REPORT

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SHEBOYGAN RIVER AND HARBOR BIODEGRADATION PILOT STUDY WORK PLAN

Tecumseh Products Company

Sheboygan Falls, Wisconsin

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GREAT LAKES NATIONAL PROGRAM OFFICE
REGION V
U.S. ENVIRONMENTAL PROTECTION AGENCY

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SECTION 1 - INTRODUCTION

1.1 Overview

The Sheboygan River and Harbor Site is located approximately 55 miles north of Milwaukee, Wisconsin. The site, which includes approximately 14 miles of river and a 100-acre harbor, was placed on the National Priorities List (NPL) in May 1986. The chemicals of concern include PCBs and various metals. At all sites on the NPL, the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA), mandates that a Remedial Investigation/Feasibility Study (RI/FS) be performed. The two-fold purpose of the RI/FS is to delineate the nature and extent of contamination associated with a site and to identify remedial measures for mitigating potential site-related human health or environmental risks. The Remedial Investigation (RI) for this site was conducted from May 1987 to June 1988 by Blasland & Bouck Engineers, P.C., on behalf of Tecumseh Products Company (the only participating potentially responsible party). The remedial investigation work efforts were summarized in the draft Remedial Investigation/ Enhanced Screening (RI/ES) Report submitted in September 1988.

The RI identified PCBs and metals in the River and Harbor sediments, with higher concentrations of PCBs observed in the Upper River (from the Sheboygan Falls Dam to the Waelderhaus Dam in Kohler) than in downstream sections. In order to evaluate the potential long-term threat to human health and the environment posed by existing conditions, a site-specific endangerment assessment was performed. The endangerment assessment identified the following potential human health exposure scenarios which posed an unacceptable risk:

- Long-term dermal exposure to River sediments containing the maximum observed PCB concentrations;
- Long-term ingestion of certain fish species which contain PCB concentrations greater than the Federal Drug Administration (FDA) limit (2.0 ppm); and
- Long-term ingestion of certain waterfowl species which contain PCB concentrations greater than 4 mg/kg in edible portions.

Potential remedial technologies were screened to determine the most effective approach for mitigating the risks identified in the endangerment assessment. The screening process initially evaluated potential PCB remedial technologies based on feasibility and applicability. Those technologies which were retained underwent an enhanced screening to assess their respective effectiveness in reducing potential toxicity, mobility, and/or volume. Technical and administrative feasibility were also evaluated. Technologies retained for further consideration were then classified under one of the following headings:

- In-Situ Remediation;
- Sediment Removal, Treatment, and Disposal;
- Sediment Removal and Disposal (without treatment); and
- No action.

The results of the RI, endangerment assessment, and remedial technologies screening are detailed in the RI/ES Report finalized in May 1990.

Upon review of the draft RI/ES Report, the United States Environmental Protection Agency (USEPA) requested in 1989 that the three sediment areas within the Upper River (i.e., Sheboygan Falls Dam to the Waelderhaus Dam) with significantly higher PCB concentrations, be removed. In response to this request, Tecumseh Products Company proposed a comprehensive Alternative Specific Remedial Investigation (ASRI) program to study several remedial technologies for their potential applicability to the Site.

The removed sediments with elevated PCB concentrations were placed in a specially constructed confined treatment facility (CTF) for the purpose of studying in-vessel PCB biodegradation. Sediments containing lower PCB concentrations were armored in the River to prevent PCB migration to the water column. Armoring involved the placement of layers of geotextile, stone, and rocks over the sediment deposit areas. Sampling ports were installed in four of these areas to periodically monitor the progress of *in situ* PCB biodegradation.

This Work Plan outlines the procedures to be followed in performing the pilot-scale investigation of PCB biodegradation. The studies will be conducted by Blasland & Bouck Engineers, P.C., on behalf of Tecumseh Products Company, in conjunction with the USEPA Assessment and Remediation of Contaminated Sediments (ARCS) Program. Background information on previous sampling activities and on going bench-scale studies are presented herein. This preliminary information is followed by descriptions of tasks required to accomplish a tracer study, adequate sampling and analysis, application of amendments, establishment of treatment objectives, and an assessment of the progress of PCB biodegradation.

1.2 Objectives

The overall objective of these studies is to assess the feasibility of utilizing biodegradation as a remedial treatment for PCBs contained in aquatic sediments. As previously noted, a confined treatment facility (CTF) will be used to study in-vessel treatment. The overall study objective will be met through the completion of the following tasks:

- o testing of a system(s) to effectively deliver amendments to sediments in the CTF;

- o amendment of two CTF cells to maintain aerobic and anaerobic conditions, respectively;
- o periodic sampling and analysis of both CTF and armored sediments;
- o development of treatment objectives for PCB biodegradation under anaerobic and aerobic conditions;
- o establishment of temporal trends in selected indices chosen to gauge the progress of biodegradation in the CTF; and
- o characterization of the extent and progression of PCB dechlorination in the armored sediments as part of the ASRI program.

These objectives will be met through a coordinated effort between Blasland & Bouck and USEPA, and will involve ongoing studies, intermittent sampling, and data evaluation.

SECTION 2 - BACKGROUND

2.1 CTF Design and Construction

Pilot-scale evaluation of in-vessel PCB biodegradation will be conducted in the confined treatment facility (CTF). The CTF was constructed of structural-steel sheet-piling with a capacity for approximately 2,500 cubic yards of River sediment. The 14,000-square-foot structure is divided into four separate cells (Figure 2-1): two larger study cells (#1 and #4), and two control cells (#2 and #3) which are each about one-third the size of the study cells. Each cell is hydraulically independent and is lined with two high-density polyethylene (HDPE) sheets with a leak detection system in between (Figure 2-2). Details are illustrated in the separately bound Appendix 2 to the ASRI Work Plan.

Water that accumulates in each cell flows through an independent discharge and exits through a permeable treatment wall (PTW). This special design feature was provided for use in studying alternative means of treating discharged water. Various configurations of sand and organic material were placed within the wall to adsorb PCBs in solution. Water from the four cells flows through the PTWs from top to bottom for Cells #1 and #2 and horizontally through crevices between an unlined sheet-pile wall for Cells #3 and #4.

At the bottom of each cell, an amendment distribution system has been provided to facilitate the introduction of materials for the enhancement of biological activity. This distribution system consists of several individual subsystems per cell, with each subsystem having a separate header (Figure 2-3). Each subsystem is composed of 1-inch perforated HDPE pipes placed at 5-foot intervals. The pipes are surrounded by geotextile and a layer of coarse sand. Three such subsystems are located in each of the study cells, while two are present in each of the control cells. As such, 10 independent connection headers rise to the top of the CTF at one central location. At this location,

amendments can be pumped downward into the piping network, which will in turn distribute the material upward through the sediment.

The CTF (approximately 106 feet in length, 135 feet in width, and up to 10 feet in height) is an above ground structure, designed and built to withstand a flood with a recurrence interval of 100 years. The CTF is located adjacent to the Sheboygan River on property owned by Tecumseh Products Company in Sheboygan Falls, Wisconsin.

2.2 Sediment Removal and Placement

Sediment was removed from the Sheboygan River and placed into the CTF during November and December 1989 and between March and August 1990. Sediments were removed from Areas 1, 2, 3, 4, 5, 9, 13, 14, and 15 of the River. The locations of these areas are illustrated in the separately bound Appendix 2 to the ASRI Work Plan.

Two modes of operation were used for sediment removal. Within the River, a work barge with crane and modified clamshell was used. In some instances, sediment was removed with a backhoe located on the river bank. The excavated sediment was placed in sealed containers, which were then decontaminated and transported by truck to the CTF site for unloading; material from nearby sediment areas was loaded directly into the CTF. At the site, the transported sediment containers were unloaded by crane and emptied into the CTF. Cells #1 and #2 were filled concurrently, as were Cells #3 and #4. Containers were emptied in several places where the sediment sloughed to the sides, resulting in uneven mounds.

2.3 Armoring

Armoring involved the confinement of sediment by covering the deposits with successive layers of materials to minimize resuspension and retard PCB

movement. The materials used, listed in the order in which they were placed, are: geotextile, a 6-inch layer of run-of-bank material, another layer of geotextile, rock-filled wire cages (gabions) placed along the periphery of the sediment area to anchor the geotextile layers, and a layer of stone for ballast.

The purposes of the armoring pilot study are to: demonstrate the technology, evaluate its effectiveness in reducing water-column PCB concentrations and associated bioaccumulation, and assess *in situ* biodegradation of PCBs in the armored sediments. Complete armoring of existing sediment deposits was conducted in Areas 5A, 7, 8, 10, and 11. To accommodate the removal of sediment samples for monitoring biological activity under the armoring materials, a sampling port (Figure 2-4) was constructed in each of armored sediment Areas 7, 8, 10, and 11. Each port consists of a 3-foot section of 12-inch PVC pipe which was perforated with several small holes to allow for the movement of water. The sampling ports were made flush with a final rock layer and were filled with both a gravel-filled geotextile and an additional bag of sand.

2.4 Review of Selected Literature

Overview

PCBs can be degraded by both aerobic and anaerobic microorganisms (bacteria). Aerobic PCB-degrading bacteria live in oxygenated environments and attack PCBs at proton-substituted positions of the molecule in a primarily co-metabolic process. Cometabolism is degradation of a compound that does not provide a nutrient or energy source for the degrading organisms but is broken down during the degradation of other substances. Anaerobic PCB-degrading bacteria live in oxygen-free environments and degrade PCBs by removing chlorine atoms, leaving the biphenyl rings intact while apparently deriving a

physiological benefit from the process. Hence, highly chlorinated PCB congeners are anaerobically dechlorinated into less chlorinated derivatives. Since the lower, rather than higher, chlorinated PCB congeners are more amenable to aerobic degradation, both processes may be employed in sequence to completely destroy PCBs. Further, since these two complementary processes are naturally occurring (Abramowicz, 1990), *in situ* treatment, if feasible, would greatly reduce excavation and transportation costs.

Aerobic Degradation

A majority of the identified organisms capable of aerobic degradation of PCBs are members of the genus *Pseudomonas*, which are commonly found in soils and natural systems. The principal route of PCB degradation by aerobic microorganisms seems to include a 2,3-dioxygenase attack at an unsubstituted 2,3- (or 5,6-) position (Furukawa, 1982). Consequently, aerobic biodegradation is effectively restricted to mono-, di-, and trichlorobiphenyls. Thus, for a PCB mixture such as Aroclor 1248, which constitutes roughly 25, 60, and 15 percent of tri-, tetra-, and pentachlorobiphenyls, respectively, microorganisms capable of only the 2,3-dioxygenase attack will not be very successful at effecting significant PCB reductions. Hence, the PCBs would need to be partially dechlorinated before substantial PCB biodegradation of Aroclor 1248 can occur.

Enhancement of PCB metabolism has been achieved by using biphenyl as a structural analog to induce cometabolism of Aroclor 1242 (Focht and Brunner, 1985) and Aroclor 1254 (Kohler *et al.*, 1988). Other substrates that support cometabolism of PCBs are acetate, carbohydrates, and other PCB congeners (Focht and Brunner, 1985). Availability of substrates and other nutrients, and a lack of toxic or inhibitory

compounds, would also result in enhanced conditions for microbial growth and associated PCB degradation.

Anaerobic Dechlorination

The microbially mediated process of chlorine removal from the PCB molecule, which occurs in the absence of oxygen, is termed anaerobic dechlorination. Chlorine removal from high-molecular-weight PCBs results in an increase in levels of lower-molecular-weight PCBs (Brown *et al.*, 1987). The anaerobic microorganisms seem to use the PCB molecule as a terminal electron acceptor, where the electron is added to the carbon-chlorine bond, followed by loss of a chlorine atom and subsequent hydrogen substitution (Abramowicz, 1990). The process appears, in general, to selectively remove meta- and para-positioned chlorines (Brown, 1990), which incidentally are the main contributors to PCB toxicity (Safe *et al.*, 1985).

Activity of dechlorinating anaerobes have been observed to increase with the addition of a simple mineral medium to levels greater than that observed in unsupplemented sediment (Abramowicz *et al.*, 1989). Increases in dechlorination rates have also been observed with the use of a complex carbon source (fluid thioglycollate medium with beef extract) or a detergent such as Triton X-705 (Abramowicz *et al.*, 1989). These enhancements and combinations thereof may result in greatly improved activity. Addition of organic substrates further stimulated dechlorination in Hudson River (New York State) sediments (Nies and Vogel, 1990), while the same effect was less pronounced with Sheboygan River sediments (Nies and Vogel, 1991).

General Considerations

PCB Aroclors are complex mixtures of various congeners that are affected differently under varying biological conditions. Cometabolism is

the predominant mode of aerobic PCB degradation (Focht and Brunner, 1985), and consequently, the choice of a substrate analog takes on increasing importance. Growing cells have been shown to be far superior to resting-cell suspensions in effecting PCB transformations (Kohler *et al.*, 1988).

Aerobic microorganisms cannot readily degrade highly chlorinated PCBs. It is, therefore, beneficial to reduce the chlorine content of the PCB molecule prior to attempting degradation by aerobic microorganisms. This chlorine removal could be achieved through the activity of anaerobic dechlorinating microorganisms. Consequently, PCB biodegradation can be effected through a two-step sequential process comprising an initial anaerobic phase followed by an aerobic phase. Such dechlorination of PCBs has been observed in Sheboygan River sediments, which presumably exist under predominantly anaerobic conditions.

2.5 Performance Criteria for Anaerobic PCB Dechlorination Technology

Performance criteria are needed to gauge the progress of anaerobic PCB dechlorination. Observations of total PCB concentrations alone will not be very useful since the dechlorination process primarily removes meta- and para-substituted chlorine atoms from the PCB molecule. These constitute a limited portion of the mass of the Sheboygan River and Harbor PCB mixture. For example, if all the nonortho-chlorine atoms were removed from an Aroclor 1248 mixture, the total PCB mass would be reduced by only about 30 percent. Criteria need to be relevant to the environmental and public health concerns regarding PCBs, reasonably easy to monitor, and relatively sensitive to the changes effected by anaerobic dechlorination.

Models of PCB toxicity, PCB bioaccumulation in birds and mammals, anaerobic PCB dechlorination, and sediment-water PCB partitioning, in addition

to the composition of PCB Aroclors, collectively give rise to several proposed indices. These indices include a three-compound PCB toxicity index based upon aryl hydrocarbon hydroxylase (AHH) induction potency and the concentration of AHH-inducers in Aroclor 1248-like PCB mixtures; an index of 18 bioaccumulative congeners characterized by the blockage of epoxidation sites on the molecule; and the average number of nonortho-chlorine atoms per molecule.

The ability to estimate values of these indices is directly related to the analytical methods used for PCB quantitation. There are as yet no standard and commercially available methods that can resolve and quantify all of the individual PCB congeners in Aroclor mixtures and environmental samples. However, there are readily available high-resolution, gas-chromatographic methods which produce useful data for quantitatively monitoring meta- and para-chlorine removal and, hence, the extent of detoxification of environmental PCB mixtures by anaerobic dechlorination. The elution sequence of PCBs on capillary columns such as SE-54, DB-1, and Dexsil 410, as well as the congener composition of Aroclors, has been well studied (Shulz *et al.*, 1987; Brown *et al.*, 1987; Cappel *et al.*, 1985; Albro *et al.*, 1981). For the Sheboygan River sediments, PCB congener analyses are being performed using a 30-meter DB-1 column (Northeast Analytical, 1990).

The estimation of the average number of ortho- and nonortho-chlorine atoms per molecule is a straightforward process using the results of PCB congener analyses. Co-elution of PCB congeners, in general, does not pose a significant problem in quantifying ortho- and nonortho-chlorine content. This is due either to the predominance of a single congener associated with the peak, or to the generally similar distribution of ortho- and nonortho-chlorine atoms on the co-eluting PCBs.

Analysis of the three coplanar PCBs and the eight monoortho-coplanar PCBs (AHH inducers) is relevant to monitoring the detoxification of PCB mixtures, but individual quantitations are not fully supported by the commercially

available capillary-column PCB analyses. However, three monoortho-congeners, referenced by International Union of Pure and Applied Chemists (IUPAC) numbers 105, 118, and 156, appear to account for a major portion of the proposed toxicity of Aroclor 1248. The analysis of these compounds can be supported by the analytical methods being used.

Safe (1990) has reviewed the mechanisms of dioxin-like PCB toxicity and has proposed toxic equivalency factors (TEFs) for PCBs based upon the binding affinity for the Aryl hydrocarbon (Ah) receptor. Table 2-1 presents the coplanar and monoortho-coplanar PCB compounds, their TEFs, and their reported concentrations in various Aroclors. These data were used to develop the summary analysis of Aroclor 1248 presented in Table 2-2. Table 2-2 also presents the proportion of TEF congeners relative to their co-eluting partners. Based upon the data in Table 2-2, it can be concluded that the three monoortho-coplanar congeners, 105, 118, and 156, which account for 68 to 75 percent of their co-eluting mixtures, collectively comprise 46 percent of the proposed "dioxin-like toxicity" of Aroclor 1248. Since the three compounds have the same TEF of 0.001, they can be summed without the need to compensate for different TEF values by weighing.

Maack and Sonzogni (1988) characterized the presence and relative abundance of PCB congeners in fish samples from Wisconsin waters including Lake Michigan and the Sheboygan River. Of the coplanar and monoortho-coplanar PCBs, only compounds 105 and 118 were detected. Each of these was found in the range of one to five percent of the total PCB concentration. Hence, the sum of PCB concentrations represented by the peaks containing compounds 105, 118, and 156 appears to be a reasonable index for tracking the "dioxin-like toxicity" of environmental PCB mixtures. Development of such performance criteria would ultimately lead to the protection of aquatic organisms and consumers from any "dioxin-like" PCB effects.

As noted by Safe (1989) and others, the role of the Ah receptor in the carcinogenicity of PCBs, as observed in rats and mice, is not defined. In his review of the information regarding PCB mutagenicity and carcinogenicity, Safe (1989) concluded that "the more highly chlorinated PCB mixtures (i.e., greater than 50 percent chlorine by weight) are hepatocarcinogens in rodents, whereas data from a limited number of studies suggest that the lower chlorinated mixtures are not carcinogenic." As evidenced in Table 2-1, Aroclor 1260, which is the most potent Aroclor, contains lower concentrations of the coplanar and monoortho-coplanar compounds than other mixtures. Although the higher-molecular-weight PCBs appear to be responsible for the carcinogenic effects in rodent studies, the specific class of congeners is yet to be defined.

In general, relatively few PCB compounds accumulate to any great extent in humans and birds. Focardi *et al.* (1986) found that five congeners (IUPAC numbers 118, 138, 153, 170, and 180) accounted for approximately 60 percent of the PCB content in 26 human adipose tissue samples from Italian males and females. Similar findings have been made by Mes *et al.* (1989) and Williams and LeBel (1990) in separate studies of Canadian residents. In comparing congener-specific metabolism between fish-eating birds and humans, Borlakoglu and Walker (1989) noted the very close correspondence, indicating that some 12 compounds accounted for 80 percent of the total PCB content of birds and humans.

