Design and Construction of Control System for Radioisotope Production Through Gas Target

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The NIRVAN control system can be used for various Radioisotope production line such as : FDG, Kripton, Iodine, etc, This control system is based on programmable logical controller (PLC) and the communication between the operator and the control system is performed by a personal computer (PC) which is programmed with a Microsoft Visual Basic version, 4.00 for 32-bit window development. In this work the NIRVAN control system was applied to the Iodine 123 production system in NRCAM , Karadj, Iran.

1. Description of the NIRVAN control system

1.1 Programmable logical controller (PLC)

The main part of NIRVAN control system is the PLC which controls all parts of the system and is connected to the switching components, electrical status, and analog signals.

The PLC crate consists of :

- Central processor unit
- Analog input boards
- digital input boards
- digital output boards

All switching components (i.e. pumps, valves, heaters, ...) are connected to the digital output boards.

All electrical status signals (i.e. positions switches, push keys, hardware thresholds, ...) are connected to the digital input boards.

Analog signals (i.e. temperature, pressure, activity,...) are connected to the analog input boards.

1.2 Monitoring

The communication between the operator and the control system is performed by a personal computer (PC) which is programmed with a Microsoft Visual Basic version, 4.00 for 32-bit window development. The operator's commands are entered to the control system Via the keyboard of PC while the status and the process parameters are displayed on the Monitor.

The PC provides a user friendly method of process control and monitoring.

The user program Software for the PLC can be stored on either RAM or EPROM module, whereas the user program software for the PC can be on the Hard Disk Memory.

In case of using RAMs as the storage medium, the memory is buffered by the back-up battery in the central rack of the PLC. If the RAM is unplugged, the user program will be lost.

1.3 Communication with NIRVAN control system

the NIRVAN control System delivers status information on the PC Monitor. For starting an operation, the operator has to enter the desired parameters to the control system Via the PC keyboard whereas the commands are selected via clicking upon the command buttons on the status screen.

2. Production System Operation

All of the operations which have to be done for the routine production of Iodine-123 solution Via the software of the NIRVAN control system are as follows:

1. Automatic mode operation
2. Manual mode operation
3. Production - order operation

2.1 Automatic Mode Operations

this part pertains a schematic view of all routine operation in the right temporary sequence.

The start of Target Evacuation (SOTE) is set at time < 0 >. although the time can arbitrarily be shifted :

Any operation duration strongly depends on some Hard ware parameters (i.e. liquid nitrogen supply , adjustment of vacuum meters, adjustment of position switches , ...) as well as some software parameters (i.e. setting of threshold valves ...)

The operation duration's labeled in the schematic view are the average values.

The total processing time from the first step, the (SOET) and Helium Cooling loop (HCL), to the final production step, the Distribution and Hot cell preparation takes approximately two and half hours without taking into accont the bombardement and decay times . (see figure1)

For all operations, the operator must select the right templates on the monitor. The menu lines are located at the buttom of each template, where the coordinations of the commands are displayed.

In order to exit from the program selection screen (PSS),operator has to click upon the exit button at the top left of the template. However, To exit from any other screens , the operator has to click the program selection button to activate the PSS first and exit accordingly.

2.1.1 Automatic Mode Panel Discription

The Automatic mode template pertains 12 selection panels all to gather that are described briefly below(see figure 2).

a) **Evacuation of target and HCL :** warms up the vacuum pump , and evacuate the gas target assembly as well as the HCL to the preset values. All processes can be monitored simultaneously through the flow diagram which enables the operator to observe and manipulate the processes. (see figure 3).

b) **Gas transfer into Target :** The target is evacuated first, and then by utilizing Cryogenic system the gas transfer takes place. At this stage all parameters can be monitored and controlled on line.

c) **Gas transfer into Storage Bottle 1:** After the gas target irradiation and allowing the decay time, the xenon gas is transferred back to the bottle 1.(see figure 4.a, 4.b).

d) **Gas purification:** The gaseous impurities such as He/N2/... are pumped out from bottle 1.

e) **Target wash out**

f) **Target Drying**

g) **Evacuation of P_2- Trap**

h) **Foil change:** In case of foil breakage, replacement of a new foil takes place.

i) **Load Column:** The pure water is pumped into the I-123 receiver, followed by rising the Cathion and Anion exchanger column.
The above steps are repeated and the residual Iodine-123 is loaded onto the column.

j) **Elute column:** Elution into the vial number 1 takes places.(see figure 5.a, 5.b).

k) **Rinsing Hot Cell**

l) **Irradiation:** At this stage one can control the irradiation process and in case of foil breakage it traps the Xenon gas in the reservoir-via HCL.

