

# **AUTOMATION SYSTEM FOR QUALITY CONTROL IN MANUFACTURE OF IODINE-125 SEALED SOURCES USED IN BRACHYTHERAPY**

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## **ABSTRACT**

The objective of this work is to develop an automation system for Quality Control (QC) in the production of Iodine-125 sealed sources, after undergoing the process of Laser Beam Welding (LBW). These sources, also known as Iodine-125 seeds are used, successfully, in the treatment of cancer by brachytherapy, with low-dose rates. Each small seed is composed of a welded titanium capsule with 0.8 mm diameter and 4.5 mm in length, containing Iodine-125 adsorbed on an internal silver wire. The seeds are implanted in the human prostate to irradiate the tumor and treat the cancerous cells. The technology to automate the quality control system in the manufacture of Iodine-125 seeds consists in developing and associate mechanical parts, electronic components and pneumatic circuits to control machines and processes. The automation technology for Iodine-125 seed production developed in this work employs Programmable Logic Controller (PLC), step motors, drivers of control, electrical-electronic interfaces, photoelectric sensors, interfaces of communication and software development. Industrial automation plays an important role in the production of Iodine-125 seeds, with higher productivity and high standard of quality, facilitating the implementation and operation of processes with Good Manufacturing Practices (GMP). Nowadays, the Radiation Technology Center at IPEN-CNEN/SP imports and distributes 36,000 Iodine-125 seeds per year for clinics and hospitals in the whole country. However, the Brazilian potential market is of 8,000 Iodine-125 seeds per month. Therefore, the local production of these radioactive seeds has become a priority for the Institute, aiming to reduce the price and increase the supply to the population in Brazil.

## **1. INTRODUCTION**

Prostate cancer occurs when cells within the prostate grow uncontrollably, creating small tumors. The term “cancer” refers to a condition in which the regulation of cell growth is lost and cells grow uncontrollably. Most cells in the body are constantly dividing, maturing and then dying in a tightly controlled process. Unlike normal cells, the growth of cancer cells is no longer well-regulated. Instead of dying as they should, cancer cells outlive normal cells and continue to form new, abnormal cells [1].

Abnormal cell growths are called tumors. The term “primary tumor” refers to the original tumor; secondary tumors are caused when the original cancer spreads to other locations in the body. Prostate cancer typically is comprised of multiple very small, primary tumors within the prostate. At this stage, the disease is often curable (rates of 90% or better) with standard interventions such as surgery or radiation that aim to remove or kill all cancerous cells in the

prostate. Unfortunately, at this stage the cancer produces few or no symptoms and can be difficult to detect [1].

With Low Dose Rate (LDR) brachtherapy treatment, tiny little metal pellets containing radioactive Iodine-125 or Palladium-103 are inserted into the prostate via needles that enter through the skin behind the testicles. As with 3D conformal radiation therapy, careful and precise maps are used to ensure that the seeds are placed in the proper locations. Over the course of several months, the seeds give off radiation to the immediate surrounding area, killing the prostate cancer cells. By the end of the year, the radioactive material degrades, and the seeds that remain are harmless. Compared with external radiation therapy, brachytherapy is less commonly used, but it is rapidly gaining ground, primarily because it doesn't require daily visits to the treatment center.

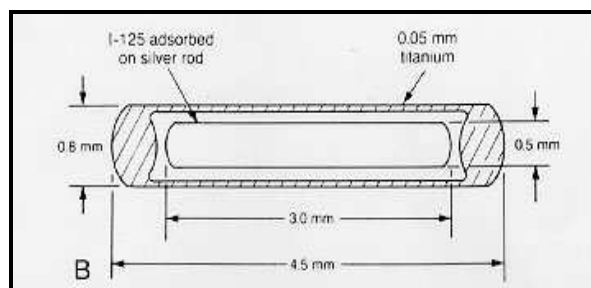
The Iodine-125 seeds are implanted into the human prostate to irradiate the tumor for cancer treatment. Nowadays, the Radiation Technology Center, at IPEN-CNEN/SP imports and distributes 36,000 Iodine-125 seeds per year, for the clinics and hospitals in the whole country. However, the Brazilian market potential is now over 8,000 Iodine-125 seeds per month. The local production of these Iodine-125 radioactive sources became a priority for the Institute, in order to reduce the price and the problems of prostate cancer management. It will permit to spread their use to a larger number of patients in Brazil. On the other hand, the industrial automation plays an important role for Iodine-125 seeds in order to increase the productivity, with high quality and assurance, avoiding human factors, implementing and operating with Good Manufacturing Practices (GMP).