The structural requirements for bioaccumulation of high-molecular-weight PCBs in humans and birds have been discussed by a number of investigators. The presence of meta-para-vicinal protons appears to be the general requirement for relatively rapid metabolism by the cytochrome P-450 type enzyme systems. Hence, as an example, compounds with di-para-substituted chlorine atoms tend to accumulate. A review of several studies suggests that the following 18 congeners (by IUPAC numbers), which lack meta-para-vicinal protons, represent

bioaccumulative compounds for humans and birds: 28, 74, 90, 99, 118, 138, 153, 156, 170, 180, 183, 187, 194, 196, 201, 203, 206, and 209.

SECTION 3 - PREVIOUS SAMPLING AND ANALYSIS

3.1 Sediment Characteristics

Physical and chemical characteristics of the River sediments have been previously determined during the RI and ASRI. The results indicate that PCB concentrations range from undetectable, to 4500 parts per million (ppm). Samples analyzed for metals showed less than 2 ppm of mercury and cadmium, and maximum concentrations of 16, 40, 58, 32, 28, and 95 ppm for arsenic, chromium, copper, lead, nickel, and zinc, respectively. Volatile organic compounds (VOCs) were largely undetectable, with trace levels observed in some samples. Total organic carbon (TOC) averaged approximately 2 percent on a dry-weight basis.

Physical characteristics of three bulk sediment samples (one from the Harbor and two from the River) were evaluated. Moisture content was in the range of 16 to 38 percent on a dry-weight basis. Coarse sand was found to be present in the range of less than one to 78 percent; fine sand in the range 15 to 76 percent; and silt and clay in the range of 7 to 80 percent (ASTM D422, D653 classification).

Moisture content was determined for four samples each taken from the following: Areas 1, 11, 15, and the Harbor. These samples had respective "*in situ*" moisture contents of 42, 22, 49, and 51 percent (wet-weight basis). In September 1990, soon after the CTF was filled, the sediment was sampled in one-foot intervals to a maximum depth of 4 feet, and moisture content was determined. Among the four cells, moisture content for 11 samples ranged between 16 and 35 percent. For saturated sediments, the moisture content indicates a porosity range of 25 to 60 percent.

3.2 CTF Sampling

3.2.1 Preliminary Round (1990)

The CTF Cell #4 was sampled in November 1990 to assess the variability of PCB concentrations, as well as other indices which could potentially be used to monitor the progress of the overall experiment. The expected high degree of spatial variability led to a composite-sampling approach. Lexan® tubing was used to collect 49 sediment cores from a sampling grid in Cell #4. Five to nine individual cores were composited to provide seven randomly distributed composite samples. The composites were well-mixed in a stainless-steel bowl. Aliquots were then transferred to 16-ounce glass jars with teflon-lined lids and sent to the laboratory for analysis.

The seven samples, designated CTF4-1C through -7C, were analyzed for PCB congeners and TOC. Results are provided in Table 3-1 for total PCBs, PCB homologs, relative levels of ortho- and nonortho-substituted (meta- plus para-positioned) chlorine, and select dechlorination products. The total PCB concentrations ranged from 160 to 595 ppm, with mean, standard deviation, and coefficient of variation values of 325 ppm, 175 ppm, and 54 percent, respectively.

3.2.2 Baseline Round (1991)

3.2.2.1 Methodology

The analytical results from the 1990 sampling of CTF Cell #4 were used to develop a statistically-based sampling design for monitoring all four cells. Using this design, baseline sampling of the four cells was conducted in July 1991, and the resulting data were evaluated to establish the current degree of PCB dechlorination.

During the baseline sampling, 35 cores were removed from each cell and composited in groups of seven to provide five composite samples per cell. Efforts were made to choose samples from widely distributed

locations within the cell in order for the composite to be representative. These samples were collected by gently tapping Lexan® tubing into the sediment and then driving it to refusal with a stainless-steel core driver. The tubing was then retrieved and the sediment core extruded into a stainless-steel bowl, thoroughly mixed, and placed into laboratory-supplied, glass sample containers. The samples were shipped to the laboratory and analyzed to provide individual PCB congener, oil and grease (O&G), and total organic carbon (TOC) content data. Four samples, one from each of the four cells, were analyzed in triplicate. One additional sediment sample from each of the four cells was analyzed for particle size distribution.

During a subsequent sampling exercise, CTF sediment and pore water were sampled at about mid-depth and analyzed for several microbial nutrients. At three random locations within each cell, well points with 2 feet of 0.05-inch slotted screen were driven such that the top of the screen was located approximately 6 inches below the sediment surface. An extension that was then added to the well point rose above the water surface. This arrangement allowed the collection of pore water samples from within the sediment and precluded the intrusion of surface water. Prior to actual sample collection, each well point was purged (about one-half gallon water removed) and allowed to recharge. Samples were collected directly into laboratory-supplied containers (with the appropriate preservative) using a portable peristaltic pump. Additionally, field measurements of pH, temperature, and specific conductivity were obtained for both the pore water samples and the overlying surface water. At the laboratory, the water samples were filtered with a 0.45-micron filter and analyzed for the following: alkalinity, calcium, iron, magnesium,

potassium, sodium, chloride, nitrate, ortho-phosphate, nitrite, sulfate, sulfide, ammonia nitrogen, and total phosphorus.

Sediment samples were collected from approximately mid-depth, by hand-turning a stainless-steel auger at locations adjacent to the well points. These samples were placed in laboratory-supplied containers with a stainless-steel spatula and submitted for analyses of total Kjeldahl nitrogen (TKN), cation exchange capacity, and total phosphorus.

Northeast Analytical Environmental Lab Services performed congener-specific PCB, oil and grease, and TOC analyses. Congener-specific PCB analysis was conducted by gas chromatography using a 30-meter DB-1 capillary column (Northeast Analytical, 1990). Analysis for TOC was performed using a Dohrmann DC-180 TOC Analyzer as per EPA Method SW846-9060 (September 1986). Total recoverable oil and grease was determined using EPA Method SW846-9070 (September 1986).

A second laboratory, Hazleton Environmental Services (Hazleton), was retained to determine particle size distribution and analyze CTF pore water and sediments for macro-nutrients. Alkalinity was measured by titration; calcium, iron, magnesium, potassium, and sodium by inductively coupled plasma (ICP) spectroscopy; chloride, nitrite, ortho-phosphate, nitrate and sulfate by iron chromatography; sulfide as per standard methods; and nitrogen, cation exchange capacity, and total phosphorus by EPA-specified methods. Particle sizes were determined by Warzyn, Inc. (a subcontractor to Hazleton) using the American Society for Testing and Materials (ASTM) Method D422 and classified using the Unified Soils Classification System (USCS).

3.2.2.2 Results

In addition to laboratory analytical data, certain data were collected in the field during sampling. Descriptions of the sediment samples are

presented in Table 3-2. Temperature, pH, and specific conductivity values for CTF pore water samples, determined during the macro-nutrient sampling, are provided in Table 3-3. In addition, sediment samples described in Table 3-4 were also collected for macro-nutrient analyses.

The laboratory results include quantities of total PCBs, ortho- and nonortho-chlorine ratios, homolog distributions, the respective sums of the monoortho-coplanar and the bioaccumulative congeners, dechlorination products, oil and grease, and TOC. Individual results for Cells #1, #2, #3, and #4, and the average of all four cells, are presented in Tables 3-5, 3-6, 3-7, 3-8, and 3-9, respectively.

Particle size distributions for one composite from each of the four cells, presented in Table 3-10, are expressed in terms of the percent gravel-, sand-, silt-, and clay-sized particles. The particle size distributions for Cells #1, #2, and #3 are similar; the sample from Cell #4, however, has more silt- and clay-sized particles and less gravel.

Results of analyses for select macro-nutrients in CTF pore water include quantities of alkalinity, calcium, iron, magnesium, potassium, sodium, chloride, nitrate, nitrite, sulfate, sulfide, ammonia nitrogen, ortho-phosphate, and total phosphorus (Table 3-11). Results of analyses for select macro-nutrients in CTF sediment include nitrogen content (TKN), cation exchange capacity, and total phosphorus (Table 3-12).

3.2.2.3 Discussion

The average ortho-chlorine fraction was relatively constant at 1.56 for each of the four cells. The nonortho-chlorine fraction was reduced relative to Aroclor 1248 by between 13 and 37 percent among the 20 composites. Of the individual homologs, the amounts of pentachlorobiphenyls were reduced slightly, though the

tetrachlorobiphenyls were substantially reduced by between 35 and 71 percent, relative to Aroclor 1248. Enrichment of the di- (6- to 20-fold) and trichlorobiphenyls (11 to 63 percent) relative to Aroclor 1248 were noted. Monochlorobiphenyls, essentially absent from Aroclor 1248, were evident in the samples. Among the dechlorination products evaluated, congener 2,4' predominated (10- to 33-fold increases). The presence of the para-substituted chlorine atom in this product indicates a dechlorination system, in CTF sediment, with an apparent preference for dechlorination of meta-substituted chlorines.

In general, sediment from all four cells currently exhibit significant amounts of dechlorination. The greatest degree of dechlorination was observed in composite 4 from Cell #4. For this sample the sum of the PCBs (in mole percent) with four or more chlorine atoms showed decreases of about fifty percent relative to Aroclor 1248. Consequently, a majority of the resulting mixture in this sample contained PCB molecules with one, two, or three chlorine atoms. Substantial reductions (20 to 60 percent) in the sum of the 30 bioaccumulative congeners were also evident. Reductions were observed in the concentrations of monoortho-coplanar congeners also.

The pilot study represents a deviation from the controlled conditions of the laboratory and tends toward the greater heterogeneity of the natural environment. Although the size and contents of the CTF are somewhat defined, the distribution of the sediment is fairly heterogeneous. This is partly because sediment was removed from nine different areas and placed in the CTF without any deliberate mixing of layers. However, Cell #1 was filled concurrently with Cell #2, and Cell #3 was filled concurrently with Cell #4.

It is necessary that samples be sufficiently representative to allow a true assessment of PCB biodegradation. While this can be achieved by increasing the number of subsamples comprising a composite, there are practical limitations as to the number of subsamples that can be taken (e.g., difficulty in uniformly mixing a large amount of sediment).

It had been expected that normalization of PCB concentration to TOC content would reduce variability and hence increase the sensitivity of the indices which are being used to monitor the experiments. However, significant relationships between TOC and these indices did not materialize for results from either the preliminary sampling of Cell #4 or the subsequent baseline sampling of all four cells.

3.3 Armored Area Sampling

3.3.1 Methodology

Each of the four sediment areas containing sampling ports (7, 8, 10, and 11) were sampled in August 1990, April 1991, and November 1991. Access to the sediment was obtained by removing both the sand and gravel bags from the sampling ports. A single sediment core was then removed from each port by driving Lexan^{R} tubing into the sediment with a stainless-steel core driver until refusal. To keep the sediment in the tube during retrieval, a vacuum was created within the Lexan^{R} tube with a hand pump. The samples were extruded on shore, mixed to achieve uniformity, and shipped to Northeast Analytical Environmental Lab Services for congener-specific PCB analysis.

3.3.2 Results

Congener-specific PCB data were evaluated to provide total PCBs, ortho- and nonortho-chlorine ratios, homolog distributions, the respective sums of the monoortho-coplanar and bioaccumulative congeners, and predominant

dechlorination products. Tables 3-13, 3-14, and 3-15 provide data for the August 1990, April 1991, and November 1991 sampling rounds, respectively.

All samples exhibited significant reductions in amounts of tetrachlorobiphenyls and increases in dichlorobiphenyls relative to Aroclor 1248. Area 11 samples were least dechlorinated, while in general, Area 10 samples displayed the most dechlorination. For the November 1991 sampling round, the sum of the mono-, di-, and trichlorobiphenyls from the Area 10 sample amounted to 87 percent. This represents a 59 percent increase in the sum of these three homologs from an unaltered Aroclor 1248 standard.

Dechlorination has also apparently achieved partial detoxification. Of the 12 samples analyzed during the three sampling rounds, reductions of the three-compound index of monoortho-coplanar congeners (up to 93 percent reduction) and the bioaccumulative congeners (up to 85 percent reduction) are evident in the majority of samples.

3.3.3 Discussion

Despite being unamended, substantial PCB dechlorination and associated detoxification are evident in sediment samples from the armored areas. However, dechlorination is apparently not uniform at the four areas sampled. It seems as though there are differences among the four areas that are affecting PCB dechlorination. The Area 10 samples are most dechlorinated, followed in order of decreasing dechlorination by samples from Areas 8, 7, and 11. Results from the last sampling round (November 1991) indicated that in the Area 10 sample, the sum of the mono-, di-, and trichlorobiphenyls was twice that in the Area 11 sample.

The results of the latest sampling round also indicated progressive dechlorination of intermediate products at para-substituted positions. In armored Areas, 7, 8, and 10, the sum of the ortho-substituted products (2;

2,2'; 2,6, and 2,2',6) are about twice th vels (mole percent) observed in the CTF samples.

3.4 Bench-Scale Studies

Bench-scale PCB biodegradation studies using Sheboygan River and CTF sediments were conducted at the University of Michigan. A draft report of interim results was provided by the researchers, Mr. Loring Nies and Dr. Timothy Vogel. Their experiments included: rapid assays to test biphenyl enrichments for aerobic degradative competence of selected groups of PCB congeners; and anaerobic experiments to test the effects of additives on PCB dechlorination in the River and CTF sediment samples.

3.4.1 Methodologies

Experiments were conducted in replicate static microcosms of 100 milliliter serum bottles and sampled repeatedly (microcosms were not sacrificed). The degradative abilities of the biphenyl enrichments were determined by growing them in an aerobic mixture of 10 PCB congeners. Anaerobic experiments were conducted on River sediments to investigate the effect of: select organic substrates (acetone, methanol and glucose); microbial enrichments from Hudson River sediments; and added PCBs. The PCB concentrations of the River sediments used in this study were taken from locations R-212 and R-8. During the RI, these locations were found to contain PCBs greater than 500 ppm and less than 10 ppm, respectively. Samples were incubated at 30°C.

Experiments were also conducted using combinations of Sheboygan and Hudson River sediments. The PCBs added were Aroclor 1242 and the single congener 2,3,4,5,6-pentachlorobiphenyl. CTF sediment samples were amended with one or combinations of: inorganic nutrients, the single PCB

congener, or a surfactant. Controls were prepared identically to live incubations, except that the controls were autoclaved.

3.4.2 Results and Discussion

The results of the rapid assays indicated that the aerobic PCB degrading competence of the biphenyl enrichments was limited. The most competent microorganisms isolated from the River samples degraded only mono- and dichlorobiphenyl congeners. There were no trichlorobiphenyls in the rapid assay mixture, and the tetrachlorobiphenyls were not degraded; this may have been due to the enrichment method which probably selected fast-growing biphenyl degraders rather than competent PCB degraders.

There did not appear to be any benefit to adding either microorganisms or substrate to the anaerobic cultures containing Sheboygan River sediments. Similarly, sediment mixes from the Sheboygan and Hudson Rivers showed little dechlorination. However, added PCBs were observed to be dechlorinated rather rapidly, suggesting that they may be more bioavailable to the microorganisms than previously existing PCBs.

In the ongoing experiments using sediment from the CTF, dechlorination has been noted, most significantly in the batches receiving acetone and more extensively in the batches receiving the additional PCB congener. At the end of 32 weeks 53 percent of the PCBs in the control had three or less chlorine atoms. For samples receiving distilled water, mineral media, acetone, pentachlorobiphenyl congener and surfactant, the percentage of PCBs with three or less chlorine atoms were 61, 58, 63, 69 and 50, respectively. With the exception of the control and the surfactant-treated sample, these numbers represent increases over that previously observed after 16 weeks. These experiments will continue to be monitored.

SECTION 4 - DESCRIPTION OF WORK TASKS

4.1 Introduction

This section of the Work Plan addresses the tasks to be carried out in an effort to achieve the pilot study objectives. Performance of these tasks will provide information necessary to evaluate the feasibility of the bioremediation alternatives for PCB-containing sediments within the Sheboygan River and Harbor Site. Monitoring of the four armored areas containing sampling ports will provide data for evaluating the progress of *in situ* PCB biodegradation by anaerobic dechlorination. The CTF will be used to evaluate the effects of enhancements on aerobic and anaerobic PCB biodegradation as viable remedial alternatives. While the CTF serves as a possible model for future bioremediation efforts, treatment strategies will have to be modified to suit given field situations.

The treatment scenarios in the CTF will involve both anaerobic and aerobic conditions, which are relevant to both *in situ* and amended in-vessel treatment. That is, initial anaerobic conditions will be maintained to facilitate further dechlorination of the higher-chlorinated PCB congeners in Cell #1. Aerobic conditions will be developed and maintained in Cell #4 to provide an enhanced environment for microbial mineralization of PCBs, including the already dechlorinated congeners. Cell #1 will remain under anaerobic conditions with the only amendments to be added being inorganic nutrients in RAMM. Cell #2 will serve as the control cell for Cell #1 and will receive no treatment. Cell #4 will be maintained under aerobic conditions by introducing oxygen-saturated water and macro-nutrients to the sediment. Cell #3 will serve as the control cell for Cell #4 and will receive no treatment and hence will remain anaerobic.

The decision to utilize both Cells #2 and #3 as respective controls for Cells #1 and #4 was deliberate. This is because Cells #1 and #2 were filled

concurrently, as were Cells #3 and #4. Consequently, each treatment cell should contain material similar to its associated control cell. A comparison of the values of various indices from the baseline sampling round between the four cells suggests that the pairings are justified.

Results from previous and future bench-scale treatability studies will guide implementation of various treatment modifications in the CTF. Bench-scale studies using Sheboygan River sediments were conducted at the University of Michigan under the auspices of Dr. Timothy Vogel (see Section 3.4). Other bench-scale studies at the USEPA Environmental Research Laboratory in Athens, Georgia, have been initiated under the direction of Dr. John E. Rogers.

Prior to the addition of any amendments, a tracer study will be performed to evaluate the effectiveness of the amendment delivery system. Preliminary checks have indicated there are no obvious blockages in the piping. Should the existing system prove to be inadequate, alternate delivery systems will be assessed and an appropriate choice made.

Periodic sampling, analysis, and data evaluation will be performed over the course of one year, at least, and possibly over several years. Sampling frequency and intervals will be modified if deemed necessary after review of available data on a periodic basis. Sediment and water (pore water and supernatant) will be sampled, and pore water monitoring will be conducted in the field. The data will be evaluated to determine the progress of PCB biodegradation in terms of the treatment objectives. Discussions pertaining to the performance of bench-scale studies, amendment addition, sampling, monitoring, analysis, and data evaluation to accomplish treatment goals, follow.

