6. ANALYTICAL METHODS

The purpose of this chapter is to describe the analytical methods that are available for detecting and/or measuring and monitoring RDX in environmental media and in biological samples. The intent is not to provide an exhaustive list of analytical methods that could be used to detect and quantify RDX. Rather, the intention is to identify well-established methods that are used as the standard methods of analysis. Many of the analytical methods used to detect RDX in environmental samples are the methods approved by federal organizations such as EPA and the National Institute for Occupational Safety and Health (NIOSH). Other methods presented in this chapter may be those that are approved by groups such as the Association of Official Analytical Chemists (AOAC) and the American Public Health Association (APHA). Additionally, analytical methods may be included that refine previously used methods to obtain lower detection limits, and/or to improve accuracy and precision.

6.1 BIOLOGICAL SAMPLES

Analytical methods specifically used for the determination of RDX in biological fluids and tissues are limited. Methods were located which discussed the analysis of RDX in blood, tissues, urine, and hand swabs. The separation methods employed were either high-performance liquid chromatography (HPLC) or gas chromatography (GC). These were combined with detection by thermal energy analyzer (TEA), ultraviolet (UV), electrochemical detector (ED), or electron capture detector (ECD). Both HPLC and high-resolution gas chromatography (HRGC) can rapidly separate RDX from other explosives, but HPLC has the advantage of being run at ambient temperature, which helps prevent breakdown of the analyte. Sample preparation for RDX analytical methods is relatively simple, consisting of collection, one or two extraction/clean-up steps, and concentration of the sample. Pertinent data on the these methods are presented in Table 6- 1.

Detection of RDX in human and animal plasma and human urine and cerebrospinal fluid has been accomplished by HPLC/TEA and HPLC/UV (Army 1981a; Fine et al. 1984; Turley and Brewster 1987). While both methods provide relatively rapid sample turn-around times, HPLC/TEA is the most sensitive and selective of the two, and requires little sample preparation (Fine et al. 1984). The older HPLCU/UV method (Army 1981a) had the problem of coelution of a plasma component with the RDX peak. This was eradicated by clean-up on a C_{18} bonded-phase extraction column (Turley and Brewster 1987: Woody et al. 1986), but the sensitivity of HPLC/UV was still several orders of magnitude less

TABLE 6-1. Analytical Methods for Determining RDX in Biological Samples

Sample matrix	Preparation method	Analytical method	Sample detection limit	Percent recovery	Reference
Plasma	Extract with methylene chloride and pentane; filter; concentrate	HPLC/TEA	100 ng/L	No data	Fine et al. 1984
Plasma	Add NaCl/acetic acid solution to sample; extract with toluene; add water; evaporate organic phase; combine aqueous phase with acetonitrile-containing internal standard; filter	HPLC/UV	146 mg/L	87.7	Army 1981a
Serum and urine	Mix sample with internal standard; clean up on C_{18}-bonded-phase extraction column, eluting with methanol; concentrate	HPLC/UV	100 µg/L	90–101 (serum); 98–101 (urine)	Turley and Brewster 1987
Kidney	Add NaCl/acetic acid solution to sample; extract with toluene; add water; evaporate organic phase; combine aqueous phase with acetonitrile-containing internal standard; filter	HPLC/UV	95 ng/g	99.5	Army 1981a
Muscle/fat	Homogenize sample; extract with acetonitrile; concentrate; add internal standard and purified water; filter	HPLC/UV	62 ng/g	102.9	Army 1981a
Liver	Homogenize sample; add NaCl/acetic acid solution; evaporate; redissolve in acetonitrile-containing internal standard; filter	HPLC/UV	150 ng/g	87.7	Army 1981a
Hand swabs	Wipe hand with swab soaked in acetone; squeeze out acetone and concentrate	HPLC/TEA; HRGC/TEA	10 pg/inj	No data	Fine et al. 1984
Hand swabs	Wipe hand with swab soaked in ether; extract with ether; centrifuge to remove debris; decant supernatant and evaporate; redissolve in pentane; clean up on Amberlite XAD-7 beads, eluting with ethyl acetate; evaporate; redissolve in pentane and repeat Amberlite XAD-7 clean-up	GC/ECD	50 ng/swab (1.7 ng/inj)	47	Douse 1982
		TLC	20 ng/swab	No data	
Hand swabs, standards	Wipe hand with dry swab; extract with methanol/potassium phosphate; directly inject standards	HPLC/PMDE	8 pg/inj (standards)	No data	Lloyd 1983