In the Radiation Technology Center, at IPEN-CNEN/SP a methodology was developed for quality control in production process sealed sources of Iodine-125 for use in brachytherapy, which objective of this work and automate this process [2,3].

## 2. MATERIALS AND METHODS

The iodine-125 seeds are placed inside a titanium tube with a 125-iodine adsorbed silver wire; this step follows the sealing of the titanium tube two ends by laser welding,- as shown in FIG. 1 [4,5].

Next, the seeds are sent to glove box 3, where they undergo the quality process, having their surfaces cleaned and tested. If a leak is found in any seeds, they are tested separately in order to identify the fault and consider whether they should be disposed as radioactive waste.



**FIG 1. Iodine-125 radioactive seed produced at IPEN – CNEN/SP.**

The objective of automation is to simplify and streamline the process of quality control in the manufacture of Iodine-125 seeds.

## **2.1 Automated process for testing sealing**

The automation process for Iodine-125 seed testing sealing includes [3]:

- a) Receive the seeds of the welding device;
- b) Separate batch of seeds in a plastic tube;
- c) Wash the seeds( in the batch);
- d) Immerse them into distilled water;
- e) Remove the liquid and measure the activity;
- f) Measure the activity , refuse seeds (still in batch);
- g) Approve seeds, dry and pack them into shields;
- h) Separate rejected seeds and segregate the lot;
- i) Separate each seed in a plastic tube;
- j) Immerse the seed in distilled water;
- l) Remove the liquid and measure the activity;
- m) With the measure of activity, either approve or refuse the seed;
- n) Dry approved seed and wrap it in armor;
- o) Send refused seed to radioactive waste; and
- p) End of the process.

Observation: steps a-h are performed with the batch of seeds; i–p refer to each single seed.

## **2.2 Automation**

Automation is the use of control systems (numerical control, programmable logic control and other industrial control systems), in concert with other applications of information technology, such as, computer-aided technologies (CAD, CAM, CAx) to control industrial machinery and processes, reducing the need of human intervention. In the scope of industrialization, automation is a step beyond mechanization. Whereas mechanization provided human operators with machinery to assist them with the physical requirements of work, automation greatly reduces the need for human sensory and mental requirements as well.

Processes and systems can also be automated. Automation plays an increasingly important role in the global economy and in daily experience. Engineers strive to combine automated devices with mathematical and organizational tools to create complex systems for a rapidly expanding range of applications and human activities. Many roles for humans in industrial processes presently lie beyond the scope of automation. Human-level pattern recognition, language recognition, and language production ability are well beyond the capabilities of modern mechanical and computer systems.

Tasks requiring subjective assessment or synthesis of complex sensory data, such as scents and sounds, as well as high-level tasks such as strategic planning, currently require human expertise. In many cases, the use of humans is more cost-effective than mechanical

approaches even where automation of industrial tasks is possible. Specialized hardened computers, referred to as Programmable Logic Controllers (PLCs) are frequently used to synchronize the flow of inputs from (physical) sensors and events with the flow of outputs to actuators and events. This leads to precisely controlled actions that permit a tight control of almost any industrial process.

Human-machine interfaces (HMI) or computer human interfaces (CHI), formerly known as man-machine interfaces, are usually employed to communicate with PLCs and other computers, such as entering and monitoring temperatures or pressures for further automated control or emergency response. Service personnel who monitor and control these interfaces are often referred to as stationary engineers [6].

An automation system is a precisely planned change in a physical or administrative task utilizing a new process, method or machine that increases productivity, quality, and profit while providing methodological control and analysis. The value of system automation is in its ability to improve efficiency; reduce wasted resources associated with rejects or errors; increase consistency, quality and customer satisfaction; and maximize profit [6].

### **2.3 Programmable Logic Controllers**

Control engineering has evolved over time. In the past humans were the main methods for controlling a system. More recently electricity has been used for control and early electrical control was based on relays. These relays allow power to be switched on and off without a mechanical switch. It is common to use relays to make simple logical control decisions. The development of low cost computer has brought the most recent revolution, the Programmable Logic Controller (PLC). The advent of the PLC began in the 1970s, and has become the most common choice for manufacturing controls. Programmable Logic Controllers (PLCs) have been gaining popularity on the factory floor and will probably remain predominant for some time. Most of this is because of the advantages they offer, as well as:

- Cost effective for controlling complex systems;
- Flexible and can be reapplied to control other systems quickly and easily;
- Computational abilities allow more sophisticated control; and
- Trouble shooting aids make programming easier and reduce downtime.

