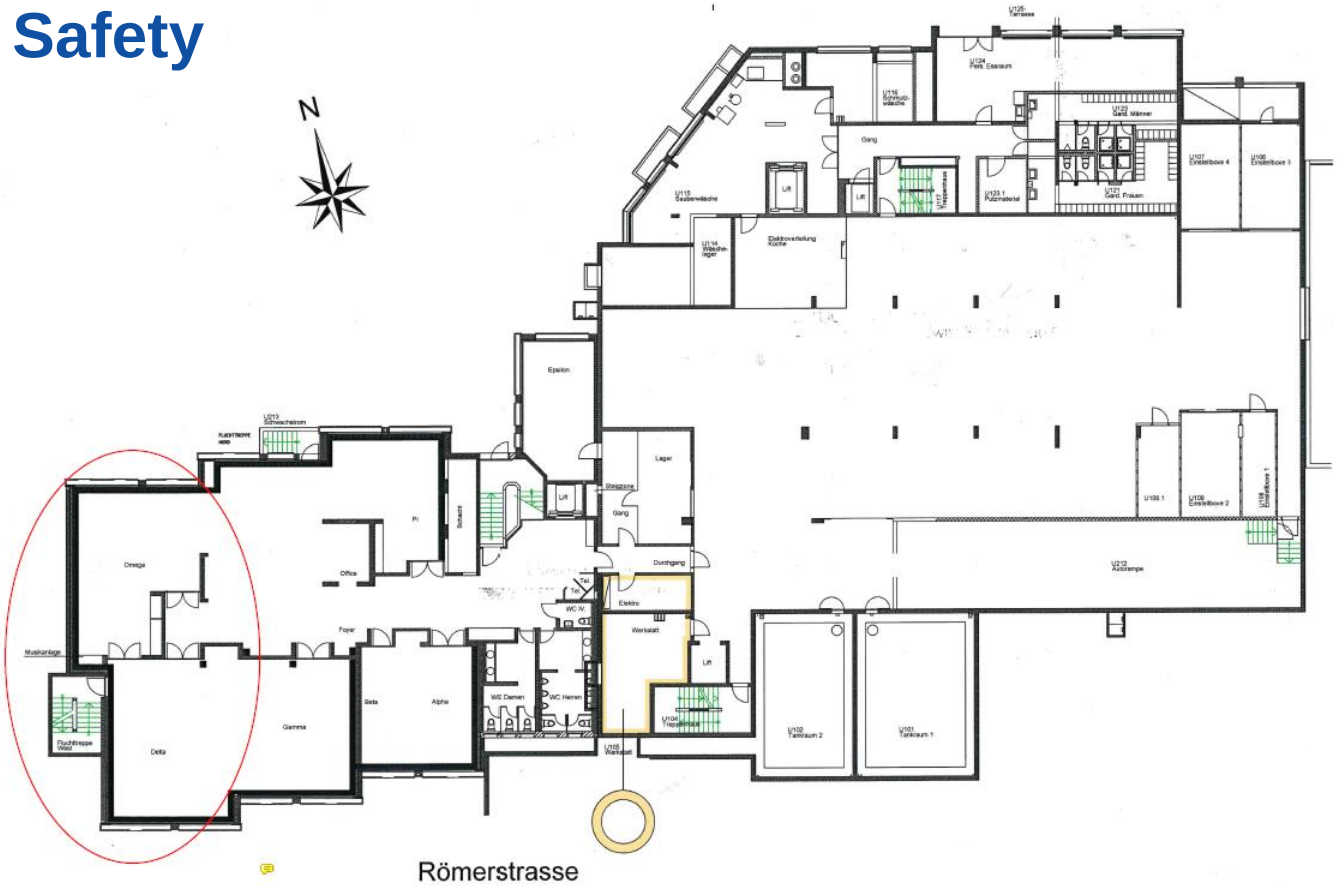


2. Update on Framatome

AGENDA

The Fuel Business Unit

Fuel design & service activities

Zirconium components manufacturing

Fuel manufacturing

Conclusion

Fuel main facts & figures

13 sites (France, Germany, U.S.) and one **integrated worldwide fuel supply chain**, from Zirconium to fuel assembly

>40 years of experience

2nd worldwide actor for PWR and BWR reactors with 32 % market share

3840 employees in France, Germany, U.S.