2.2. Manual Mode:

In the center of any difficulties with automated mode or in the situation of emergency one can proceed all control stages manually.

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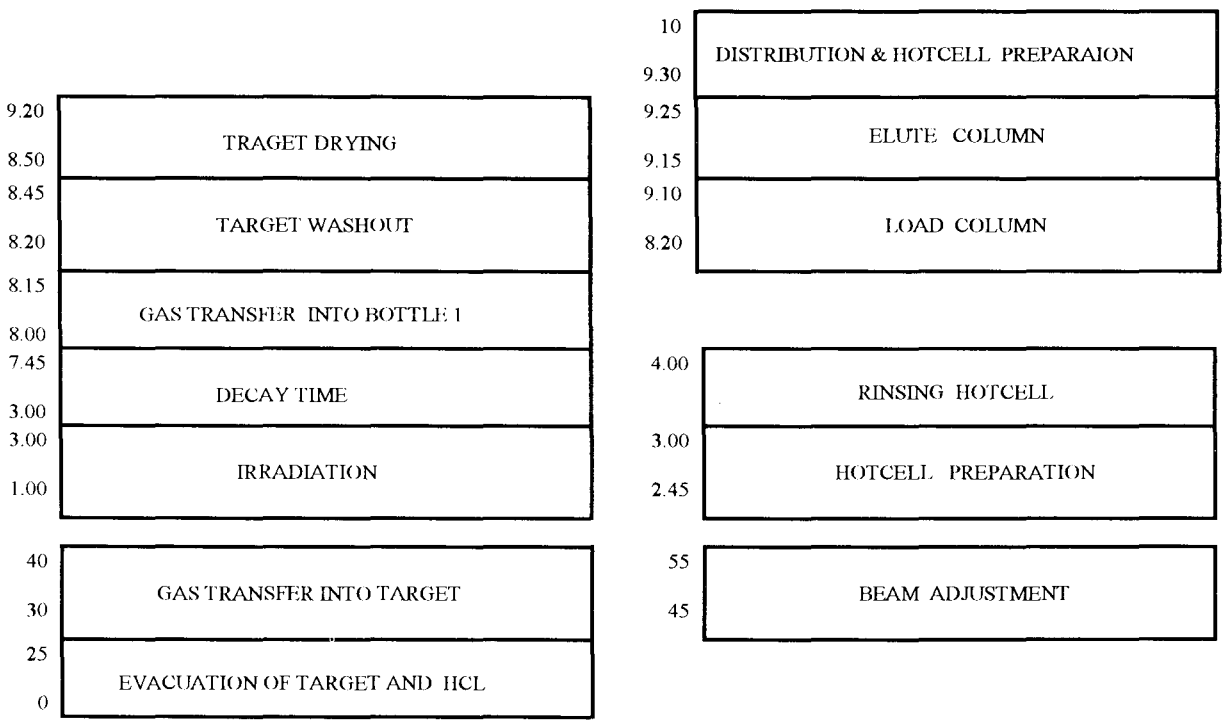