### **2.4 Ladder Logic**

Ladder logic is the main programming method used for Programmable Logic Controllers (PLCs). As mentioned before, ladder logic has been developed to mimic relay logic. The decision to use the relay logic diagrams was a strategic one. By selecting ladder logic as the main programming method, the amount of retraining needed for engineers and trades people were greatly reduced.

### **2.5 Stepper Motor and Driver**

A stepper motor is a brushless, synchronous electric motor that can divide a full rotation into a large number of steps. The motor's position can be controlled precisely, without any feedback mechanism. Stepper motors are similar to switched reluctance motors, which are very large stepping motors with a reduced pole count, and generally are closed-loop commuted [7].

Driver is an electrical circuit or other electronic component used to control another circuit or other component, such as a high-power transistor. The term is used for a specialized computer chip that controls the high-power transistors in DC-to-DC voltage converters. An amplifier can also be considered the driver for loudspeakers or a constant voltage circuit that keeps an attached component operating within a broad range of input voltages [8].

## **2.4. Supervisory and Data Controls**

SCADA stands for Supervisory Control and Data Acquisition. It generally refers to an industrial control system (computer system monitoring and controlling a process). The process can be industrial, infrastructure or facility. Industrial processes include those of manufacturing, production, power generation, fabrication and refining, and may run in continuous, batch, repetitive or discrete modes. Infrastructure processes may be public or private, and include water treatment and distribution, wastewater collection and treatment, oil and gas pipelines, electrical power transmission and distribution, civil defense siren systems, and large communication systems. Facility processes occur both in public facilities and private ones, including buildings, airports, ships, and even spaceship stations. They monitor and control HVAC, access, and energy consumption [9].

## **3. AUTOMATION PROCESS**

The automation system technology for Iodine-125 seeds production developed in this work was mainly assembled employing:

- Electro-electronic and mechanical components;
- Programmable Logic Controller (PLC);
- Stepper motors and drives;
- Microcomputer, supervisory and interfaces;
- Photoelectric and optical sensors; and
- Distribution systems seeds Iodine-125.

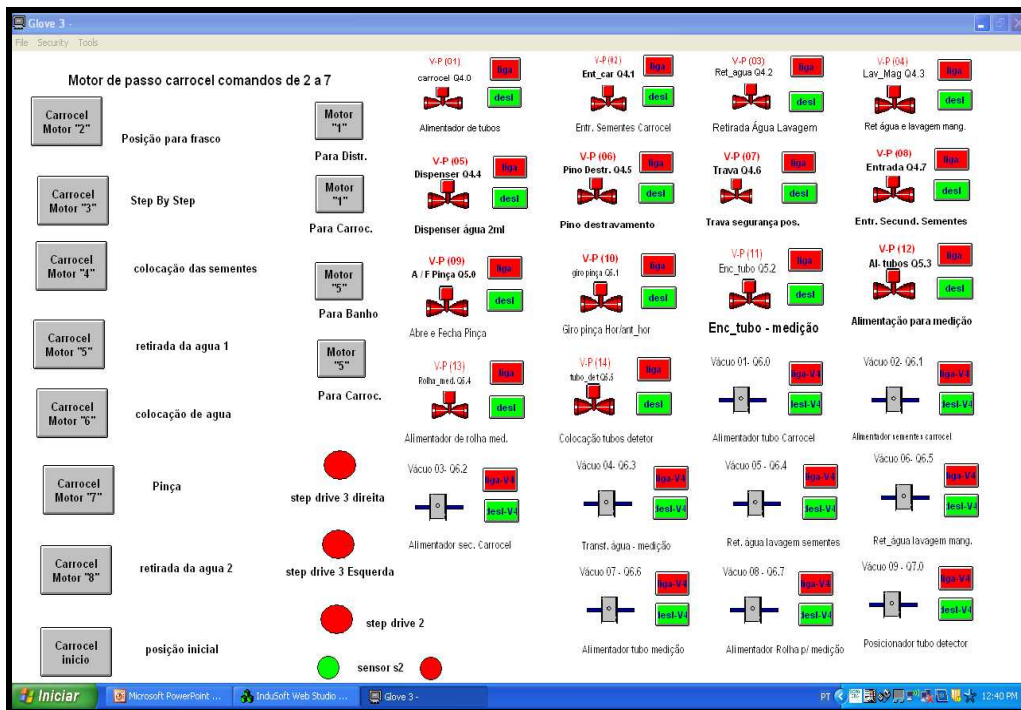
### **3.1. Integrate Hardware and Software**

