WHITE PAPER

STAINLESS STEEL NUCLEAR DECONTAMINATION

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STAINLESS STEEL NUCLEAR DECONTAMINATION

THIS WHITE PAPER IS INTENDED TO GIVE OUR CUSTOMERS BEST PRACTICES IN THE TREATMENT OF CONTAMINATED PARTS AND PROVIDES GUIDELINES AND RESOURCES ON WHAT LEVEL OF DECONTAMINATION CAN BE ACHIEVED USING A DEFINED DECONTAMINATION PROTOCOL.

The first part of this document provides an overview of the most relevant parameters that will define if a connector or/and a cable assembly can withstand a defined decontamination protocol.

The second part presents the performances (decontamination levels) that Fischer Core Series Stainless Steel achieved using a recommended decontamination protocols.

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Jean Baptiste Gay is involved in the development of new products at Fischer Connectors. His main motivation is to provide the best technical expertise and solutions to respond to customer's needs.

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INTRODUCTION

The main purpose of this white paper is to discuss the key factors associated with the nuclear decontamination of parts. Whenever there is a need for manipulating our processing radioactive products, the protection and security of humans is the main focus of concern. Radioactive decontamination has to be possible on parts that are handled in these environments. In order to efficiently process a connector that has been accidentally contaminated by a radioactive substance, a specific decontamination process has to be applied.

NUCLEAR CONTAMINATION

Nuclear contamination is one of the main security concerns when working with radioactive materials. The main difficulty is that radioactive contamination is impossible to detect without specific equipment. A contaminated object can be very harmful to people who have to operate it. Radioprotection plays a central role when designing or using devices that involve handling radioactive materials.

Nuclear contaminant can be present in most known states of matter (solid, liquid, gas). The liquid state is a concern for lots of equipment because, if spilled, the contaminant gets spread in an uncontrolled manner on many parts and can easily penetrate hidden places or cavities. The parts' cleanability is therefore a key factor in offering maximum security to users.

If a radioactive liquid solution spills on a mechanical part, surface diffusion will take place, allowing radioactive ions to slowly migrate from the solution inside the material molecular structure, thus contaminating it. Once radioactive ions have diffused, it is very difficult to remove them whilst preserving the part integrity. The last resort, if decontamination protocols fail, is either surface etching to remove the diffused layer, or leaving sufficient time to let the ions decay naturally.

APPLICATION FIELDS

One typical application requiring the design of premium components to guarantee optimal radioprotection is nuclear medicine. It combines the need for both radioactive decontamination and sterilization.

Nuclear medicine uses many radioactive agents in its broad range of applications. Radioactive isotopes are used either for curative applications or imagery applications.
Radioactive isotopes that are injected into a patient must be selected carefully in order to fine tune exposure duration and efficiency. In most applications, the injected isotopes are selected according to their short half-life in order to minimize the total dose that a patient gets exposed to.

Some examples:

PET scanner imagery

PET scan uses 18F (Fluor isotope) synthetized on a glucose molecule to produce FDG (fluorodeoxyglucose) that can then be injected into the patient for analysis.

The 18F has a typical half-life of 109.7 minutes, which helps minimize patient exposure. The drawback of such short half-life is that FDG product has to be produced locally. PET scanner

equipment therefore generally comes with a dedicated FDG production line, including a hot cell part where decontamination is a critical matter for operators' radioprotection.
The 18F is created out of 18O (Oxygen) precursor by activating enriched water with high energy H+ ions from a cyclotron (particle accelerator).

Scintigraphy imagery

Scintigraphy imagery uses many different contrast agents following the targeted organ system.