figure1: schematic view of the NIRVAN routine operations

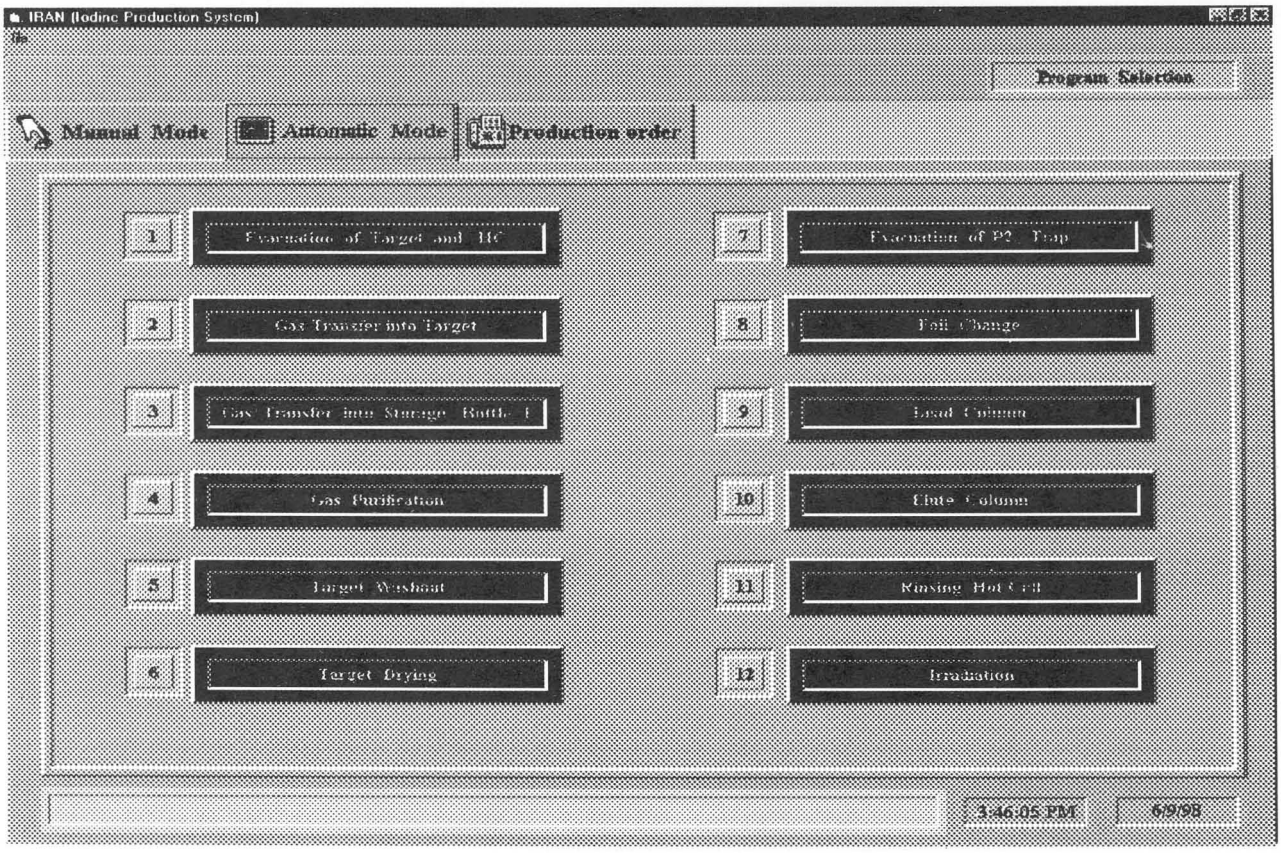

figure 2: Automatic