Application of national regulations for metallic materials' recycling from the decommissioning of an Italian nuclear facility.

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1. INTRODUCTION

The start of decommissioning of italian nuclear facilities requires proper management of clearance for large volumes of metallic materials.
This paper describes the Italian current regulatory framework according to standard regulatory system for materials unconditional removal feasibility from nuclear facilities, with particular reference to the recycling of metals , carrying two examples : the first relating to removal of a steel tank located in not Classified Zone but within the perimeter of the nuclear installation , the second relating to removal of metals from the Controlled Zone.
The definition of the Levels of Removal, whether General or Specific, ensures the non-relevance of radiological materials removed without additional controls. The Italian legislation on radiation protection provides that the removal of materials from installations subject to authorization is exposed to special requirements included in authorization measures. They expect that clearance levels take into account the legislations, recommendations, and technical guidelines provided by the European Union. The current regulatory framework requires compliance with technical – managerial requirements, issued by the Authority Control enclosed in ministerial authorization, which show the levels of surface concentration of activity and specific activity determined for metallic materials unconditional removal from nuclear facilities.

2. ITALIAN AND EUROPEAN REGULATORY FRAMEWORK

The Basic Safety Standards [1] suggests the levels of exemption (Exemption Level), which are defined in a more restrictive sense in national law. [2] The unconditional clearance levels (Clearance Level) are also suggested in the publications Radiation Protection (RP) [3], specifically the RP 89 offers specific levels of removal (Specific Clearance Level), respectively for metal and building rubble.
The definition of clearance levels, whether they are general or specific, guarantees the radiological non-relevance of materials removed without needing additional controls: the same RP 122 Part I [4] to par. 5.1 states that the materials removed should not be subjected to further examination otherwise it would contradict the principle of Unconditional Removal that prescribes instead the release of materials from the regulatory system (Clearance = release from regulatory requirements). The Italian legislation on radioprotection [2] (Article 154 paragraph 3 bis of Legislative Decree 230/95 and subsequent modifications and additions) states that "... the removal of installations subject to authorization ... of materials containing radioactive substances intended to be disposed of, recycled

or reused .... is subject to specific requirements to be included in authorization measures... The clearance levels ... take into account the guidelines, recommendations, and technical guidance provided by the European Union". The Operating License of ITREC Trisaia [6], issued by the Ministry of Economic Development pursuant to art. 50 of Legislative Decree 230/95, and subsequent modifications and additions, requires compliance with technical and management requirements - issued by the Control Authority (ISPRA - Institute for Environmental Protection and Research), in particular the management prescription 2.9 [5] indicates the surface and mass concentration levels established for the unconditional removal of solids by ITREC facility.
Over the last few years the concept of "*materials from nuclear installations*" has been extended by the Competent Authorities not only to those materials from the areas classified pursuant to Legislative Decree 230/95 and subsequent modifications and additions [2], but also to those originating in areas free of radiological restrictions and inside the nuclear facility's perimeter .
For the material from nuclear facility not classified areas the Competent Authority authorized the use of a procedure ("*criterion of the Three Zeros*") that allows you to verify the removability of the materials based on the concept of "*Critical Level* "[6].

3. STRATEGIES AND POLICIES FOR UNCONDITIONAL RELEASE OF METALLIC MATERIALS FROM ITREC FACILITY

3.1 Metallic materials from Controlled Area

The unconditional removal of metals from ITREC Controlled Area is authorized verifying the compliance with the levels of radioactivity present in Table 1 [5].

Radionuclide (i)	(C_{li}) Metallic materials	
	Surface (Bq/cm^2)	Mass (Bq/g)
^{3}H	10.000	1
^{55}Fe	1.000	1
^{60}Co	1	1
^{59}Ni	1.000	1
^{63}Ni	1.000	1
^{90}Sr	1	1
^{134}Cs	1	0,1
^{137}Cs	10	1
^{152}Eu	1	1
^{154}Eu	1	1
α emitters $^{(*)}$	0,1	0,1
$^{(*)}$ As U and/or Th		

Table 1: *Unconditional release levels*

The condition to be met in the case of multiple radionuclides is the following:

$$\sum_i \frac{C_i}{C_{li}} < 1$$

being C_i the concentration of the i-radionuclide and C_{li} the appropriate limit value.

To verify the condition above, considerating the material to be analyzed, is established a scaling factor set between easy measureable (Easy To Measure ETM like ^{137}Cs, ^{134}Cs, ^{60}Co, ^{152}Eu, ^{154}Eu e ^{60}Co) and hardly measureable radionuclide (Hard To Measure HTM come ^{90}Sr, ^{233}U, ^{235}U, ^{238}U, ^{232}Th, ^{3}H, ^{55}Fe, ^{59}Ni e ^{63}Ni): the definition of radionuclide's vector is object of study by Competent Authority.

