Architectural design of a mobile irradiation unit for the treatment of industrial effluents in Brazil

Lainetti, F. F. [1]; Duarte, C. L. [1]; Somessari, S. L. [1]; Sprenger, F. E.[1]; Feher, A. [1]; Sampa, M. H. O.[1]; Gaspar, R. R.[1]; Fuga, D.[2]; Rodrigues, M.[2]; Calvo, W. A. P[1].

[1] Nuclear and Energy Research Institute, Radiation Technology Centre (IPEN-CNEN/SP)
[2] Truckvan Industry
fabilainetti@usp.br; wapcalvo@ipen.br

Av. Prof. Lineu Prestes, 2242 - ZIP 05508-000,
Sao Paulo, SP, Brazil

Abstract

The Nuclear and Energy Research Institute (IPEN-CNEN/SP) decided to develop and build a mobile beam irradiation unit for the treatment of industrial effluents. The mobile unit will have as one of its main advantages the possibility of treating effluents in the place where the source is located, eliminating costs and bureaucratic problems associated with the transportation of waste, besides publicizing the technology in several places in Brazil. To implement the project, IPEN-CNEN/SP has been consolidating partnerships with national and international companies. The resources for the development of the unit have been supplied by the Brazilian Innovation Agency (FINEP) and International Atomic Energy Agency, financing the IAEA TC Project BRA1035 – Mobile electron beam accelerator to treat and recycle industrial effluents. The Institute hired a specialized company (Truckvan Industry) for the unit design and development. Several meetings have been realized with the company and the IAEA experts aiming the compatibility of the design and the exchange of information necessary for the project development. Regarding the mobile lab, several layout options have been developed to better meet the needs of each device and its users. The layout has been discussed with the objective of facilitating the maintenance of the equipment; the well-being and ergonomics of operators; optimization of spacing and also to make compatible the need for the presence of equipment and space for operators. Thus, several studies have been prepared to allow the discussion between the areas involved and to optimize the project, as well as the visualization of the spaces available. In this paper is presented the approach adopted for the architectural design of a mobile irradiation unit in Brazil.

***Keywords*: Mobile irradiation unit, Treatment of industrial effluents, IAEA TC Project BRA 1035, Electron beam accelerator, Architectural design of a mobile unit.**

1. INTRODUCTION

In the world, there is a growing increase in the demand for water for human consumption, as well as the prioritization of the use of available water resources for public supply. According to the 2010 United Nations Environment Program (UNEP) report, 2 Million ton of sewage from industrial and agricultural waste are dumped into the waterways worldwide. In developing countries, such as Brazil, about 90% of wastewater is dumped untreated into rivers, lakes or oceans. Therefore, it is necessary to adopt strategies that aim to maximize the use of water resources and minimize the negative impacts related to the generation of effluents by the industries. The necessity to preserve the environment as well as the demand for sustainable development has generated various actions by non-governmental groups and changes in legislation in many countries. As a consequence, restrictions have been imposed regarding the release of effluents into the environment. Currently, several technologies are used in the treatment of industrial effluents for recovery and reuse of these waters [1-2].

The Radiation Technology Center at the Nuclear and Energy Research Institute (IPEN-CNEN/SP) decided to develop and build a mobile electron beam irradiation unit for the treatment of industrial effluents. The mobile unit will have as one of its main advantages the possibility of treating effluents in the place where the source is located, eliminating costs and bureaucratic problems associated with the transportation of waste, besides publicizing the technology in several places in Brazil [3].

To implement the project, IPEN-CNEN/SP has been consolidating partnerships with national and international companies [4]. The resources for the development of the unit have been supplied by the Brazilian Innovation Agency (FINEP) and International Atomic Energy Agency, supporting the IAEA TC Project BRA1035 – Mobile electron beam accelerator to treat and recycle industrial effluents. The Institute has associated with a specialized industry (Truckvan) in an innovation project for the unit design and development [5]

Several meetings have been realized with the company and the International Atomic Energy Agency experts, aiming the compatibility of the design and the exchange of information necessary for the project development. This paper presents the approach adopted for the architectural design of a mobile irradiation unit in Brazil [6].

