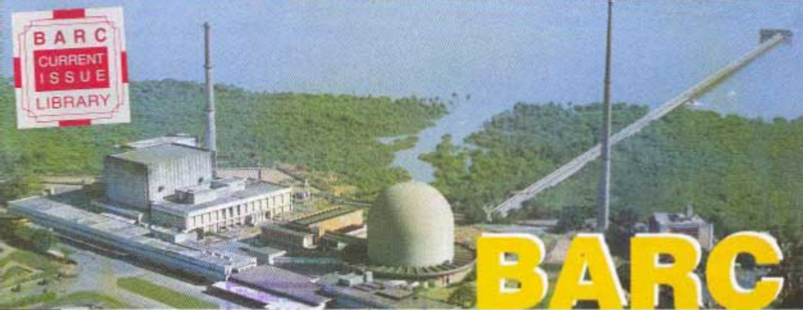


BARC NEWSLETTER

No. 186
July
1999

POST SHOT RADIOACTIVITY MEASUREMENTS ON SAMPLES EXTRACTED FROM THERMONUCLEAR TEST SITE

S.B.Manohar, B.S.Tomar, S.S.Rattan, V.K.Shukla,
V.V.Kulkarni and Anil Kakodkar

The five nuclear tests conducted during May 11-13, 1998 at Pokhran in Rajasthan desert included a thermonuclear device, a standard fission device and three small nuclear devices of subkiloton yields *(1-3)*. In the present report, the results of some of the radiochemical measurements carried out at BARC on samples extracted from the thermonuclear test site are reported.

The type of radioactivity generated in a nuclear explosion depends upon the nature of the device. For example, in a pure fission device the energy is released from fission of the fissile material. A typical fission reaction is given below,

$$^{1}n + ^{239}Pu \rightarrow ^{145}Ce + ^{92}Kr + 3n + Q \qquad (1)$$

Several such fission events occur producing fission products with mass numbers ranging from 80 to 155. A typical mass yield distribution curve is given in Figure 1. The total energy released in a fission event is about 200MeV. One kiloton ($\approx 4.18 \times 10^{19}$ ergs of primary energy release) of yield corresponds to 1.46×10^{23} fission, that is, fission of about 57g of the fissile material. Thus, the yield of a fission device can be determined by measurement of the amount of the fission products in the debris. Over the years, the basic studies on mass and charge distribution in nuclear fission have resulted in very reliable data on fission yields *(4)*.

Contents

EDITORIAL

India detonated five nuclear devices, including a thermonuclear device, during May 11-13, 1998 at Pokhran in Rajasthan desert.

Preliminary studies of crater formations at the test site and analysis of seismic signals recorded at seismological observatories world-wide have shown that the total yield of the five detonations was around 60 kT. (BARC Newsletter, No. 172, May 1998).

Recently, radiochemical measurements were carried out at BARC on the samples extracted from the thermonuclear test site at Pokhran, and the result of these measurements also proved that the yield of the thermonuclear device was 50 ± 10kT, which is in close proximity to the estimated value of 45kT. In the feature article in this issue, S.B. Manohar et al. discuss some of the procedures adopted for the radiochemical analysis of the samples as well as the calculation of the yield.

Organophosphorus metal extractants find wide application in nuclear, base and precious metal industries. Di-2-ethyl-hexyl-phosphoric acid (D,EHPA) is a highly effective metal extractant, commercially used in the hydrometallurgy of cobalt, nickel, copper, zinc, rare earths and transuranic elements. BARC has developed a novel process for synthesising technical grade D,EHPA with a yield of ~ 98% at a relatively low cost. The process was successfully implemented at Heavy Water Plant, Talcher, for industrial scale production of D,EHPA.

People all over the world are worried whether the Y2K problem posed by the computer systems and their applications will jeopardize the smooth transition of economic, social, scientific and industrial activities into the next millennium. Umesh Chandra and A.K. Chandra discuss how the problem is being tackled in BARC. A Y2K Task Force has been constituted by Dr Anil Kakodkar, Director, BARC, to spread awareness, compile an inventory of all susceptible equipment, systems and software, carry out a detailed assessment for Y2K vulnerability, execute remediation wherever required and prepare contingency plans.

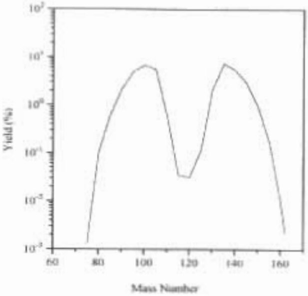


Fig 1. Fission product mass distribution

Table 1 gives the relevant nuclear data on fission products used in the present measurements.

Table 1
NUCLEAR DATA OF FISSION PRODUCTS

Nuclide	Halflife (Days)	Eγ (keV)	Iγ (%)	Expected Activity at zero time (kCi/kT)
^{95}Zr	64.02	724.2	44.15	20.0
		756.7	54.50	
^{103}Ru	39.26	497.07	91.00	49.0
^{106}Ru	371.59	621.9	9.93	5.6
^{137}Cs	10957.3	661.6	85.20	0.19
^{141}Ce	32.50	145.44	11.10	4.2
^{144}Ce	284.90	133.54	99.98	3.4

In a fusion reaction, the energy is released from fusion of hydrogen isotopes such as D and T, e.g.,

$$D + T \rightarrow {}^{4}He + {}^{1}n + 17.5\ MeV \qquad (2)$$

Usually the high temperature (10^8 °K) needed for such a reaction is achieved by a fission trigger. The thermonuclear device tested at Pokhran used a fusion boosted fission trigger. One kT of fusion yield corresponds to 1.5×10^{24} reactions which corresponds to fusion of 2.47 moles each of D and T. The number of neutrons produced during fusion is same as the number of fusion reactions and about 4 to 5 times more than that produced in fission reaction to produce the same energy release. The high energy (~14 MeV) neutrons produced in the above fusion reaction induce nuclear reactions of the type (n,2n), (n,p) and (n,α) in the surrounding rock mass and construction materials and thus form the characteristic signature of such an event. Table 2 gives the relevant nuclear data of 14 MeV neutron activation products measured in the present investigations.

