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Automatic sample changer control software for automation of neutron activation analysis process in Malaysian Nuclear Agency

N. Yussup^{1,a)}, M. M. Ibrahim¹, N. A. A. Rahman¹, M. Mokhtar¹, N. A. A. Salim², S. C. Soh@Shaari¹, A. Azman¹, L. Lombigit¹, A. Azman² and S. A. Omar²

¹Technical Support Division, ²Waste and Environmental Technology Division, Malaysian Nuclear Agency, Bangi, 43000 Kajang, Malaysia.

^{a)}nolida@nm.gov.my

Abstract. Most of the procedures in neutron activation analysis (NAA) process that has been established in Malaysian Nuclear Agency (Nuclear Malaysia) since 1980s were performed manually. These manual procedures carried out by the NAA laboratory personnel are time consuming and inefficient especially for sample counting and measurement process. The sample needs to be changed and the measurement software needs to be setup for every one hour counting time. Both of these procedures are performed manually for every sample. Hence, an automatic sample changer system (ASC) that consists of hardware and software is developed to automate sample counting process for up to 30 samples consecutively. This paper describes the ASC control software for NAA process which is designed and developed to control the ASC hardware and call GammaVision software for sample measurement. The software is developed by using National Instrument LabVIEW development package.

1. Introduction

Neutron activation analysis (NAA) activity has been started in Malaysian Nuclear Agency (Nuclear Malaysia) since 1983 with the establishment of the NAA laboratory, not long after the installation of the only nuclear research reactor in Malaysia, Nuclear Malaysia TRIGA Mark II reactor in 1982 which provides the neutron source for the NAA work [1]. It was set up as part of the reactor utilisation programme to provide elemental analysis needs for the research and training activities in this research centre as well as for other potential users in the country. Since then, the NAA has become a major analytical tool and has been used as a reference analytical technique for elemental analysis, owing to its better accuracy compared to other analytical techniques. In Nuclear Malaysia, the NAA activity is performed by personnel of the Analytical Chemistry Application (ACA) group under the Division of Waste and Environmental Technology.

Most of the NAA processes established in Nuclear Malaysia from sample receiving and preparation to reporting of result as shown in figure 1 are performed manually. These manual procedures carried out by the NAA lab personnel are tedious, time consuming and inefficient especially in sample counting and measurement process. Currently, the NAA Counting Laboratory had only one detector equipped with a commercial automatic sample changer (ASC) which can perform round the clock measurement for only up to 20 samples. However, at present the commercial ASC is broke down and



cannot be operated due to motor problem. Meanwhile, the other seven units of detector system are utilised manually with limited counting hours per day. More radiation is also exposed to NAA personnel during sample handling and manual counting process.

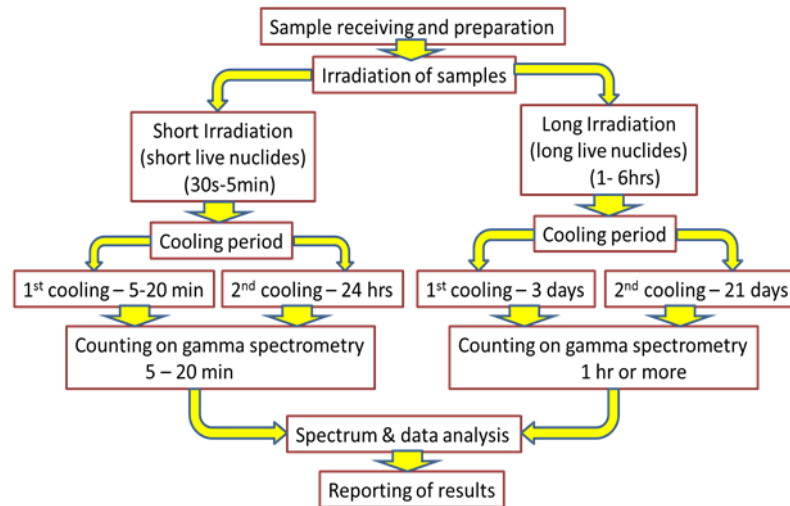


Figure 1. Established NAA procedure.

The purpose of NAA automation system as a whole is to analyse multiple samples efficiently by reducing human intervention during the process from sample preparation stage to computation of elemental concentrations. There are three stages in the system which are sample registration, ASC and sample analysis. The in-house developed ASC consists of hardware as shown in figure 2 and software development. The system itself contains three separate software developments including ASC control software. The other two software programs are Sample Registration Software [2] and Sample Analysis Software. On the ASC part, the control software must communicate via RS-232 communication interfacing with the peripheral interface controller (PIC) microcontroller implemented on the ASC hardware control board as illustrated in figure 3. The main goal of this project is to develop a user-friendly interface in order to automate sample counting process and reduce the human intervention in the NAA laboratory process.