4.2 Bench-Scale Studies

Bench-scale studies involving PCB biodegradation in Sheboygan River and CTF sediment were initiated by the University of Michigan. Some of these studies

have been completed while others are still being monitored. Results thus far have indicated that further PCB dechlorination can be stimulated by using the organic substrate acetone and an added single PCB congener (possibly due to its increased bioavailability). Other bench-scale studies using CTF sediment are being initiated at the USEPA Environmental Research Laboratory in Athens, Georgia. These studies will include, but not be limited to, aerobic experiments with and without amendments.

4.3 Tracer Study

4.3.1 Overview

An effective solute delivery system is necessary for delivering amendments to the microbial populations within the sediments of the CTF. Liquid flow through the CTF sediments can occur by gravity when added to the top, or by pumping upward through the distribution piping located at the bottom of each of the four cells. The effectiveness of this system to deliver and distribute amendments throughout the CTF sediments must be determined. This evaluation will be performed by pumping a bromide salt solution (a conservative substance, termed a "tracer") through the sediments via the distribution system. On September 20, 1991, preliminary checks of the CTF amendment distribution system indicated that no obvious blockages were present.

Sodium bromide was selected for this test because it does not undergo reactions such as precipitation and sorption (i.e., it is conservative); it is non-toxic; it is present at low background levels in the CTF pore water; it is very soluble; and it can be detected down to a level of 0.4 ppm in the field (Davis *et al.*, 1985). The spatial distribution of the tracer will be established by systematic sampling and analysis along both the horizontal and vertical

planes of the sediment. The tracer study will be conducted in Cell #1, which will eventually be amended and maintained under anaerobic conditions.

Bromide concentrations will be analyzed in the field with a digital pH/mV meter (with a resolution of 0.1 mV) equipped with a combination bromide selective-ion/reference electrode. Prior to the start of the tracer test, a calibration curve of electron potential in millivolts (mV) versus bromide concentration will be prepared.

Limited data are available on background concentrations of bromide in the CTF water. Three of four pore water samples from the November 1991 sampling event had concentrations of less than 0.75 mg/L; the fourth was reported at 3.5 mg/L. Before the start of the tracer test, these levels will be verified in the field using the pH/mV meter and bromide selective-ion electrode. Background bromide concentrations in water that will be used as the tracer carrier will also be checked. Ionic concentrations in available water (CTF supernatant and Sheboygan River water) are not expected to vary sufficiently to require an ionic strength adjuster.

Distribution of the tracer (or amendments in future applications) will largely depend on advective transport by water within the CTF sediments. Based on previous experience at the site, when the distribution system was checked for blockages, an injection rate of between 5 and 30 gallons per minute in each subsystem could be maintained. Prior to the initiation of the tracer injection, the rates at which water can be delivered to, or withdrawn from, the CTF sediments by various methods will be confirmed. These methods will include the use of the delivery system beneath the sediments and well points driven midway into the sediments. The maximum achievable pumping rates will be used when refining the temporal aspects of the tracer test (i.e., total injection time, period between sampling), assessing possible

modifications to the delivery scheme and providing a relative measure of hydraulic conductivity.

4.3.2 Methodology

Sodium bromide will be injected into the southernmost piping subsystem in Cell #1, through the existing amendment delivery piping for the cell. Water will be simultaneously pumped through one or both of the other two subsystems in the cell. A sodium bromide concentrate containing a total mass of 6 kilograms of bromide (7.7 kg as sodium bromide) will be prepared and added to 50,000 liters of overlying water removed from the cell, to provide an initial delivery concentration of 120 mg/L of bromide solution for injection.

Each test cell is estimated to contain 500,000 liters of water prior to any removal for use in preparing the bromide solution. Complete mixing of the existing water with injection water would therefore result in a theoretical concentration of 12 mg/L bromide, 30 times the detection limit, and more than 3 times the highest bromide concentration reported for the CTF. Since the tracer injection and monitoring will be concentrated in one-third of the cell, complete mixing is not anticipated and, consequently, higher concentrations are expected in the area being monitored.

Prior to initiation of the tracer test, a network of at least 14 sampling locations within Cell #1 will be established above the subsystem in which tracer is being injected. At each location, samples will be withdrawn from up to three depths, depending on the actual depth of sediment, using hand-driven well points. To minimize vertical mixing of pore water in the samples, screening on the well points will be limited to a maximum of 6 inches. Since distribution of the bromide throughout the sediment is the major concern, most locations will be sampled only after injection is complete. A subset of these locations will, however, be sampled and bromide analysis conducted

during the injection phase of the tracer study to provide information on the movement of the tracer on a "real-time" basis. Initially, a few locations in the cell would be monitored during the injection. However, the exact number of locations will be determined after rates of injection have been established.

Samples will also be taken from the overlying water in the cell and any water present in the effluent and leak detection systems. All samples will be analyzed in the field, immediately after collection, for bromide. If a 30 gallon per minute injection flow for each subsystem is realized, the injection period will last about seven and one-half hours.

4.3.3 Data Analysis

After samples from all locations and depths have been analyzed for bromide, the resulting data will be reviewed to determine the relative degree of bromide movement, and to observe any evidence of channeling or the existence of "dead zones". Both the vertical and horizontal distribution of the tracer will be noted. For the purposes of this test, the solute will be considered delivered to an area if the pore water bromide concentration exceeds 15 mg/L (a 10 percent injection solution plus approximately 90 percent high background). An even distribution, although desirable, is not necessary. A preliminary mass-balance calculation will be performed.

If more detailed information on hydraulic properties of the sediments is needed after the initial tracer study in Cell #1, appropriate constant-head, falling-head, or slug tests will be conducted *in situ*. Sediment cores may be obtained on an "as needed" basis to relate physical properties of the sediment to observed tracer distribution patterns. Sediment cores may also be taken from selected locations to relate results obtained during the tracer study to the local physical characteristics of sediment. This may involve a simple qualitative description of the sediment or a more detailed particle size analysis.

Depending on the results obtained from the tracer injection, the goal of the next phase of the study will be to determine how best to manipulate water flow through the sediment so that the water will act as an advective agent, distributing a solute through the sediment.

The use of well points to inject or withdraw water, in conjunction with the underlying amendment delivery system, is a possible alternative. Further addition of tracer to recycle water is an option during any of these steps. The choice of alternatives, if necessary, would be made after reviewing the initial results of the tracer test. The utility of existing sampling locations, or the need for establishing new ones in nearby locations would also be considered at that time.

4.4 Amendment Addition

Following the establishment of an effective amendment/solute distribution method in the CTF, selected RAMM components (Table 4-2) will be introduced into Cell #1. Cell #4 will be amended with oxygenated water and a modest supplement of macro-nutrients.

The armored areas will not receive any amendments but will be monitored so that an evaluation of unenhanced *in situ* biodegradation can be made. While the entire pilot study addresses bioremediation of sediments both in place and in vessel, amendment addition studies will be limited, at least initially, to the CTF.

4.4.1 Aerobic Treatment

The operation of the aerobic treatment cell, Cell #4, will involve: withdrawal of overlying or interstitial water from the cell; continuous aeration of the withdrawn water with compressed air; nutrient (nitrogen and phosphorus) addition as required based upon the results of periodic monitoring; and reinjection of the aerated water into Cell #4 through the

distribution system or through a series of injection wells. At all times, attempts will be made to keep water being pumped through this cycle within the confines of the CTF. Pumps for the recycling and distribution of the water and amendments will, to the extent possible, be located on or near a central work platform in the CTF.

In April 1990, water was observed in the CTF leak detection systems (LDS). Since then, approximately 1200 gallons of water have been pumped daily from the Cell #4 LDS back into the cell or treated in a nearby contingency water treatment facility (CWTF) and subsequently discharged into the River. Treatment and discharge of excess water are only performed when necessitated by excessive precipitation.

Preliminary calculations indicate that Cell #4 contains an estimated 492,000 liters (130,000 gallons) of water, including pore and overlying water. The desired flow rate of water through the CTF is one volume per day, which would require a pumping rate of 90 gallons per minute. Should the large volume of overlying water restrict the use of lower pumping rates, overlying water levels may be reduced prior to water re-circulation.

This rate of water exchange in Cell #4 could in theory provide approximately one liter of re-aerated water per day for every three kilograms of sediment. This ratio can be compared to results of any oxygen consumption bench-scale studies that might be conducted to determine the rate at which oxygen needs to be transferred to the CTF sediments for maintaining an acceptable aerobic environment. Suggested bench-scale tests which may provide greater insight into the oxygen consumption characteristics of the sediments range from simple BOD determinations to column studies designed to assess the effects of varying water to sediment ratios.

If deemed necessary, a series of six well points (two above each distribution subsystem) will be used to augment the delivery of nutrients and

oxygen into the areas of greatest sediment depth in Cell #4. These six well points will be located in areas of maximum sediment depth and screened 1.5 to 3 feet above the sediment bottom. Flexible hosing will be used to connect these well points to a header running along the edge of the cell and connected to the amendment source. The injection rates of nutrients and oxygenated water into these well points, while dependent on local permeability of the sediments, are expected to be much lower than the rates of injection beneath the sediments. These injection well points may be utilized either continuously or on an "as needed" basis.

Overlying water will be withdrawn from Cell #4, at a rate equal to the injection rate, through the distribution system and injection wells. The proposed location for water withdrawal will be somewhat central and furthest from the outer walls of the CTF. Such a location will allow withdrawal of water in near-equal amounts from each subsystem of the cell and should establish a flow of overlying water generally from near the outer walls toward the withdrawal point.

Well points will also be installed to collect samples for assessing the effectiveness of the distribution system. These samples will be collected weekly over the experimental period. Process control will be maintained by analyzing the samples from these well points for pH, dissolved oxygen, nitrogen and phosphorus. At least one well point will be screened near the lower third of the sediments, and another will be located in an area of relatively deep sediment and screened 1 to 1.5 feet below the sediment surface. Each well point will be fitted to allow for pumping of samples from a central work area. The water recycling and distribution lines may also be fitted with ports at the central work area for collecting in-line samples.

4.4.2 Anaerobic Treatment

The anaerobic treatment cell, Cell #1, will not require a continuous source of amendments as will the aerobic cell, but many aspects of the distribution approach to be used in the aerobic cell will also be used in Cell #1. This includes the use of excess overlying water with added amendments which will be reinjected into the CTF sediment through the underlying distribution system and possibly through a series of well points. As with Cell #4, water is collected daily from the LDS of Cell #1 and subsequently returned to the cell. However, only approximately 120 gallons (about one-tenth the average removed from Cell #4) are removed from Cell #1.

The RAMM will only be added as required; therefore, the rate of injection is not as critical as in the aerobic cell. After the desired quantity of RAMM has been introduced to the cell, additional water recycling may be employed to provide a more uniform distribution. Pumping of two cell water volumes should be sufficient. A series of six well points may be located in areas of deepest sediment to augment RAMM distribution. The well points will be screened from 2 to 4 feet into the sediment. These wells will only be used during RAMM injection, if deemed necessary, and then removed. Only certain constituents of RAMM, (mineral salts and trace metals) will be added to the CTF. The recipe for RAMM is provided in Table 4-2, and the elemental composition is provided in Table 4-3.

4.5 Sampling and Analysis

4.5.1 CTF Sediment

Time-zero sampling will be conducted just prior to the onset of sediment amendment (RAMM addition to Cell #1 and aeration of Cell #4), and subsequent sampling will be conducted at intervals of roughly 2, 4, 6, and 12 months. The last four sediment sampling rounds will be conducted in

August, October, and December, 1992 and June 1993. A total of 35 individual sediment cores will be removed from each cell and composited in groups of seven to provide five composite samples per cell. Samples will be collected in such a manner so as to obtain sediment cores that are most representative of the vertical distribution. Method(s) to be employed will be determined by the sampling crew onsite, depending on the conditions encountered. Approximately 10 kg of sediment per composite sample are collected in a stainless-steel mixing bowl (approximately 2 feet in diameter) and mixed for about five minutes or longer if needed until the sediment mixture appears visually uniform. Mixing is performed by hand with a steel trowel-like scoop. Small amounts of the mixed sediment are collected from various locations within the bowl and used to fill one-pint (approximately one-half-liter) glass jars. These jars are placed on ice and shipped to the laboratory for duplicate samples to be analyzed. Samples will be collected from randomly selected locations on a pre-established grid. For each cell, the locations of 180 individual cores will be referenced in terms of x and y coordinates measured from a fixed datum. These 180 locations will be equally spaced within a given cell. The locations of the seven cores making up a given single composite sample will be randomly chosen (with a random number generator) from among these pre-established locations. No location will be sampled more then once during the study. During subsequent sampling events, the number of core locations available for sampling will be reduced from 180, by the number of cores removed during previous sampling. Individual core samples will be carefully logged, noting depth of sediment penetrated, length recovered, and physical characteristics of the composite sample.

The samples will be sent to the USEPA Environmental Research Laboratory in Athens, Georgia, for congener-specific PCB analysis in accordance with

their quality assurance/quality control measures. Additionally, for the first two and possibly other sampling rounds, two of the composite samples from Cells #1 and #4 and one from each of Cells #2 and #3 will be sent to Northeast Analytical Lab Services (Northeast) in Schenectady, New York, for congener-specific PCB, oil and grease, and TOC analyses. During the first two sampling rounds, all of the five composite samples from each of the four cells will be analyzed for TOC and oil and grease. As a quality control measure, Northeast will analyze one of the samples for PCB analysis in duplicate, and a subsample of one of the composites spiked with a PCB mixture of known concentration. The percent recovery of the known total PCBs will then be calculated.

Two composite sediment samples per cell will also be analyzed during the first two sampling rounds, and perhaps during subsequent rounds (depending on initial results), for the following: total Kjeldahl nitrogen (TKN), sulfate and ortho-phosphate.

4.5.2 CTF Pore Water

Pore water may be periodically monitored for dissolved organic carbon, ammonia, nitrate, nitrite, sulfate, ortho-phosphate, iron, TKN, and sulfide. Temperature, redox potential, and pH will be monitored in Cells #1 and #4, and dissolved oxygen (DO) levels will be monitored in Cell #4 (the aerobic cell).

4.5.3 Armored Areas

Each of the four armored sediment areas containing sampling ports (Areas 7, 8, 10, and 11) has been sampled three times thus far, in roughly six-month intervals. These samples were shipped to Northeast for congener-specific PCB analysis with results indicating that further monitoring is warranted. Consequently, the applicability of the existing sampling approach is currently

being re-evaluated, and any modifications will be provided as a supplement to this Work Plan.

4.5.4 Field Decontamination Procedures

Field decontamination involves the cleaning of reusable equipment (sampling and other) and the proper disposal of non-reusable materials. All reusable equipment which comes into direct contact with sediment will be cleaned. Heavier equipment will be cleaned on the decontamination pad located in close proximity to the CTF. Cleaning will be repeated, as necessary, until all residual sediment is removed. Wash/rinse water will be collected and placed in the CTF. Sampling equipment will be cleaned in-between sampling cells during composite sampling, and after sampling each location when individual samples are collected. Gloves worn by sampling personnel will be changed in-between composites to avoid cross-contamination.

When samples are to be analyzed for organic constituents, the field sampling equipment will be cleaned as follows:

1. Non-phosphate detergent and water wash;
2. Tap water rinse;
3. Solvent rinse (e.g. hexane);
4. Laboratory supplied distilled/deionized water rinse; and
5. Repeat solvent and water rinse (steps 3 and 4) twice and allow equipment to air dry.

Equipment to be used in collecting samples for analysis of inorganic constituents will be cleaned as follows:

1. Non-phosphate detergent and water wash;
2. Nitric acid rinse; and
3. Tap water rinse.

During the cleaning of equipment, safety procedures presented in this document and the ASRI Health, Safety and Contingency Plan (Blasland & Bouck, 1989) will be strictly adhered to.

All cleaning water generated during any cleaning procedure will be collected and contained onsite for placement into the CTF. All solvent rinse solutions will be contained and either treated or disposed at an appropriate hazardous waste facility, if necessary. Solids resulting from personnel cleaning activities (e.g., disposable gloves, disposable clothing, and other disposable equipment) will be placed in plastic bags. These bags will be transferred into appropriately labelled 55-gallon drums for disposal at an appropriate hazardous waste facility.

4.5.5 Analytical Methods

Congener-specific PCB analysis will be performed with gas chromatography using a 30-meter DB-1 capillary column (Northeast Analytical, 1990). Analysis for organic carbon will be performed using a Dohrmann DC-180 TOC Analyzer as per EPA Method SW846-9060 (September 1986) while total recoverable oil and grease will be determined using EPA Method SW846-9070 (September 1986). The USEPA Environmental Research Laboratory will conduct the bulk of the congener-specific PCB analysis at its Athens, Georgia location. Hazleton Environmental Services will analyze the CTF pore water and sediments for macro-nutrients using analytical methods presented in Table 4-4.

4.6 Data Evaluation and Treatment Objectives

Blasland & Bouck has proposed the use of several criteria to evaluate the progress of sediment remediation by anaerobic PCB dechlorination (see Section 2.5 of this Work Plan). The proposed criteria are: a three-compound PCB toxicity index of monoortho-coplanar congeners; an index of bioaccumulative congeners; the average number of nonortho-chlorine atoms per molecule;

characteristic dechlorination products; and relative quantities of individual homologs. These indices are relevant to public health and environmental issues, relatively easy to monitor, and sensitive to the changes effected by anaerobic dechlorination.

The three-compound toxicity index is made up of the sum of monoortho-coplanar PCB congeners with IUPAC numbers 105, 118, and 156. Although each of these congeners has a co-eluting partner (congeners 132, 149, and 171, respectively), in Aroclor 1248 the three monoortho-coplanar compounds are at higher concentrations than their co-eluting partners.

The group of 18 predominantly bioaccumulative congeners are made up of the following, listed by IUPAC numbers: 28, 74, 90, 99, 118, 138, 153, 156, 170, 180, 183, 187, 194, 196, 201, 203, 206, and 209. Twelve additional congeners, though not predominantly bioaccumulative, complete the group of bioaccumulative congeners; they are, by IUPAC numbers: 33, 44, 49, 52, 61, 66, 70, 84, 87, 105, 128, and 146. Several of these bioaccumulative congeners also have inseparable co-eluting partners which, are therefore also included in the summation.

The products targeted for evaluation were those in the five most abundant product peaks. By IUPAC numbers, these are 1 (congener 2), 4 co-eluting with 10 (congeners 2,2' & 2,6); 5 co-eluting with 8 (congeners 2,3 & 2,4'); 16 co-eluting with 32 (congeners 2,3,'3 & 2,4,'6); 17 (congener 2,2,'4) and 19 (congener 2,2,'6). These are all early eluting congeners, as would be expected for PCBs with lower molecular weight arising from chlorine losses due to dechlorination.

The analytical results as received from the laboratory provide values for both the weight and mole percent contributions of each chromatographic peak. Some of these peaks contain co-eluting congeners which are indicated on the data sheet provided by the laboratory. Additionally, for each sample, the data sheet

contains summaries of total PCBs, the ortho- and nonortho-chlorine ratios, and the homolog distributions. Consequently, it is necessary to extract and sum, where necessary, the monoortho-coplanar, bioaccumulative, and dechlorinated congeners.