On the automation system for Iodine-125 seed production developed in this work was necessary to integrate:

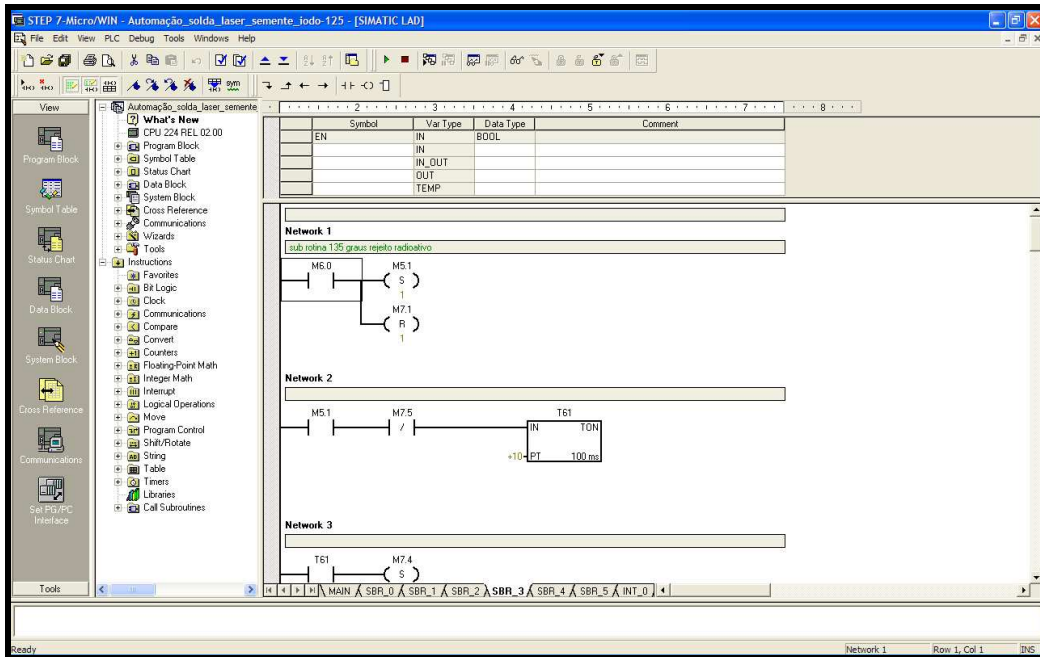
- Electro-electronic and mechanical parts and components (FIG. 2);
- InduSoft Web Studio 6.1 supervisory – computer control [10] (FIG. 3);
- Siemens Programmable Logic Controller (PLC) and Step S7 200 MicroWin 4.0 software [11] (FIG. 4 and 5); and
- Applied Motion drives of the stepper motors [12] (FIG. 6).