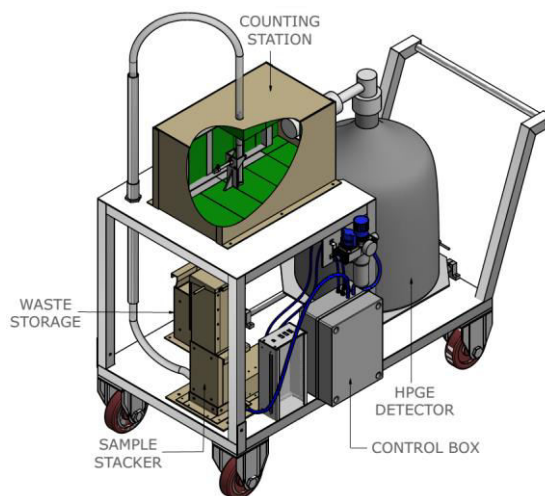


Figure 2. ASC hardware.

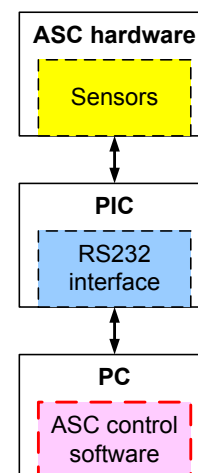


Figure 3. ASC block diagram.

2. Software Development

The ASC control software is developed to control the sample transfer of ASC hardware [3] and initiates the data acquisition process in gamma spectroscopy software. The graphical user interface (GUI) is developed by using National Instruments LabVIEW 2014 development package. VISA functions are used to communicate via serial interfacing of the ASC hardware. File I/O functions are used to create, open, read from and write to files. The controls and functions like String, Array and Structures offered by LabVIEW are utilized in order to develop user-friendly control software.

For data acquisition and sample measurement, the selected gamma spectroscopy software is Ortec GammaVision version 7 since most of the nuclear counting systems at the NAA laboratory are from Ortec and GammaVision version 7 which has several additions and improvements in JOB functions in order to optimize automation process compare to the previous version. Two files are required to run GammaVision software automatically which are .SDF file to setup GammaVision acquisition and analysis setting; and .JOB file to automate the functions. Nuclides library file (.LIB) and calibration file (.CLB) are optional based on user requirement for sample measurement and analysis during the sample counting process.

Prior to the control software development, three steps are identified in the software execution in order to run accordingly as desired. The three steps and the respective main task are as below:

- Initialization: Set acquisition and analysis setting
- Data acquisition settings: Set sample counting sequence and parameters
- Data acquisition status: Run sample counting process

Figure 4 shows the flowchart of the ASC control software execution. The more detailed tasks for each step are shown in figure 5. The software interface and program are designed and developed based on these steps and the tasks.

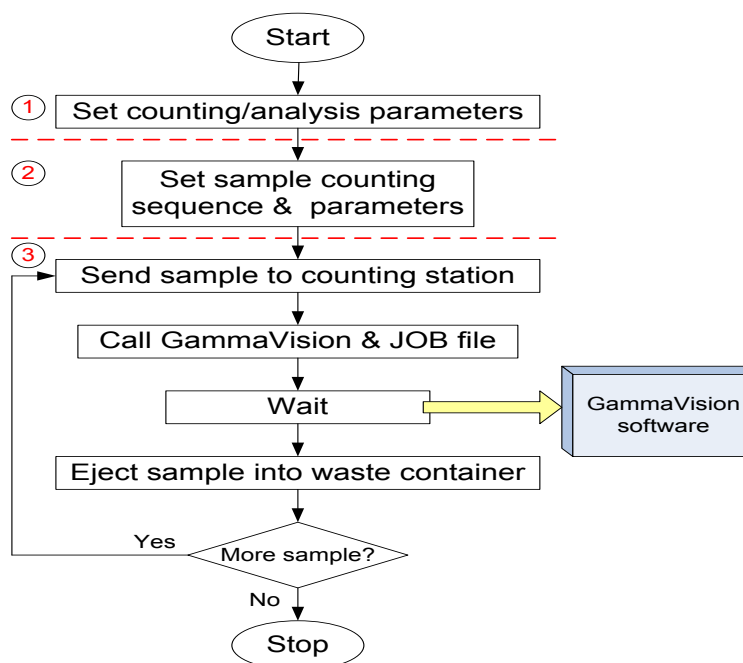


Figure 4. ASC control software flowchart.