Data management and evaluation would be accomplished through the use of a computer spreadsheet (database) and simple programming routines. This would facilitate the analysis of complex data sets where each congener-specific PCB analysis produces in excess of one hundred peaks per sample.

Aerobic biodegradation will be gauged by tracking reductions in both total PCB concentrations and aerobically biodegradable congeners relative to biorecalcitrant (non-biodegradable) congeners. Biodegradable and non-degradable congener reductions, will be compared to compensate for losses due to non-biological (physical and chemical) processes.

Treatment objectives will be developed in consultation with the regulatory agencies. Necessary objectives include the extent of dechlorination required prior to making any switch in Cell #1 from anaerobic to aerobic conditions, as well as, the extent to which the final concentrations of relevant PCB congeners need to be reduced so that no further treatment is necessary.

SECTION 5 - QUALITY ASSURANCE/QUALITY CONTROL

5.1 General

Efforts will be made to maintain the integrity, quality, and accuracy of data generated during the Biodegradation Pilot Study. Quality assurance/quality control (QA/QC) guidelines will follow those set forth in the ASRI Quality Assurance Project Plan (QAPP) and will be supplemented by this section of the Biodegradation Work Plan. In instances where inconsistencies between the two documents may arise, this Work Plan will supersede the ASRI-QAPP.

5.2 Project Responsibilities

As mentioned previously, this study is a cooperative venture between Blasland & Bouck Engineers, P.C. (acting on behalf of Tecumseh Products Company), and the ARCS program (acting on behalf of the USEPA and specifically the Great Lakes National Program Office, GLNPO). Consequently, the USEPA Environmental Research Laboratory (ERL) has been designated as an additional laboratory for chemical analyses - predominantly congener-specific PCB analysis. Changes to personnel mentioned in the ASRI-QAPP follows:

a) Replacements:

o USEPA Oversight Project Manager (B&V Waste Science Technology)	Scott Anderson, P.E., (Replaces Martin Chapple)
o Project Coordinator (Blasland & Bouck)	Dawn S. Foster, P.E. (Replaces Robert K. Goldman, P.E.)
o Project Manager (Blasland & Bouck)	Mark P. Brown, Ph.D. (Replaces Dawn S. Foster, P.E.)
o QA Coordinator (Blasland & Bouck)	Laurie Johnston (Replaces William A. Ayling)

o	Project Coordinator (WDNR)	Paul L. Kozol, P.E. (Replaces Robin R. Schmidt)

b) Additions:

o	USEPA-Region V, Project Manager	Bonnie Eleder
o	USEPA-GLNPO, Project Manager	Richard Fox
o	USEPA-ERL, Project Manager	John Rogers, Ph.D.
o	USEPA, QA Officer	Eric Weber, Ph.D.
o	USEPA, Sample Custodian	Eric Weber, Ph.D.
o	USEPA, Laboratory Manager	Jack Jones, Ph.D.

5.3 Field Measurements

Field measurements to be taken in addition to those mentioned in the ASRI-QAPP are:

- o Sodium bromide concentrations in water samples during the tracer study; and
- o Dissolved oxygen concentration in water samples from CTF Cell #4.

The measuring devices used in taking these measurements will be calibrated as per manufacturer recommendations.

5.4 Analytical Procedures

Analytical procedures to be employed in this study are discussed in subsection 4.5.5 and summarized in Table 4-4. In general, anions will be measured by ion chromatography (IC) rather than the calorimetric and spectrophotometric methods specified in the ASRI-QAPP. Total and dissolved organic carbon will be measured using Method SW846-9060, instead of Method 505B in "Standard Methods", as specified in the ASRI-QAPP. The method for oil and grease will be SW846-9071 instead of Method 413.1, as specified in the ASRI-QAPP.

SECTION 6 - HEALTH AND SAFETY CONSIDERATIONS

A Health, Safety and Contingency Plan (HSCP) was developed for the ASRI by Blasland & Bouck and was dated October 1989. Health and safety considerations for the biodegradation pilot study will follow those provided in the ASRI-HSCP to the extent to which they apply. Certain chemicals that will be used in this study were not discussed in the ASRI-HSCP and are therefore discussed herein; these chemicals are the sodium bromide tracer, as well as the macro-nutrient amendments and RAMM. Where inconsistencies may arise, this Work Plan will supersede the HSCP.

Sodium Bromide

As indicated on the material safety data sheets (MSDS) included in the Appendix, sodium bromide is moderately toxic when inhaled or ingested but there are no set limits on occupational exposure. Protective eyeglasses or safety goggles and impervious gloves, boots, and aprons should be worn.

RAMM

The RAMM mixture contains inorganic ions which are found naturally in soils and water. They are at relatively low concentrations and the pH of the CTF is near neutrality. While RAMM is not corrosive, dermal contact and ingestion should be avoided. The Appendix contains available MSDS for the RAMM components used in this study.

SECTION 7 - SCHEDULE AND ORGANIZATION

7.1 Project Schedule

Time-zero sediment sampling is scheduled for initiation shortly after the tracer study, weather depending. Amendments will be added soon thereafter and activities will follow the schedule provided in Figure 7-1. Periodic sampling and analysis will be performed at intervals indicated on the figure. Bench-scale studies will proceed concurrently with appropriate modifications to design, protocols, and sampling frequency to be made as deemed appropriate. An interim report will be prepared in early 1993, and a final report will be provided at the end of the project.

7.2 Project Organization

This project is being conducted jointly by Blasland & Bouck Engineers, P.C., on behalf of Tecumseh Products Company, and the USEPA (a project organization chart is provided on Figure 7-2). For Blasland & Bouck (Figure 7-3), Dawn S. Foster, P.E., will continue to serve as coordinator of the overall project and will provide administrative oversight. Mark P. Brown, Ph.D., will manage the biodegradation pilot study and provide technical oversight for treatment design, sampling, data evaluation, and coordination with the ARCS program. Kendrick Jaglal will assist with project management to supplement the efforts of Ms. Foster and Dr. Brown, and will be responsible for overseeing day-to-day project activities. Field activities will be performed under the direction of Richard P. DiFiore with technical support provided by Patrick N. McGuire and Charles R. Barnes. For the USEPA, Bonnie Eleder will coordinate administrative activities while John E. Rogers, Ph.D., will be responsible for technical management.

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Tables

TABLE 2-1

SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

COPLANAR AND MONOORTHO-COPLANAR PCBS IN AROCLORS

Congener	IUPAC No.	TEF(6)	Aroclor 1016	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
Coplanar PCBs							
3,3',4,4',5 - Penta CB	126	0 1	ND(1)	<0 025(1)	<0 025(1)	<0 025(1)	<0 025(1)
					ND(3)	0 16(3)	1 59(3)
				0 0019(4)	0.0052(4)	0 0038(4)	0.00032(4)
3,3',4,4',5,5' - Hexa CB	169	0.05		ND(4)	ND(4)	0 000051(4)	ND(4)
3,3',4,4' - Tetra CB	77	0.01	ND(1)	0 24(1)	0.34(1)	0 02(1)	ND(1)
				0.35(2)	0.65(2)	0 11(2)	0.11(2)
				0.51(4)	0.47(3)	0.12(3)	0.04(3)
				0.45(5)	0.62(4)	0.062(4)	0 026(4)
Monoortho-Coplanar PCBs							
2,3',4,4',5 - Penta CB	118	0.001	1.62(5)		6.39(5)	0.57(5)	
2,3,3',4,4' - Penta CB	105	0 001		0.31(2)	1.11(2)	2.71(2)	0.03(2)
				0.86(5)	<0 01(3)	<0.01(3)	<0.01(3)
						3.83(5)	0 07(5)
2',3,4,4',5 - Penta CB	123	0.001		ND(5)		0.81(5)	ND(5)
2,3,4,4',5 - Penta CB	114	0 001		ND(5)		ND(5)	ND(5)
2,3,3',4,4',5 - Hexa CB	156	0.001		0.09(5)		1.62(5)	0 88(5)
2,3,3',4,4',5' - Hexa CB	157	0.001		ND(5)		ND(5)	0 14(5)
2,3',4,4',5,5' - Hexa CB	167	0.001		ND(5)		0.21(5)	0 26(5)
2,3,3',4,4',5,5' - Hexa CB	189	0.001		ND(5)		ND(5)	0.11(5)

References:

1 - Huckins, et al., 1988.
2 - Mullin, 1980 in Huckins, et al., 1988
3 - Albro, et al., 1981.
4 - Kannan, et al., 1987.
5 - Schulz, et al., 1987.
6 - Safe, 1990.

Notes:

CB - chlorobiphenyl
ND = None detected
TEF = Toxic equivalency factor
IUPAC = International Union of Pure and Applied Chemists
Values reported in mole percent

TABLE 2-2

SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

ANALYSIS OF COPLANAR AND MONOORTHO-COPLANAR PCBS
IN AROCLOR 1248

Compound (IUPAC No.)	TEF	Weight Percent	Reference	Percent of Co-Eluting PCBs
126	0.1	0.005	1	0.3
169	0.05	ND	1	100
77	0.01	0.6	1,2	7.4
118	0.001	4.0*	3	74
105	0.001	1.1	2	68
123	0.001	0.4*	3	100
114	0.001	ND	3	7.6
156	0.001	0.9*	3	75
157	0.001	ND	3	100
167	0.001	0.1*	3	100
189	0.001	ND	3	100

Notes:

* Mean reported for Aroclors 1242 and 1254
ND = None detected
TEF = Toxic equivalency factor
IUPAC = International Union of Pure and Applied Chemists
Column: DB-1 fused silica capillary coated with a 0.25 um bonded liquid phase of Polydimethylsiloxane

References:

1. Kannan, et al., 1987
2. Mullin, 1980 in Huckins, et al., 1988
3. Schulz, et al., 1989

TABLE 3-1
SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

ANALYTICAL RESULTS OF CTF SEDIMENT SAMPLING

CELL 4 (NOVEMBER 1990)

Index	Composites 1	2	3	4*	5	6	7	Mean +/- SD
Total PCBs, ppm	160	260	210	200	295	560	595	325 ± 175
Ortho-chlorine ratio	1.56	1.55	1.56	1.61	1.64	1.63	1.60	1.59 ± 0.04
Non-ortho-chlorine ratio	1.66	1.67	1.63	2.02	1.57	2.38	2.09	1.86 ± 0.30
Homologs, mole%								
mono-	1.7	2.7	2.5	1.6	2.2	0.31	1.5	1.8 ± 0.79
di-	27	28	26	17	32	5.7	13	21 ± 9.5
tri-	36	33	38	29	29	21	29	31 ± 5.5
tetra-	22	21	21	28	20	45	35	28 ± 9.3
penta-	10	11	10	17	13	21	17	14 ± 4.3
hexa-	2.5	3.0	2.2	5.3	3.3	5.3	4.1	3.7 ± 1.3
hepta-	0.51	0.57	0.48	0.96	0.52	0.88	0.72	0.66 ± 0.19
Sum of mono-ortho coplanar PCBs, mole %	2.1	2.5	1.9	4.4	2.2	5.0	3.8	3.1 ± 1.3
Sum of 18 predominantly bioaccumulative congeners, mole %	11	11	12	14	8.2	15	14	12 ± 2.4
Sum of all 30 bioaccumulative congeners, mole %	27	28	28	39	25	54	44	35 ± 11
Products, mole %								
2	1.5	2.3	2.	1.4	1.9	0.25	1.4	1.5 ± 0.65
22' & 26	2.0	2.1	2.0	1.3	1.9	0.32	1.1	1.5 ± 0.64
24'	23	24	21	14	29	3.2	9.4	18 ± 9.1
22'6	2.3	2.1	2.4	1.5	2.0	0.42	1.1	1.7 ± 0.72
22'4	10	9.3	10	6.7	8.5	2.5	5.5	7.6 ± 2.8
22'3 & 24'6	6.6	5.9	6.9	4.6	6.3	2.7	3.9	5.3 ± 1.6
TOC, %	1.5	1.5	1.7	1.4	1.7	0.9	1.7	1.5 ± 0.30

Notes:
* Average of duplicates
Results are expressed to two significant figures except as noted below.
Total PCBs are expressed to the nearest multiple of 5.
Ortho- and non-ortho-chlorine ratios are expressed to two decimal places.
Index values for unaltered Aroclor 1248 mixture are presented in Table 5-9.

TABLE 3-2
SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

CTF SEDIMENT DESCRIPTIONS

Cell Number	Composite Number	Recovered Depths[1] (ft)	Date	Sample Description
1	1	0.7, 2.2, 1.1, 0.7, 1.0, 1.0, 1.2	7/22/91	Fine sand to coarse sand and gravel, brown clay with some silt, moderate organic odor
1	2	1.9, 0.6, 1.3, 1.1, 1.5, 0.6, 0.7	7/22/91	Brown clay and gravel, some coarse sand and silt, strong organic odor
1	3	1.0, 1.1, 1.0, 1.5, 1.2, 1.8, 2.1	7/23/91	Coarse sand and gravel, clay, some silt, moderate organic odor
1	4	1.7, 0.9, 1.8, 2.5, 1.4, 0.8, 1.6	7/23/91	Clay and silt, some sand and gravel, moderate organic odor
1	5	2.1, 1.3, 1.0, 1.9, 2.0, 1.6, 0.8	7/23/91	Coarse sand and gravel, clay, some silt, moderate organic odor
2	1	1.8, 1.2, 0.9, 1.0, 1.2, 1.3, 0.7	7/23/91	Coarse sand and gravel, trace of silt, slight organic odor
2	2	1.5, 1.9, 1.7, 1.3, 1.3, 1.8, 1.3	7/23/91	Clay, silt, and gravel, some sand, moderate organic odor
2	3	1.6, 2.1, 1.1, 1.4, 2.2, 1.9, 1.6	7/24/91	Dark brown silt and clay, some gravel and coarse sand, strong organic odor, visible oil sheen
2	4	1.1, 1.8, 1.2, 0.7, 1.4, 0.8, 1.0	7/24/91	Fine to coarse sand with gravel, some clay, trace of silt, moderate organic odor

TABLE 3-2
SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

CTF SEDIMENT DESCRIPTIONS
(Continued)

Cell Number	Composite Number	Recovered Depths[1] (ft)	Date	Sample Description
2	5	1.6, 2.0, 1.1, 2.5, 1.6, 1.0, 1.2	7/24/91	Brown clay with coarse sand and gravel, trace of silt, moderate organic odor
3	1	2.3, 0.8 2.0, 2.0, 0.8, 1.2, 1.0	7/24/91	Clay, coarse sand and gravel, trace of silt, slight organic odor
3	2	0.8, 1.6, 1.0, 1.1, 1.9, 2.2, 1.1	7/24/91	Coarse sand and gravel, some clay and silt, moderate organic odor
3	3	1.3, 1.7, 1.0, 1.0, 1.4, 0.7, 1.4	7/24/91	Clay with coarse sand, some gravel, silt, moderate organic odor
3	4	1.9, 1.3, 1.1, 1.0, 0.6, 0.9, 1.9	7/24/91	Clay with gravel, some sand and silt, slight organic odor
3	5	1.1, 1.3, 0.8, 1.7, 1.8, 1.2, 1.3	7/24/91	Fine sand and clay with silt, some gravel, moderate organic odor
4	1	1.8, 1.0, 1.7, 0.9, 1.4, 1.3, 1.4	7/25/91	Clay with some silt, coarse sand, slight organic odor
4	2	1.5, 2.0, 1.1, 1.1, 1.5, 1.6, 1.4	7/25/91	Medium to coarse sand and gravel, clay, trace of silt, slight organic odor
4	3	1.0, 1.6, 1.2, 1.8, 0.8, 1.2, 1.6	7/25/91	Fine to coarse sand and clay, some silt, moderate organic odor

TABLE 3-2
SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

CTF SEDIMENT DESCRIPTIONS
(Continued)

Cell Number	Composite Number	Recovered Depths[1] (ft)	Date	Sample Description
4	4	2.0, 1.3, 2.0, 1.6, 0.9, 1.6, 1.6	7/25/91	Medium to coarse sand, clay, some silt and gravel, moderate organic odor
4	5	1.8, 1.1, 2.1, 1.0, 1.8, 1.8, 0.7	7/25/91	Dark brown silt and clay with fine to medium sand, slight organic odor

Note:

[1] Depth of sediment recovered for each of the seven cores comprising one composite sample.

TABLE 3-3
SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

CTF MACRO-NUTRIENT PORE WATER FIELD SAMPLING RESULTS[1]

Sample Location	Date	Time	Temperature (°C)	pH	Conductivity (mS/cm)	Sample Depth[3] (ft)
Cell 1 - W1	11/14/91	15:50	6	6.54	1.190	3.0-3.5
Cell 1 - W2	11/14/91	15:10	7	6.76	0.676	3.0-3.5
Cell 1 - W3	11/14/91	15:30	7	6.40	1.290	3.0-3.5
Cell 1 - Surface Water[2]	11/14/91	16:00	3	8.20	0.362	----
Cell 2 - W1	11/15/91	9:30	7	6.29	1.910	2.0-2.5
Cell 2 - W2	11/15/91	9:00	7	6.31	1.990	2.0-2.5
Cell 2 - W3	11/15/91	8:30	5	6.91	0.608	2.0-2.5
Cell 2 - Surface Water[2]	11/15/91	9:40	3	7.51	0.446	----
Cell 3 - W1	11/14/91	10:45	6	6.25	1.800	1.0-1.5
Cell 3 - W2	11/14/91	11:30	6	6.29	1.570	1.0-1.5
Cell 3 - W3	11/14/91	12:15	6	6.41	1.520	1.5 2.0
Cell 3 - Surface Water[2]	11/14/91	12:30	3	8.13	0.488	--
Cell 4 - W1	11/13/91	13:45	6	6.60	4.200	2.0-2.5
Cell 4 - W2	11/13/91	14:45	7	6.50	2.440	2.0-2.5
Cell 4 - W3	11/13/91	15:45	6	6.63	0.536	2.0-2.5
Cell 4 - Surface Water[2]	11/13/91	16:00	3	6.87	0.465	----

Notes:

1 Water samples were analyzed for the following: sulfide, chloride, sulfate, nitrate, nitrite, phosphate, calcium, potassium, sodium, magnesium, iron, ammonia, total phosphorus, and alkalinity.
2 Surface water samples were not analyzed.
3 Sample depths were measured from top of sediment.
-- Readings taken at the water surface.