Mode Panel Description

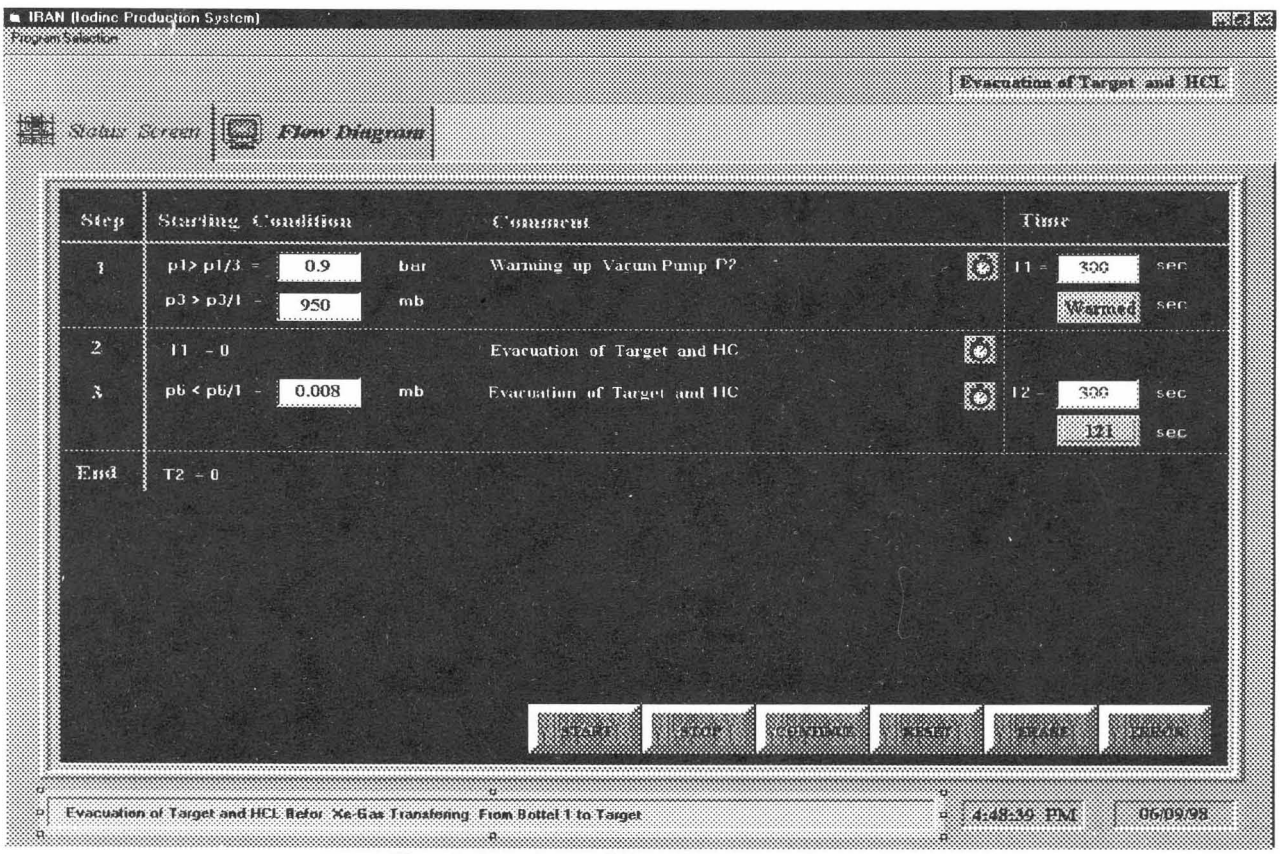

Figure 3: Status Screen of Target Evacuation and HCL