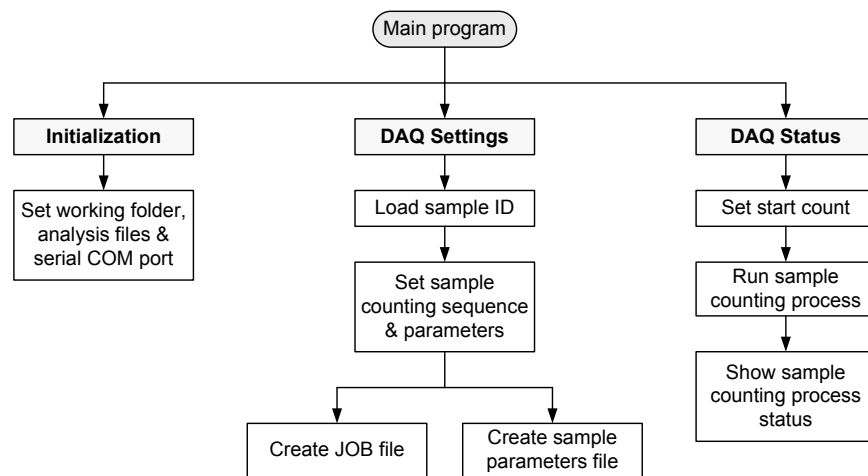


Figure 5. The hierarchy chart of ASC control software development.

The most important task of ASC control software is the sample counting process. This process is performed in the final step of the software execution which is Data Acquisition Status as shown in figure 4 and figure 5. In this process, the ASC hardware mechanism is controlled to change sample one by one and GammaVision spectroscopy software is called for data acquisition of sample count. The data acquisition process is performed by GammaVision by using JOB Control Service where .JOB file for each sample is created by the ASC control software in text file format based on sample parameters entered by user [4]. The .JOB file is called upon by the control software following the sample counting sequence set up by the user. The flowchart of sample counting process is shown in figure 6.

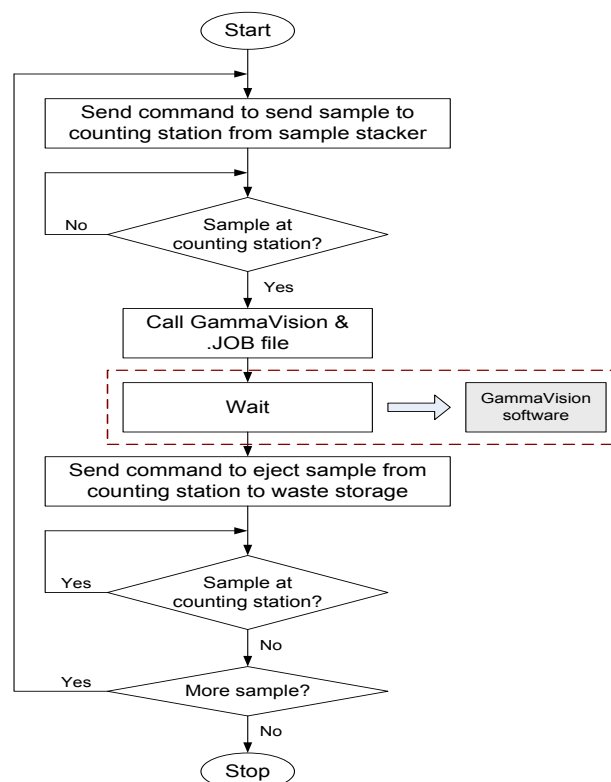


Figure 6. Sample counting process flowchart.

There are six states involved in the design of the sample counting process program including Finish state. The state machine of the program is illustrated in figure 7. During the states of Send Sample and Eject Sample, character 's' and 'e' is transmitted respectively via serial communication to the control box where PIC microcontroller is implemented in order to send sample to counting station and to eject sample from counting station to waste storage of ASC hardware. GammaVision software and .JOB file for the current sample is called by ASC control software during the Sample Count state. Timers with certain delay period are set up for every state transition. The transitions for Sample Ready and Sample Out state are based on a reading of infrared (IR) sensor located at the counting station of ASC hardware. Both states will move to the next state only when they read the desired condition of IR sensor.