The irradiation system with electron accelerators allows treating different types of effluents. Depending on the effluent, the amount of ionizing radiation energy required for treatment may vary, as well as the amount of treated effluent per day [7]. For the construction of the mobile unit, the estimated cost is about US$ 1.5 Million. The type of treated effluent, the treatment cost per m^3/day and other information regarding the cost of maintenance and operation of the mobile unit are presented in Table 1. All data were obtained from the Business Plan of the Mobile Unit [8-9].

Table 1: Quantities of energy, treatment capacity and costs by type of effluent treated in the Mobile Unit.

Effluent	**Dose (kGy)**	**Amount (m^3/day)**	**Power (kW)**	**Capital cost (Million US$)**	***Variable cost **(Variable and fixed costs) (US$)**	**Cost/m^3 of effluent treated (US$)**
Removal of geosmine (GEO) and methilisoborneol (MIB) from drinking water	1	1,000	20	1.5	0.20 (0.38)	0.60 (1.14)
Removal of industrial textile dyeing from wastewater	2	500	20	1.5	0.20 (0.38)	1.20 (2.28)
Elimination of coliforms from raw sewage, secondary and chlorinated effluents	3	340	20	1.5	0.20 (0.38)	1.77 (3.36)
Removal of organic compounds from petroleum production water	20	50	20	1.5	0.20 (0.38)	12.0 (22.8)
Removal of PCB from transformers oils	50	20	20	1.5	0.20 (0.38)	30.1 (57.1)

* Variable cost only (maintenance, electricity and labor); and
** Both variable and fixed costs (depreciation, bank interest and management).

1.1. OBJECTIVE

The aim of this study is to develop an architectural design of a mobile electron beam irradiation unit at the Nuclear and Energy Research Institute (IPEN-CNEN/SP) in partnership with the Truckvan Industry, which is known to have experience in this business area. Moreover, this study will also design an internal layout of the mobile unit, focusing on the constructive characteristics, on the materials used in the construction and on the specified equipment that will be installed for industrial effluents treatment and samples analysis.

2. RESULTS AND DISCUSSIONS

This study achievement was based mainlyon bibliographic research, mobile unit structures analysis, visits to Truckvan Industry (responsible for the mobile electron beam irradiation unit construction) and exchange information between the company managers and operators involved in the project. Furthermore, alternative materials and equipment were searched and designers consulted to project the laboratory installation. In this project, the priority was to ensure adequate and safe working conditions for operators.

The software used in this project to develop the plant architecture and three dimensions (3D) images of the mobile unit were AUTOCAD, SKETCHUP and PHOTOSHOP. The mobile unit is constituted by a cart, whose cargo compartment contains all the necessary equipment for the treatment of solid, liquid and gaseous wastes by electron beam irradiation.

Differently from other works that have an experimental plan, this study involves the development of a totally new installation project, which requires several studies of spaces and materials alternatives. The architectural work requires innumerous exercises and attempts to find the best layout design.

The idealized project divides the cart in the following modules: a) control room and laboratory for technical and scientific dissemination of the technology; b) industrial electron beam accelerator, hydraulic units, ventilation system, cooler and bunker with irradiation device; and c) transformer and power source supply.