ECD = electron capture detection; GC = gas chromatography; HPLC = high-performance liquid chromatography; HRGC = high-resolution gas chromatography; inj = injection; NaCl = sodium chloride; PMDE = pendant mercury drop electrode; TEA = thermal energy analyzer; TLC = thin layer chromatography; UV = ultraviolet detection

(limit of detection in low ppb) than that of HPLC/TEA (limit of detection in low ppt). Reported recoveries, which ranged from 87.7 to 101%, were excellent (Army 1981a; Turley and Brewster 1987; Woody et al. 1986). Precision was comparable and ranged from 0.65 to 10% coefficient of variation (CV).

A single method of analyzing feces for RDX was located (Woody et al. 1986). This method used HPLC/UV and required extraction of the sample with acetonitrile and sonication. The limit of detection was not reported but, based on the data presented, is assumed to be in the low ppb. Accuracy and precision were comparable with similar measurements in serum, urine, and cerebrospinal fluid.

Only one method was located for analysis of tissue samples. The method used HPLC/UV to analyze bovine kidney, muscle/fat, and liver samples for RDX, but it could be used to analyze human tissues (Army 1981a). Optimal sample preparation methods varied slightly for the different tissues, as did detection limits and precision. In general, the detection limit was in the low ppb and recovery was excellent (range of 87.7-102.9). Precision ranged from 7 to 16% CV. The primary problem with analysis of tissue using this method is the variation in selectivity. Minor differences in sample extraction and contamination from unknown sources can create interferences that drastically affect interpretation of results and may also adversely affect the sensitivity.

The only other methods for biological matrices located were for analysis of hand swabs. These are of primary importance in forensics, but they could also be used to determine if dermal exposure of workers has occurred. Methods that have been used for the determination of trace amounts of RDX on hands include HPLC with TEA or electrochemical detection and HRGC with TEA or ECD (Douse 1982; Fine et al 1984; Lloyd 1983). Thin-layer chromatography has also been tested, but because of the large amounts of sample that are required for the analysis, it is useful only as a confirmatory test (Douse 1982). Separation of the sample by HPLC and HRGC are comparable, but reported recovery for HRGC is low (Douse 1982). This is likely because of decomposition of the sample;‘but the data are not available to adequately compare the recovery of the two methods. The nature of the detector seems to be the most important factor in determining which of the reported methods is most useful for the analysis of RDX in hand-swab extracts. ECD appears to be less sensitive (ng amounts) than either electrochemical detection using the pendant mercury drop electrode (PMDE) or TEA (pg amounts). In addition, in the method reported, clean-up was required to prevent matrix interference (Douse 1982).

For both the PMDE and TEA methods, clean-up of the sample was not required, and both methods were rapid, selective, and of high precision (Fine et al. 1984; Lloyd 1983).

6.2 ENVIRONMENTAL SAMPLES

A large variety of methods have been described for the detection of RDX in environmental samples. These primarily include HRGC combined with ECD, TEA, mass spectrometry (MS), or flame ionization detection (FID); HPLC combined with UV, TEA, MS, photoconductivity (PD), or electrochemical detection; and several stand-alone MS techniques. Other methods have also been proposed, including fluorescent quenching; supercritical fluid (SFC) with UV; liquid chromatography (LC) with thermospray (TSP) and MS; and bioassays based on chemical oxygen demand (COD) and total oxygen demand (TOD). Table 6-2 is a summary of several representative methods for determining RDX in various environmental media.