~60 Major customers worldwide

3 dedicated research centers at the service of innovation and R&D in Erlangen (Germany), in Ugine and in CERCA (France)

~30 million out of 45 million nuclear medical examinations in the world are performed using irradiation targets for medical use produced by CERCA

Our organization

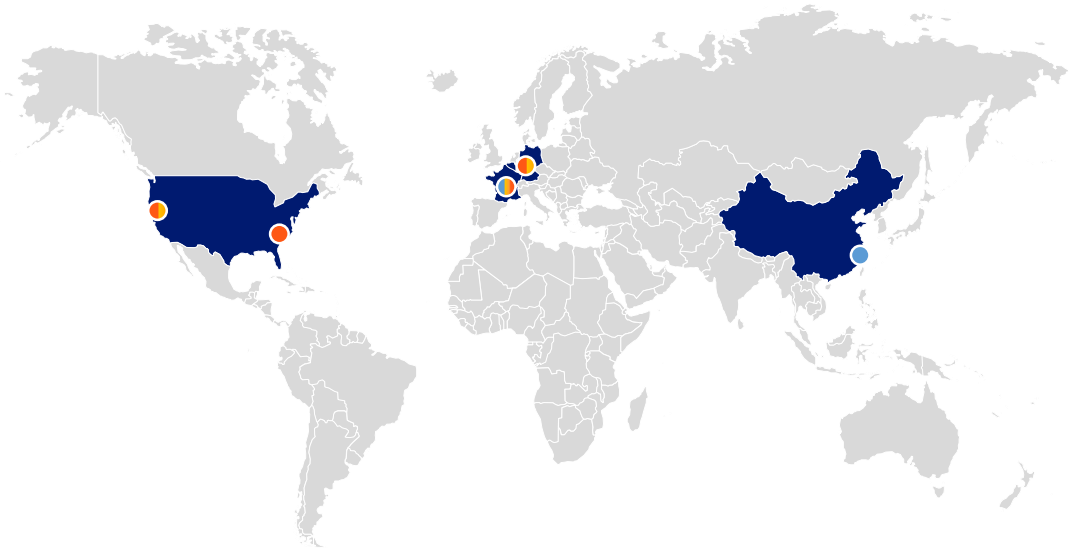
Fuel Business Unit

Lionel GAIFFE

Products, Technologies	Fuel Design	Sales Customers & Services	CERCA	Supply Chain	DO Components	DO Fuel
						
Alain FRICHET	Mario LEBERIG	Ala ALZABEN	François GAUCHÉ	François GAUCHÉ	Carole LECOUEDIC	Caroline JOURDAIN

Our worldwide integrated platform close to markets and to serve our customers

SOLUTIONS PORTFOLIO



Components manufacturing in France and in Asia

- Jarrie, Ugine, Rugles, Montreuil-Juigné, Paimbœuf – France
- 1 subsidiary: Tubes Nucléaires Montbard SAS - France
- Joint-Venture: CAST - China

Fuel manufacturing in Europe and USA

- Romans - France
- Lingen, Karlstein – Germany
- Richland (WA) - USA

Fuel Design, Contracts & services and Support functions in Europe and USA

- Lynchburg (Virginia), Richland (WA) - USA
- Lyon - France
- Erlangen - Germany

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Our overall activities

Mastering the entire process from design to fuels manufacturing for PWRs and BWRs light water reactors as well as for research reactors

Fuel assembly design

- Design expertise and calculation codes for neutronics, thermal hydraulics, thermo-mechanics and mechanics

Production of zirconium and its alloys

- Chemistry and metallurgy technologies
- Technology transfer, licensing

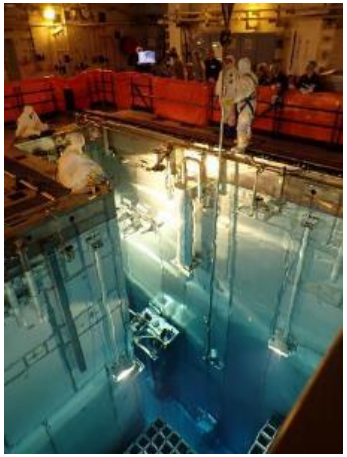
Fuel assembly fabrication

- Chemistry, powder metallurgy, various assembly techniques: advanced welding, mechanical, machining, NDE, physical and chemical analysis, scrap recovery

