Decontamination Laboratory Design for Iron Pipes Contaminated with Uranium and Thorium Series

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Abstract. The Brazilian soil is very rich in the ore processing, after some time, the pipes are contaminated with trace levels of uranium and thorium. When the pipes are exchanged, to recovery the funds, the best is to sell them as scrap, however, because they are contaminated and present a considerable amount of dose can not be marketed until they are decontaminated. The question is that the tube is incrusted with the contaminated material, and is difficult to remove it. For the removal this material, that comes to be 2 inches thick, for the larger pipes diameter, requires special equipments as a motor-pump units with ultra high pressure water jetting, of the order of 40000 psi. The purpose of this paper is to suggest a design of one laboratory able to perform the decontamination avoiding large scale production of radioactive wastes. The solids and liquids wastes produced during the process of decontamination will be collected in different containers and classified according to their contamination level. The laboratory was designed to facilitate its decontamination with a minimum dose for their operators. The most difficult question to be solved during the project, was to perform the laboratory decontamination during the pipe decontamination in continuous operation since we can't stop the process for the reason of it expensive cost. The paper will show how will be made all the steps of the tubes decontamination and the laboratory decontamination. It will be shown how we collect the liquids and solids wastes, separate, for their classification. After the pipe, decontamination we show as will be measure the dose to release or to return for the laboratory to development a further decontamination. At last, it will show the temporary storage place for the decontaminated pipes that will be later collected as scrap.

KEYWORDS: Decontamination Procedure; Uranium Series; Thorium Series; Industrial Iron Pipes; Decontamination Laboratory Equipment; Decontamination Equipment.

1 Introduction

The Brazilian soil presents a very high level of uranium and thorium traces and their radioactive series. Therefore, during the ore milling, in time, the pipelines are contaminated with these series.

When the pipelines are changed, it would be desirable to sell them as scrap, so as to recover some funds; however, as they are contaminated and present an appreciable dose value, they cannot be traded without being decontaminated. The problem is that the pipes are encrusted with contaminant material that is very difficult to be removed.

This contaminant material forms a layer that can be 2 inches thick in the widest pipes, that is, 16 inches in diameter. The smaller pipes are about 10 inches in diameter. To decontaminate these pipes specific equipment is required such as motor pump units with ultra high pressure hydrojetting of the order of 40000 psi or more.

The purpose of this paper is to propose the design of a laboratory able to perform decontamination, so as to avoid large scale production of radioactive waste.

The solid and liquid waste produced during the decontamination process will be collected in different environments and classified according to its contamination level.

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2. Control of Lots

In order to comply with the international regulations, first of all the basic principles of radioprotection described in BSS 115 Regulation [1] will have to be considered:

a) The principle of justification: the doses received by workers and public have to be justified and must also provide a positive net benefit for the population;

b) The principle of optimization: the doses received by workers and public must be kept ALARA, that is, as small as reasonable achievable;

c) Annual dose limits for workers and individuals of the public as well as dose constrain, when pertinent, must be obeyed;

From these three principles we conclude that efforts must not be saved to keep doses for workers and individuals of the public the smallest practicable.

In order to avoid doses in individuals, the identification of the lot will be carried out by considering the maximum load that the transport vehicle is able to support.

The maximum load to be carried for each identified lot will be defined in two ways and the most restrictive one will prevail:

1) Maximum capacity of transport of the vehicle in weight or volume;

2) Maximum Transport Index equal or lower than 50 as it is an exclusive transport.

The pipes will be identified by the diameter of the circular base and their quantity; identification of individuals will not be performed in order to avoid unnecessary expositions of the worker.

In this way there will be total control in the transport of the pipes, since those which may suffer any kind of damage or even be lost will be immediately identified.

The final identification of each pipe of the lot will be carried out after decontamination by high pressure hydrojetting and evaluation of residual contamination in case it exists. If necessary, from the second decontamination on, the decontamination ratio will be determined for each pipe. In case of residual contamination above exemption level new decontamination will be performed.

The successive decontaminations will be stopped in two cases:

a) When the process shows evidence that the pipe can suffer damage;

b) When the increase in the decontamination ratio is too small in relation to the previous ratio.

We do not intend to select lots of pipes according to the dates they have operated, unless they have already been properly separated in the pipes park. Nor do we intend to separate the older lots already out of operation from the more recent ones; this classification would indicate how near they are to reach secular radioactive equilibrium and therefore the biggest dose, which is also a function of the amount of impregnated material, because in both cases unnecessary expositions of the workers will occur. The selection of the lots will depend on the facility and rapidity with which they are placed in the transport vehicle, which will be lined with washable canvas in order to avoid contamination. In figure 1 we present a partial sight of a park of pipes.