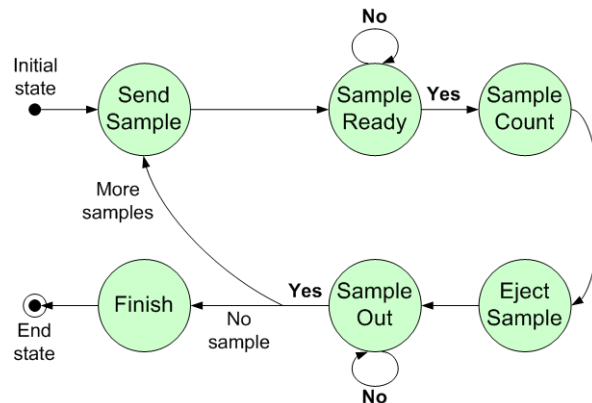


Figure 7. Sample counting process state machine.

The .JOB file is created by ASC control software based on user requirements and standard gamma spectroscopy data acquisition setting performs using GammaVision software during manual handling. The analysis setting is saved in .SDF file which is called by the .JOB file created for each sample during the automation of sample changing and counting process. The flowchart of .JOB file created in the program to be run by GammaVision software is shown in figure 8. The LabVIEW program for calling GammaVision and .JOB file for each sample is shown in figure 9. As mentioned previously, the GammaVision software is called during Sample Count state of sample counting process.

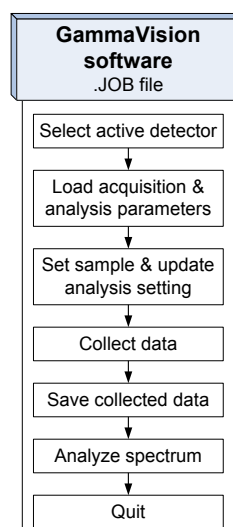


Figure 8. .JOB file function automation flowchart.

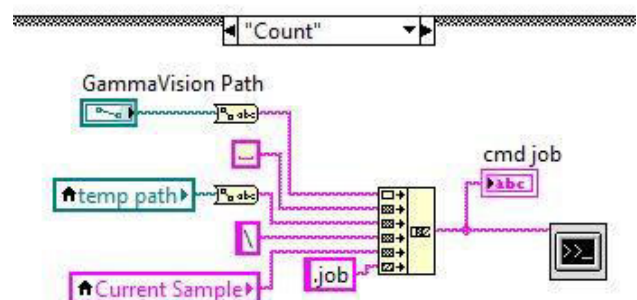


Figure 9. LabVIEW program for calling GammaVision and .JOB file.

3. Results and Discussion

The ASC control software is developed not only to control ASC hardware and automate the sample changing and counting process. It is designed to also capable to load sample ID and the respective weight automatically based on the samples text file created by Sample Registration Software. In counting process, the software ensures output report (.RPT) text file is generated by GammaVision to be read by Sample Analysis Software for sample analysis and reporting purposes. Besides .RPT file, GammaVision software also generates ORTEC spectrum (.AN1) file, spectrum (.SPE) file which is in ASCII format and analysis result (.UFO) file.

The ASC control software is capable to automate sample counting process for up to 30 samples per batch. This limitation is due to the ASC hardware design where only 30 samples are fit into the sample stacker. Each state of sample counting process requires certain amount of delay period which resulted in total delay required for each sample count is 24 seconds. This delay is necessary to write command to control the ASC, read the sensor at counting station and analyse the data. Therefore, the developed ASC can automate sample changing and counting process for up to 23 samples per day for one hour counting live time.



Figure 10. ASC control software GUI.

Each window of the ASC control software shown in figure 10 represents the three steps of the ASC control software execution as described in previous section. On Initialisation window, user has to determine the GammaVision software path, .SDF file that will be used by GammaVision to set the data acquisition parameters, nuclide library (.LIB) and calibration file (.CLB) that can be leaved as default. These parameters will ensure GammaVision software can be called by the ASC control software correctly with the required analysis settings for data acquisition and measurement. Besides that, user is also required to determine the working folder path where the samples text file produced by Sample Registration Software is saved.

On Data Acquisition Settings window, as shown in figure 10(b), the user is required to set up the sample counting sequence along with the parameter for each sample in the sequence. The .JOB file is created and saved in a temporary folder located in the working folder. The final window will show the status of data acquisition process as shown in figure 10(d). During this step, the ASC control software will communicate with the ASC hardware via the serial interface circuit to change sample accordingly and call GammaVision software with the respective .JOB file for each sample to execute data acquisition process. The .RPT files and other measurement files generated by GammaVision are saved directly in the working folder path.

4. Conclusions

The main responsibilities of the ASC control software are setting up sample counting sequence, automate the sample changing process and calling GammaVision software for sample counting process. The software also acts like an interface between Sample Registration Software and Sample Analysis Software to produce comprehensive NAA automation software. Computer serial connection needs to be stable to ensure the reliability of the automatic sample counting process. The software is open for modification and improvement based on the user requirement for sample changing and counting process.

5. References

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