Services associated with fuel

- Engineering, development & fabrication of material, on-site interventions (reactor)



AGENDA

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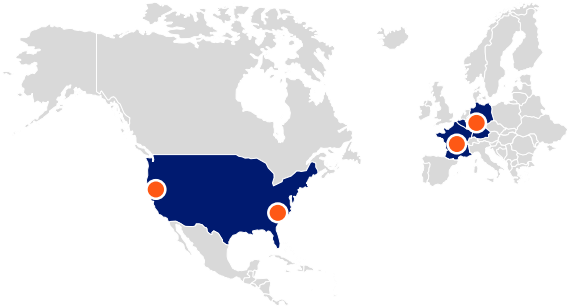
Fuel design & engineering services for Light Water Reactors



ACTIVITIES

- **Design safe, reliable and performant fuel & rod cluster control assemblies**
- **Develop and maintain cutting edge codes and methods** to conceive and license core and fuel assembly designs
- **Deliver engineering services to customers** based on our unique expertise in fuel assembly design, core management and safety analysis
- Contribute to worldwide research networks activities for advanced fuel and reactor designs

KEY FIGURES

- **2 European sites** (Lyon in France, Erlangen in Germany) and **2 US sites** (Richland, Lynchburg)
- **> 500 employees with > 8000 men years** of collective experience at the service of innovation and business
- **> 100 certified experts & advisors** in fuel and nuclear engineering for PWR, BWR and SMR based on our OEM knowledge
- Fuel designs **serving 1/3 of the worldwide operated reactors** involving all major safety authorities

KEY DATES

- **2009:** creation of the integrated worldwide fuel engineering unit
- **2015**: licensing of modern reactor physics simulation packages for PWR and BWR
- **2015:** 1st partnering for development and licensing of Fuel for SMR with NUSCALE
- **2021 (BWR) & 2022 (PWR):** Licensing of advanced LOCA and Non-LOCA methods

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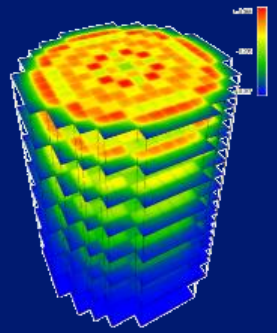
Fuel design & engineering

4 competence fields in steady state and transients

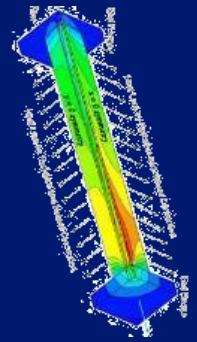
1 NEUTRONICS

Mastering motions and interactions of neutrons with the nuclear core materials and environment



2 THERMAL-HYDRAULICS

Mastering adequate core cooling, hydraulic forces and the associated coolant circulation

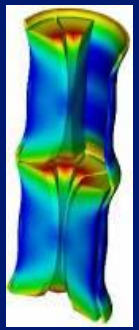


3 MECHANICS

Mastering the fuel assembly mechanical behaviour when influenced by the constraints of core environment

4 MATERIALS & THERMAL-MECHANICS

Mastering materials, fuel rod behaviour and fuel assembly performance



Framatome | Competence.hub

WHAT IS IT?

Most innovative Onboarding Training for Career Starters to the Nuclear Industry

- 100% Online & On-Demand
- Learn anytime, anywhere, as often you like
- >60 e-learning videos + 2 online live discussions
- Duration: 2 weeks (ca. 0.5 hrs/day)

WHAT'S IN?

- Highly modern Learning Platform
- Basics of Nuclear Technology
- Nuclear terms and relevant context
- Management Safety & Failure Tools
- 2 online Live Session (questioning)
- Using a large network

COSTS & BENEFITS?