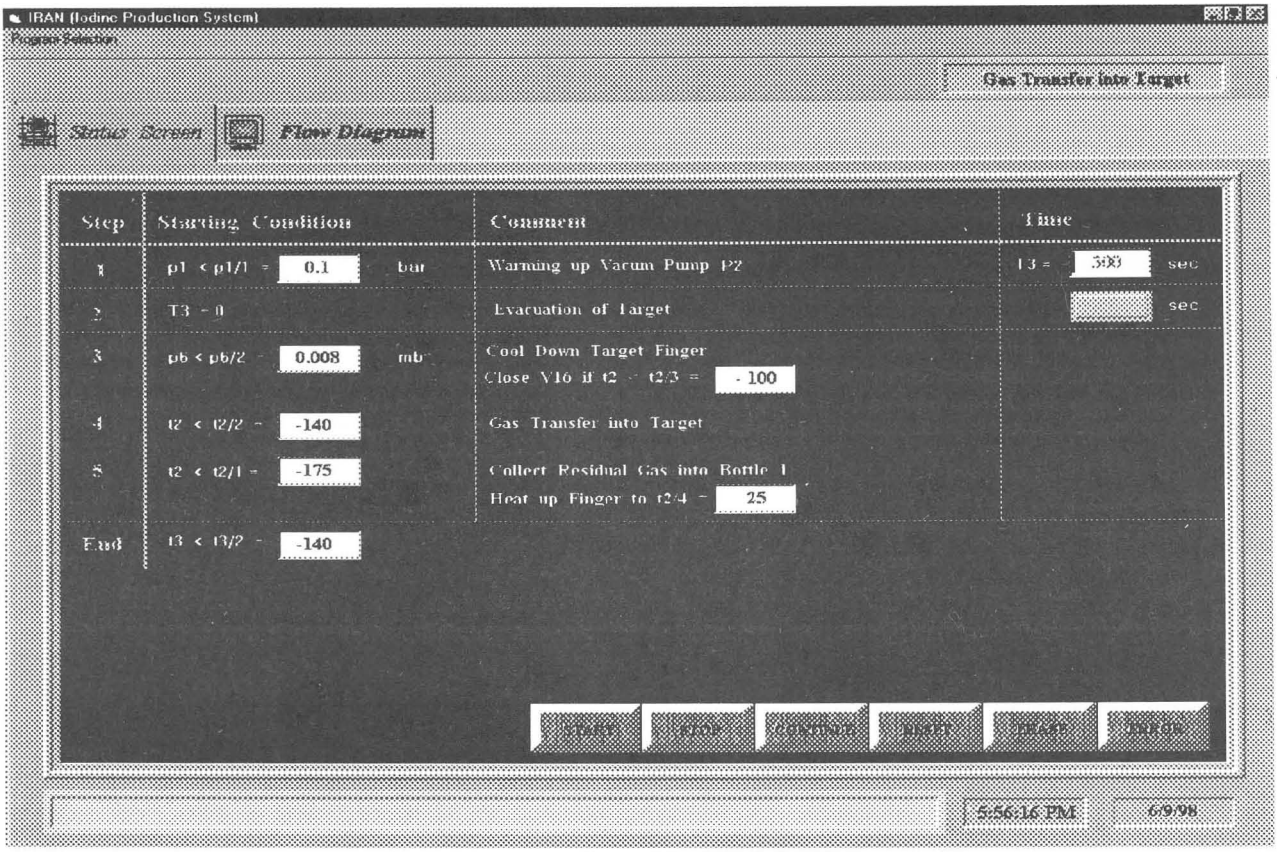

Figure 4a: Status Screen of Gas Transfer into Target

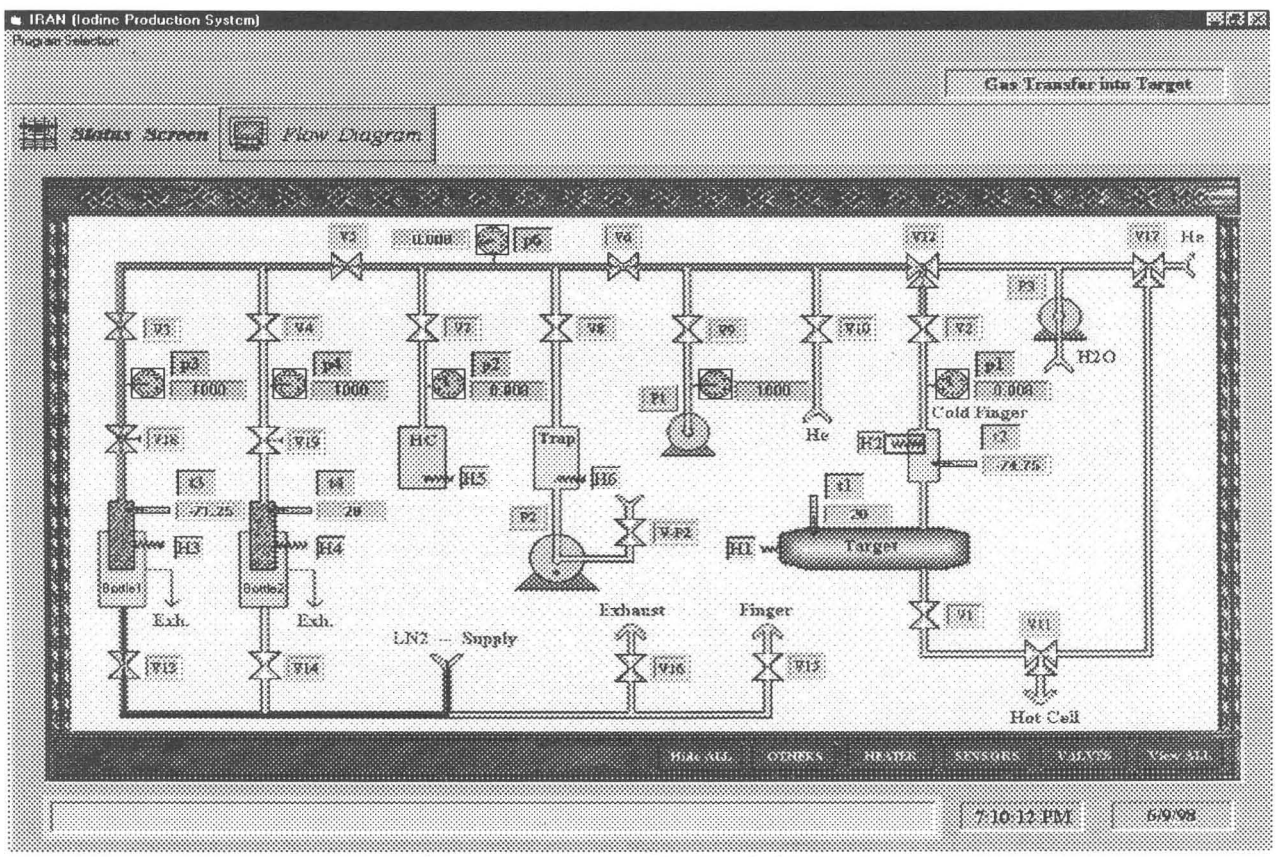