3.2 Metallic materials from not Classified Zone

For the purpose of metal unconditional release from not Classified Zone pursuant to Legislative Decree no. 230/95 and subsequent amendments, the Control Authority allows the verification of the absence of radioactivity is conducted through the criterion of the "three zero" [6]:

1. Historical: based on the operating history of the facility, there must be a guarantee that the areas and structures to be release have never been affected by contamination events or activation;
2. Logical - Plant designed: based on the location and function of the areas and structures linked to it, there must be a guarantee that they have never come into contact with contaminated fluids or subjected to neutron flows;
3. Instrumental: the absence, in the environmental matrix in areas and materials constituting the outbuildings, of artificial radioactivity, net environmental background, must be confirmed on the basis of radiometric measurements to be performed according to an appropriate characterization plan.

The verification of the instrumental criterion is conducted in accordance with the terms described in the UNI 11458:2012 [7]: it defines strategies for the measurement of low levels of radioactivity in solid materials from nuclear facility.
For each batch of removable material is necessary to submit to the Authority "for consideration" a characterization plan able to demonstrate the fulfillment of the three criteria above.

4 EXAMPLES OF METAL UNCONDITIONAL REMOVAL

4.1 Metallic materials from Controlled Area

The removal of metal parts is performed as reported in par. 3.1, as indicated in the management regulation 2.9 [5] on levels of surface and mass concentration established for the unconditional removal of metallic materials , with the approval of characterization plan containing scaling factors by the Authority Control .
The verification of condition "Surface" in Table 1 is being conducted on 100 % of the areas to be investigated. In particular, the determination of surface contamination of alpha emitters or beta / gamma emitters radionuclides is performed in terms of "gross alpha", " beta / gamma total" using

portable contamination monitor. Not being able to discriminate the contribution of each radionuclide present in Table 1, is attributed all the activity measured to the radionuclide with the more restrictive release level among those present in Table 1.
infact:

$$\sum_i \frac{C_i}{C_{li}} = \frac{C_1}{C_{l1}} + \frac{C_2}{C_{l2}} + \cdots + \frac{C_n}{C_{ln}} < \frac{C_1}{C_{min}} + \frac{C_2}{C_{min}} + \cdots + \frac{C_n}{C_{min}} = \frac{C_{tot}}{C_{min}}$$

where C_{min} is the most restrictive among those present in Table 1 and C_{tot} is the total activity measured per unit area .
If it appears that

$$\frac{C_{tot}}{C_{min}} < 1$$

then it is certainly respected the formula

$$\sum_i \frac{C_i}{C_{li}} < 1$$

The verification of condition "*mass*" recalled in Table 1 is tested on a statistically representative sample of the lot to be removed , using a system of high resolution gamma spectrometry ,
The representativeness of the sample is assured by compliance with the requirements defined in the UNI 11458:2012 [7] .
In particular, consider the following assumptions:

- Probability of error of the first type(the material has a radioactivity which does not exceed the levels of removal, but it is not considered as such and is not removed) $\alpha = 0.05$;
- Probability of error of the second type(the material has a radioactivity exceeding the levels of removal, but it is not considered as such and is removed) $\beta = 0.05$;
- C_{LR} (clearance levels) of 0.1 Bq / g for ^{137}Cs and ^{60}Co (more conservative value among those listed in Table 1) ;
- C_0 (estimated value of residual activity in the material) considered 0.05 Bq / g for ^{137}Cs and ^{60}Co;
- σ_m standard deviation of the measure, conservatively assumed equal to 20 % of the C_{LR}.
- σ_s standard deviation of the spatial distribution of radioactivity considered equal to σ_m;

The sampling strategy used was that of fixed sampling plan, or with a number of analysis points determined by the Noether's formula [8] :

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4 \times (p - 0{,}5)^2}$$

Where $Z_{1-\alpha} = Z_{1-\beta} = 1{,}645$ (percentile of the normal distribution);

$$p = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\frac{\Delta}{\sigma}} e^{-x^2} dx$$

With

$\Delta = C_{LR} - C_0$

x = value of the size in measure

$\sigma = \sqrt{\sigma_s^2 + \sigma_m^2}$ total standard deviation.