Table 2
NUCLEAR DATA OF ACTIVATION PRODUCTS

Nuclide	Half life (Days)	Reaction	Cross section (mb)	E_γ (keV)	I_γ (%)
^{46}Sc	83.81	$^{46}Ti(n,p)$	290	889.28	99.98
^{54}Mn	312.2	$^{55}Mn(n,2n)$ $^{54}Fe(n,p)$	855 350	834.83	99.98
^{58}Co	70.92	$^{59}Co(n,2n)$ $^{58}Ni(n,p)$	655 410	810.77	99.50

ASSESSMENT OF YIELD OF THE THERMONUCLEAR DEVICE

Introduction

An underground explosion is carried out at a sufficient depth to avoid any radioactive contamination even at ground zero. The explosion creates a cavity above which a chimney is formed. The total energy of the reaction is released in less than a microsecond causing a tremendous rise in temperature as a result of which a large amount of material gets melted and evaporated. The gas expands in a few milliseconds and exerts great pressure on the surrounding walls. Thus, a cavity is produced in few tenths of a second. As the cavity expands, the internal pressure decreases and the molten material flows towards the bottom of the cavity forming a puddle (high activity zone). The fractured rock pieces having sizes varying from few microns to few centimeters fall into the molten puddle and start solidifying forming an inhomogeneous mass. The true molten portion of such a material has a glassy structure, mainly because of large amount of silica present in the rock, while even the adjacent portion may have a porous structure due to fine rubble particles which get embedded in this glassy material extracted from the test site. Figure 2 is a photograph of one

Fig 2. Photograph of a typical rock sample

such core sample. Radiochemical methods of determining the yield of the device involve measurement of radioactivity in the samples retrieved from this region. Several measurement strategies involving estimation of fission and fusion reactants, different fission and activation products and their daughter products are used to estimate the yield. It is also essential that a large number of samples be analysed to obtain the pattern of the distribution of these activities and, wherever necessary, evolve a method of integration to obtain the overall activity produced since any small sample taken in this puddle can hardly be expected to be a true representative of concentrations which can be related to the yield. What is reported here is one such methodology.

Methodology

The measurements consist of drilling and sampling, radiochemical measurements of radioactivity of fission and activation products and calculation of the yield.

Drilling and sampling

Drilling operations at the site of explosion were started within a few weeks of the event. These will be reported separately. Samples from drilling at the site of thermonuclear test were brought to BARC after initial measurements at the site. Samples from the near surface showed no radioactivity indicating complete containment of radioactivity from the explosion. Some of the samples at lower depths were very active giving gamma dose in the range of several mSv and hence had to be transported in well shielded boxes.

Radiochemical measurements of radioactivity

In order to take care of the expected inhomogeneity of the rock samples, about 100g of samples were ground to powder with a mesh size of less than 164 micron. In view of the large variation in the level of radioactivity, three different types of samples were prepared and assayed using high resolution gamma-ray spectrometry. These include (a) 25-30 g samples in a standard counting vial, (b) 100-200mg samples in the form of thin disc source, and (c) dissolution of a known amount of the powdered samples and assay of an aliquot (standard 5ml volume). In order to confirm the noninterference of gamma rays, radiochemical separations on a few selective samples were also carried out for measurement of activity of Zirconium, Cerium and Cobalt. The results obtained by all the four methods were found to agree within the experimental errors (5-7%).

For the gamma-ray spectrometric measurements, a well shielded 100 CC HPGe detector coupled to a PC based 4K MCA system was used. The resolution of the detector was 2.0 keV at the 1332 keV gamma-ray peak. Efficiency calibration of the system was carried out using ^{152}Eu activity and the multiple standards were prepared in the required geometry. The efficiency (ε) was fitted to a polynomial of the form, $\ln(\varepsilon) = a + b.\ln(E_\gamma) + c.(\ln(E_\gamma))^2$. The efficiency values were checked periodically. The counting times for the samples varied from 20Ksec to 100Ksec so as to achieve good counting statistics (better than 1%). The peak areas of the photopeaks were obtained by the peak fitting program SAMPO as well as Fourier Transform based DSP software developed in Radiochemistry Division *(5)*. The absolute activity (A) of a radioisotope was expressed as Bq/g as on May 11, 1998 and was obtained using the formula,

$$A\ (Bq/g) = PA.\ e^{\lambda t}/(T.\ \varepsilon.\ I_\gamma.\ w) \qquad (3)$$

where PA = photo peak area of the gamma-ray peak
T = counting time in seconds.
I_γ = branching intensity of the gamma-ray
w = weight of the sample in grams.
λ = decay constant of the radioisotope
t = decay time

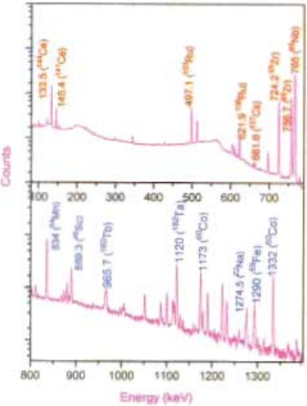


Fig. 3. Gamma-ray spectrum of a typical sample of thermonuclear test

Figure 3 gives the gamma-ray spectrum of a typical sample indicating the gamma-ray peaks due to fission and activation products. The measured radioactivities of fission products were used to arrive at the number of fission per gram of the sample using the appropriate fission yields. Though the activities were measured for all the fission products listed in Table 1, the fission per gram was obtained from the activity data of ^{95}Zr and ^{144}Ce. These are high yield fission products, are refractory in nature and do not have gaseous precursors which can escape (like ^{137}Cs), or form volatile compounds (like $^{103,106}Ru$). The number of fissions/gram (F) as a function of the height for these two nuclides is plotted in Figure 4. Both the nuclides give the identical distribution pattern indicating the overall reliability of the measurements.