- 799€ / Person
- Own Customer group possible

Register now

- ✓ Ideal entry for career starters
- ✓ Fully flexible, digital & on-demand, asynchronous learning
- ✓ No travelling costs & time

www.fuel-training.framatome.com/competence-hub-home

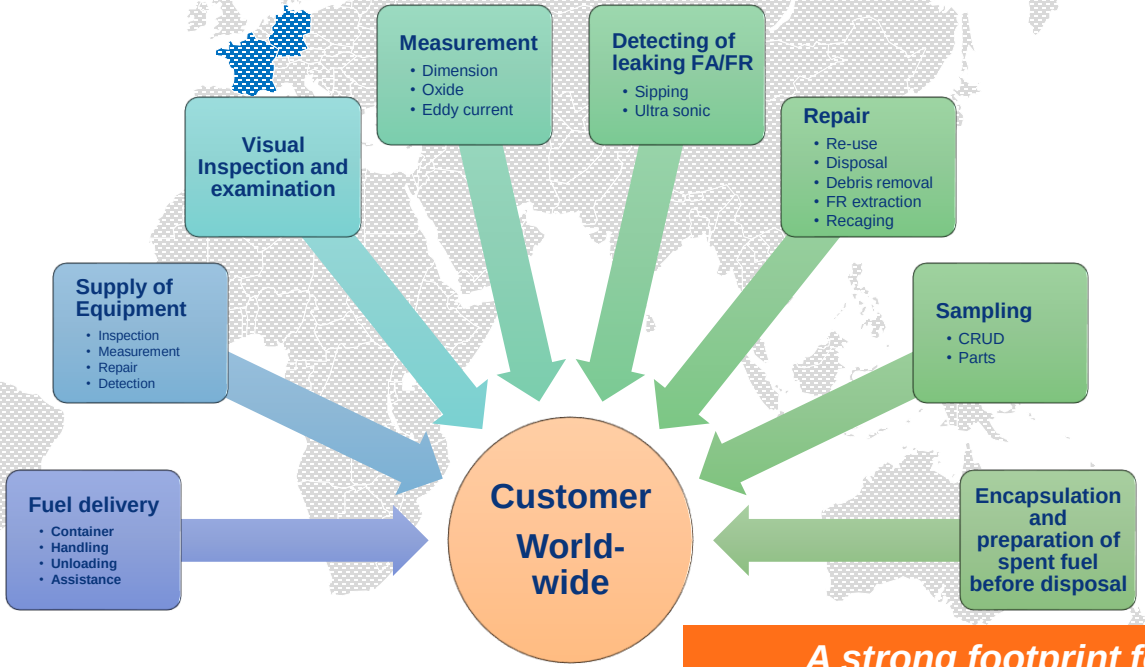
Framatome Fuel Services - what do we do

Fuel assets

- 3 Controlled areas: Cadarache, Erlangen, Lynchburg
- Maintenance & repair, test, preparation and storage of equipment
- Laboratories, training areas and pools

Fuel Services onsite

- 150 highly skilled experts from France, USA and Germany supports our customer world wide on PWR, BWR and VVER fleet
- More than thousands service campaign performed since 80s
- Unexpected event management, wide data base, rapid assistance



A strong footprint for a strong customer service

AGENDA

The Fuel Business Unit

Fuel design & service activities

Zirconium components manufacturing

Fuel manufacturing

Conclusion

Zirconium components manufacturing

Zirconium activities integrated into the fuel cycle

PERIMETER

- Mastery of the complete process of nuclear fuel design and fabrication, including the development of zirconium and its alloys, and extending through to final assembly and associated services for nuclear reactor operators.

- **Expertise in all stages of zirconium metallurgy, from the ore to the manufacturing of zirconium alloy components:** flat products, bars and tubes entering into the fabrication of nuclear fuels.

Zirconium components manufacturing

An industrial integrated tool with a R&D capacity

2020 KEY FIGURES

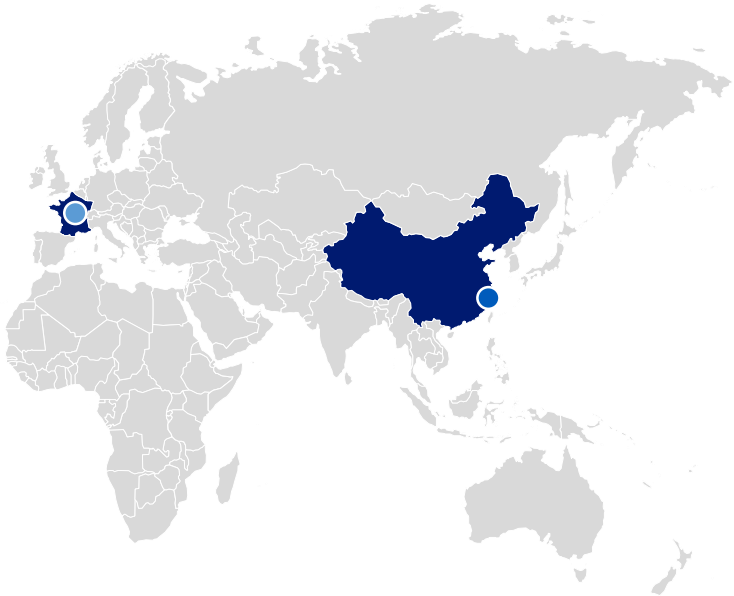
Annual production capacities:

- **1,600** t zirconium sponge
- **9,000** equivalent km tubes
- **700** t flat products

Dedicated Sales & Marketing team based in France, US and Japan

Dedicated Technical & Quality team based in France

1 R&D center in Ugine with representatives in Jarrie and Paimboeuf (France)



Components manufacturing: 6 sites in France

- Jarrie
- Ugine
- Rugles
- Montreuil-Juigné
- Paimbœuf
- 1 subsidiary: Tubes Nucléaires Montbard SAS

China

- 1 Joint venture : CAST, Shanghai

Jarrie

ACTIVITIES

- **Conversion of zirconium ore into nuclear industrial products.** However, a portion of its production is sold, along with some by-products, for other applications including aeronautics, medical applications, optics and electronics.
- **Production of zirconium sponge** through a series of chemical operations and extractive metallurgy.
- **Recovery of by-products of zirconium fabrication, such as zirconium and hafnium salts, hafnium oxides, hafnium metal and magnesium chloride** (for aeronautic, pharmaceutic and electronic).

KEY FIGURES

- **1,600t** Zirconium sponge
- **35t** Hafnium
- **280** employees
- **€7,3M** investments

KEY DATES

- **2017**: electrolyze 3rd line
- **2017**: new incinerator
- **2017**: new crisis meeting room
- **2018**: new area of cleaning and new separation facilities

Ugine

ACTIVITIES

Manufacturing of zirconium alloys

- **Transformation of zirconium sponge** supplied by the Jarrie site (France) **into semi-finished zirconium products.** These materials are melted, forged and shaped into **slabs** (rectangular bars), **bars or extruded hollows**.
- From zirconium sponge, production of alloys and to melt and forge **titanium** products for TIMET SAVOIE.

KEY FIGURES

- **300** employees
- **2,513** Teq*/year produced
- **60 %** Zirconium (nuclear and medical industry
- **20 %** Titanium
- **20 %** Recycling

Teq: Ton equivalent quantity

KEY DATES

- **1962**: Zirconium and Titanium activities start
- **1996/97:** TIMET Savoie is created to start titane activity at Ugine
- **2015:** ISO 50 001 certification on energy management system
- **2020**: triple-ISO renewed (ISO 9001, ISO 14001, ISO 45001)

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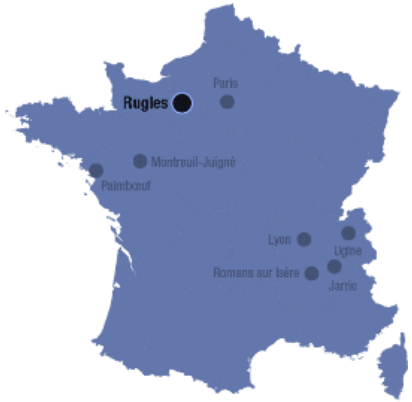
Rugles



ACTIVITIES

- The world leader in the market for **flat zirconium to be used in the manufacturing of elements of grids and castings for fuel assemblies.**
- Renowned worldwide for its excellence in the manufacturing of flat products.
- Rolling of **zirconium alloy sheets and strips**.
- More than 50% of its production exported.

KEY FIGURES

- Production: **838 Teq***
- **11** recruitments
- **4193 k€** of investments (2021)

**Teq: Ton equivalent quantity*

KEY DATES

- **1800 :** Copper and brass activities
- **1951 :** Development of aluminium rolling activities
- **2018** : Elan building built, start of the new rolling mil equipment reception
- **2022**: ELAN rolling mil shop operational

Montreuil-Juigné

ACTIVITIES

- **Transformation of extruded hollows** manufactured at the Ugine site (France), **using a cold pilgering process into semi-finished Tube-Reduced EXtrusions (TREX)** for further cladding tube manufacturing operations.
- Tubes pilgered on-site are subsequently delivered around the world to plants that manufacture cladding tubes and guide tubes.