Several methods for determining RDX in air have been investigated. Based on the limited data available, the two most common methods are GC/ECD and MS. The data reported are not sufficient to make comparisons of sensitivity and reliability between the methods. However, GC/ECD appears to have good sensitivity (low ppb), accuracy, and precision (Bishop et al. 1981, 1988). The sensitivity of this method (mid ppb) is approximately 30 times greater than that achieved with GC/FID (Army 1975), and precision is also better (±4% CV for GC/ECD versus ±15% CV for GC/FID). An alternate method based on spectrophotometry also provided very good results for accuracy and precision (±12.4% CV) and had a detection limit of the same order of magnitude as that reported using GC/ECD (Eminger and Vejrostova 1984). MS methods with sensitivity in the sub-ppb range have been described, but specific information on their reliability is limited. MS is generally accepted to be highly selective. Of the two MS methods described, isotope dilution MS (IDMS) (St. John et al. 1975) and MS/MS with atmospheric pressure chemical ionization (APCI) (Tanner et al. 1983), the latter (APCI/MS/MS) is the most rapid and simple to perform because the sample of air containing RDX vapors is-directly injected into the instrument. The high sensitivity and selectivity of MS/MS allow the air sample to be injected without prior treatment or concentration. However, the method as presented appears to be primarily useful as a screening technique to determine if more rigorous quantitative analysis is required. IDMS requires some sample preparation in order to incorporate the known amount of labeled analyte in with the sample containing the unknown amount of RDX. IDMS has been used to measure the vapor pressure of RDX, which is in the sub-ppb range.

TABLE 6-2. Analytical Methods for Determining RDX in Environmental Samples

Sample matrix	Preparation method	Analytical method	Sample detection limit	Percent recovery	Reference
Air	Collect sample on Tenax-plus-filter tubes; desorb with acetonitrile	HRGC/ECD	17 µg/m^3	No data	Bishop et al. 1988
Air	Collect sample on Tenax-GC; desorb with acetonitrile	HRGC/ECD	No data	93–102	Bishop et al. 1981
Air	Collect sample on glass-fiber filter; extract with ethyl acetate	GC/FID	0.5 mg/m^3	No data	Army 1975
Air	Collect sample in sampling tube of glass-microfibers and silica gel; transfer to H_2SO_4 solution and react with dihydroxynapthalene-disulfonic acid and water; dilute with water	Spectrophotometry	40 µg/m^3	95.7–97.3	Eminger and Vefrostova 1984
Air	Incorporate sample into bulb containing isotopically-labeled RDX; extract with benzene; transfer to capillary tube and evaporate	IDMS	Sub-ppb	No data	St. John et al. 1975
Air	Inject sample directly into instrument	APCI/MS/MS	Sub-ppb	No data	Tanner et al. 1983
Waste-water effluents	Add internal standard to sample; elute from reverse-phase column with methanol/water	HPLC/UV	0.2 mg/L	72–103	Army 1983c
Groundwater, waste-water effluents	Dilute sample with methanol/acetonitrile; filter; elute from reverse-phase column with water/aceto-nitrile/methanol	HPLC/UV	22 µg/L	101	Army 1985c; Jenkins et al. 1986
Groundwater	Collect sample on Hayesep R solid sorbent cartridge; elute with acetone; concentrate; add internal standards; dilute with methanol/water	HPLC/UV/UV/PD	5–7.5 µg/L	104–121	Army 1989a

TABLE 6-2. Analytical Methods for Determining RDX in Environmental Samples (continued)

Sample matrix	Preparation method	Analytical method	Sample detection limit	Percent recovery	Reference
Surface water, well water	Collect sample on Porapak resin; rinse sorbent with distilled water and elute with acetone; concentrate; add ethanol; concentrate; add methanol/water	HPLC/ED	≈1 µg/L	57–63	Maskarinec et al. 1984
Water	Collect sample on XAD-4 resin; elute with ethyl acetate; concentrate	HRGC/ECD	<0.1 µg/L	97	Richard and Junk 1986
Groundwater, drinking water	Extract sample with isoamyl acetate	HRGC/ECD	0.3 µg/L	56–84	Hable et al. 1991
Sea water	Add internal standard to sample; extract with benzene; evaporate; redissolve in benzene	GC/ECD	5 ng/L	70	Hoffsommer and Rosen 1972
Groundwater, drinking water	Extract sample with isoamyl acetate	HRGC/ECD	0.3 µg/L	56–84	Hable et al. 1991
Sea water	Add internal standard to sample; extract with benzene; evaporate; redissolve in benzene	GC/ECD	5 ng/L	70	Hoffsommer and Rosen 1972
Water	Evaporate sample; redissolve in acetone; filter; concentrate	HRGC/ECD	60 ng/L	85	Haas et al. 1990
Water	Inject sample directly into instrument	MS (CI)	4 mg/L	No data	Yinon and Laschever 1982
Groundwater	Add sample to cyclo-hexanone/pyrenebutyric acid/cellulose triacetate/isodecyl diphenylphosphate membrane in cuvette	Fluorescense quenching	≈10 mg/L	No data	Jian and Seitz 1990