Calculation of Yield

Figure 4 shows a large variation in number of fissions in the vertical direction.

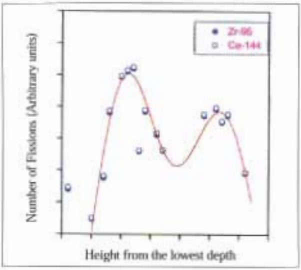


Fig 4. Depth profile of fission products

In order to obtain the total number of fissions, it is necessary to devise a method of integration. The radius of the crush zone was obtained from the drilling data and was found to be about 60 m. This gave an estimate of the cavity radius (Rc) as 40 ± 4 m. The early samples from the recent drilling operations at a position 32 m away from the earlier position showed nearly same level of radioactivity indicating that the Rc is positively more than 32m. The total number of fissions (TF) was obtained by integrating the fitted curve (Figure 4) over the entire active zone . This integration was carried out using the following equation,

$$TF = \int_0^H F\pi R_c^2 h\rho dh \qquad (4)$$

where ρ is the density of the material.

As stated earlier, the signatures of the fusion reaction are activation products due to 14 MeV neutrons, such as, ^{54}Mn, ^{22}Na, ^{58}Co, ^{46}Sc, as marked in the gamma-ray spectrum (Figure 3). The estimation of 14 MeV neutron yield from the measured radioactivity of these products requires the knowledge of the amount of the target elements present at the site of the event and the reaction cross sections. The two major radionuclides which could be assayed in most of the samples were ^{54}Mn and ^{46}Sc. Although the fission neutron spectrum has a high energy tail, the total number of neutrons produced by fusion fraction being much larger, the majority of the high energy neutrons can be attributed to fusion neutrons.

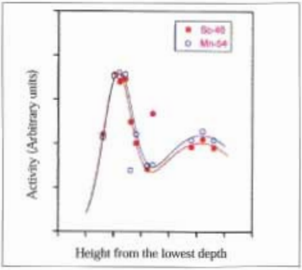


Fig. 5. Depth profile of 14 MeV neutron activation products

Figure 5 shows the profile of the activity of these 14 MeV neutron activation products. The total activity of ^{46}Sc and ^{54}Mn was obtained by integration procedure as that for the fission products. In order to obtain an estimate of the yield of the fusion part of the thermonuclear device, the measured activities of these products were compared with the calculations based on the Monte Carlo simulations *(6)*.

The two main factors determining the amount and nature of radioactivity generated in the rock are: i) the chemical composition of the rock, and ii) the number and energy of neutrons escaping from the device. Monte Carlo simulation of the activity of radionuclides formed by reactions, such as (n,p), (n,2n), (n,γ), etc., were carried out, with certain assumptions (a) about the number of neutrons escaping from the device, and (b) that the number of neutrons absorbed in any element is proportional to the weighted cross section of all constituent isotopes for both the thermal and fast neutrons. The integrated yield following the methodology described above is estimated to be 50kT.

Error analysis

The possible sources of error in the measurement of fission yield are : assay of radioactivity (5-7%); nuclear data such as half life, gamma-ray branching intensity and fission yields (8%); and the error in integration which arises mainly due to the error in Rc (15%). In the assessment of fusion yield, the sources of errors are uncertainty in the elemental composition of the surrounding rock and its effect on the neutron spectrum used in the Monte Carlo simulations of the activity. The propagation of these errors leads to an overall error on the measured yield which is around 20%. Thus it is concluded that the total yield of the thermonuclear device is 50 ± 10 kT.

Acknowledgement

Authors wish to express their gratitude to Dr R. Chidambaram for his keen interest and encouragement during this work. The authors acknowledge with thanks the contribution of Dr.S.K.Sikka and Mr. D.S.C.Purushotham in these assessments. The authors would also like to express their thanks to Dr A.V.R. Reddy, Dr A.Ramaswami, Dr A.Goswami, Dr A.G.C.Nair, Mr. S.P.Dange, Mr R.N. Acharya, and other colleagues from Radiochemistry and Fuel Chemistry Divisions who have contributed in these measurements.

References

1.S.K.Sikka and Anil Kakodkar, *BARC Newsletter* No. 172, May 1998.
2.S.K.Sikka, Falguni Roy, G.J.Nair, V.G.Kolvankar and Anil Kakodkar, *BARC Newsletter* No. 178, Nov. 1998.
3.S.K.Sikka, Falguni Roy and G.J.Nair, *Current Science*, 75, 486 (1998).
4.B.F. Rider, 'Compilation of Fission Product Yields', NEDO-12154-3 ©, 1981
5.S.S.Rattan and V.K.Madan, BARC Report E-038 (1994).
6.V.K.Sharma, Private Communication.

BARC PROCESS HELPS IN INDUSTRIAL SCALE PRODUCTION OF D_2EHPA

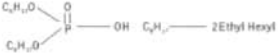
U.R. Marwah, J.N. Sharma, P.M. Sakhalkar, D.K. Bose and C.K. Gupta
Solvent Development Section
Uranium Extraction Division, Materials Group

Introduction

The property of phosphorus to extend high-coordination sphere due to vacant 'd' orbitals renders it one of the most eligible candidates for tailoring a variety of useful organic derivatives that find extensive commercial applications. The wide choices available in structural parameters and stereospecificity in organophosphorus compounds open up the possibilities of tailor-making the organophosphorus solvents of desired characteristics which has resulted in stimulating research into their structural properties and synthesis. Organophosphorus solvents are one of the largest family of metal extractant used in hydrometallurgical applications and play a vital role in nuclear fuel cycle.