TABLE 3-4
SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

CTF MACRO-NUTRIENT SEDIMENT FIELD SAMPLING RESULTS[1]

Sample Location	Date	Time	Sample Depth[2] (ft)	Sample Description
Cell 1 - W1	11/14/91	15:50	3.0 - 3.5	Dark brown silt, fine sand, coarse gravel.
Cell 1 - W2	11/14/91	15:10	3.0 - 3.5	Brown clay and gravel, some fine sand.
Cell 1 - W3	11/14/91	15:30	3.0 - 3.5	Brown fine sand, some silt, and coarse gravel.
Cell 2 - W1	11/15/91	9:30	2.0 - 2.5	Dark brown silt and fine sand.
Cell 2 - W2	11/15/91	9:00	2.0 - 2.5	Brown silt, with medium to coarse sand.
Cell 2 - W3	11/15/91	8:30	2.0 - 2.5	Brown coarse sand, some silt.
Cell 3 - W1	11/14/91	10:45	1.0 - 1.5	Brown medium to coarse sand and gravel.
Cell 3 - W2	11/14/91	11:30	1.0 - 1.5	Brown fine, medium, and coarse sand and gravel.
Cell 3 - W3	11/14/91	12:15	1.5 - 2.0	Brown medium to coarse sand and gravel.
Cell 4 - W1	11/13/91	13:45	2.0 - 2.5	Brown silt, trace of clay and roots.
Cell 4 - W2	11/13/91	14:45	2.0 - 2.5	Brown and dark brown fine sandy silt.
Cell 4 - W3	11/13/91	15:45	2.0 - 2.5	Brown fine to coarse sand and gravel.

Notes:

1 Samples were analyzed for cation exchange capacity, total phosphate, and total Kjeldahl nitrogen.
2 Sample depths were measured from top of sediment.

TABLE 3-5
SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

ANALTYICAL RESULTS OF CTF SEDIMENT SAMPLING

CELL 1

Index	Composites 1	2	3*	4	5
Total PCBs, ppm	160	215	245	390	260
Ortho-chlorine ratio	1.54	1.53	1.51	1.62	1.59
Non-ortho-chlorine ratio	1.71	1.69	1.61	2.08	2.00
Homologs, mole %					
mono-	2.3	3.0	2.2	1.8	1.4
di-	24	22	31	17	15
tri-	38	41	36	30	34
tetra-	23	22	19	25	31
penta-	9.2	8.7	8.4	16	13
hexa-	3.2	2.6	2.9	8.7	5.4
hepta-	0.62	0.51	0.59	1.5	0.92
Sum of mono-ortho-coplanar PCBs, mole %	2.4	2.0	2.2	5.6	3.8
Sum of 18 predominantly bioaccumulative congeners, mole %	11	13	11	17	14
Sum of all 30 bioaccumulative congeners, mole %	29	27	25	40	39
Products, mole %					
2	1.9	2.6	2.0	1.6	1.2
22' & 26	1.9	2.0	2.0	1.4	1.3
24'	20	18	27	14	12
22'6	2.1	2.0	2.2	1.5	1.6
22'4	9.2	9.5	9.9	6.7	6.7
22'3 & 24'6	5.7	5.5	6.1	4.1	4.7
Oil & Grease, mg/g	0.25	0.17	0.31	0.37	0.35
TOC, %	0.94	0.29	0.62	1.3	0.49

Notes:
* Average of triplicates.
Results are expressed to two significant figures except as noted below.
Total PCBs are expressed to the nearest multiple of 5.
Ortho- and non-ortho-chlorine ratios are expressed to two decimal places.
Index values for unaltered Aroclor 1248 mixture are presented in Table 5-9.

TABLE 3-6
SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

ANALTYICAL RESULTS OF CTF SEDIMENT SAMPLING

CELL 2

Index	Composites 1	2*	3	4	5
Total PCBs, ppm	185	145	105	360	125
Ortho-chlorine ratio	1.59	1.54	1.53	1.59	1.53
Non-ortho-chlorine ratio	2.06	1.67	1.72	2.13	1.56
Homologs, mole %					
mono-	0.78	2.5	2.4	1.2	2.3
di-	14	26	24	12	27
tri-	32	39	37	30	44
tetra-	33	20	23	36	17
penta-	13	8.9	9.0	14	7.0
hexa-	5.5	3.4	3.2	6.0	2.2
hepta-	0.91	0.69	0.64	0.93	0.48
Sum of mono-ortho-coplanar PCBs, mole %	3.9	2.3	2.4	4.3	1.7
Sum of 18 predominantly bioaccumulative congeners, mole %	15	12	11	14	15
Sum of all 30 bioaccumulative congeners, mole %	42	28	27	44	28
Products, mole %					
2	0.58	2.2	2.2	1.1	2.0
22' & 26	1.4	1.9	2.0	0.95	2.3
24'	11	22	20	10	23
22'6	1.2	2.2	2.0	1.0	3.1
22'4	5.8	9.7	8.7	4.7	11
22'3 & 24'6	4.2	5.9	5.5	3.7	7.9
Oil & Grease, mg/g	0.33	0.25	0.48	0.20	0.27
TOC, %	0.62	0.66	1.3	0.93	0.78

Notes:
* Average of triplicates.
Results are expressed to two significant figures except as noted below.
Total PCBs are expressed to the nearest multiple of 5.
Ortho- and non-ortho-chlorine ratios are expressed to two decimal places.
Index values for unaltered Aroclor 1248 mixture are presented in Table 5-9.

TABLE 3-7
SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

ANALTYICAL RESULTS OF CTF SEDIMENT SAMPLING

CELL 3

Index	Composites 1*	2	3	4	5
Total PCBs, ppm	100	100	95	75	130
Ortho-chlorine ratio	1.54	1.55	1.58	1.55	1.59
Non-ortho-chlorine ratio	1.62	1.64	1.84	1.69	1.78
Homologs, mole %					
mono-	2.6	2.2	2.0	2.9	2.0
di-	25	25	19	24	18
tri-	41	42	37	38	42
tetra-	19	20	24	22	24
penta-	8.1	8.1	12	9.2	10
hexa-	2.7	2.7	4.5	3.1	3.4
hepta-	0.56	0.60	0.81	0.65	0.66
Sum of mono-ortho-coplanar PCBs, mole %	2.0	2.1	3.2	2.5	2.9
Sum of 18 predominantly bioaccumulative congeners, mole %	13	14	14	12	16
Sum of all 30 bioaccumulative congeners, mole %	27	28	33	28	33
Products, mole %					
2	2.3	1.9	1.7	2.4	1.8
22' & 26	2.3	2.1	1.9	2.2	2.1
24'	21	20	16	20	14
22'6	2.7	2.6	2.2	2.5	2.9
22'4	10	11	8	10	10
22'3 & 24'6	6.8	7.2	5.4	6.5	7.2
Oil & Grease, mg/g	0.16	0.21	0.13	0.18	0.19
TOC, %	0.49	0.25	0.29	0.60	0.46

Notes:
* Average of triplicates.
Results are expressed to two significant figures except as noted below.
Total PCBs are expressed to the nearest multiple of 5.
Ortho- and non-ortho-chlorine ratios are expressed to two decimal places.
Index values for unaltered Aroclor 1248 mixture are presented in Table 5-9.

TABLE 3-8
SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

ANALTYICAL RESULTS OF CTF SEDIMENT SAMPLING

CELL 4

Index	Composites 1	2	3	4*	5
Total PCBs, ppm	65	125	105	145	185
Ortho-chlorine ratio	1.56	1.56	1.55	1.50	1.64
Non-ortho-chlorine ratio	1.82	1.78	1.79	1.51	2.00
Homologs, mole %					
mono-	2.2	2.6	2.6	2.8	2.0
di-	24	23	21	34	19
tri-	33	35	36	37	31
tetra-	24	23	26	16	22
penta-	11	11	10	7	16
hexa-	4.9	4.7	3.8	2.6	8.9
hepta-	0.91	0.85	0.74	0.53	1.6
Sum of mono-ortho-coplanar PCBs, mole %	3.4	3.2	2.7	1.8	5.5
Sum of 18 predominantly bioaccumulative congeners, mole %	12	12	11	10	17
Sum of all 30 bioaccumulative congeners, mole %	31	31	32	22	37
Products, mole %					
2	1.9	2.1	2.3	2.4	1.7
22' & 26	1.7	1.9	1.8	2.2	1.7
24'	21	20	17	31	16
22'6	1.9	2.1	1.8	2.4	2.0
22'4	8.1	8.7	7.6	10	7.7
22'3 & 24'6	5.4	5.7	5.1	6.6	4.9
Oil & Grease, mg/g	0.20	0.24	0.18	0.23	0.28
TOC, %	0.62	0.48	0.76	0.47	0.67

Notes:
* Average of triplicates.
Results are expressed to two significant figures except as noted below.
Total PCBs are expressed to the nearest multiple of 5.
Ortho- and non-ortho-chlorine ratios are expressed to two decimal places.
Index values for unaltered Aroclor 1248 mixture are presented in Table 5-9.

TABLE 3-9
SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

SUMMARY OF CTF SEDIMENT SAMPLING RESULTS

Index	Cell Mean -/+ Standard Deviation 1*	2*	3*	4*	Aroclor 1248
Total PCBs, ppm	225±86	185±100	100±20	125±45	--
Ortho-chlorine ratio	1.56±0.05	1.56±0.03	1.56±0.02	1.56±0.05	1.52
Non-ortho-chlorine ratio	1.82±0.21	1.83±0.25	1.71±0.09	1.78±0.18	2.41
Homologs, mole %					
mono-	2.2±0.62	1.9±0.80	2.3±0.39	2.5±0.33	0
di-	22±6.3	21±6.8	22±3.3	24±5.9	1.6
tri-	36±4.3	36±5.7	40±2.1	34±2.5	27
tetra-	24±4.4	26±8.1	22±2.1	22±3.7	55
penta-	11±3.5	10±3.1	10±1.7	11±3.3	13
hexa-	4.5±2.6	4.1±1.6	3.3±0.74	5.0±2.4	3.6
hepta-	0.83±0.42	0.73±0.19	0.66±0.10	0.92±0.4	0.80
Sum of mono-ortho-coplanar PCBs, mole %	3.2±1.5	2.9±1.1	2.6±0.51	3.3±1.4	3.9
Sum of 18 predominantly bioaccumulative congeners, mole %	13±2.3	14±1.9	14±1.3	12±2.8	16
Sum of all 30 bioaccumulative congeners, mole %	32±6.9	34±8.6	30±2.8	31±5.3	55
Products, mole %					
2	1.9±0.51	1.6±0.72	2.0±0.32	2.1±03.0	0
22' & 26	1.7±0.33	1.7±0.54	2.1±0.15	1.9±0.19	0.01
24'	18±6.0	17±6.1	18±3.1	21±5.8	0.9
22'6	1.9±0.3	1.9±0.85	2.6±0.09	2.0±0.21	0.12
22'4	8.4±1.6	8.0±2.6	9.8±0.85	8.5±1.0	1.3
22'3 & 24'6	5.2±0.82	5.4±1.6	6.6±0.75	5.5±0.61	2.7
Oil & Grease, mg/g	0.29±0.08	0.30±0.11	0.18±0.03	0.23±0.04	--
TOC, %	0.73±0.40	0.86±0.27	0.42±0.14	0.60±0.12	--

Notes:
* Mean of five sample results.
Results are expressed to two significant figures except as noted below.
Total PCBs are expressed to the nearest multiple of 5.
Ortho- and non-ortho-chlorine ratios are expressed to two decimal places.
-- Not applicable

TABLE 3-10
SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

CTF SEDIMENT PARTICLE SIZE DISTRIBUTION BY PERCENT WEIGHT

	Cell 1 Composite 5	Cell 2 Composite 1	Cell 3 Composite 2	Cell 4 Composite 2
Percent gravel-sized particles (75 - 4.75mm)	26.6	28.1	28.1	11.3
Percent sand-sized particles (4.75 - 0.075mm)	56.0	58.6	57.4	59.1
Percent silt-sized particles (0.075 - 0.005mm)	10.2	7.6	9.1	19.3
Percent clay-sized particles (<0.005mm)	7.2	5.7	5.4	10.3

TABLE 3-11
SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

MACRO-NUTRIENTS IN CTF PORE WATER
(all values are expressed in mg/L)

	Cell 1			Cell 2			Cell 3			Cell 4		
Analyte	W1	W2	W3	W1	W2	W3	W1	W2	W3	W1	W2	W3
Alkalinity (as $CaCO_3$)	518	265	510	948	234	982	846	715	840	212	275	207
Calcium	159	144	188	198	235	128	227	380	183	566	297	168
Iron	23.1	19.9	34.6	28.8	39.7	26.3	52.3	81.1	37.7	74	53.5	67.8
Magnesium	71.6	68.4	82.5	90.1	106	67.3	110	177	86.3	197	122	91.2
Potassium	7.88	9.17	11.1	9.15	11.2	10.7	10.2	15.9	7.75	8.77	8.92	17.7
Sodium	22.8	21.4	34.0	66.5	46.7	21.1	26.3	25.7	23.7	117	28.1	24.8
Chloride	39.3	36.3	46.5	47.8	61	55.0	59.5	34.7	65.5	201	34.8	37
Nitrite	<0.50	<0.50	<0.50	<0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.5	<0.5	<0.50
Phosphate (ortho)	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25
Nitrate	<0.75	<0.75	<0.75	<0.75	<0.75	<0.75	<0.75	<0.75	<0.75	<0.75	<0.75	<0.75
Sulfate	<1.25	1.80	<1.25	<1.25	<1.25	7.64	<1.25	<1.25	<1.25	<1.25	6.15	11.0
Sulfide	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.10
Ammonia Nitrogen	1.79	2.30	16.8	12.8	3.42	1.13	28.5	24.5	0.81	5.44	4.21	7.61
Total Phosphorus	0.05	0.03	0.13	0.04	0.03	0.05	5.45	5.6	0.60	0.05	0.03	0.09

TABLE 3-12
SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

MACRO-NUTRIENTS IN CTF SEDIMENT

	Cell 1			Cell 2			Cell 3			Cell 4		
Analyte	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3
Nitrogen (TKN), %	0.03	<0.02	0.06	0.12	0.13	0.09	<0.02	<0.02	<0.02	0.21	0.14	<0.02
Cation Exchange Capacity, meq/100g	14	21	19	26	20	20	8	10	8	26	24	11
Total Phosphorus, mg/kg	251.7	454	240.5	447.2	424.4	300.3	148.5	263.6	150.6	477.7	538.3	248.5

TABLE 3-13
SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

ANALYTICAL RESULTS OF ARMORED SEDIMENT SAMPLING

August 22, 1990

Index	Armored Area 7*	8	10	11	Aroclor 1248
Total PCBs, ppm	36	270	150	25	--
Ortho-chlorine ratio	1.76	1.54	1.60	1.80	1.52
Non-ortho-chlorine ratio	1.79	1.34	1.52	2.03	2.41
Homologs, mole %					
mono-	1.6	3.8	4.7	1.5	0
di-	14	39	30	10	1.6
tri-	37	37	33	29	27
tetra-	28	28	18	31	55
penta-	15	15	11	20	13
hexa-	3.9	1.8	2.7	6.8	3.6
hepta-	0.60	0.40	0.58	1.1	0.8
Sum of mono-ortho-coplanar PCBs, mole %	3.9	1.0	2.0	4.0	3.9
Sum of 18 predominantly bioaccumulative congeners, mole %	9.9	7.6	9.7	14	16
Sum of all 30 bioaccumulative congeners, mole %	31	16	24	42	55
Products, mole %					
2	1.3	1.8	1.1	0.94	0
22' & 26	1.5	2.2	1.6	0.88	0.01
24'	10	35	27	7.5	0.9
22'6	1.8	2.5	2.3	0.92	0.12
22'4	8.4	11	10	4.6	1.3
22'3 & 24'6	4.7	7.6	7.3	3.3	2.7

Notes:
* Average of duplicates
Results are expressed to two significant figures except as noted below.
Ortho- and non-ortho-chlorine ratios are expressed to two decimal places.
-- Not applicable

TABLE 3-14
SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

ANALYTICAL RESULTS OF ARMORED SEDIMENT SAMPLING

April 19, 1991

Index	Armored Area 7	8	10*	11	Aroclor 1248
Total PCBs, ppm	15	190	74	12	--
Ortho-chlorine ratio	1.68	1.55	1.50	1.82	1.52
Non-ortho-chlorine ratio	1.66	1.26	1.20	2.15	2.41
Homologs, mole %					
mono-	3.7	4.2	6.4	1.6	0
di-	19	38	46	9.0	1.6
tri-	36	39	33	26	27
tetra-	25	12	9.0	31	55
penta-	12	4.8	4.0	22	13
hexa-	2.9	1.3	1.2	9.2	3.6
hepta-	0.52	0.41	0.35	1.5	0.8
Sum of mono-ortho-coplanar PCBs, mole %	1.0	0.28	0.31	2.2	3.9
Sum of 18 predominantly bioaccumulative congeners, mole %	8.5	6.5	2.3	17	16
Sum of all 30 bioaccumulative congeners, mole %	28	13	8.3	43	55
Products, mole %					
2	3.2	3.6	4.5	1.4	0
22' & 26	2.2	2.8	2.9	0.84	0.01
24'	14	34	41	6.5	0.9
22'6	1.9	2.9	3.0	0.7	0.12
22'4	7.8	13	13	3.7	1.3
22'3 & 24'6	4.8	8.1	8.2	2.6	2.7
TOC, %	1.12	0.31	0.41	0.30	--

Notes:
* Average of duplicates
Results are expressed to two significant figures except as noted below.
Ortho- and non-ortho-chlorine ratios are expressed to two decimal places.
-- Not Applicable

TABLE 3-15
SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

ANALYTICAL RESULTS OF ARMORED SEDIMENT SAMPLING

November 11, 1991

Index	Armored Area 7	8	10	11*	Aroclor 1248
Total PCBs, ppm	5.6	27	100	37	–
Ortho-chlorine ratio	1.54	1.55	1.49	1.62	1.52
Non-ortho-chlorine ratio	1.36	1.38	1.14	2.10	2.41
Homologs, mole %					
mono-	5.8	2.9	5.1	1.3	0
di-	32	35	48	11	1.6
tri-	40	40	34	32	27
tetra-	15	14	8.6	34	55
penta-	5.4	5.7	3.4	15	13
hexa-	1.8	2.0	1.1	5.6	3.6
hepta-	0.41	0.45	0.40	0.96	0.80
Sum of mono-ortho-coplanar PCBs, mole %	1.0	1.1	0.66	3.6	3.9
Sum of 18 predominantly bioaccumulative congeners, mole %	4.7	6.3	3.5	14	16
Sum of all 30 bioaccumulative congeners, mole %	16	17	8.6	44	55
Products, mole %					
2	5.0	2.4	3.9	0.96	0
22' & 26	8.5	6.7	7.4	2.4	0.01
24'	21	26	39	6.8	0.9
22'6	2.5	2.4	2.8	0.79	0.12
22'4	11	12	13	4.4	1.3
22'3 & 24'6	6.1	6.9	8.5	3.3	2.7

Notes:

* Average of duplicates
Results are expressed to two significant figures except as noted below.
Ortho- and non-ortho-chlorine ratios are expressed to two decimal places.
– Not applicable

TABLE 4-1

SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

PROJECTED TRACER STUDY, FIELD WORK SCENARIO

	Tasks
Day 1	- location of sampling sites - background bromide check - pumping rate tests - preparation for tracer injection
Day 2	- tracer injection Cell #1 - "real-time" sampling Cell #1
Day 3	- network sampling Cell #1 - review of results Cell #1 - selection of modifications for Cell #1
Day 4	- tracer test modifications Cell #1 - continued monitoring Cell #1

TABLE 4-2

SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

RECIPE FOR REVISED ANAEROBIC MINERAL MEDIUM (PER LITER)

Buffer for Adjusting pH to 7

0.27 g KH_2PO_4

0.35 g K_2HPO_4

Mineral Salts

0.53 g NH_4Cl

75 mg $CaCl_2.2H_2O$

100 mg $MgCl_2.6H_2O$

20 mg $FeCl_2.4H_2O$

Trace Metals

0.5 mg $MnCl_2.4H_2O$

0.05 mg H_3BO_3

0.05 mg $ZnCl_2$

0.03 mg $CuCl_2$

0.01 mg $NaMoO_4.2H_2O$

0.5 mg $CoCl_2.6H_2O$

0.05 mg $NiCl_2.6H_2O$

0.05 mg Na_2SeO_3

Optional

1.2 g $NaHCO_3$

0.5 g $Na_2S.9H_2O$

TABLE 4-3

SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

COMPONENTS OF REVISED ANAEROBIC MINERAL MEDIUM

Mineral	mM
K	6.0
NH_4^+	10.0
PO_4^{2-}	4.0
Ca	0.5
Mg	0.5
Fe	0.1
S^{2-}	0.5

Metal	mM
Mn	2.53
Zn	0.37
Cu	0.22
Co	2.10
Ni	0.21
B	0.81
Mo	0.04
Se	0.29

Optional	
$NaHCO_3$	1.2 g/L
$Na_2S.9H_2O$	0.5 g/L

Note:
Reference: Shelton and Tiedje, 1984.