KEY FIGURES

- **80** employees
- **1 250** Teq* delivered

KEY DATES

- **1929**: 1st industrial site
- **1978**: pilgering activity creation
- **2009**: new rolling mill revamping
- **2017 :** Start-up of the wire rolling mill

**Teq: Ton equivalent quantity*

Paimbœuf

ACTIVITIES

- **Pilgering of zirconium tubes** originating from the Montreuil-Juigné site (France) **to manufacture** finished products: **cladding tubes, Guide thimble tubes, for PWR, Candu (PHWR) and BWR technologies**
- **Pilgering of zirconium bars** originating from the Ugine site (France) **to manufacture endplug barstock** using bars coming from the Ugine plant.

KEY FIGURES

- **9.000** Teq* delivered
- **400** employees
- More than **120** product references

*Teq: Ton equivalent quantity

KEY DATES

- **1978**: plant creation
- **2018**: production record: 8,034 Keq*
- **2019**: production target: 9,000 Keq*
- **Since 2016 :** investments of approx. 5 M€ / year including:

✓ Pilgering for rolling bars and tubes, endplug barstocks grinding machine replacement, new tubes length cutting machine, glass-polishing filtering, tubes visual monitoring & control machine (OPAL)

✓ Extension of the Finishing & Control Lab

✓ Tubes chrome-coating project (program PROtect enhanced accident tolerant fuel - EATF) and chrome-coating equipment

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Fuel manufacturing

Main product families

Fuel for PWR

Fuel for BWR

Fuel elements for research reactors (CERCA)

RCCA
TPA

Fuel manufacturing

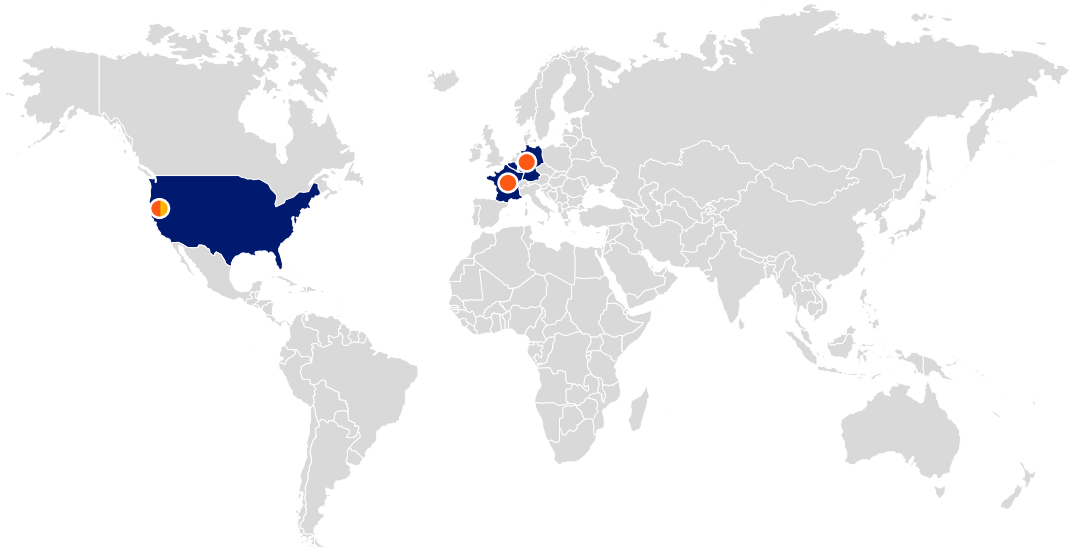
A worldwide footprint serving the global market with shared best practices and technologies

3 European sites

- Romans - France
- Lingen - Germany
- Karlstein - Germany

Richland, WA - USA

- Fuel manufacturing, Design plant



KEY FIGURES

- **1792** employees
- **> 230,000 Fuel Assemblies** (PWR/BWR) serving 125 worldwide reactors

Lingen

ACTIVITIES

- Fabrication of fuel assemblies (FA) for pressurized water reactors (PWR) and boiling water reactors (BWR).
- Supply of uranium dioxide (UO2) powder and Gadolinium (Gd) rods for European Framatome demand.
- The site is equipped and licensed to receive and ship all intermediate nuclear fuel assembly products (i.e. UO2 powder, ENU and ERU pellets and fuel rods).
- The Lingen site owns and is specialized in technologies, equipment and processes essential to the fabrication of nuclear fuel, e.g. fuel rod upset shape welders (USW), Automated Pellet Inspection System (APIS), and sinter furnace technology.
- Technology transfer and engineering studies to Framatome and third parties.
- Capacity to accommodate special orders such as disassembling fresh fuel elements for uranium recovery.