In view of the wide range of applications of these metal extractants in nuclear, base and precious metal industries, and due to their nonavailability in the country, Solvent Development Section, Uranium Extraction Division, Materials Group, BARC, undertook development of technologies for the synthesis of various organophosphorus metal extractants which are of immediate interest to Department of Atomic Energy. In the meantime, Heavy Water Board, in its search for various technologies for diversification in order to utilize the infrastructure available at Heavy Water Plant, Talcher, showed keen interest in the technologies developed in this Section. Among the various synthetic processes developed, di-2-ethyl-hexyl phosphoric acid (D_2EHPA), a universal solvent, was picked up as the first candidate for scaling up. Based on this, the technology at about fifteen litre batch capacity was demonstrated both inhouse and onsite. Easy availability of the raw materials, high process yield (more than 95 percent), high purity, ease to scale up makes the technology attractive for industrial scale production. Moreover, the byproduct RCl (alkyl chloride) produced finds application in the synthesis of phosphoric acid ester, the process for which has already been established in this laboratory. The process has added advantage since the pollutant produced and the effluent discharge are minimal which makes it environmental friendly.

These developments led to signing of a Memorandum of Understanding between Heavy Water Board and Bhabha Atomic Research Centre in February/March, 1997 to set up a plant for the commercial production of D_2EHPA of 150 kg batch capacity. Accordingly, fifteen litre batch capacity set-up made of glass was transferred to the site and the staff was trained in the technology as well as in the handling of various chemicals. Training was also imparted in the necessary safety precautions both during the synthesis process, routine handling of the chemicals, quality control and also in the method for evaluating the purity of D_2EHPA. Simultaneously, the data required for the scale up like material balance, energy balance, selection of material of construction, and testing of equipment were generated. Heavy Water Board carried out the process design and detailed engineering. The plant has been installed and commissioned on July 23, 1999. The first trial run has given almost the stoichiometric yield and the product was found to be better than that available in the international market. The commercially successful production of D_2EHPA with the required yield and purity was made possible by the various organisations in the Department of Atomic Energy working in tandem with a goal to achieve the target within a stipulated time. D_2EHPA is a highly effective metal extractant, commercially used in the hydrometallurgy of cobalt, nickel, copper, zinc, rare earths and transuranic elements. The chemical structure of D_2EHPA is

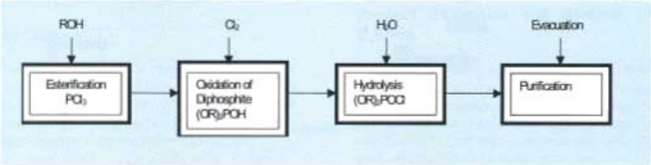


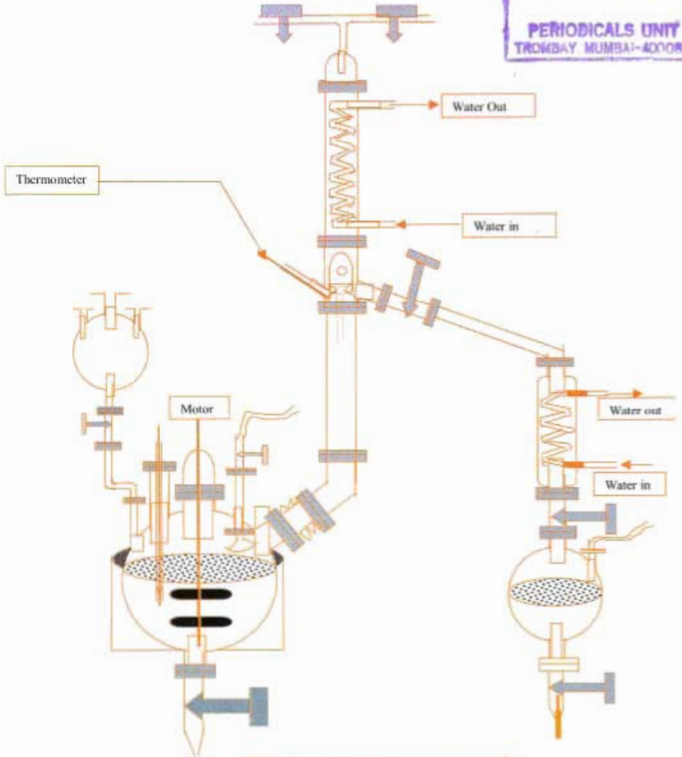
The extraction of metal ions M^{n+} from their aqueous solution into the organic phase containing the extractant RH, where R is $(C_8H_{17}O)_2P(O)O$, derives mainly by cation exchange mechanism depicted as

$$nHA(org) + M^{n+}(aq.) \longrightarrow nMA(org.) + n^{+}(aq.)$$

It thus falls under the category of acidic metal extractant.

Different process routes have been cited in the literature for the synthesis of D_2EHPA. Considering the advantages and disadvantages of these processes, a route has been developed using phosphorus trichloride as the starting material for synthesising technical grade D_2EHPA with much higher yield than reported in the literature. The process is batch type and broadly classified in to four steps as shown below:





Esterification Unit

Process Details

(a) Esterification

It involves synthesis of di-2-ethyl-hexyl-phosphite (D_2EHP) by reacting phosphorus trichloride with 2 ethyl hexanol as per the following reaction:

$$PCl_3 + 3ROH \rightarrow (OR)_2POH + RCl + 2HCl$$

The reaction is exothermic and hence once initiated is self-sustaining. The product, D_2EHP, is unstable at high temperature and in the presence of hydrogen chloride. Optimum conditions are required to get maximum yield. The presence of gaseous hydrogen chloride also tends to generate side products as indicated in the following reactions :

$$(OR)_2POH + HCl \rightarrow OR\,P(OH)_2 + RCl$$

monophosphite

$$(OR)P(OH)_2 + HCl \rightarrow OP(OH)_2 + RCl$$

$R = C_8H_{17}$ (2 ethyl-hexyl) phosphorus acid

The generation of monophosphite has to be minimal since it generates impurity of mono-2-ethyl-hexyl phosphoric acid in the final product and it greatly affects the phase disengagement, besides forming emulsion in its stage in the solvent extraction process. The removal of mono impurities is not only difficult but also involves one more unit operation, thus affecting the economics of the process and may even make it uneconomical. This can be achieved by scavenging the hydrogen chloride as soon as it is formed during the course of the reaction. After thorough investigation of various conditions, the parameters have been so established that, without using any scavenger, the conversion to diphosphite is nearly stoichiometric. The schematic diagram of the set up in this operation is shown schematically in the figure.