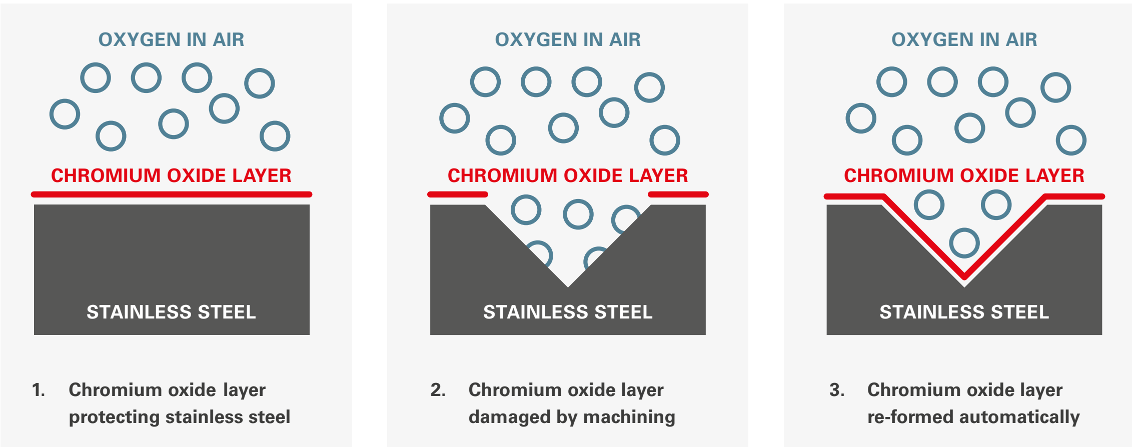
Isotopes like 99mTc (Technetium); 131I (Iodine) are a commonly used and have to be produced from the decay of larger atoms. The process therefore requires easy decontamination of products that might come into contact with these heavier elements. The use of glove boxes and laboratory equipment is mandatory to manipulate such preparations.

DESIGN GUIDELINES

When designing components to be used in these fields, it is essential to choose materials and performances wisely.

Fischer Connectors uses premium grade 316L stainless steel for all exposed parts, thus giving our customers the best possible decontamination performances.

FIG.1



Stainless steel's special auto passivation property makes it one of the best candidates where surface diffusion has to be limited. Its natural passivation induced by the presence of chromium in the alloy allows the natural formation of highly sealed chromium oxide (CrO2) on its surface.

Another key factor used in the design of Fischer Connectors parts that might be in contact with contaminants are low surface roughness, coupled to a smooth design. These features improve cleaning efficiency by limiting cavities, thus helping decontaminant liquid flow and efficiency.

Stainless steel (especially 316L) is recommended in highly corrosive environments or where surface diffusion must be avoided. Its high resistance to radiation, temperature and chemicals, coupled to low diffusion rate, allows it to be a very good candidate for nuclear, chemical or medical applications.

NUCLEAR DECONTAMINATION

Nuclear decontamination is a technique that consists in removing all radioactive contaminants from the material surface. The industry generally uses aqueous solution made of water and cleaning product (generally an alkaline mix of surfactant agents and other active molecules).

Common products include:

RBS25 (FROM R. BORGHGRAEF S.A.)

DECON 90 (FROM DECON LABORATORIES LIMITED)

The decontamination process involves one or several rinsing stages that transfer radioactive ions from the surface of the part into the decontamination solution. Many parameters can be adjusted to optimize the cleaning process to the parts to be cleaned. The contaminated solutions are then sent to special retreatment or left to decay naturally.

The usual process parameters are:

- Number of decontamination steps
- And for each step
    - →Decontamination solution temperature
    - →Decontamination solution concentration
    - →Parts impregnation duration
    - →Mechanic activation

Fischer Connectors has worked together with HESGE (Geneva University of Applied Sciences) to recommend a process that gives the best decontamination results on our Fischer Core Series Stainless Steel connectors.

DECONTAMINATION PROTOCOL RECOMMENDATION

The connectors have been tested under two different contaminations:

1. Alkaline contaminant solution: cesium chloride 137Cs   pH = 10
2. Acid contaminant solution: cesium + nitric acid 137Cs + NH3   pH = 1

The connectors have been immerged in the contamination solutions for 20 minutes in order to have a homogenous radioactive contamination all over the connector.