KEY FIGURES

- Employees: **350**
- Export Share: **100%**
- Fuel assemblies: **185 tU**
- Gadolinium -Pellets: **23 tU**
- Powder: **322 tU**

KEY DATES

- Founded in 1975
- Fabrication experience of nearly 40,000 fuel assemblies
- Unlimited license
- Significant increase in technology share of total business volume since 2015

New FCC Building at Lingen

Karlstein

ACTIVITIES

- Fabrication of Fuel element components related to all marketed Framatome designs for pressurized water reactors (PWR) and boiling water reactors (BWR).
- Center of excellence for spacer grids and BWR cages.
- Key supplier for upper and lower tie plates as well as for assembly parts such as fuel rod end plugs, sleeves, screws and other small components.

KEY FIGURES

- **138** employees
- **30.000** spacers, for use in more than **40** reactors
- **2.000** tie plates
- **400.000** small components

KEY DATES

- Founded **1965**: more than 50 years of manufacturing experience
- Since **1998**: apprenticing company
- **2014**: all Framatome spacer designs qualified for production

New Prototyping Lab at Karlstein

New Prototyping Lab at Karlstein

New Prototyping Lab at Karlstein

AM proceedings in the Fuel Prototyping Lab

Machine Portfolio

Metal (1):

Concept Laser Mlab Cusing R

- Technology: SLM
- Materials: 316L (Inconel718)
- Build volume: 90x90x90 mm^3

Polymer (5):

Keyence Agilista / Stratasys Objet 30 pro V2

- Technology: Material Jetting
- Materials: UV curable resins
- Build volume: 300x210x200 mm^3 (DIN A4 x 200mm)

Sinterit Lisa Pro

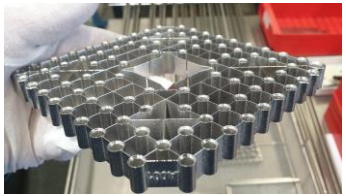
- Technology: SLS
- Materials: PA12
- Build volume: 230x160x110 mm^3

Flashforge Creator Pro Mk2 / Raise3D Pro 3

- Technology: FDM
- Materials: PLA, ABS, TPU, PA, PC, PP (CF and GF filled)
- Build volume: up to 305x305x300 mm^3

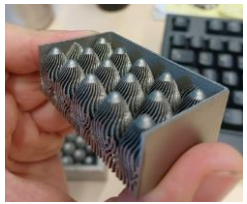
Applications

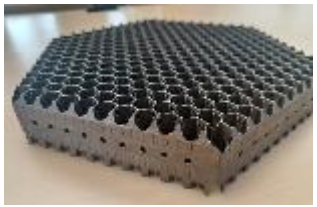
Components – normalise AM in manufacturing



← 3D printed upper tie plate, 2 LTAs inserted 05/22 into FMK3

Prototyping – speed up development





Fixtures – support manufacturing

Demonstrators – advertisement

→ **Establishing Center of Compentence for Additive Manufacturing**

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Romans

ACTIVITIES

- **Fabrication of fuel assemblies for nuclear power plants and fuel elements for research reactors using enriched uranium.**

BASIS NUCLEAR INSTALLATION (BNI)

- BNI No. 63-U: fabrication of fuel elements for research reactors - CERCA. and fabrication of fuel assemblies for nuclear power plants.
- Framatome is the sole operator of the Romans site. The French Nuclear Safety Authority (ASN), monitors the activities of the nuclear installation of the site. Framatome covers the production of fuel assemblies for nuclear-power plants and for research reactors in terms of safety, radiation protection, environmental protection and the overall management of industrial operations.