(b) Oxidation

The D_2EHP formed in esterification is to be oxidized in controlled manner for conversion from D_2EHP to D_2EHPA. This is first converted to the corresponding phosphochloridate by oxidizing it with chlorine as per the following reaction :

$$(OR)_2POH + Cl_2 \rightarrow (OR)_2POCl + HCl$$

Diphosphite Phosphochlorid

The reaction being highly exothermic needs to be carried at low temperature under controlled conditions so that the conversion to phosphochloridate is maximum and the impurities are not generated due to the reaction of phosphochloridate and the unreacted diphosphite. These impurities not only affect the final purity of the end product but are also difficult to remove in the final stage of purification. The excess chlorine and hydrogen chloride formed during the reaction are removed before proceeding for the next step. In the process developed in this laboratory, the conditions have been so standardized that the conversion of phosphite to the corresponding phosphochloridate is stoichiometric.

(c) Hydrolysis

The phosphochloridate obtained in the above process is hydrolysed in which diester and the monoester phosphochloridates get converted into their corresponding acids. As mentioned above, particular attention has to be given to the fact that mono-2-ethyl-hexyl-phosphoric acid formation is minimal. Based on the exhaustive laboratory studies, the conditions and medium have been so standardized that this step not only converts phosphochloridate stoichiometrically to D_2EHPA, but also removes to a large extent the monoester impurity.

(d) Purification

D_2EHPA produced in the above step is finally purified under reduced pressure to get the end product having composition of diester greater than 95 percent and monoester less than 1 percent which is suitable for application in the solvent extraction process directly.

Product Evaluation and Analysis of D_2EHPA

Product evaluation is done by physical methods of Quantification such as potentiometric titration and Gas Chromatography. Qualitative analyses are carried out by specific gravity, viscosity measurement, Infrared spectroscopy and its performance in the extraction processes.

In the course of development, mathematical software has been used to determine the percentage composition of D_2EHPA and M_2EHPA. This method greatly reduces uncertainties and the error in evaluating the product with high percentage of D_2EHPA and low percentage of M_2EHPA.

Conclusion

Easy and indigenous availability of raw materials combined with high process yield of ~ 98%, inspite of four unit operations involved in the production, alongwith the effective utilization of the by-product, makes the process highly economical. The optimum design and engineering of the plant and the low operating cost should make the product highly cost competitive even in the international market. With the increasing applications of metal extractants in the metallurgical industries, the development work on production of D_2EHPA assumes great significance.

This programme eminently stands as an illustrative example of synergism in an accomplished work. A laboratory scale technology developed by BARC was translated to engineering scale by Heavy Water Board, and eventually the pilot plant was established at Talcher. A number of other extractants such as TBP, PC88A and TOPO are also in the process of being scaled up for various commercial applications. Very soon, the Heavy Water Plant at Talcher is expected to wear altogether a different complexion producing a variety of extractants. Its future impacts are destined to be profound in the country.

Y2K READINESS PROGRAMME IN BARC

Umesh Chandra and A. K. Chandra
Reactor Control Division

The Y2K Issue

The year 2000 (Y2K) issues pertain to the potential for date-related problems that may be experienced by computers, by process systems controlled by computers, by devices and instruments with embedded chips and by software applications. An example of a date-related problem is the potential misreading of "00" as the year 1900 rather than 2000.

In addition to the date roll-over issue at midnight on December 31, 1999, the Y2K issues may pose problems in computer systems or applications to accurately process date/time data (including but not limited to calculating, comparing, and sequencing from, into, and between the 20^{th} and 21^{st} centuries and leap year calculations). Further, the Y2K issues are not only related to computers but to all devices that contain firmware and embedded chips.

All those items which involve digital technology with a microprocessor/ microcontroller are potential Y2K significant items. The root cause of the fault may lie in hardware (Real Time Clock-RTC), operating system, application package, and user program or data storage format. In scientific organisations such as BARC, the Y2K significant items mainly comprise Personal Computers, scientific instruments with embedded processors, real time control and monitoring systems in operating plants, and communication systems. The issues in Personal Computers and embedded systems need special attention.

Personal Computers

A battery operated CMOS Real Time Clock (RTC) chip in the PC maintains time and date even when PC is off. Most of the chips maintain only 2 digit date. The BIOS in PCs updates the century information whenever RTC is accessed. In addition, the operating system (e.g., Windows-95), Application Package, User programs and the Data Packets also use dates in various ways. During assessment, it is necessary to address all the above parts to ensure Y2K compliance. For CMOS RTC and BIOS, test programs are easily available and a hardware solution in the form of an add-on card is available to make the PCY2K compliant. Regarding softwarepackages, information and certification from the vendor can be utilised to check and test the PC, depending on the end use.

Embedded Systems

Embedded systems are systems and devices using microcontrollers and other logic ICs with permanently coded programs (firmware) stored in ROM. These electronic components are often an integral part of instruments and devices, and their presence may not be obvious from the outside. The embedded processors provide automation and Y2K issue is relevant where absolute time or relative time may be required for performing operations and for maintaining timed records. A significant percentage of embedded systems are non-compliant.