TABLE 6-2. Analytical Methods for Determining RDX in Environmental Samples (continued)

Sample matrix	Preparation method	Analytical method	Sample detection limit	Percent recovery	Reference
Soil	Air-dry, grind, and sieve sample; extract with acetonitrile in ultrasonic bath; add $CaCl_2$; filter; elute from reverse-phase column with water/methanol	HPLC/UV	0.74 µg/g	84–112	Army 1987b; Bauer et al. 1990; Jenkins and Grant 1987; Jenkins et al. 1989 (interim AOAC method)
Soil	Adjust sample moisture to 20–30%; homogenize and sieve; extract with acetonitrile and sonication; centrifuge and filter; elute from reverse-phase column with methanol/water	HPLC/UV	0.6 µg/g	103.7	Bongiovanni et al. 1984
Soil	Air-dry sample; extract with acetonitrile; filter; evaporate; redissolve in acetonitrile; elute from reverse-phase column with acetonitrile/water	HPLC/UV	0.005 µg/g	No data	Lyter 1983
Soil	Homogenize sample; extract with acetone; filter	HRGC/ECD	75 ng/g	95	Haas et al. 1990
Soil	Homogenize sample; extract with acetone; evaporate; react with diphenylamine/H_2SO_4	Spectrophotometry	5 mg/L	No data	Haas et al. 1990
Explosive preparations	Elute from HPLC column with isooctane/ethanol	HPLC/TEA	No data	98–102	Lafleur and Morriseau 1980
Explosives, explosion debris	Dissolve sample in acetone; dilute in methanol	HPLC/TEA HRGC/TEA	Low pg	No data	Fine et al. 1984

TABLE 6-2. Analytical Methods for Determining RDX in Environmental Samples (continued)

Sample matrix	Preparation method	Analytical method	Sample detection limit	Percent recovery	Reference
Explosives	Extract sample with acetone; elute from HPLC column with methanol/potassium phosphate	HPLC/EC (PDME)	8 pg/g	No data	Lloyd 1983
Explosion debris	Extract sample in acetone; clean up on cyclohexyl column; eluting with methylene chloride/hexane; clean up on cyanopropyl column; eluting with acetonitrile/water	HPLC/UV	No data	99	Strobel and Tontarski 1983
Munitions products	Dissolve sample in acetonitrile; add water; elute from reverse-phase column with methanol/water	HPLC/UV	No data	No data	Burrows and Brueggemann 1985
Explosives	Extract with acetone; evaporate; redissolve in dichloroethane; elute from HPLC column with dichloroethane/hexane	HPLC/MS (CI)	≈1 ng	No data	Vouros et al. 1977
Explosives, explosive residues	Dissolve in acetone or methanol; elute from HPLC column with methanol/ammonium acetate	HPLC/TSP/MS	Low pg	No data	Berberich et al. 1988

APCI = atmospheric pressure chemical ionization; AOAC = Association of Official Analytical Chemists; $CaCl_2$ = calcium chloride; CI = chemical ionization; EC = electrochemical detection; ECD = electron capture detection; ED = electrochemical detection; FID = flame ionization detection; GC = gas chromatography; HPLC = high-performance liquid chromatography; HRGC = high-resolution gas chromatography; H_2SO_4 = sulfuric acid; IDMS = isotope dilution mass spectrometry; MS = mass spectrometry; PD = photoconductivity detection; PDME = pendant mercury drop electrode; TEA = thermal energy analyzer; TSP = thermospray; UV = ultraviolet detection

