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NASA GRANT NO. NSG1119

"Analysis of Solid-rocket Effluents for Aluminum, Silicon and Other Trace Elements by Neutron Activation Analysis"

(NASA-CR-143208) ANALYSIS OF SOLID-ROCKET EFFLUENTS FOR ALUMINUM, SILICON, AND OTHER TRACE ELEMENTS BY NEUTRON ACTIVATION ANALYSIS Semiannual Progress Report, Jul. - Dec. 1974 (Virginia Polytechnic Inst. and G3/28 N75-28246 Unclas 29873

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Neutron Activation Analysis (NAA) provides an excellent method for non-destructive analysis of very small samples for a large number of trace elements. The proposal, which formed the basis of the current work, involved the use of the facilities of the VPI & SU Nuclear Reactor Laboratory for analysis of samples of rocket effluent collected on filters for a number of elements. In this laboratory, a continuing program for improving the sensitivity and reliability of NAA, has been underway for some time with several thousand samples analyzed annually as a service to the university. However, problem areas needing further study still exist which formed part of the current study.

In a typical reactor, neutrons from the fission process are slowed down by a moderator material, such as graphite or water, until they are in thermal equilibrium with their surroundings in order to increase the possibility of sustaining a nuclear reaction. However, in the normal irradiation positions for samples to be placed in the nuclear reactor, there is a mix of thermal neutrons and incompletely thermalized neutrons. In most cases, in the final analysis where activity in a sample is compared to activity induced in a standard of an element of interest, the presence of an energetically heterogeneous neutron flux causes no problems, but where aluminum and silicons are involved, the presence of fast neutrons and thermal neutrons leads to difficulties in interpreting the data due to the following interactions:

$$\text{thermal neutrons or fast neutrons} + {}^{27}\text{Al} \longrightarrow {}^{28}\text{Al}$$

$$\text{fast neutrons} + {}^{28}\text{Si} \longrightarrow {}^{28}\text{Al} + \text{proton}$$

In both cases the same radioactive nucleus is created, ^{28}Al, which decays by emission of a 1.778 MeV gamma which then is detected by the nuclear counting equipment. There are two different measures which can be taken to distinguish between the two reactions above. The first of these is to activate the samples surrounded by cadmium. Cadmium has the property that only very thin thicknesses are necessary to completely absorb thermal neutrons ($\approx$ 0.75 mm) so that, if only aluminum were present in the sample, ^{28}Al would be formed only by fast neutrons. In the sample irradiation facility at VPI & SU, this takes place for aluminum at approximately 4% of the thermal activation rate. This is not sufficient alone to distinguish between the presence of aluminum and silicon since the transmutation of ^{28}Si to ^{28}Al would not be affected significantly.

In order to fully distinguish between the two elements, one can use a feature of the VPI & SU reactor, which is becoming a feature not always found on other reactors, a thermal column. In this facility, a graphite duct approximately 5 feet square and more than five feet long has been built adjacent to the reactor core. In this duct the moderation of neutrons continues until very few fast neutrons exist among the neutrons at the end of the column furthest away from the core. However, a heavy penalty is paid since the intensity of the neutron flux falls off drastically. For silicon irradiated in this column, virtually no ^{28}Al atoms are produced. Even with a total flux decrease of a factor of 34, quite adequate sensitivity for aluminum quantitative measurements exists. Thus in this scheme, the aluminum results can be based on the thermal column irradiations and silicon values can be inferred from the difference in the initial irradiation and the thermal column irradiation data, taking into account the fast neutron induced activity from aluminum. The results of this technique for aluminum can be quite good, while data for silicon suffers somewhat since the data for this element frequently represent quite small differences between two relatively large numbers when aluminum is abundant.

As part of this work, a thermal column irradiation unit has been constructed and checked during the first 6 months of the grant and initial data appear quite good. A visit was made at this time (in December, 1974) to NASA Langley to meet with Mr. Sentell and others to discuss our progress on the entire analytical program. Data on samples supplied by NASA has been supplied routinely as part of this work for approximately 30 elements for each of the samples. The equipment and data processing procedures appear to be working well although further refinements are continuing to be made.