Due to lack of adequate documentation as well as lack of provisions in the device to set dates, it is very difficult to check these systems for compliance. Hence, assessment and remediation by the original designer is the preferred strategy. As an alternative, a suitable work-around solution has to be evolved based on the available documents and provisions. In critical areas, replacement with a compliant alternative may be the best strategy.

Y2K Readiness Programme

The Y2K issue has potential of causing concurrent failures at several places. The consequences of Y2K related problems could be subtle but widespread. These failures have potential to disrupt normal operations, degrade services and/or cause loss of data. Hence Y2K issues have to be addressed by all organisations in a formal manner.

Y2K readiness of an organisation can be achieved by implementing a structured and well documented programme that ensures that all relevant items are properly assessed and those which are not compliant are remedied in a manner that no significant Y2K related faulty event occurs. In addition, it is important to implement a well rehearsed contingency plan to take care of internal and external risks.

The methodology to achieve Y2K readiness is well established worldwide. It consists of four phases, viz.,

1. Inventory preparation and initiaasssessment
2. Detailed assessment
3. Remediation
4. Contingency planning

In the first phase, an inventory of all Y2K significant items is compiled, and the items are classified in terms of relevance to safety and operability to enable assignment of priorities for assessment and remediation.

In detailed assessment phase, inspection of available design information and investigative testing are carried out on Y2K significant items to determine their functionality and data consistency on critical dates. In addition to the tests for normal operation, tests for off-normal conditions need to be conducted. The items which do not qualify as Y2K compliant have to be remedied before the critical dates.

The remediation strategies are : "retire, replace, modify or work-around". Non-essential items can be retired. The remaining may be modified or replaced as per the situation to make them Y2K compliant.

Work-around is a procedure by which the fault date is shifted or partially corrected such that the consequences are acceptable. Such items are not Y2K compliant but can be termed as 'Y2K acceptable'. It is essential that after remediation, the item is carefully assessed for compatibility with associated items and validation is performed to ensure full functionality.

After the above three phases, if all items in the inventory list are either Y2K Compliant or Y2K Acceptable (work-around), then the nuclear facility can be termed as Y2K Ready.

In addition to achieving Y2K readiness, it is essential to perform contingency planning. The contingency plan addresses issues arising out of internal risks (e.g., when some items or scenarios are missed in Y2K readiness programme) as well as external risks which may result because of external event like grid failure, communication failure, etc. The purpose is to provide a logical approach to anticipate and prepare for such events and reduce their impact on the facility.

Y2K Programme in DAE

Recognizing the significance of year 2000 problem,Government of India has taken a number of initiatives at the highest level with an objective to ensure that services in various key sectors do not get affected by this problem. As a follow up, a High Level Action Force on "Managing the Impact of Year 2000 Problem in India" has been constituted under the Chairmanship of Member, Planning Commission. As desired by the Action Force, DAE has set up a DAE-Y2K Action Group under the Chairmanship of Additional Secretary, DAE, to assess and monitor the status of Y2K related preparedness in all the units of DAE. The Action Group has asked each Unit to set up a Task Force to ensure that all functions, i.e. operation of plants, functioning of scientific laboratories and facilities, communications as well as administrative and accounts functions are working in a normal manner during and after Y2K related dates.

BARC - Y2K Task Force

Director, BARC constituted a BARC-Y2K Task Force to formulate a Y2K Readiness Program including identification of vulnerable items, assessment of these to determine Y2K compliance, carrying out remediation if necessary and defining and rehearsing contingency plans. Group Boards were entrusted with the responsibility to ensure that the Y2K Readiness Program is implemented fully and in a timely manner. Chairmen of various Group Boards nominated representatives to the Task Force and these members have been meeting regularly to evolve and pursue a defined modus operandi. Each Division is required to ensure Y2K readiness in all areas under its domain and issue a compliance report. The role of the Task Force is to provide methodology and assistance in achieving this task.

The broad plan of action of the Task Force is to spread awareness, compile an inventory of all susceptible equipment, systems and software, carry out a detailed assessment for Y2K vulnerability, execute remediation wherever required and prepare contingency plans.

The Task Force organised a Y2K Awareness Seminar for BARC on April 19, 1999 to disseminate information to the representatives from all Divisions on the Y2K problem. The Seminar included presentations on Y2K Awareness, Inventory Preparation, Y2K Assessment, Strategies for Remediation, Contingency Planning and specific requirements in the areas of operating plants, scientific laboratories, MIS, etc.

Dr. Anil Kakodkar, Director, BARC, inaugurating the Y2K Awareness Seminar

The Task Force also organised presentations with solution providers. Several companies, including ISO 9000 certified ones, who supply packages to conduct Y2K compliance tests, and provide remediation services, were invited to make presentations on their methodology and tools for testing and remediation, their client base, etc.

The Task Force decided to request each Division / Section to nominate one representative for carrying out the Y2K Program activities in their Division/Section. These representatives, who effectively constituted Group Board Task Teams, have established the infrastructure required in their Division to carry out the program. Using a form devised by the Task Force, these representatives have generated a Preliminary Inventory list within the Division.

The Task Force has also provided a test scheme recommended by IAEA to test equipment and systems for Y2K compliance. Since PCs are the single largest type of equipment in use in BARC, the Task Force identified test programs suitable for testing PCs (RTC, BIOS and Operating System) for compliance.

The major 'concern areas" identified with respect to BARC comprise the following: Research Reactors, Nuclear Recycling Facilities, Health and Safety and Medical systems, Management Information

Systems (Administration, Personnel and Finance), and Research Facilities.

The members of the Task Teams have completed the Preliminary Assessment. Nearly 5000 items were identified and assessed for Y2K concern; almost 4000 items of these have been determined to be Y2K ready, Y2K compliant or having no Y2K concern. About 1000 items are in the process of being subjected to a detailed assessment to identify those requiring remediation. This exercise is scheduled to be completed shortly.