Process parameters

- Cleaning agent concentration in solution:
  - →For RBS 25 cleaning solution: 5% (pH ≈ 13)
  - →For Decon 90 cleaning solution: 5% (pH ≈ 13)
- Cleaning solution temperature: 60°C
- Cleaning solution agitation: Yes (with a laboratory 30mm PTFE magnetic agitator)
- Cleaning stage duration: 20 minutes
- Rinsing with distilled water
- Drying stage with infrared lamp

CORE SERIES STAINLESS STEEL PERFORMANCES (TEST RESULTS)

IC: Initial contamination → 100 [%]
RC: Residual contamination → Nf /Ni ×100 [%]
D: Decontamination factor → Ni /Nf [abs]
Ni: Initial counting rate in the ^{137}Cs → ray peak (after contamination)
Nf: Final counting rate in the ^{137}Cs → ray peak (after decontamination)

Alkaline contaminant

Short diffusion time between contamination and decontamination (a few hours)

Solution	IC [%]	RC [%]	Interval [%]	D [abs]
RBS 25	100	1.4	0.8	69
Decon 90	100	3.5	0.6	29

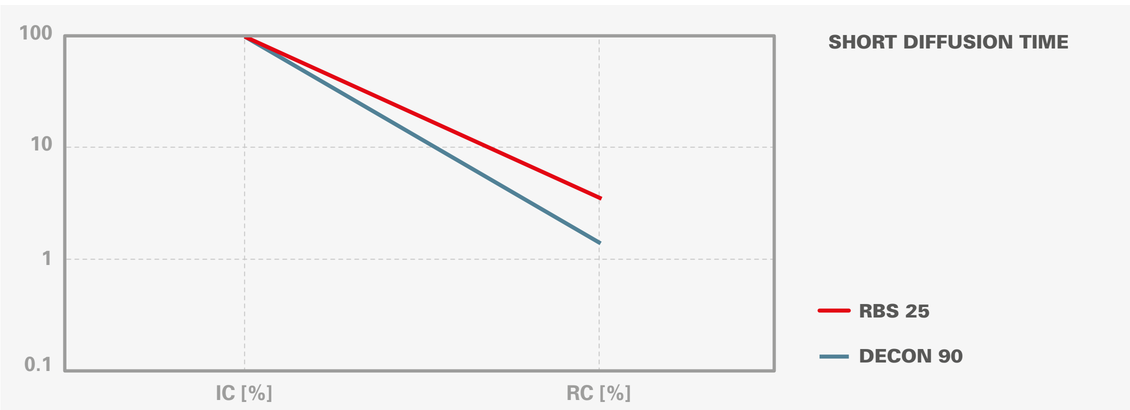


FIG.2

The data show that the decontamination products give very good results. The decontamination process is efficient because the short period of time after the contamination does not allow much surface diffusion.

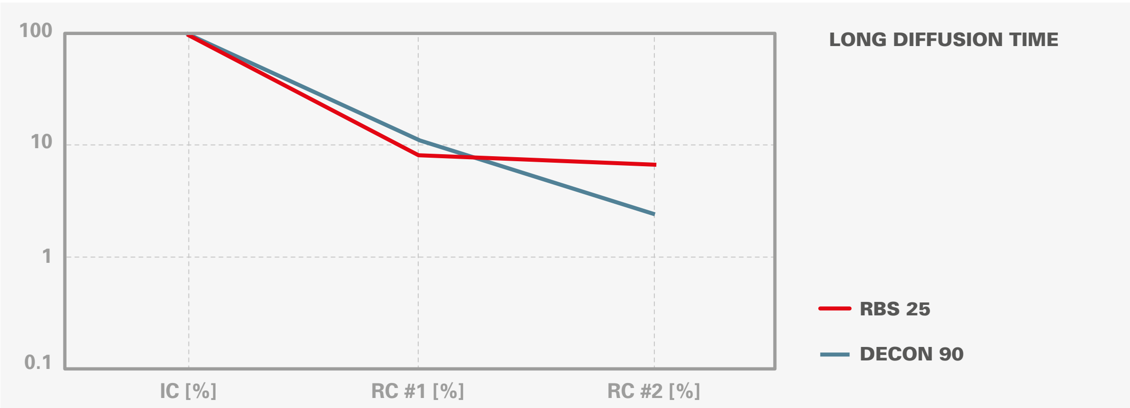
Long diffusion time between contamination and decontamination (one week)

The process differs slightly between the two products regarding the second decontamination process:

- The part decontaminated with the Decon90 has been left for one more week after the first decontamination process.
- The part decontaminated with the RBS25 has been done straight after the first decontamination.