6. ANALYTICAL METHODS

The primary analytical methods for determining RDX in water are HPLC/UV and GC/ECD. These methods have been used to determine the chemical in waste-water effluents, groundwater, well water, drinking water, and sea water. The critical step in the analysis of RDX by HPLC/UV is separation of the sample on a reverse-phase column, which provides good selectivity without risk of thermal breakdown of the analyte (Army 1983c, 1985c; Jenkins et al. 1986). The method is simple, quick, and reproducible. Sensitivity is in the low- to mid-ppb range, with very good recovery and excellent precision (2-7.6% CV). The use of HPLC in combination with photodiode-array detection improves the reliability of peak identification (Emmrich et al. 1993). The HPLC-photodiode-array detection method can provide a detection limit of 0.09 ppb for RDX in aqueous samples concentrated l,000-fold by liquid-liquid extraction or by solid phase extraction (C-18) (Levsen et al. 1993). The extraction efficiency of RDX from water to acetonitrile can be improved by using salting out agents (Miyares and Jenkins 1991). The sensitivity and selectivity of RDX detection was improved by combining a solid sorbent cartridge to concentrate RDX from water and HPLC-tandem ultraviolet and photoconductivity detection (HPLC/UV/UV/PD) (Army 1989a). The serial use of the three detectors effectively differentiated RDX from other explosives and from contaminants in the solid sorbent cartridge. In addition, the sensitivity was improved by a factor of about 3, and the accuracy and precision (±13-19.6% CV) were only slightly less than HPLC/UV values. To prevent negative baseline drift and random spikes in the PD, only highly purified water must be used, and the effluent must be exhaustively degassed. For analysis by GC/ECD, water samples may be solvent-extracted (Belkin et al. 1985; Haas et al. 1990; Hable et al. 1991; Hoffsommer and Rosen 1972) or collected on a solid sorbent (Richard and Junk 1986). Solvent extraction is most commonly used, but solid sorbent collection has the advantages of being faster and cheaper than solvent extraction (Richard and Junk 1986). Sensitivity for the GC/ECD methods ranges from low to mid ppt, and the recovery and precision are acceptable. Use of the solid sorbent improved recovery and precision compared to solvent-extraction methods (Richard and Junk 1986). Substitution of electrochemical detection (ED), using a gold-mercury electrode, improved selectivity compared to ECD detection. Sensitivity was not as good, but it remained within an order of magnitude of that found with GC/ECD (Maskarinec et al. 1984). Recove-Q and precision were comparable. Other methods that have been used to determine RDX in water are MS, fluorescence quenching, chemical oxygen demand (COD), and total organic carbon (TOC) (Jian and Seitz 1990; Roth and Murphy 1978; Yinon and Laschever 1982). COD and TOC (Roth and Murphy 1978) are well-established standard methods for determining organic pollution in water, but they are not selective for RDX. MS with chemical ionization (CI) permits direct injection of the water sample into the analytical instrument, but the sensitivity is substantially less than

with the HPLC and GC methods (Yinon and Laschever 1982). Fluorescence quenching also lacks sensitivity, and the method is still under development. However, it does permit *in situ* measurement of samples, and further improvements in the technology may make it a desirable field method (Jian and Seitz 1990).

The few methods that were located for detection of RDX in soil are based primarily on HPLC/UV analysis (Army 1987b; Bauer et al. 1990; Bongiovanni et al. 1984; Jenkins and Grant 1987; Jenkins et al. 1989; Lyter 1983). All the methods involve extraction of the sample with acetonitrile, separation using a reverse-phase column, and in most cases, elution with acetonitrile/water. Sensitivity for these methods is in the sub- to low-ppm range with good recovery (84-l 12%) and precision (2.3-24% CV). A variation of the method, which involves the soil sample being extracted with acetonitrile in an ultrasonic bath, has been approved on an interim basis by the AOAC (Jenkins et al. 1989). The only other methods located were based on GC/ECD and spectrophotometry (Haas et al. 1990). For both of these, the sample was extracted with acetone. The detection limit for spectrophotometric determination of RDX in soil was in the low-ppm range, while the detection limit for GC/ECD was in the mid-ppb range. No information on accuracy and precision were given for the spectrophotometric method; however, the accuracy of GC/ECD was comparable to HPLCAJV.

Several methods have been used to detect and measure RDX in explosive materials and debris from explosions. The most common separation procedure is HPLC, but HRGC has also been used. These methods have been paired with several types of detectors, including TEA, MS, electrochemical detection, and UV. The TEA is very selective for nitroso compounds and when paired with either HPLC or HRGC gives excellent selectivity, recovery, and precision and high sensitivity (Fine et al. 1984; Lafleur and Morriseau 1980). The limited reports of analysis of materials using HPLC and electrochemical detection indicate detection limits in the low ppb and good reliability (Krull et al. 1984; Lloyd 1983). UV detection has also been used with HPLC separation, but few data are available for comparison with other methods (Burrows and Brueggemann 1985; Strobe1 and Tontarski 1983). The data suggest that this method has very good accuracy and precision; however, the selectivity may not be as good as that obtained with other detectors. GC/MS has been used for confirmation of RDX in samples (Burrows and Brueggemann 1985), and HPLC/MS and MS/MS have been investigated as screening methods for explosives (McLucky et al. 1985; Vouros et al. 1977). A sophisticated method linking HPLC, thermospray (TSP), and MS or MS/MS (with both positive and negative chemical ionization) has also been proposed as an extremely sensitive (low pg range) and