The Task Force is compiling the status of the programme in BARC and communicating the same to the DAE Y2K Action Group. The Task Force has scheduled completion of the Remediation process by August 31, 1999 and completion of Contingency Planning by September 30, 1999.

AERB Review of Y2K Issues

The Safety Review Committee for Operating Plants (SARCOP) of the Atomic Energy Regulatory Board has appointed a Y2K Committee to review detailed inventory, remedial measures planned, and contingency plans relevant to systems used in nuclear installations, radiation exposure monitoring, fuel burnup calculations, etc. The BARC Y2K Task Force has also been compiling the status and communicating the same to AERB for Apsara, Cirus, Dhruva, Purnima and recycling facilities at Kalpakkam, Mumbai and Tarapur and those related to Health and Safety.

TECHNOLOGY TRANSFER FROM BARC

BARC has transferred the technology on Lascan Dia Gauge developed by Laser & Plasma Technology Division to M/s Suresh Indu Lasers Pvt Ltd., Pune. The technology transfer agreement was signed on May 27, 1999 in the office of Mr A.K. Anand, Director, Technical Coordination & International Relations Group and Reactor Projects Group. Lascan dia gauge is a laser based non-contact diameter/ linear dimension measuring (1 to 25 mm) instrument, ideally suitable for dimensional measurement of high temperature, toxic, radioactive or corrosive products. It can also be used for on-line measurement and for process monitoring and control.

Dr S.K. Sikka, Director, SSS Group, BARC, and Mr Shah of M/s. Suresh Indu Lasers Pvt Ltd. greet each other after signing the agreement.

It works on the principle of laser beam scanning. A fine beam of visible light from a laser diode is reflected by a high speed rotating mirror on to a lens to produce parallel scanning beams. These parallel beams after interacting with the object are focussed by receiver optics on to a photodiode. Any object kept in the measuring plane will obstruct the scanning beam for a period proportional to its dimension. The parallel beams are then focussed by optical means on to a photodiode to generate a shadow pulse of the object, which is electronically processed to give the dimension of the object.

Dr S.K. Sikka, Director, Solid State & Spectroscopy Group; Dr N. Venkatramani, Head, Laser & Plasma Technology Division (L&PTD); Dr R.B. Grover, Head, Technology Transfer & Collaboration Division (TT&CD; Mr R.C. Khattar, Mr A.S. Rawat and Mr U.C. Bhartiya from L & PTD; Dr A.K. Kohli and Mr S. Nawathe from TT & CD; and Dr S.T. Shah and Mr Goshal Shah from M/s Suresh Indu Lasers Pvt Ltd. participated in the technology transfer programme.

DISPOSAL OF VERY HIGH RADIOACTIVE SPENT Co^{60} RADIATION SOURCES

Waste Management Division has successfully completed the disposal of 95 pencils of radioactive Co^{60} each having 200-500 Ci. The radiation sources were declared as radioactive waste mainly due to depletion in strength. Campaign of this nature involves specialised equipments and procedures to ensure safety in handling, transportation and disposal at near surface repository. The spent radioactive sources are transported in a shielded container qualified for such a job. To ensure long term containment of radioactivity for about fifty years (10 half lives for the decay of Co^{60}), high integrity engineered containments called tile holes are used. Tile holes are underground steel lined cylindrical concrete structures. In view of high decay heat, provision has been kept for cooling and monitoring of temperature.

Most important feature of this campaign has been the safety and very low exposure of operating personnel. A total of 18000 Ci of Co^{60} has been disposed. Disposal of such a large number of spent radiation sources and radioactivity has been accomplished for the first time at Trombay site.

BARC HOSTS IAEA MEET

BARC hosted the meeting of National Project Coordinators on "Preparation for the Disposal of Low and Intermediate Level Wastes (LILW) with Emphasis on Non-Power Sources" during June 21-25, 1999 at the request of International Atomic Energy Agency (IAEA). The meeting is a part of Regional Cooperation Agreement (RCA) amongst the different countries in South and South East Asia and Asia Pacific. While inaugurating the meeting, Dr Anil Kakodkar, Director, BARC, complimented the IAEA for its activities under RCA and for bringing together the countries in the region with a common goal of spreading the benefits of peaceful uses of atomic energy. He stressed the importance of development of R&D base, human resources and long term perspective in various areas of radioactive waste management. India has a sound base and expertise in the field of radioactive waste management in design, development, construction and operation of waste management facilities for the waste arising from the entire nuclear fuel cycle as

Participants of IAEA meet on "Preparation for the Disposal of Low and Intermediate Level Wastes with Emphasis on Non-Power Sources"

well as the use of radioisotopes in industry, agriculture and medicine.

During the meeting, the status of current practices in disposal of spent radiation sources used in medicine, research and industry was reviewed. Various disposal concepts for LIL waste were discussed and detailed with respect to site hydrology, annual precipitation, geology, meteorology, etc. Criteria for selection of disposal site was formulated to serve as a guide to be issued by IAEA. The meeting was attended by participants from twelve countries and IAEA. They had an opportunity of visiting BARC facilities at Trombay and Waste Management Facilities, Tarapur. The meeting was organised by Waste Management Division.

BARC SIGNS MOU WITH NDDB

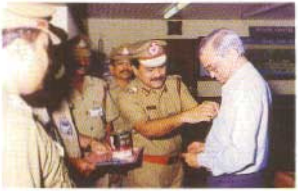
A Memorandum of Understanding for providing consultancy services to Nagpur University for the NDDB-funded project on development of 'Double

Zero" quality mustard was signed between BARC and National Dairy Development Board, Anand, on June 24, 1999 by Mr A.K. Anand, Director, Technical Co-ordination & International Relations Group, BARC, and Dr N.K. Chawla, Executive Director, NDDB, Anand. The programme envisages the development of low erucic acid and low glucosinolate (toxic compounds) varieties of rapeseed/ mustard using induced mutation and conventional methods. This will help to improve the quality of oil and meal, and ensure higher return to cultivators and the exporters. Dr S.E. Pawar of Nuclear Agriculture & Biotechnology Division will provide expertise for executing the project at Nagpur Unversity sponsored by NDDB.