Figure 1: Park of Pipes

3. Control of the Access to Supervised and Controlled Areas

The park of pipes will be considered a demarcated area, as well as the installation as a whole, sketches A and B, that will be described below as decontamination areas. These areas will be kept locked when they are not in operation.

The controlled area consists of:

a) The park of pipes;

b) The area inside the installation for unloading the contaminated pipes. This area will be isolated and has the warning signs recommended by international recommendations;

c) The Decontamination Unit;

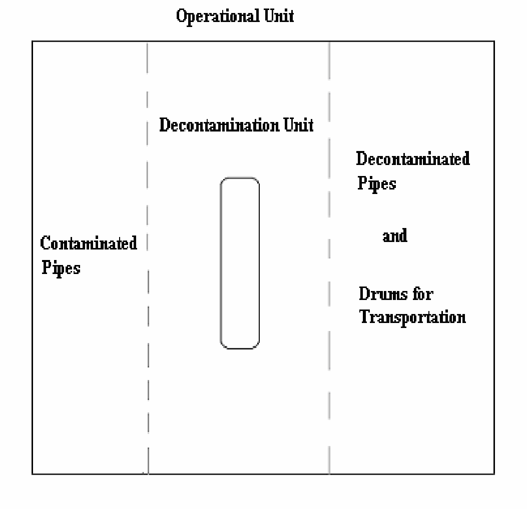
d) The dressing rooms and laboratory of decontamination next to the Decontamination Unit.

The other areas will be considered supervised areas.

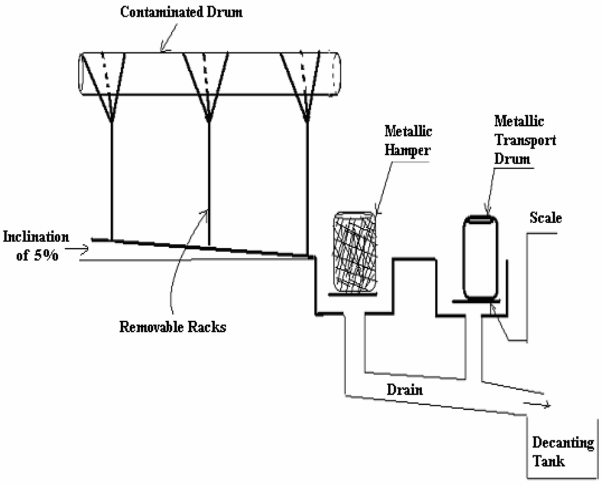
The routes destined for people and for the transport vehicles will be separated and demarcated by lines on the ground.

The dressing rooms giving access to the Operational Unit will be considered supervised areas. In the dressing rooms monitoring equipment for feet, hands and clothes will be available.

Sketch A



Sketch B **(Decontamination Place)**



4. Transport of Pipes to the Decontamination Plant

The pipes placed in the Park of Pipes (fig 1) will be carried to the decontamination plant by container trucks; the containers have internal walls covered with canvas to avoid their contaminations. The loading will be performed by stackers.

The transport will observe the rules for Safe Transport of Radioactive Material of the International Atomic Energy Agency, IAEA [2]. For the safe loading of the pipes the monitoring of the areas of permanence of workers will be necessary and sufficient. The vehicle will also be monitored in accordance with international rules.

The way to the decontamination plant will have its route predetermined and fixed; it will be also necessary to determine an alternative route.

The vehicle will be monitored as defined by international recommendations concerning the driver, the sides of the vehicle and the load.

The external doses expected for the pipes vary from 20 to 40 μSv/h and will be monitored by means of a GM model radiation detector.

5. Decontamination Environment

This section describes the area of decontamination. Sketches A and B make its visualization easier and quicker.

We will start by presenting a sketch that shows the Unit of Decontamination itself.

The masonry project will be described first. The floor as well as the four walls of the room will be coated with epoxy paint, for it can be easily decontaminated by just being removed and repainted. The floor must have an inclination of 5% in relation to the depression where the metallic hamper is placed, so that any liquid solution reaching it flows into the depression and follows to the decanting tanks through the drain. As shown in the sketches there will be two depressions, both linked to the decanting tanks by drains: one from the metallic hamper and the other from the transport drum placed on a scale able to support at least one ton. The Unit of Decontamination is not covered by a roof so that the pipes to be decontaminated can be put inside it and then taken out. If there is not a door at the back of the room, the same entrance can be used for the drums.