TABLE 4-4

SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

ANALYTICAL SUMMARY

Matrix	Analysis	Laboratory	Method (Reference)	Estimated Sample Quantities				
				Single Sample	Field Duplicate	Analytical Duplicate	Matrix Spike	Laboratory Blank
CTF Sediment	Congener-Specific PCB	NEA	(1)	30	30	5	5	5
	Oil & Grease	NEA	SW846-9071 (2)	40	0	2	2	2
	Total Organic Carbon	NEA	SW846-9060 (2)	40	0	2	0	0
	Total Kjeldhal Nitrogen	HES	EPA 351.3 (3)	16	0	2	0	0
	Sulfate	HES	EPA 300.0 (3)	16	0	2	0	0
	Ortho-phosphate	HES	EPA 300.0 (3)	16	0	2	0	0
CTF Pore Water	Dissolved Organic Carbon	HES	SW846-9060 (2)	14	--	2	--	--
	Ammonia Nitrogen	HES	EPA 350.2 (3)	14	--	2	--	--
	Nitrate Nitrogen	HES	EPA 352.1 (3)	14	--	2	--	--
	Nitrite Nitrogen	HES	EPA 354.1 (3)	14	--	2	--	--

TABLE 4-4

SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

ANALYTICAL SUMMARY
(Cont'd)

Matrix	Analysis	Laboratory	Method (Reference)	Estimated Sample Quantities				
				Single Sample	Field Duplicate	Analytical Duplicate	Matrix Spike	Laboratory Blank
	Total Kjeldhal Nitrogen	HES	EPA 351.3 (3)	14	--	2	--	--
	Sulfate	HES	EPA 375.4 (3)	14	--	2	--	--
	Ortho-phosphate	HES	EPA 365.1 (3)	14	--	2	--	--
	Sulfide	HES	EPA 376.1 (3)	14	--	2	--	--
	Iron	HES	EPA 200.7 (3)	14	--	2	--	--

Laboratories:

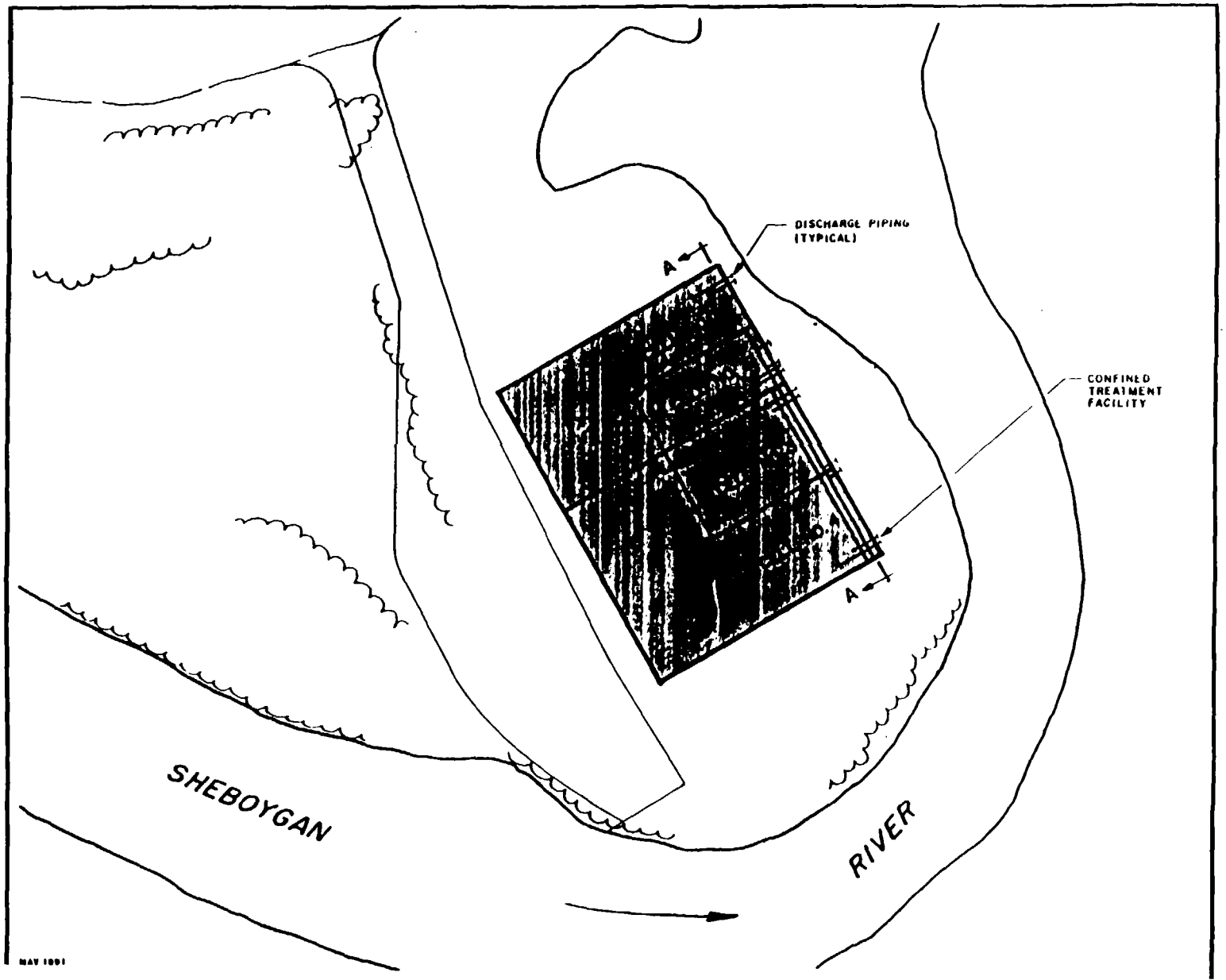
NEA - Northeast Analytical Lab Services
HES - Hazleton Environmental Services

Methods:

1. Northeast Analytical, Inc., "Standard Operating Procedure, Laboratory Method NEA - 608CAP, Revision 3," Schenectady, New York, June, 1990.
2. Solid Waste - 846 Laboratory Manual. 3rd Edition, 1986.
3. Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020; U.S. EPA, Cincinnati, OH, 1979.

Figures

FIGURE 2-1



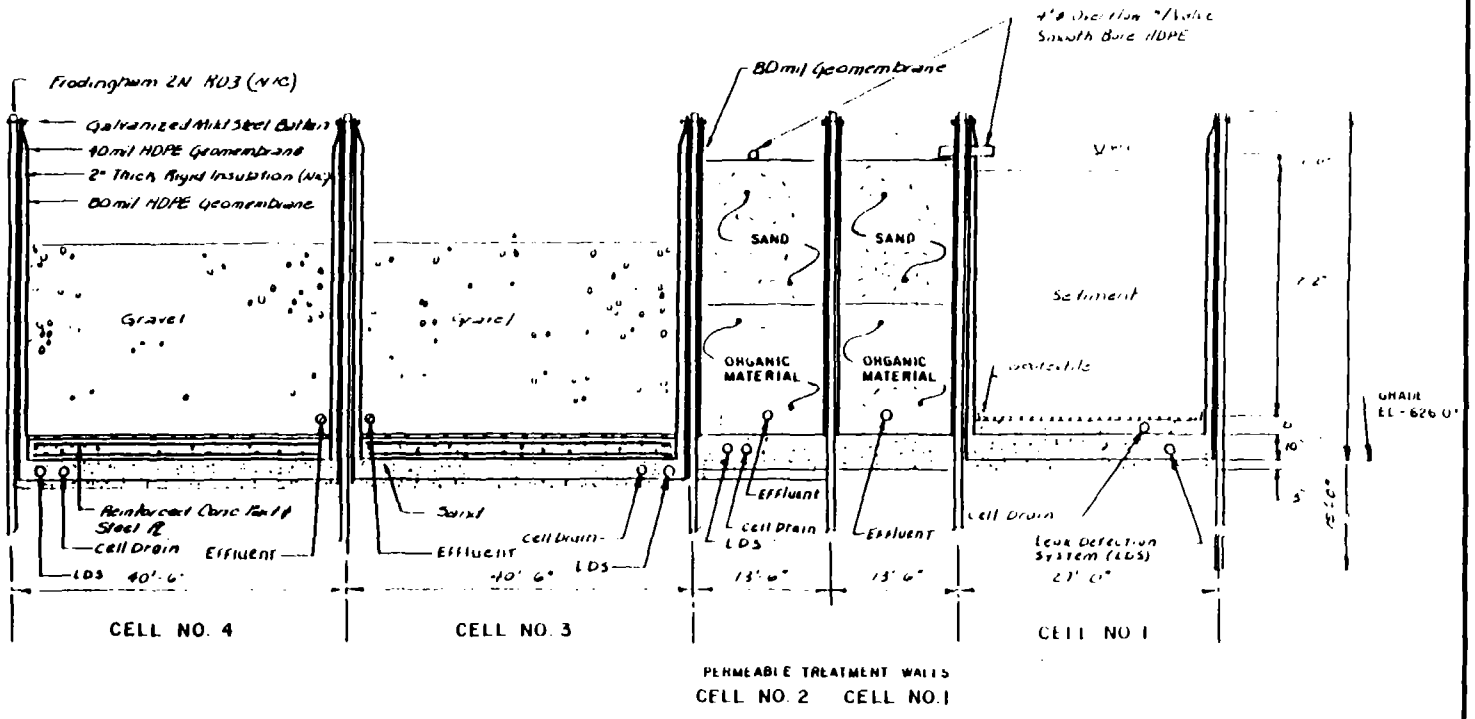
SHEBOYGAN RIVER AND HARBOR

BIODEGRADATION PILOT STUDY

CONFINED TREATMENT FACILITY SITE PLAN

BLASLAND & BOUCK ENGINEERS P.C.

FIGURE 2-2

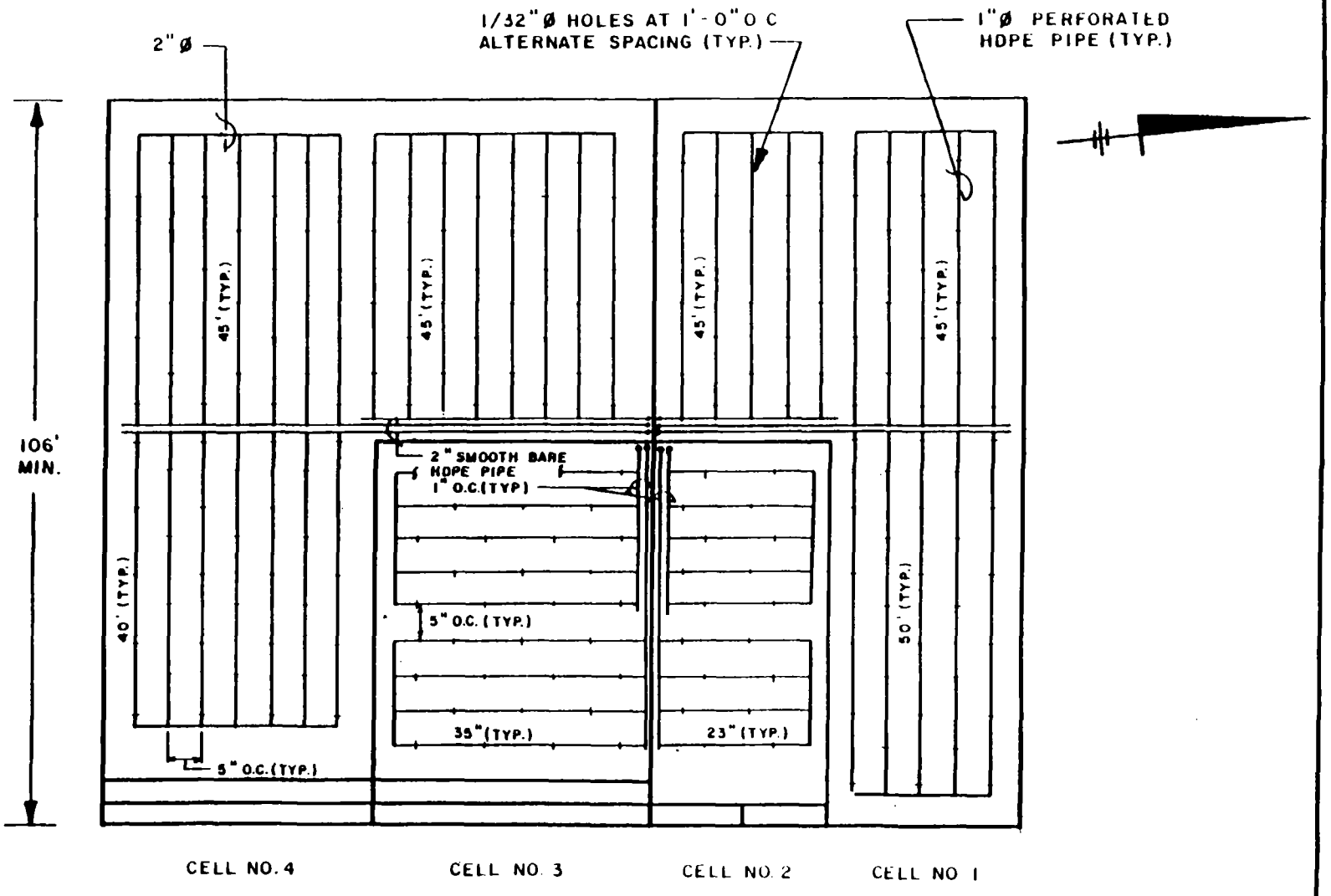


CROSS-SECTION A-A

SHEBOYGAN RIVER AND HARBOR

BIODEGRADATION PILOT STUDY

CONFINED TREATMENT FACILITY CROSS-SECTION



SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY

AMENDMENT DISTRIBUTION SYSTEM

FIGURE 2-3

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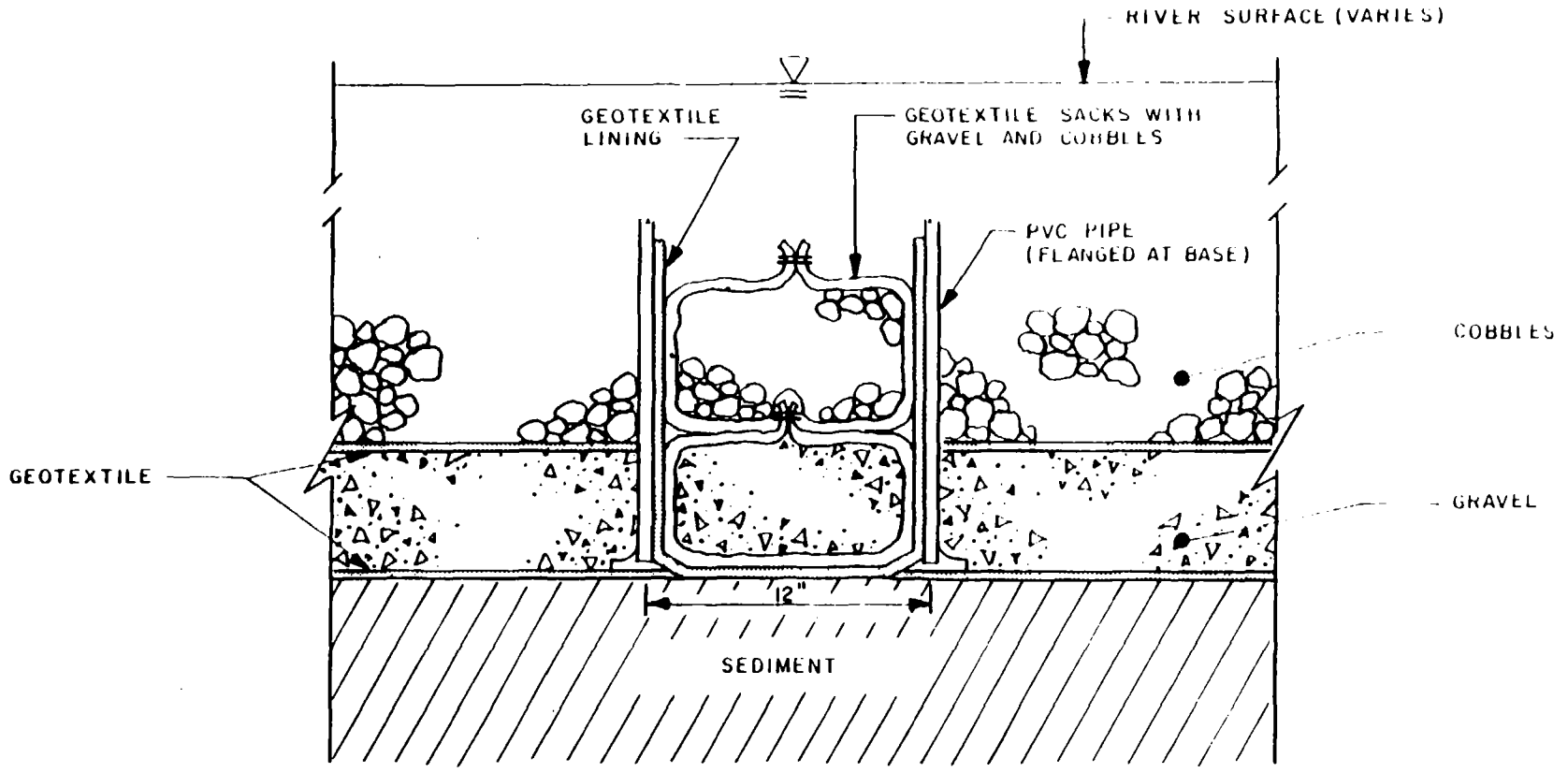