Figure 4b: Flow Diagram of Gas Transfer into Target

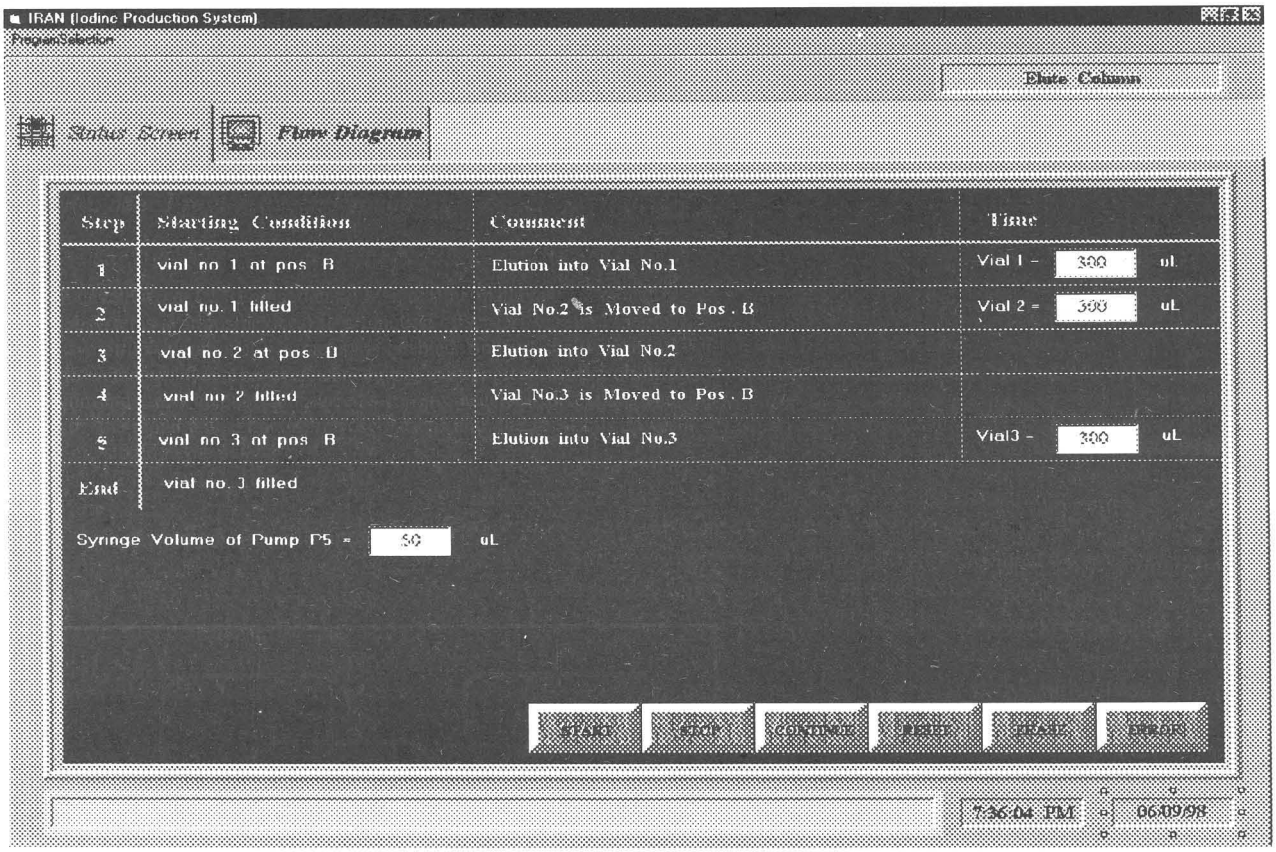