Sketch A shows the Operational Unit, which includes the Unit of Decontamination. Derricks (cranes) or a rolling bridge will be used for unloading the vehicles used to transport the pipes to be decontaminated and their removal after the process is over. It can also be used for placing and removing the transport drum.

5.1 Procedures for Decontamination

The vehicle coming from the park of pipes and loaded with an identified lot of pipes to be decontaminated is unloaded inside the installation with the help of cranes. These are positioned in such a place as to facilitate the unloading of pipes inside the Unit of Decontamination. Such as the Unit of Decontamination, this must be a place that can be easily decontaminated and the used waters must flow to the decanting tanks.

With the help of a crane (we will use this term meaning either derrick or rolling bridge, depending on the choice) the pipe will be introduced in the Unit of Decontamination and laid on racks that can be easily removed. The platform on which these racks are fixed must have an inclination in relation to the metallic hamper, so as to facilitate the flow of the used water inside the pipe and of the solid waste produced by the high pressure hydrojetting into the metallic hamper, which must be 200 dm^3 or more in capacity.

During the hydrojetting operation the pipe must be kept firm in its position with the help of supports fixed to the walls and/or to the floor. When the decontamination is over, a rack, on which there will be a GM counter with its reader at a distance, will be fixed to the pipe. Minimum and maximum doses will be registered and the average dose will be calculated, in case there is not a connected recorder which can give a curve reply along the extension of the pipe. The examination of this monitoring will provide the final result and determine the necessity (or not) of another decontamination.

After the decontamination is performed, the pipe will be removed by a crane to another place inside the installation presented in sketch A.

The liquid material flown into the metallic hamper will go out through its openings, fall into the depression and go down through the drain into the decanting tanks. Making use of a crane, the solid material will be transferred from the hamper to the metallic transport drum positioned in the depression and placed on a scale with the minimum capacity of one ton. When it reaches its maximum capacity, the drum will be closed and sealed.

Then, still at that same place, making use of a wiping test, a monitoring will be performed in order to detect external contamination that may have occurred during the transference of the waste from the hamper to the drum.

If contamination is detected, decontamination will be carried out still at that place.

Once the drum is externally clean, it is removed with the help of the crane or through a door adjacent to the depression and put on an appropriate place inside the plant, where it will be identified and monitored by GM detectors in order to be characterized as exempt, Low Specific Activity (LSA) or radioactive waste.

To decontaminate more than one pipe at a time several hydrojetters will be necessary. In this case, several platforms, identical to the one shown in sketch B, must be built in the Unit of Decontamination: one for each hydrojetter, positioned parallel to each other or in line. It must be remembered that the cranes must be able to reach all the platforms, the deposition places for contaminated pipes, the decontaminated pipes, the empty and full metallic drums for transport as well as a place for monitoring, identification and characterization of the metallic drums that have been filled.

Evidently a flowchart and accounting including all these stages of the procedure will be kept.

6. Control of Instruments for Measurement and Analysis

1. In principle, the measurement instruments are the GM counters, for they are more sensible and present results already expressed in dose unit and/or dose rate.

They will be used for monitoring the shipment of pipes to be decontaminated, the transport vehicle, as well as the unloading in the decontamination installation shown in sketch A.

They are also used on the rack for monitoring the drum when it has been filled.

2. For decontamination procedures, pancake type monitors will be used and for the wipe test a reading in the pancake counter will be made, and in some samples of interest a spectrometry will be carried out as well as the measurement of concentration of activity in Bq/cm^2.

3. The spectrometry will be performed in laboratories authorized by the official agency, making use of Germanium or Sodium Iodine detectors connected to a multichannel analyzer.

Equipments mentioned in item 1 and 2 will have individual cards with the description of their main characteristics and of everything that is of interest regarding the equipment in question; for example, date of last calibration, date of next calibration, maintenance services performed, where the equipment has been kept and who has been responsible for it since the last calibration, etc.

There must be a surplus equipment to replace the equipment in use when it needs a new calibration or maintenance service.

6.1 Formulary for Measurements

For each type of measurement an appropriate formulary will be used. The only information common to all the formularies are the main characteristics and identification of the entrance of the instrument.