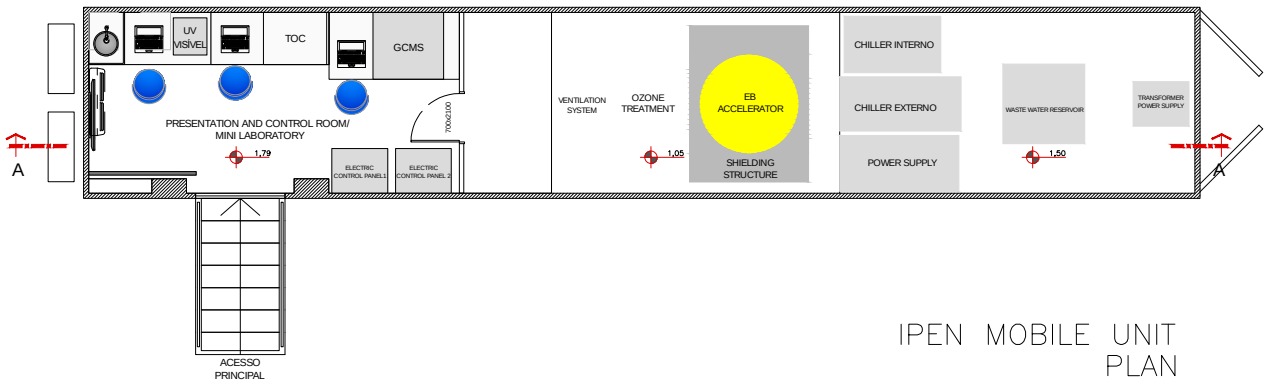
To attend the installation necessities, several distribution trials and volumetric studies were done to optimize the area distribution. At this point was crucial to know all the equipment that would be used for the unit operation, to search mainly for approximate dimensions and weights, and then start the structural design.

Regarding the mobile laboratory, several layout options have been developed to better meet the needs of each device and its users. The layout has been discussed with the objective of facilitating the maintenance of the equipment; operators well-being and ergonomics; space optimization and also to make compatible the need for the presence of equipment and space for operators.

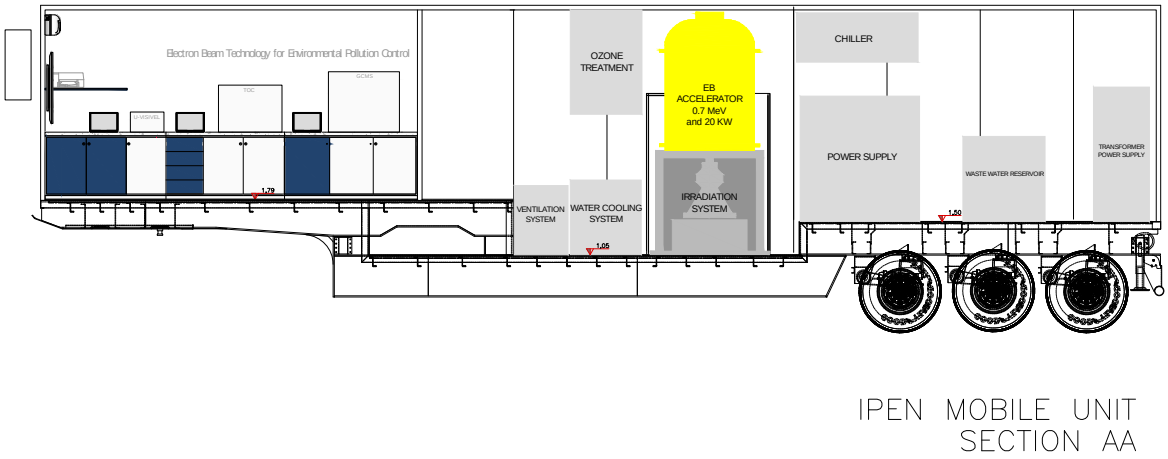
Thus, several studies have been prepared to allow the discussion between the areas involved and to optimize the project, as well as the visualization of the spaces available. In the Figure 1 is shown the architectural design of the mobile electron beam irradiation unit developed by IPEN-CNEN/SP in partnership with Truckvan Industry.

Figure 1. Architectural drawings of the IPEN-CNEN/SP's mobile unit (a) Plan; and (b) section AA.