Solution	IC [%]	RC #1 [%]	Interval #1 [%]	RC #2 [%]	Interval #2 [%]	D [abs]
RBS 25	100	11	0.8	2.4	0.2	42
Decon 90	100	8	0.8	6.7	1.5	15

FIG.3



The data show that if the first process does not allow for sufficient results, a second decontamination process can be undertaken, but its efficiency is greater if done within a short period of time. The diffusion has taken place and we can assume that, after two weeks of diffusion, the decontamination process will not have any relevant effect. This confirms that decontamination has to be done as quickly as possible after contamination in order to guarantee optimal efficiency.

Acid contaminant

Short diffusion time between contamination and decontamination (a few hours)

Solution	IC [%]	RC #1 [%]	Interval #1 [%]	RC #2 [%]	Interval #2 [%]	D [abs]
RBS 25	100	16.1	2.3	6.3	0.7	16
Decon 90	100	13	1.6	3.5	0.7	19

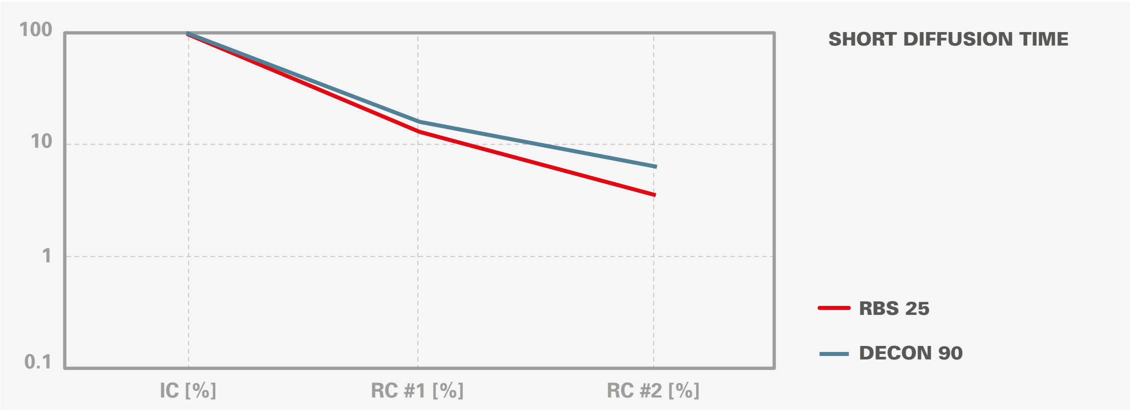


FIG.4

The data show that, if the contaminant is an acid solution, the decontamination products will be less efficient and two stages will be necessary to reach similar decontamination levels to the alkaline contaminant product. This might be induced by the fact that the natural oxide layer on the surface of the part is more sensitive to acid solutions than alkaline ones. The diffusion therefore occurs more efficiently within an acid solution.

CONCLUSION

Radioactive decontamination is a process that has to be adapted to the product and contaminant properties. The use of specific decontamination fluids helps to guarantee optimal process repeatability. The main factor to take in account if a part gets contaminated is to proceed to the decontamination within the shortest period of time. The pH of the contaminant is also an important factor, as it will have an influence on the surface and therefore change the diffusion process that can induce definitive part contamination. The data presented in this white paper can be used as general information to decide whether or not there is a chance to remove enough contaminant to be under the maximum activity limit specified by radioprotection norms. Fischer Core Series Stainless Steel offers very good decontamination performances, thus allowing maximum equipment lifetime whilst preserving the user's security.

FISCHER CORE SERIES **STAINLESS STEEL**

ULTRA-RESISTANT | STERILIZABLE | EASY TO HANDLE

References

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ABOUT FISCHER CONNECTORS

Fischer Connectors has been designing, manufacturing and distributing high-performance connectors and cable assembly solutions for more than 60 years. Known for their reliability, precision and resistance to demanding and harsh environments.

Fischer Connectors' products are commonly used in fields requiring faultless quality, such as medical equipment, industrial instrumentation, measuring and testing devices, broadcast, telecommunication and military forces worldwide.

Primary design and manufacturing facilities are located in Saint-Prex, Switzerland, with subsidiaries and distributors located worldwide.

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