6.1.1 Formulary for the Monitoring of Entrance and Exit of the Plant in the Decontamination Shed. Sketch A and B.

A GM counter will be kept at the reception desk when there is nobody in the plant, together with the formulary appropriate for the situation to be described.

The first individual to enter the plant will perform a measurement of dose at the reception desk and write down its value as well as the date and time of measurement.

A new measurement will be performed when the last individual leaves the plant; he will write down the value, date and time, and will lock the entrance door. The formulary must be left at the reception desk to be filled in by the next to come.

A similar operation will be performed at the reception desk of the decontamination shed.

6.1.2 Formulary for the Monitoring of the Loading of the Contaminated Pipes on the Vehicle

This formulary will require the identification of the transport vehicle, of the lot and of the contaminated pipes, all of which must be in accordance with the initial identification, referred to in the formulary as “identification of lots and pipes”. The date of transport and the times of beginning and end of the loading will also be written down, as well as the dose present in the work environment.

6.1.3 Formulary for the Monitoring of a Transport Vehicle That Has Already Been Loaded

These formularies will obey the requirements of Safe Transport of Radioactive Material of the International Atomic Energy Agency, IAEA [2] rules and a copy will remain in the transport envelope.

6.1.4 Formularies for the Unloading of Contaminated Pipes

This formulary is similar to the loading formulary (item 2 above): writing down the initial radiation dose before loading and after unloading in the work environment.

6.1.5 Formulary for the Transference of the Contaminated Pipes to the Decontamination Shed.

This formulary will have the date and time of the beginning of a transference of one or more of the contaminated pipes, the time of the end of the transference and the respective initial and final doses in the work environment. It will also bring the identification of the lot and of the pipe, according to the initial identification.

6.1.6 Formulary for Decontamination Procedures

Besides the date and time of the beginning and end of the process, the lot and the pipe will be identified and the final identification is done. The decontamination shed will be monitored:

a) Before the arrival of the contaminated pipe;

b) After the positioning and fixing of the pipe for decontamination by high-pressure hydrojetting;

c) During the ultra high-pressure hydrojetting, if it is possible;

d) After the hydrojetting operation when the solid waste goes to the metallic hamper;

e) After transfering the waste to the metallic drum and sealing it.

6.1.7 Formulary for Dose Measurement After Decontamination Procedure

Besides the date and time of measurement, the minimum, maximum and average dose values will be written down, as well as the dose curve of the detector that will run along the pipe on the rack. The final identification of the pipe will also be registered and this procedure will be repeated for other decontaminations, if required, together with the decontamination ratio. Each pipe will be accompanied by an individual copy of this formulary. A copy of this formulary will remain in the plant.

6.1.8 Formulary for the Monitoring of the Sealed Drum Containing Solid Waste

Besides date and time of the sealing of the drum, this formulary will require the identification of the decontaminated pipe or pipes, the identification of the drum, its weight, density and the final result after decontamination of its external surface, if necessary, so as to prove the absence of transferable contamination. This formulary will accompany the identified drum together with the spectrographic analysis made on samples collected ad hoc from the metallic hamper. A copy of this formulary will remain in the plant.

6.1.9 Formulary for the monitoring of the Drum and its Classification

This formulary will inform the doses at different distances and on the drum with the purpose to transport it, identifying its type, that is, exceptive, LSA, etc. Another objective is to determine the concentration of each radioactive isotope, which contributes considerably to the dose, as was presented with further details in the formulary concerning the “Treatment of the waste produced: solid, liquid, sludge”. A copy of the form will accompany the drum another will go to the group of calculations of activity and a third one will remain in the plant.

6.1.10 Formulary for the Monitoring of the Metallic Hamper

After the removal of the decontaminated pipe and the sealed drum from the decontamination shed, the monitoring of the metallic hamper is carried out using the direct and indirect method. The latter makes use of wiping tests and the former uses a pancake counter. The appropriate formulary is fulfilled, identifying the pipe that has produced the waste, dates and time of monitoring and its results.

If the result indicates contamination, decontamination is performed on the spot, and a new monitoring will be carried out. In this case, a new decontamination ratio must be determined. The operation for decontamination can be repeated whenever it is justified. The formulary will remain with the Radioprotection Supervisor.

6.1.11 Formulary for the Monitoring of the Decontamination Shed

After the decontaminated pipe and the sealed drum have been removed from the decontamination shed and the monitoring of the metallic hamper has been performed, direct monitoring of the floor and possibly of the walls of the decontamination shed will be carried out, using the area scrutinizing method. If necessary, the decontamination will be performed and the monitoring repeated. These monitoring and the decontamination ratio will be recorded in appropriate formularies.