(a)

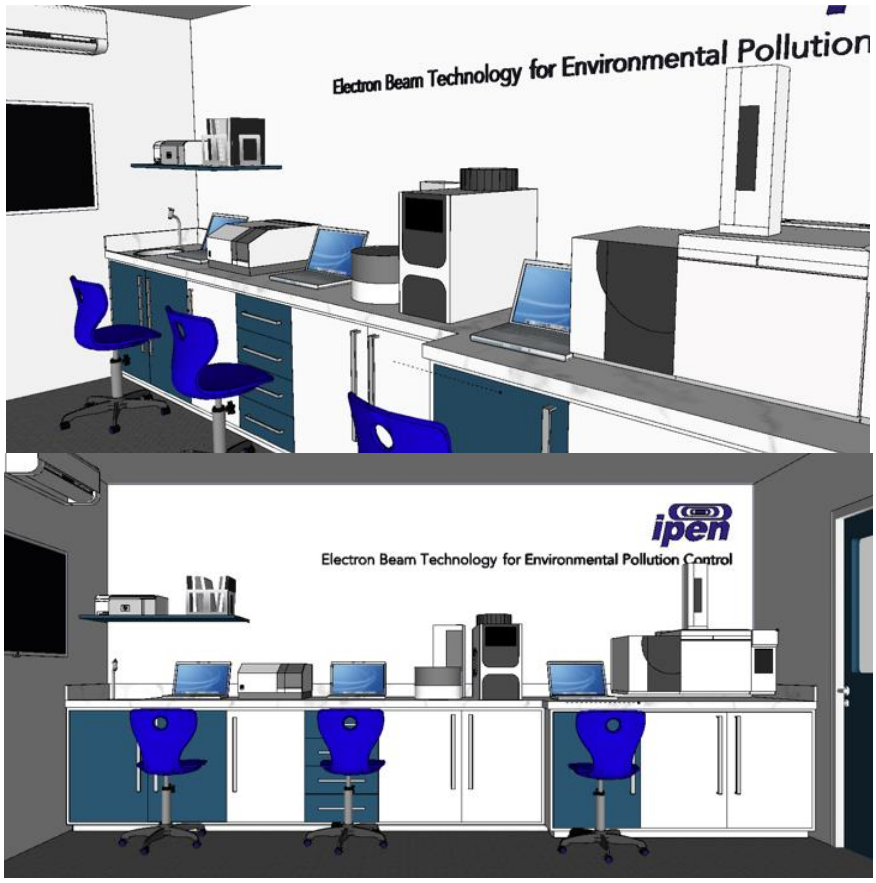


(b)



A 3D model study of the space of the control room and laboratory was done to facilitate understanding. The internal distribution of the laboratory analysis equipment (GC-MS, TOC and UV-Vis) is shown in the Figure 2.

Figure 2. Internal layout of the laboratory analysis equipment with 3D model study.



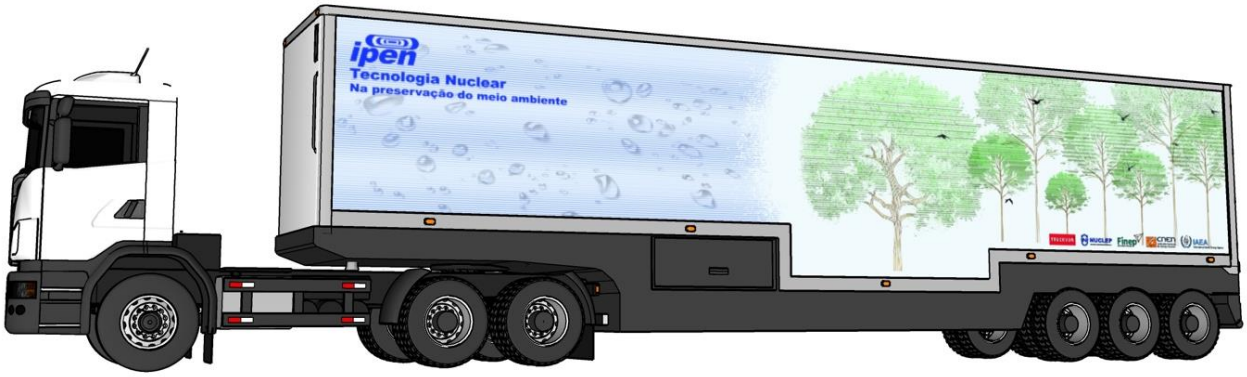
After evaluate the volume and area from all equipment in the mobile unit, it was possible to initiate the truck structural design. This project was performed by the engineers at IPEN-CNEN/SP in partnership with Truckvan Industry.