SHEBOYGAN RIVER AND HARBOR

BIODEGRADATION PILOT STUDY

TYPICAL ARMORED AREA SAMPLING PORT DETAIL

FIGURE 2-4

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176.07.16

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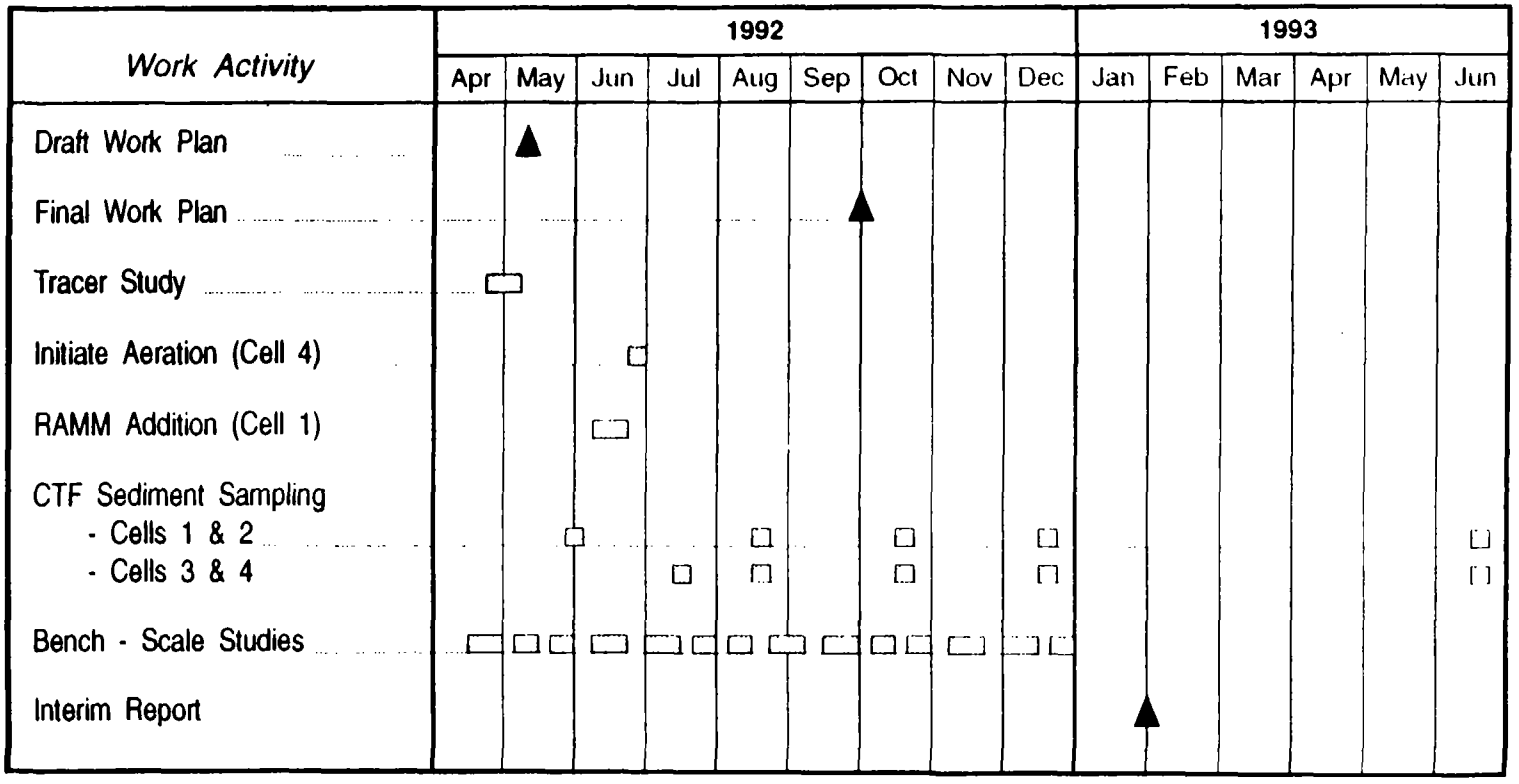
SHEBOYGAN RIVER AND HARBOR
BIODEGRADATION PILOT STUDY WORK PLAN

PROJECT SCHEDULE



LEGEND

Submittal

On Going Activities

09/92 DJH
1760716P/17607J02.CDR

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FIGURE 7-1

FIGURE 7-2

SHEBOYGAN RIVER AND HARBOR BIODEGRADATION PILOT STUDY WORK PLAN

PROJECT ORGANIZATION CHART

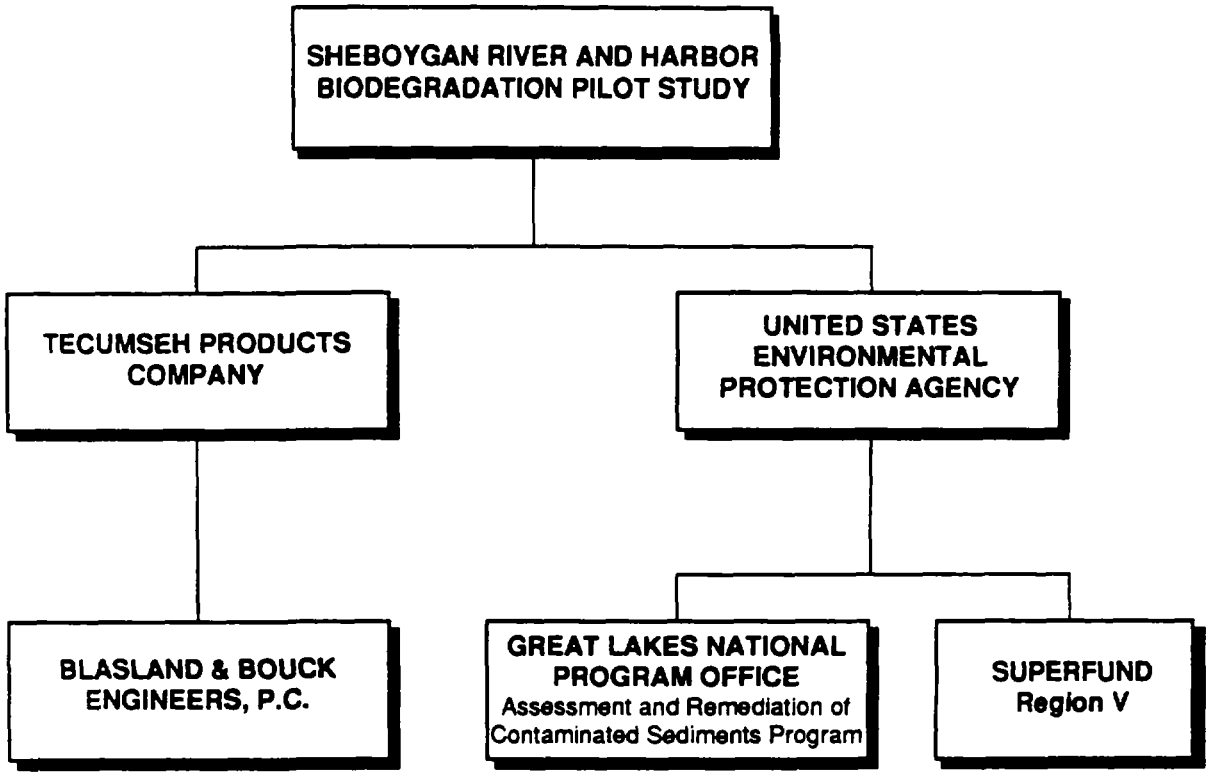
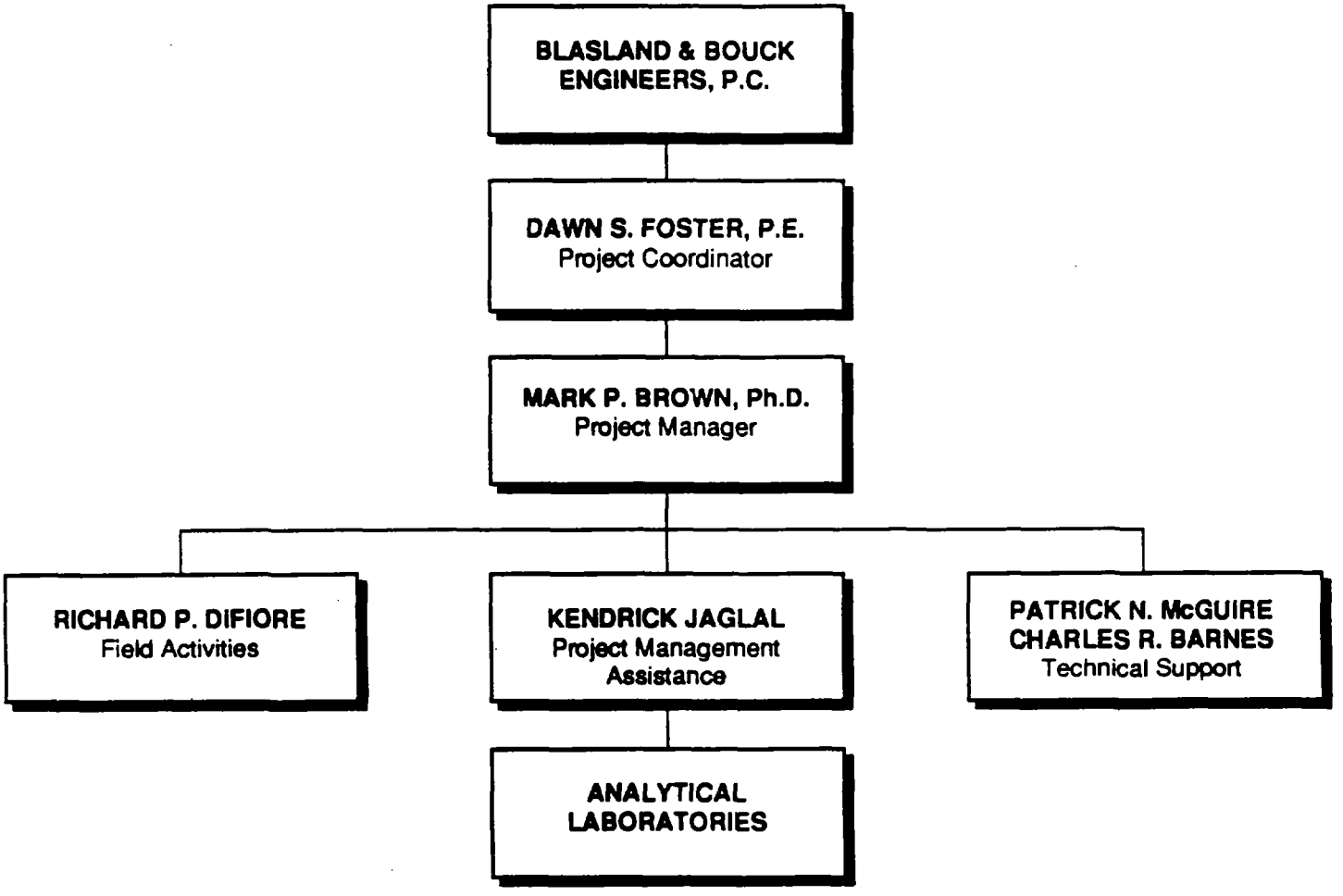


FIGURE 7-3

SHEBOYGAN RIVER AND HARBOR BIODEGRADATION PILOT STUDY WORK PLAN

BLASLAND & BOUCK PROJECT ORGANIZATION CHART



Appendix

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Sheet No. 21
Ammonium Chloride

Issued: 9/77 Revision: C, 7/91

Section 1. Material Identification

Ammonium Chloride (NH_4Cl) Description: Obtained by reaction of sodium chloride with ammonia, carbon dioxide, and water, followed by product crystallization and subsequent sodium bicarbonate removal. Used in salt substitutes to modify bitter aftertaste; in cement for iron pipes; in veterinary practices as a therapeutic (expectorant, diaphoretic, and systemic acidifier); in manufacturing any ammonia compounds; as a pickling agent in zinc coating and tinning; as a snow treatment (to slow melting on ski slopes); as an ingredient in fertilizer, mordants (dyeing and printing), resins, and bakery products; and to clean soldering irons.

Other Designations: CAS No. 12125-02-9. Amchlor,* ammonenc, ammonium chloratum, ammonium chloridum, ammonium muriate, Durammon,* sal ammonia, salmiac.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers Guide*[™] for a suppliers list.

R 1
I 2
S 2
K 0

NFPA
Nonfire: 0 / 1 / 0 / -
Fire: 0 / 2 / 0 / -

HMIS
H 1
F 0
R 0
PPG*
* Sec. 8

Cautions: Ammonium chloride is mildly irritating to skin, eyes, respiratory tract, and mucous membranes. If decomposed in a fire, highly irritating HCl ammonia can be released.

Section 2. Ingredients and Occupational Exposure Limits

Ammonium chloride, ca 100%

1990 OSHA PELs	1990-91 ACGIH TLVs	1990 NIOSH REL	1985-86 Toxicity Data*
8-hr TWA: 10 mg/m³	TWA: 10 mg/m³	None established	Rat, oral, LD_{50}: 1650 mg/kg
15-min STEL: 20 mg/m³	STEL: 20 mg/m³		Rat, intramuscular, LD_{50}: 30 mg/kg
			Dog, oral, LD_{50}: 600 mg/kg
			Rabbit, oral, LD_{50}: 1000 mg/kg

* See NIOSH, *RTECS* (BP4550000), for additional irritative, mutative, and toxicity data.

Section 3. Physical Data

Boiling Point: 968 °F (520 °C)
Melting Point: 662 °F (350 °C)
Vapor Pressure: 1 mm Hg at 320.7 °F (160.4 °C) (sublimes)*
pH: Of aqueous solutions (1%-5.5, 3%-5.1, 10%-5.0) at 77 °F (25 °C)
Molecular Weight: 53.5
Specific Gravity: 1.520 at 77 °F (25 °C)
Water Solubility: Soluble: 22.9% at 0 °C, 39.6% at 176 °F (80 °C)
Corrosivity: Corrodes metals at fire temperatures

Appearance and Odor: Occurs as odorless, colorless crystals or white granular powder with a cool saline taste. This material is slightly hygroscopic (moisture absorbing from air) with a tendency to cake.

* Passes from solid to vapor without appearing in the intermediate (liquid) state.

Section 4. Fire and Explosion Data

Flash Point: None reported **Autoignition Temperature:** None reported **LEL:** None reported **UEL:** None reported

Extinguishing Media: Ammonium chloride is noncombustible. Spraying fires freely with water effectively reduces fumes and irritant gases. For small fires, use dry chemical, halon, water spray, foam, or other noncombustible material suitable for surrounding fire. For a larger fire, *do not* scatter spilled material with more water than needed to control fire. Dike water used in fire control for later disposal.

Unusual Fire or Explosion Hazards: At fire temperatures ammonium chloride begins to corrode metals and may dissociate into ammonia and hydrogen chloride.

Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Ammonium chloride is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. This material *may* volatilize and condense on cool surfaces. Concentrated solutions of ammonium chloride may crystallize when exposed to low temperatures. Store in a dry area away from acids, alkalis, and silver salts.

Chemical Incompatibilities: Acids, alkalies and their carbonates. Reaction of ammonium chloride with lead and silver salts can form a sensitive fulminating compound, possibly silver nitride. Ammonium chloride reacts explosively with potassium chlorate or bromine trifluoride, and violently with bromide pentafluoride, ammonium compounds, nitrates, and iodine heptafluoride. Explosive nitrogen trichloride may result from reaction of ammonium chloride and hydrogen cyanide.

Conditions to Avoid: Avoid excessive heat.

Hazardous Products of Decomposition: Thermal decomposition or burning of ammonium chloride can produce ammonia and hydrochloric acid fumes.

Section 6. Health Hazard Data

Carcinogenicity: In 1990 reports, the IARC and NTP do not list ammonium chloride as a carcinogen.
Summary of Risks: Ammonium chloride can cause mild skin, eye, nose, throat, air passage or lung irritation. Some systemic toxicity may result from ingestion.
Medical Conditions Aggravated by Long-Term Exposure: Exposure to irritants, including ammonium chloride, can aggravate severe chronic lung or skin conditions.
Target Organs: Skin, lungs, eyes, mucous membranes.
Primary Entry Routes: Eyes, inhalation, ingestion, skin.
Acute Effects: Inhalation, and skin and eye contact may cause irritation, dermatitis (rash), cough, shortness of breath, or wheezing in susceptible individuals. Ingestion of large amounts may cause systemic ammonia toxicity with diuresis (increased urination), nausea, vomiting, headache, hyperventilation, drowsiness, and possibly coma. There is evidence that acidosis caused by exposure to ammonium chloride in a mother has adverse effects on a human fetus.
Chronic Effects: Repeated inhalation of soldering fumes containing ammonium chloride may cause asthma in some individuals.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing (artificial respiration) as needed. Consult a physician.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious* person drink 1 to 2 glasses of water, then induce vomiting.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Treat eye, skin, and inhalation exposures symptomatically for irritation. For systemic absorption (e.g., ingestion), monitor electrolytes (for hyperchloremic hypokalemia metabolic acidosis), ABGs, CBC, ammonia level. Charcoal/cathartic may be beneficial for ingestions. Treat acidosis and hypokalemia with IV sodium bicarbonate and potassium, respectively.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel of large spills. Cleanup personnel should protect against dust inhalation and skin or eye contact. Avoid dust generation. Cleanup methods such as vacuuming (with an appropriate filter) or wet mopping minimize dust dispersion. For a small spill, take up with sand or other absorbent, noncombustible material and place in an appropriate container. If a larger spill, dike far ahead to contain material for later disposal. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 5000 lb (2270 kg) [* per Clean Water Act; Sec. 311(b)(4)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact.
Ventilation: Provide general and local ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Protect against physical damage. Store in a dry, well-ventilated area away from acids, alkalis, and silver salts. Store at 140 °F (40 °C) or less but avoid freezing.
Engineering Controls: Avoid dust inhalation and skin or eye contact. Insure adequate ventilation in usage areas. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good housekeeping and personal hygiene procedures.
Other Precautions: Preplacement exams should emphasize lungs and skin.