6.1.12 Formulary for Monitoring the Transport Vehicle After the Unloading of the Contaminated Pipes

After unloading the transport vehicle it will be transferred to an appropriate place, where the canvas packing the lot of contaminated pipes will be monitored, using the direct method with the help of a pancake counter. If the canvas is contaminated, it will be changed by another one, decontaminated, and the decontamination of the first one is performed.

The canvases utilized in transport are resistant and impermeable in order to facilitate its decontamination. After receiving the decontaminated canvas the vehicle will be liberated for a new transport.

6.1.13 Formulary for Spectrometry

All the samples of solid and liquid wastes, sludge and wiping tests will be duly identified before going to the specialized laboratory that will determine the contaminant radioisotopes of the Uranium and Thorium series and its respective concentrations. This laboratory will provide a formulary where the results are given. Several copies of this report will be made to be sent to several sectors that need them to do its work with accuracy and effectiveness.

7. Control of Waste

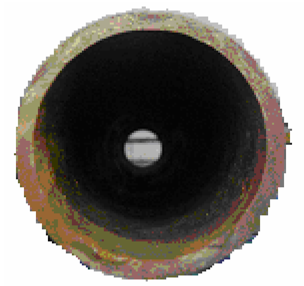
The produced waste can be solid, liquid and sludge.

7.1 Solid Waste

Figures 2 and 3: In these figures we can see a contaminated pipe and a decontaminated one.

Figure 2

Figure 3



The solid waste removed from contaminated pipes will be packed in metallic drums of 200 dm^3 that will be put on a scale so as to have its weight records when they are full or reach one ton. To reach one ton the waste must have a density of 5 g/cm^3 or more, what we believe will never happen.

The activity contained in each drum will be evaluated in three different ways in order to get at a reliable value.

The methods of evaluation used will be:

1) By the concentrations of radioactive material resulting from the spectrometric analysis and by the weight of the drum;

2) By the monitoring of the drum leaned against appropriate surfaces and at convenient distances. Also, in case of necessity, the transport index and other values required for transporting the drum

will be identified. To evaluate the total activity we can make use of the concentration of activity of the radioisotopes resulting from the spectrometry of the samples and weight of the drum;

3) By manual calculations, considering the drum a cylindrical source of density determined by its weight and volume and considering that the radioactive material is distributed uniformly inside the drum. Self-absorption inside the drum itself will be considered in the calculation.

With these three measurements, its reliability will be discussed and the most plausible value will be inferred as well as any possible deviation that could be produced.

7.2 Liquid Waste

During the operation of the pipes decontamination by means of high-pressure hydrojetting there will be a high consumption of water that may be contaminated with radioactive material. This water will be drained from the decontamination place to intercommunicating decanting tanks. Spectrometric measurements of this water will be performed for determining the probable radioisotopes and its concentrations. After the analysis of the results different procedures can be adopted, namely:

a) The result indicates that the concentrations of radioisotopes and its weighed contribution is lower than the exemption value: the water is set free to flow into the normal sewer system of the installation;

b) The result indicates that it can be considered exempt for there is reasonable dilution: in this case, served waters from the installation itself can be used before they are drained into the sewer system.

c) The second option is impracticable because of the huge amount of water needed for liquid waste dilution.

In this case, a chemical treatment is necessary. At first, the radioisotopes causing the biggest problems must be identified so as to enable the identification of possible chemical compounds that could precipitate them and cause them to be collected as solid material or paste. This way the water can be set free by one of the processes described above.

After the elimination of the water that flew into the sewer, the material deposited at the bottom of the decanting tanks will be removed and put into the drums. Then the tanks are washed to avoid fixation of contaminant material. After being washed, these tanks will be monitored by means of a GM counter and, if justifiable, making use of pancake detectors and wiping tests. Contamination material will be immediately removed and treated as solid waste.

7.3 Sludge

If there is sludge, it will float on the liquid waste and can be easily seen in the decay tank of contaminated water. In this case, by the spectrometry made on samples taken from this water we will be able to verify if the sludge can be eliminated with the water. If not, it is collected and put into the metallic drums together with the solid waste.

REFERENCES

[1] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANISATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, WORLD HEALTH ORGANIZATION, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115, IAEA, Vienna (1996).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Regulations for the Safe Transport of Radioactive Material, Safety Standards Series No. ST-1, IAEA, Vienna (1996).