For the structural design all the equipment were considered, as the laboratory with all the analysis equipment, industrial accelerator, irradiation and shield device, ventilation and cooling systems, hydraulic units, and transformer and power source.After evaluate the volume and area from all equipment in the mobile unit, it was possible to start the truck structural design.This project was performed by the engineer Francisco Sprenger in partnership with Truckvan engineers.

With the truck frame done, it was possible to start building the mobile unit trunk. For the walls and ceiling structure pieces made from duralumin alloy were used, which is composed by aluminum alloy with magnesium, manganese and copper. This alloy is known by resistant characteristics to diluted acids and salt water.The trunk sides were sealed with flat plates of aluminium alloy, with 2 mm thickness. Further, the ceiling were lined with 0,7 mm thickness aluminium alloy plates, with side gutters in the corners and drip edges in a “J” trim format, to facilitate the water flow in to the corners.

All the external finish of the mobile unit was done with a white paint and then, an adhesive was applied to the visual identification. Several adhesive models were designed and the chosen one was the image related with the environment and water, theme that represents better the project, Figure 3.

Figure 3. 3D model of the IPEN-CNEN/SP's mobile unit with the chosen adhesive design.



The colors chosen, the companybrand and institutions logos were carefully allocated and demanded a visual communication research. These topics are extremely important, once this visual information reaches the public instantly and explains the project in a different manner form from textual information.

Inside the mobile unit, polyurethane plates and stone wool were used in the walls and ceiling for thermic isolation. The whole unit ceiling, walls from control room, analytic laboratory and technical-scientific disclosure, which is localized in the front of the trunk, were coated with medium density fibreboard (MDF) plates and white Formica®.In the remainder of the mobile unit, in the place where the heavy equipment are and the place where the industrial effluents treatment will occur, the internal walls were coated with plaid duralumin plates.

All mobile unit floors were built in three layers. The first layer is composed by carbon steel sheet welded throughout the rolling base area. These steel sheets have 3 mm thickness and were treated against rust and then painted in both sides. The second layer is a naval type plywood floor, with 18 mm thickness and the wood is waterproof and fungus resistant. The third layer stays exposed and various types of coating can be used. The flooring chosen was a non-slip plaid duralumin plates.

The structural part of the truck is already built and ready to receive all the equipment that needs to be installed, photos of the mobile unit ready are shown in Figure 4.

Figure 4. Construction of the IPEN-CNEN/SP's mobile electron beam irradiation unit.

3. CONCLUSIONS

The project of the mobile electron beam irradiation unit is not fully completed as some technical information such as the equipment models, dimensions and installation characteristics are required to finish and still need to be confirmed by some manufactures.

The absent equipment are from the radiological shielding (NUCLEP Industry), the industrial electron beam accelerator of 700 keV and 20 kW (EB-Tech, Co. Ltd.), the irradiation device and the activated carbon filter.

This information is essential for the accuracy and precision to finish the internal layout development from the mobile unit, the technical drawings and the architectural design. This high level of accuracy is required, since the mobile unit is an installation with restricted space and all the areas need to be used.

Although the project is not completed, it is possible to confirm that after being built, the new installation will allow IPEN-CNEN/SP to enter into a new and significant range of activity, with a relevant importance for the environment preservation.

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