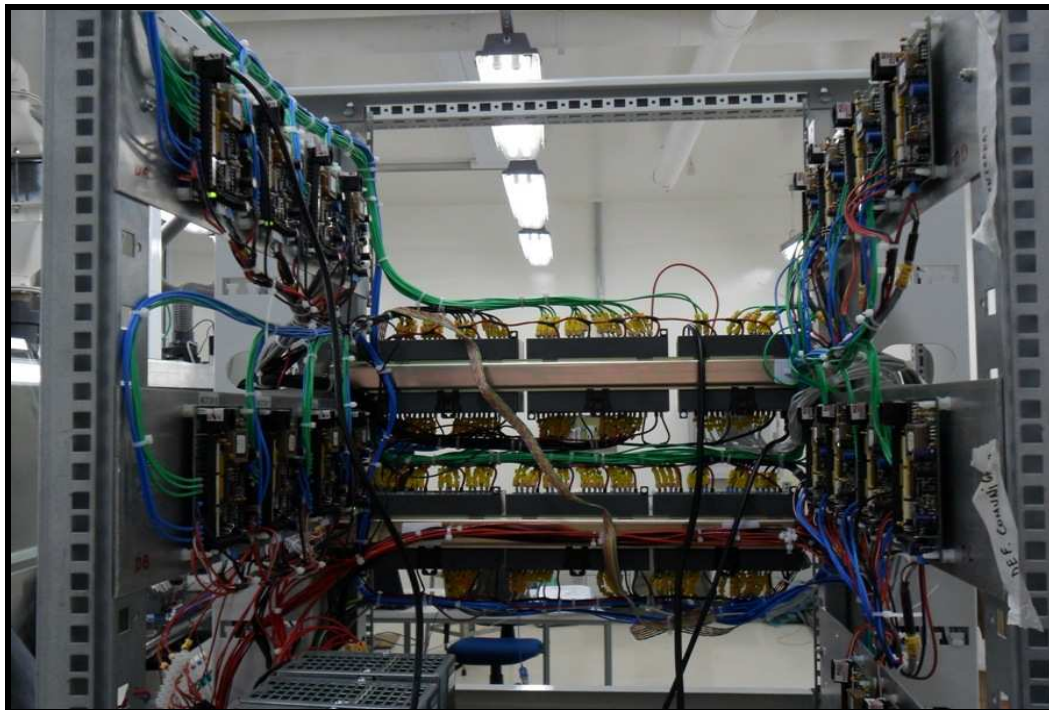
**FIG 2 - Electro-electronic and mechanical parts and components.**



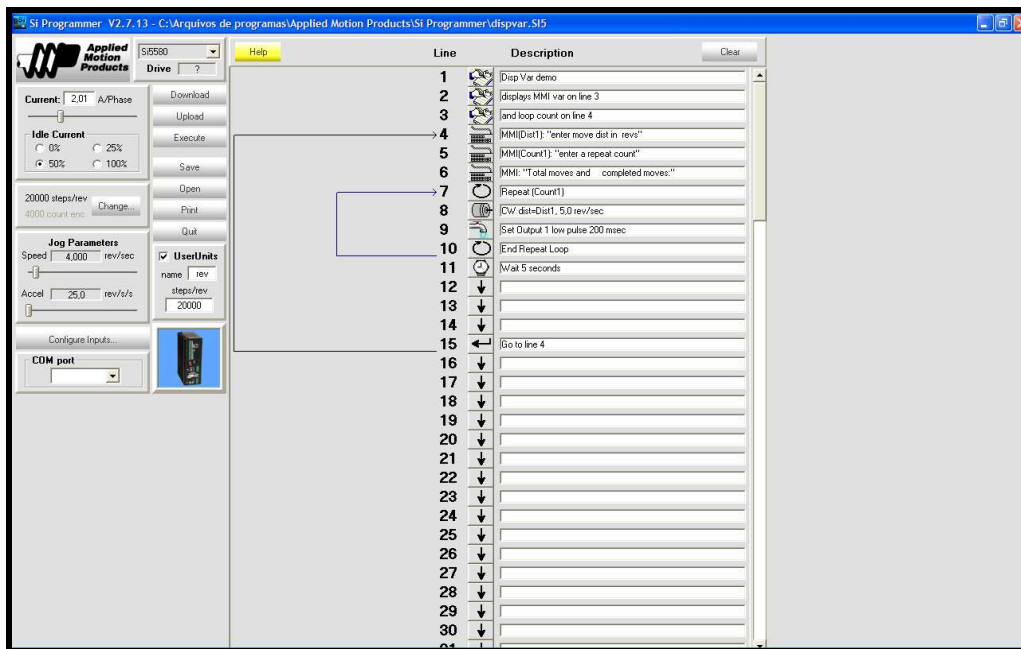
**FIG 3 - InduSoft Web Studio 6.1 supervisory – computer control.**



**FIG 4 - Step S7 200 MicroWin 4.0 software.**



**FIG 5 - Siemens Programmable Logic Controller (PLC) and Step motors driver.**



**FIG 6- Applied Motion drives of the stepper motors.**

#### 4. CONCLUSIONS

The industrial automation plays an important role for Iodine-125 seeds in order to increase the productivity and flexibility, with high quality and assurance, decreasing costs, avoiding human factors, implementing and operating with Good Manufacturing Practices (GMP).

Complex automation systems integrate computer hardware and software, robotic equipment, line equipment, shipping processes, inventory control and employee training to increase manufacturing efficiency and productivity.

Computer software and hardware play an important role in automation systems. Computers control and manage the automation of physical and analytical tasks.

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