KEY FIGURES

- **60** years of experience
- 940 employees
- **749t** of uranium transformed in assemblies

KEY DATES

- **1959**: site creation with CERCA
- **1977**: FBFC implantation to Romans
- **2003-2010**: Launch of Romans industrial facility renovation (120 M€)
- **2014**: Launch of the multi-year nuclear safety improvement program (>100M€)
- **2016**: Launch of the investments to renovate the CERCA fabrication workshop of the research assemblies (180 M€)
- **2019**: Inauguration of the CERCA Research & Innovation Laboratory (CRIL)
- **2020**: Launch of the investment related to the ERU fuel assemblies' fabrication
- **2021**: Creation of the unique BNI 63-U (Research and Power fuel activities)

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Richland

ACTIVITIES

- Home to highly-skilled workforce with nearly 50 years of nuclear fuel engineering and manufacturing expertise.
- A leading innovator in fuel design and manufacturing for today's reactor fleet and advanced fuel designs.
- World leader in manufacturing fuel with enhanced accident tolerant fuel technologies.
- A licensed facility by the U.S. Nuclear Regulatory Commission until 2049.
- Recognized by the U.S. NRC for our regulatory and safety record for 16 straight year.

KEY FIGURES

- **550** employees
- **86** million fuel pellets pressed
- **2,422** fuel assemblies manufactured
- **680** metric tons of UO2 powder manufactured

KEY DATES

- **1970**: first fuel assembly shipped to a customer
- **1998**: Dry Conversion facility put into service
- **2009**: received first 40-years NRC license renewal in the nuclear industry's history
- **2019:** 50th anniversary of fuel manufacturing
- **2020:** Delivery of the first ATRIUM 11 fuel reload
- **2021:** Delivery of the first GAIA fuel reload
- **2021:** Delivery of the first-ever fuel assembly completed with PROtect enhanced accident tolerant fuel (EATF) technologies

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CERCA

ACTIVITIES

- **The fuel elements manufactured by CERCA are supplied to research centers and universities operating research reactors for industrial and scientific purposes.**
- Uranium-based medical irradiation targets are also manufactured by CERCA. Once irradiated in a research reactor and following chemical extraction, these are used to produce radioisotopes such as Iodine-131, Xenon-133, Yttrium-90 and finally Molybdenum-99 (99Mo) which decays to Technetium-99 (99mTc).
- The latter radioisotope is the one most widely used in hospitals for carrying out nuclear medical imaging examinations, and in particular for cancer diagnosis.

Develop and industrialize uranium alloys for manufacturing fuel elements for research reactors and producing medical irradiation targets

Source: The supply of Medical Radiosiotopes OCDE 2018

KEY FIGURES

- More than **20,000** fuel cells and **80,000** medical irradiation targets manufactured to date
- **70** fuel element designs
- Of the **45 million** nuclear medical examinations carried out worldwide, around **30 million use medical targets** produced by CERCA

KEY DATES

- **1957**: establishment
- **2019 :** Inauguration of the CRIL: CERCA Research & Innovation Laboratory
- 2016: Launch of the investments to renovate the CERCA fabrication workshop of the research assemblies (180 M€)
- 2019 : Inauguration of the CERCA Research & Innovation Laboratory (CRIL)
- 2020: Launch of the investment related to the ERU fuel assemblies fabrication

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Conclusion: Our key facts

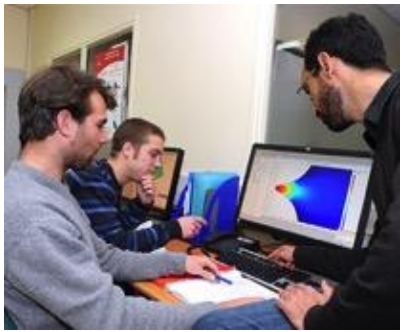
Expertise in fuel design and fabrication from zirconium technology to assembly manufacturing

High-Performing and continuously improved products portfolio

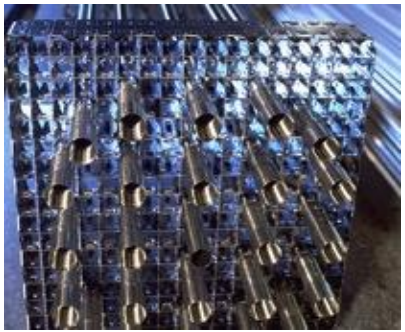
Robust supply chain

Worldwide engineering adapted to your needs

A large engineering and fuel service portfolio



High performing employees & technologies



Continuously upgraded products New generation products

« Best in Class » in Fuel services: engineering, manufacturing, on sites

A modern and optimized industrial footprint