4.2 Metallic materials from Not Classified Area

During one of the preparatory activities to the decommissioning of ITREC facility, it was necessary to demolish a steel tank, formerly used for the storage of fuel oil used to feed the thermal power plant. For this tank, obviously located in not Classified Zone, although it is possible to exclude the presence of artificial radionuclides attributable to normal operations of the facility or previous accidents, however, was carried out the verification of removability based on the criterion of the "three zero" (see par. 3.2).
The Characterization Plan planned and submitted to the Control Authority concerned the instrumental activities that were conducted on the surface of the tank object of interest (Fig. 1).

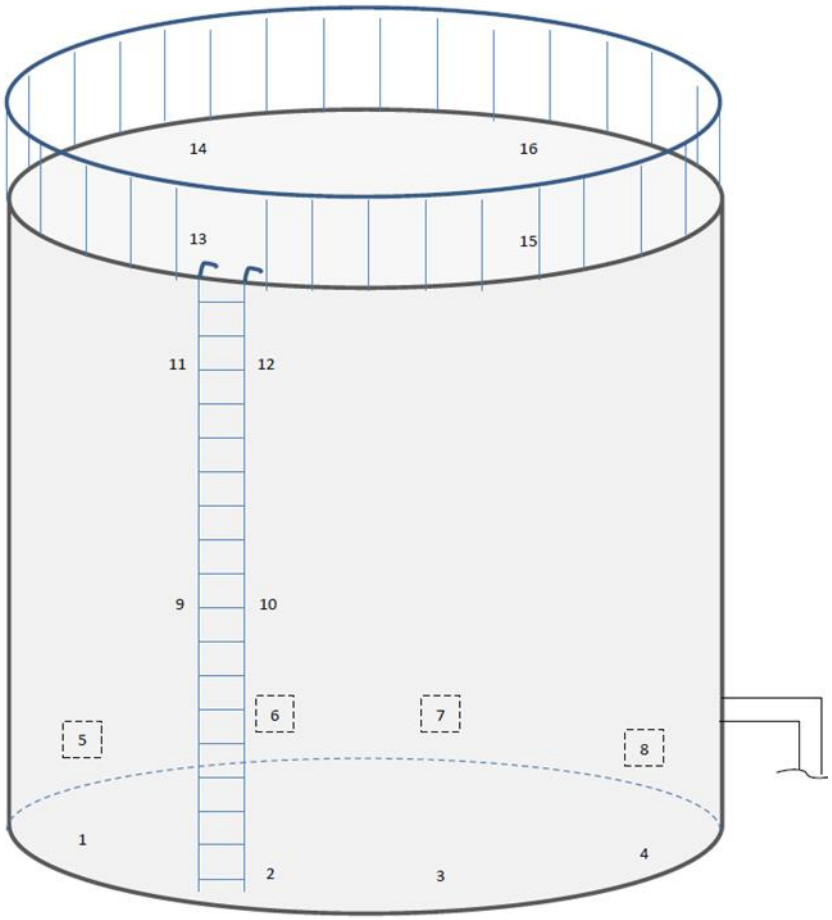

Figure 1: Fuel oil tank . Points of measurement of activity per unit of surface .

The verification of the criteria "Historical" and " Logical- plant designed " is satisfied because the totality of the tank falls into not classified area : in this area is ruled out the presence of artificial radionuclides attributable to normal operations of the plant or previous accidents.
For the verification of the criterion " Instrumental " has been implemented a program of sampling and measurement [9] divided into the following phases:

- Make a measurement of contamination, " beta / gamma total " by means of portable monitor contamination with detection surface of 177 cm^2 and equipped with a gas flow proportional counter, in an average time of 10 s, near the tank used as background environmental reference

- execution of No. 16 measurements on the points indicated in figure 1 , (the number of measurements was calculated using the Noether's formula [8] so making the sample statistically representative)
- verification of criterion " instrumental" through the use of the statistical concept of "critical level" L_C , defined as the minimum level usable for the detection of radioactivity [7] .

The "critical level" is defined as L_C

$$L_c = Z_{1-\alpha}\sqrt{2R_b}$$

With $Z_{1-\alpha} = 1{,}645$ (percentile of the normal distribution with 95% confidence level) and R_b = average rate of the background count.
The radiometric measurements performed to the structure to be characterized , net of background value, were compared with the critical level and the instrumental criterion was satisfied being such measures less than or equal to this value.

5. CONCLUSIONS

This article shows how the Italian operator Sogin S.pA applies the national legislation for the purpose of unconditional removal of metal materials from nuclear facilities.
The real challenge for the nuclear operator is the management of large amounts of waste materials arising from decommissioning activities. For this SOGIN S.p.A. considers of utmost importance the proper application of rules and regulations issued by the Control Authority, in order to allow the most effective decrease of radioactive waste amount produced during decommissioning activities.

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