selective method for detecting RDX in explosive residues (Berberich et al. 1988; Verweij et al. 1993). However, there is no evidence that any MS-based method is currently used to quantitatively measure RDX in explosives or explosion debris. A relatively new method being investigated uses supercritical fluid extraction chromatography (SFC) to separate RDX from other analytes and contaminants followed by detection by UV/FID (Griest et al. 1989). The method is slower but more selective than HPLC/UV. The precision for standard solutions was excellent. However, more work is needed to improve the mobile phase and column packing material before samples in complex matrices can be analyzed.

6.3 ADEQUACY OF THE DATABASE

Section 104(i)(5) of CERCLA, as amended, directs the Administrator of ATSDR (in consultation with the Administrator of EPA and agencies and programs of the Public Health Service) to assess whether adequate information on the health effects of RDX is available. Where adequate information is not available, ATSDR, in conjunction with NTP, is required to assure the initiation of a program of research designed to determine the health effects (and techniques for developing methods to determine such health effects) of RDX.

The following categories of possible data needs have been identified by a joint team of scientists from ATSDR, NTP, and EPA. They are defined as substance-specific informational needs that, if met, would reduce or eliminate the uncertainties of human health assessment. This definition should not be interpreted to mean that all data needs discussed in this section must be filled. In the future, the identified data needs will be evaluated and prioritized, and a substance-specific research agenda may be proposed.

6.3.1 Identification of Data Needs

Methods for Determining Biomarkers of Exposure and Effect. Few methods-exist for monitoring exposure to RDX. Methods have been reported for detection of the analyte in plasma (Army 1981a; Fine et al. 1984; Turley and Brewster 1987; Woody et al. 1986), urine (Turley and Brewster 1987; Woody et al. 1986) cerebrospinal fluid (Woody et al. 1986), feces (Woody et al. 1986), and tissues (Army 1981a), as well as on hands (Douse 1982; Fine et al. 1984; Lloyd 1983). The available methods can detect levels in urine and plasma from exposure to concentrations below

those that would be encountered in most manufacturing situations. In general, these methods are reliable and accurate; however, the development of the LC-MS methodology could be useful as a definitive method to validate the specificity of the HPLC methods. The data are insufficient to permit correlation of RDX levels in the urine or blood with exposure levels (see Section 2.5.1). Therefore, the level of RDX in urine or blood cannot be used as a biomarker of exposure.

There are no known sensitive biomarkers of effect for RDX. Therefore, no methods recommendations can be made for this chemical.

Methods for Determining Parent Compounds and Degradation Products in Environmental Media. Methods exist to detect and quantify RDX in air (Army 1974; Bishop et al. 1988; Eminger and Vejrostova 1984; St. John et al. 1975; Tanner et al. 1983), water (Army 1983c, 1985c, 1989a; Haas et al. 1990; Hable et al. 1991; Jian and Seitz 1990; Maskarinec et al. 1984; Richard and Junk 1986; Yinon and Laschever 1982), soil (Army 1987b; Bongiovanni et al. 1984; Haas et al. 1990), explosive materials (Burrows and Brueggemann 1985; Fine et al. 1984; Lafleur and Morriseau 1980; Lloyd 1983), and debris from explosions (Fine et al. 1984; Strobe1 and Tontarski 1983). These methods are relatively sensitive and reliable and can be used to detect levels of the compound in the environment that cause known adverse health effects. There are some problems involving reduced sensitivity and selectivity with all the commonly used methods. Several proposed improvements in current methods, such as combining various analytical methods to increase selectivity, sensitivity, reliability, and/or accuracy (Army 1989a; Berberich et al. 1988; Krull et al. 1984), and investigations of new methods (Griest et al. 1989; Jian and Seitz 1990) will be useful in forensics and in monitoring environmental contamination from manufacture and disposal of RDX.

6.3.2 Ongoing Studies

No ongoing methods studies were located.