figure5a : Status Screen of Elute Column

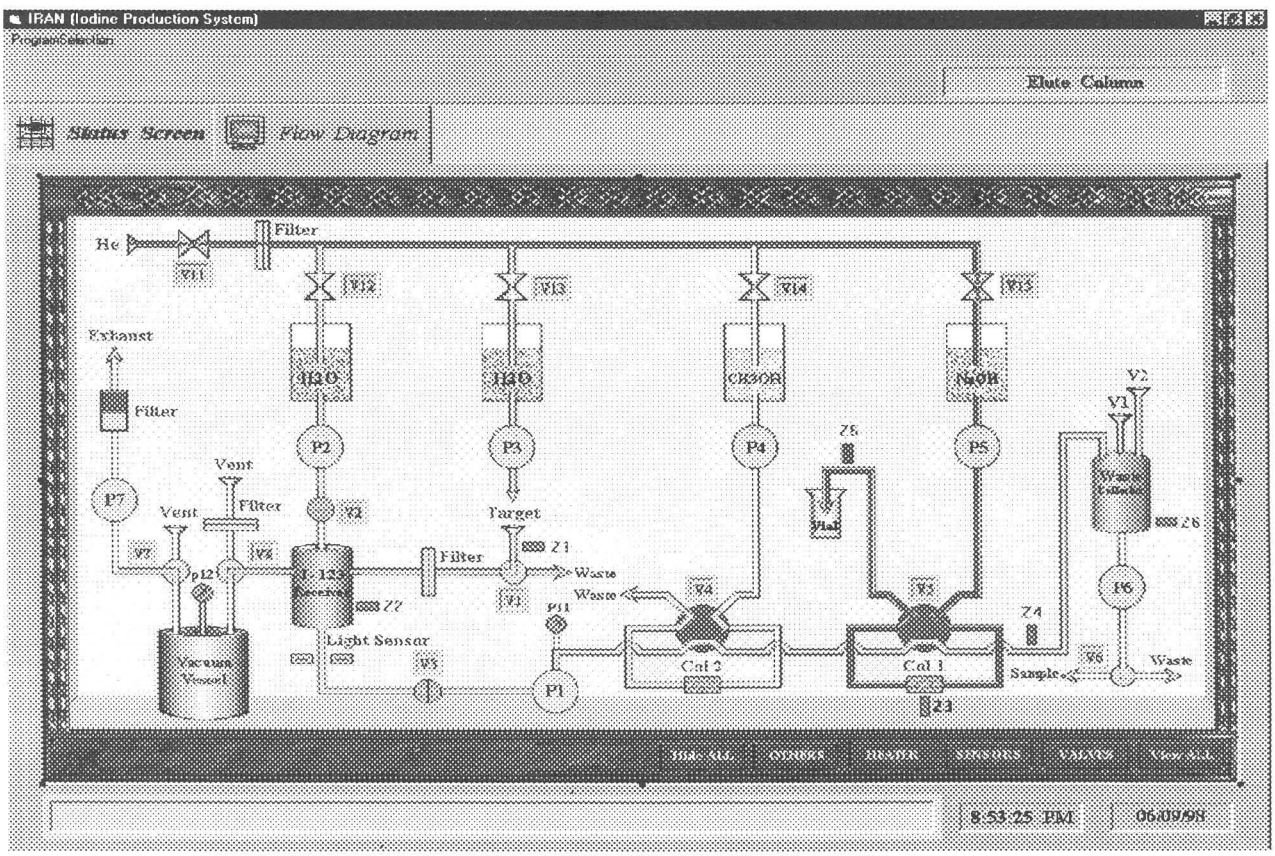

figure5b : Flow Diagram of Elute Column