FIRE SERVICE WEEK OBSERVED IN BARC

Every year, the fourteenth day of April is observed all over the country as the national Fire Service Day in remembrance of those brave service personnel who displayed courage and exemplary devotion to duty as they laid down their lives fighting the huge fire that had erupted in the 1944 Mumbai Port Trust Dock explosions.

Like an annual ritual, BARC observed the "Fire Service Week" during April 14 to 20, 1999, in the course of which a number of programmes were arranged to increase fire safety awareness among the employees in BARC and residents of Anushaktinagar. The week began with the Commemoration Day when, on behalf of BARC, Chief Fire Officer, Mr A.K. Tandle, placed a wreath at the Memorial on the grounds of Mumbai Port Trust. Another wreath was laid by him at the Mumbai Fire Brigade Headquarters, Byculla. On the following day, the Fire Service Pin Flag Fund raising campaign was started by offering pin flag to Dr Anil Kakodkar, Director, BARC. In a brief speech, Dr Kakodkar emphasized the need for spreading fire safety awareness among the personnel of BARC. Contributions received in the campaign were deposited with the Fire Advisor, Government of Maharashtra, and the money will be utilized for the welfare of the fire services personnel and their



Chief Fire Officer Mr A.K. Tandle offering Fire Service pin flag to Dr Anil Kakodkar, Director, BARC.

families. A small exhibition was arranged during the week and Chief Fire Officer delivered two lectures covering topics like fire and explosion hazards; fire prevention, detection and extinguishment; safety management in BARC; etc. The lectures were followed by demonstrations in the use of fire fighting and safety equipment. Mid week provided an impressive demonstration by Fire Services Section, BARC in co-ordination with Mumbai Fire Brigade personnel. It was witnessed by about 600 residents of Anushaktinagar at Akash Ganga building. Snorkel, turn-table, ladders, water and foam tenders, and Branto Jumbo water tankers took part in the show. Emphasis was given to high rise building fire safety and rescue operations in case of emergencies. Films provided by the National Safety Council were screened at the Central Complex Auditorium in BARC.

An exhibition arranged during the Fire Service Week for the benefit of staff members of BARC. Chief Fire Officer is explaining the exhibits

The Fire Service Week culminated with a ceremonial parade at Cross Maidan in South Mumbai with active participation of the equipment and personnel of Fire Services Section, BARC.

FORTHCOMING SYMPOSIUM / WORKSHOP

■ As a part of the Platinum Jubilee Celebrations of the Indian Chemical Society, its Mumbai branch is organising a two-day symposium on "Environmental Management for Nuclear Establishments and Chemical Industries" at UDCT, Mumbai, on September 25 and 26, 1999.

The symposium will have invited lectures by eminent experts from specialised fields, a poster session, and an exhibition on pollution control, environment management and allied instrumentation. It is proposed to bring out a souvenir containing the extended abstracts of the invited talks and the posters displayed. A concluding panel discussion will provide a useful interface between the experts, industry and instrument designers.

(Contact : Dr P.M. Dhadke, Tel. (Off.) (022) 414 56 16 Ext. 304; (Res.) (022) 5773245.)

■ To inculcate the usage of neutron scattering technique by University scientists and to prepare a community of researchers dedicated to this technique, the Inter-University Consortium for DAE Facilities (IUC-DAEF), in collaboration with BARC, periodically conducts various workshops on neutron scattering. The next workshop, which is ninth in the series, will cover different aspects of neutron diffraction, like powder and single crystal diffraction, magnetic neutron diffraction (polarized and unpolarized), crystallography of bio-molecules, etc.

The workshop will be held during November 17 to December 3, 1999 at the Department of Physics Saurashtra University, Rajkot, and at BARC, Mumbai.

(Contact : Dr V. Siruguri, Tel.: (022) 550 53 27; Fax : (022) 550 54 02;
Email : iuc@magnum.barc.ernet.in)

BARC SCIENTISTS HONOURED

■ Dr Jai P. Mittal, Director, Chemistry and Isotope Group, has been chosen to receive the Chemical Research Society of India (CRSI) Silver Medal in recognition of his outstanding contributions to Chemistry. Prof. C.N.R. Rao is the current President of CRSI. Recently, Dr Jai P. Mittal was elected the President of Indian Society of Radiation & Photochemical Sciences (ISRAPS).

Dr Jai P. Mittal currently also holds the prestigious position of the President of "Indian Chemical Society" which is the oldest professional body of Sciences founded by Acharya P.C. Ray as early as 1924.

■ Dr P.R. Chaudhari of Radiation Medicine Centre, BARC, was conferred with the "Best Young Scientist Award" by the Indian Society for Nuclear Technology in Animal Science (ISNUTAS) for his research paper entitled "Beginning of Verterinary Nuclear Medicine Practice in India : First Experiences". This paper was presented at second convention of ISNUTAS and National Symposium on "Nuclear and Related Techniques for Human and Animal Welfare in the Next Millennium" held at Kerala Agricultural University, Thrissur during February 9 and 10, 1999.

Edited and published by Dr Vijai Kumar, Head, Library & Information Services Division, Bhabha Atomic Research Centre, Trombay, Mumbai 400 085.
Editorial Management : T.C. Balan; Computer graphics & layout : P.A.S. Warriyar.

BARC Newsletter is also available at URL:http://www.barc.ernet.in
(for private circulation only)