Transportation Data (49 CFR 172.101, .102): Not listed
DOT Classification: ORM-E
ID No.: NA9085
DOT Label: None

MSDS Collection **References:** 38, 73, 84, 89, 100, 101, 103, 124, 126, 127, 132, 136, 138, 143, 146, 149
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Upfal, MD, MPH; **Edited by:** JR Stuart, MS

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DATE: 05/29/
CUST#: 916003
PO#: 1760753

MATERIAL SAFETY DATA SHEET PAGE 1

IDENTIFICATION

PRODUCT #: 13509-4 NAME: BORIC ACID, 99+%
CAS #:10043-35-3
MF: H3BO3

SYNONYMS
BORACIC ACID * BORDFAX * BORSAURE (GERMAN) * NCI-C56417 * ORTHOBORIC ACID * THREE ELEPHANT *

TOXICITY HAZARDS

RTECS NO: ED4550000
BORIC ACID
IRRITATION DATA
SKN-HMN 15 MG/3D-I MLD 85DKA8 -,127,77
TOXICITY DATA

ORL-WMN	LDLO:200 MG/KG	LANCAO 2,162,17
ORL-INF	LDLO:934 MG/KG	JAMAAP 90,382,28
SKN-INF	LDLO:1200 MG/KG	JAMAAP 129,332,45
SKN-CHD	LDLO:4 GM/KG/40	MMWDAU 52,763,05
SKN-MAN	LDLO:2430 MG/KG	JAMAAP 128,266,45
SKN-CHD	LDLO:1500 MG/KG	QJPPAL 6,714,33
SCU-INF	LDLO:1100 MG/KG	MDSR** #2,50
UNR-MAN	LDLO:147 MG/KG	85DCAI 2,73,70
ORL-RAT	LD50:2660 MG/KG	JAMAAP 123,266,45
SCU-RAT	LD50:1400 MG/KG	14KTAK -,693,64
IVN-RAT	LD50:1330 MG/KG	MDSR** #2,50
ORL-MUS	LD50:3450 MG/KG	JAMAAP 128,266,45
SCU-MUS	LD50:1760 MG/KG	JAMAAP 128,266,45
IVN-MUS	LD50:1240 MG/KG	JPETAB 134,117,61
SCU-GPG	LD50:1200 MG/KG	MDSR** #2,50

REVIEWS, STANDARDS, AND REGULATIONS
EPA FIFRA 1988 PESTICIDE SUBJECT TO REGISTRATION OR RE-REGISTRATION
FEREAC 54,7740,89
NOES 1983: HZD X7030; NIS 187; TNF 27071; NOS 128; TNE 489568; TFE 211838
EPA TSCA CHEMICAL INVENTORY, JUNE 1990
EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, MARCH 1992
NTP CARCINOGENESIS STUDIES (FEED):NO EVIDENCE:MOUSE NTPTR* NTP-TR-324, 87
TARGET ORGAN DATA
BRAIN AND COVERINGS (MENINGEAL CHANGES)
PERIPHERAL NERVE AND SENSATION (FLACCID PARALYSIS WITHOUT ANESTHESIA)
SENSE ORGANS AND SPECIAL SENSES (CONJUNCTIVA IRRITATION)
BEHAVIORAL (WAKEFULNESS)
BEHAVIORAL (SOMNOLENCE)

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PO#: 1760753

PRODUCT #: 13509-4 NAME: BORIC ACID, 99+%
CAS #: 10043-35-3
MF: H3BO3

---------- TOXICITY HAZARDS ----------

BEHAVIORAL (TREMOR)
BEHAVIORAL (CONVULSIONS OR EFFECT ON SEIZURE THRESHOLD)
BEHAVIORAL (ANOREXIA, HUMAN)
BEHAVIORAL (FLUID INTAKE)
BEHAVIORAL (ATAXIA)
LUNGS, THORAX OR RESPIRATION (CYANOSIS)
LUNGS, THORAX OR RESPIRATION (RESPIRATORY DEPRESSION)
GASTROINTESTINAL (HYPERMOTILITY, DIARRHEA)
GASTROINTESTINAL (NAUSEA OR VOMITING)
GASTROINTESTINAL (OTHER CHANGES)
SKIN AND APPENDAGES (AFTER SYSTEMIC EXPOSURE: DERMATITIS, OTHER)
PATERNAL EFFECTS (SPERMATOGENESIS)
PATERNAL EFFECTS (TESTES, EPIDIDYMIS, SPERM DUCT)
NUTRITIONAL AND GROSS METABOLIC (BODY TEMPERATURE INCREASE)
NUTRITIONAL AND GROSS METABOLIC (BODY TEMPERATURE DECREASE)

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS)
DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION

---------- HEALTH HAZARD DATA ----------

ACUTE EFFECTS
MAY BE HARMFUL BY INHALATION, INGESTION, OR SKIN ABSORPTION.
CAUSES EYE AND SKIN IRRITATION.
MATERIAL IS IRRITATING TO MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT.
MAY CAUSE NERVOUS SYSTEM DISTURBANCES.
TO THE BEST OF OUR KNOWLEDGE, THE CHEMICAL, PHYSICAL, AND TOXICOLOGICAL PROPERTIES HAVE NOT BEEN THOROUGHLY INVESTIGATED.

FIRST AID
IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES.
IN CASE OF CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND COPIOUS AMOUNTS OF WATER.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS.
CALL A PHYSICIAN.
WASH CONTAMINATED CLOTHING BEFORE REUSE.

CONTINUED ON NEXT PAGE

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M A T E R I A L S A F E T Y D A T A S H E E T

CUST#: 916003
PO#: 1760753

PRODUCT #: 13503-4 NAME: BORIC ACID, 99+%
CAS #:10043-35-3
MF: H3BO3

HEALTH HAZARD DATA

ADDITIONAL INFORMATION
TOXICITY REPORTED FOR BORIC ACID IN HUMANS: INGESTION OR ABSORPTION MAY CAUSE NAUSEA, VOMITING, DIARRHEA, ABDOMINAL CRAMPS, ERYTHEMATOUS LESIONS ON THE SKIN AND MUCOUS MEMBRANES. OTHER SYMPTOMS INCLUDE: CIRCULATORY COLLAPSE, TACHYCARDIA, CYANOSIS, DELIRIUM, CONVULSIONS AND COMA. DEATH HAS BEEN REPORTED TO OCCUR IN INFANTS FROM LESS THAN 5 GRAMS AND IN ADULTS FROM 5 TO 20 GRAMS.

PHYSICAL DATA

SPECIFIC GRAVITY: 1.435
VAPOR PRESSURE: 2.6 MM @ 20 C
APPEARANCE AND ODOR
WHITE CRYSTALLINE POWDER

FIRE AND EXPLOSION HAZARD DATA

EXTINGUISHING MEDIA
CARBON DIOXIDE, DRY CHEMICAL POWDER OR APPROPRIATE FOAM.
WATER SPRAY.
SPECIAL FIREFIGHTING PROCEDURES
WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.
UNUSUAL FIRE AND EXPLOSIONS HAZARDS
EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

REACTIVITY DATA

INCOMPATIBILITIES
REACTS VIOLENTLY WITH:
POTASSIUM
ACID ANHYDRIDES
HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
BORON OXIDES.

SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
EVACUATE AREA.
WEAR RESPIRATOR, CHEMICAL SAFETY GOGGLES, RUBBER BOOTS AND HEAVY RUBBER GLOVES.

CONTINUED ON NEXT PAGE

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MATERIAL SAFETY DATA SHEET

CUST#: 016003
PO#: 1750753

PRODUCT #: 13509-4 NAME: BORIC ACID, 99+%
CAS #: 10043-35-3
MF: H3BO3

---------- SPILL OR LEAK PROCEDURES ----------

SWEEP UP, PLACE IN A BAG AND HOLD FOR WASTE DISPOSAL.
AVOID RAISING DUST.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

WASTE DISPOSAL METHOD
FOR SMALL QUANTITIES: CAUTIOUSLY ADD TO A LARGE STIRRED EXCESS OF WATER. ADJUST THE PH TO NEUTRAL, SEPARATE ANY INSOLUBLE SOLIDS OR LIQUIDS AND PACKAGE THEM FOR HAZARDOUS-WASTE DISPOSAL. FLUSH THE AQUEOUS SOLUTION DOWN THE DRAIN WITH PLENTY OF WATER. THE HYDROLYSIS AND NEUTRALIZATION REACTIONS MAY GENERATE HEAT AND FUMES WHICH CAN BE CONTROLLED BY THE RATE OF ADDITION.

--- PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE ---

WEAR APPROPRIATE NIOSH/MSHA-APPROVED RESPIRATOR, CHEMICAL-RESISTANT GLOVES, SAFETY GOGGLES, OTHER PROTECTIVE CLOTHING.
SAFETY SHOWER AND EYE BATH.
MECHANICAL EXHAUST REQUIRED.
DO NOT BREATHE DUST.
AVOID CONTACT WITH EYES, SKIN AND CLOTHING.
AVOID PROLONGED OR REPEATED EXPOSURE.
WASH THOROUGHLY AFTER HANDLING.
IRRITANT.
HARMFUL SOLID.
KEEP TIGHTLY CLOSED.
HYGROSCOPIC
STORE IN A COOL DRY PLACE.

LABEL PRECAUTIONARY STATEMENTS
HARMFUL
HARMFUL BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
IRRITATING TO EYES, RESPIRATORY SYSTEM AND SKIN.
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
WEAR SUITABLE PROTECTIVE CLOTHING.

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DATE: 05/29/
CUST#: 916003
PO#: 1760753

MATERIAL SAFETY DATA SHEET

IDENTIFICATION

PRODUCT #: 22350-6 NAME: CALCIUM CHLORIDE DIHYDRATE, 98+%, A.C.S. REAGENT
CAS #:10035-04-8
MF: CACL2

SYNONYMS
CALCIUM DICHLORIDE DIHYDRATE * CAL PLUS * REPLENISHER (CALCIUM) *

TOXICITY HAZARDS

RTECS NO: EV9810000
CALCIUM CHLORIDE, DIHYDRATE
TOXICITY DATA
IPR-MUS LD50:20500 MG/KG CYLPON 4,110,83
REVIEWS, STANDARDS, AND REGULATIONS
NOES 1983: HZD X3596; NIS 12; TNF 1290; NOS 23; TNE 19024; TFE 10290

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION

HEALTH HAZARD DATA

ACUTE EFFECTS
HARMFUL IF SWALLOWED.
MAY BE HARMFUL IF INHALED.
MAY BE HARMFUL IF ABSORBED THROUGH THE SKIN.
CAUSES EYE AND SKIN IRRITATION.
MATERIAL IS IRRITATING TO MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT.
TO THE BEST OF OUR KNOWLEDGE, THE CHEMICAL, PHYSICAL, AND TOXICOLOGICAL PROPERTIES HAVE NOT BEEN THOROUGHLY INVESTIGATED.
FIRST AID
IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES.
IN CASE OF CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND COPIOUS AMOUNTS OF WATER.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS. CALL A PHYSICIAN.
WASH CONTAMINATED CLOTHING BEFORE REUSE.

PHYSICAL DATA

SPECIFIC GRAVITY: 0.835
VAPOR PRESSURE: .01 MM @ 20 C

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CUST#: 916003
PO#: 1760753

PRODUCT #: 22350-6 NAME: CALCIUM CHLORIDE DIHYDRATE, 99+%, A.C.S. REAGENT
CAS #: 10035-04-8
MF: CACL2

---------- PHYSICAL DATA ----------

APPEARANCE AND ODOR
WHITE POWDER

---------- FIRE AND EXPLOSION HAZARD DATA ----------

EXTINGUISHING MEDIA
NONCOMBUSTIBLE.
USE EXTINGUISHING MEDIA APPROPRIATE TO SURROUNDING FIRE CONDITIONS.
SPECIAL FIREFIGHTING PROCEDURES
WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.
UNUSUAL FIRE AND EXPLOSIONS HAZARDS
EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

---------- REACTIVITY DATA ----------

INCOMPATIBILITIES
STRONG ACIDS
HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
HYDROGEN CHLORIDE GAS

---------- SPILL OR LEAK PROCEDURES ----------

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
SWEEP UP, PLACE IN A BAG AND HOLD FOR WASTE DISPOSAL.
AVOID RAISING DUST.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.
WASTE DISPOSAL METHOD
FOR SMALL QUANTITIES: CAUTIOUSLY ADD TO A LARGE STIRRED EXCESS OF WATER. ADJUST THE PH TO NEUTRAL, SEPARATE ANY INSOLUBLE SOLIDS OR LIQUIDS AND PACKAGE THEM FOR HAZARDOUS-WASTE DISPOSAL. FLUSH THE AQUEOUS SOLUTION DOWN THE DRAIN WITH PLENTY OF WATER. THE HYDROLYSIS AND NEUTRALIZATION REACTIONS MAY GENERATE HEAT AND FUMES WHICH CAN BE CONTROLLED BY THE RATE OF ADDITION.

--- PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE ---

WEAR APPROPRIATE NIOSH/MSHA-APPROVED RESPIRATOR, CHEMICAL-RESISTANT GLOVES, SAFETY GOGGLES, OTHER PROTECTIVE CLOTHING.

CONTINUED ON NEXT PAGE

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MATERIAL SAFETY DATA SHEET

CUST#: 916003
PO#: 1760753

PRODUCT #: 22350-6
CAS #: 10035-04-8
MF: CACL2

NAME: CALCIUM CHLORIDE DIHYDRATE, 98+%, A.C.S. REAGENT

--- PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE ---

SAFETY SHOWER AND EYE BATH.
MECHANICAL EXHAUST REQUIRED.
DO NOT BREATHE DUST.
AVOID CONTACT WITH EYES, SKIN AND CLOTHING.
AVOID PROLONGED OR REPEATED EXPOSURE.
WASH THOROUGHLY AFTER HANDLING.
IRRITANT.
HARMFUL SOLID.
KEEP TIGHTLY CLOSED.
HYGROSCOPIC
STORE IN A COOL DRY PLACE.

LABEL PRECAUTIONARY STATEMENTS
HARMFUL
HARMFUL IF SWALLOWED.
IRRITATING TO EYES, RESPIRATORY SYSTEM AND SKIN.
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
WEAR SUITABLE PROTECTIVE CLOTHING.

--------- ADDITIONAL PRECAUTIONS AND COMMENTS ---------

ADDITIONAL INFORMATION
CALCIUM CHLORIDE IS ATTACKED BY BROMINE TRIFLUORIDE.

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DATE: 05/29/
CUST#: 916003
PO#: 1760753

MATERIAL SAFETY DATA SHEET

IDENTIFICATION

PRODUCT #: 20218-5 NAME: COBALT(II) CHLORIDE HEXAHYDRATE
CAS #:7791-13-1
ME: CL2CO

SYNONYMS
COBALT CHLORIDE, HEXAHYDRATE (8CI,9CI) * COBALT DICHLORIDE HEXAHYDRATE * COBALTOUS CHLORIDE, HEXAHYDRATE *

TOXICITY HAZARDS

RTECS NO: GG0200000
COBALT(II) CHLORIDE, HEXAHYDRATE
TOXICITY DATA
ORL-RAT LD50:766 MG/KG FCTOD7 20,311,82
IPR-RAT LD50:35 MG/KG JAPYAA 32,315,72
IPR-MUS LD50:90 MG/KG AEPPAE 244,17,62
IVN-GPG LD50:26 MG/KG ATXKA8 24,235,69
REVIEWS, STANDARDS, AND REGULATIONS
IARC CANCER REVIEW:HUMAN INADEQUATE EVIDENCE IMEMDT 52,363,91
IARC CANCER REVIEW:GROUP 2B IMEMDT 52,363,91
NOES 1983: HZD X4499; NIS 2; TNF 96; NOS 2: TNF 346; TFE 34
TARGET ORGAN DATA
BEHAVIORAL (TREMOR)
CARDIAC (OTHER CHANGES)
GASTROINTESTINAL (HYPERMOTILITY, DIARRHEA)
ENDOCRINE (ANDROGENIC)
SKIN AND APPENDAGES (AFTER SYSTEMIC EXPOSURE: DERMATITIS, OTHER)
PATERNAL EFFECTS (SPERMATOGENESIS)
PATERNAL EFFECTS (TESTES, EPIDIDYMIS, SPERM DUCT)
PATERNAL EFFECTS (OTHER EFFECTS ON MALE)
NUTRITIONAL AND GROSS METABOLIC (WEIGHT LOSS OR DECREASED WEIGHT GAIN)
ADDITIONAL INFORMATION
ACGIH TLV-TWA: 0.05MG/M3, AS COBALT.

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION

HEALTH HAZARD DATA

ACUTE EFFECTS
HARMFUL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN.
CAUSES EYE AND SKIN IRRITATION.
MATERIAL IS IRRITATING TO MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT.
PROLONGED OR REPEATED EXPOSURE MAY CAUSE ALLERGIC REACTIONS IN CERTAIN

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CUST#: 916003
PO#: 1760753

PRODUCT #: 20213-5 NAME: COBALT(II) CHLORIDE HEXAHYDRATE
CAS #: 7791-13-1
MF: CL2CO

---------- HEALTH HAZARD DATA ----------

SENSITIVE INDIVIDUALS.
CHRONIC EFFECTS
BLOOD EFFECTS
LABORATORY EXPERIMENTS HAVE SHOWN MUTAGENIC EFFECTS.
FIRST AID
IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES OR SKIN WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED CLOTHING AND SHOES.
ASSURE ADEQUATE FLUSHING OF THE EYES BY SEPARATING THE EYELIDS WITH FINGERS.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS.
CALL A PHYSICIAN.
REMOVE AND WASH CONTAMINATED CLOTHING PROMPTLY.
ADDITIONAL INFORMATION
LARGE AMOUNTS OF COBALT(II) CHLORIDE DEPRESS ERYTHROCYTE PRODUCTION WHICH MAY LEAD TO DEATH IN CHILDREN.

---------- PHYSICAL DATA ----------

SPECIFIC GRAVITY: 1.924
APPEARANCE AND ODOR
BURGUNDY CRYSTALS

---------- FIRE AND EXPLOSION HAZARD DATA ----------

EXTINGUISHING MEDIA
NONCOMBUSTIBLE.
USE EXTINGUISHING MEDIA APPROPRIATE TO SURROUNDING FIRE CONDITIONS.
SPECIAL FIREFIGHTING PROCEDURES
WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.
UNUSUAL FIRE AND EXPLOSIONS HAZARDS
EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

---------- REACTIVITY DATA ----------

INCOMPATIBILITIES
MOISTURE
OXIDIZING AGENTS

CONTINUED ON NEXT PAGE

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CUST#: 916003
PO#: 1760753

PRODUCT #: 20213-5 NAME: COBALT(II) CHLORIDE HEXAHYDRATE
CAS #:7791-13-1
MF: CL2CO

---------- REACTIVITY DATA ----------

ALKALI METALS
ABSORBS NH3 FROM AIR.
HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
TOXIC FUMES OF:
HYDROGEN CHLORIDE GAS

---------- SPILL OR LEAK PROCEDURES ----------

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
WEAR DISPOSABLE COVERALLS AND DISCARD THEM AFTER USE.
SWEEP UP, PLACE IN A BAG AND HOLD FOR WASTE DISPOSAL.
AVOID RAISING DUST.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.
WASTE DISPOSAL METHOD
THE MATERIAL SHOULD BE DISSOLVED IN 1) WATER; 2) ACID SOLUTION OR 3) OXIDIZED TO A WATER-SOLUBLE STATE. PRECIPITATE THE MATERIAL AS THE SULFIDE, ADJUSTING THE PH OF THE SOLUTION TO 7 TO COMPLETE PRECIPITATION. FILTER THE INSOLUBLES AND DISPOSE OF THEM IN A HAZARDOUS-WASTE SITE. DESTROY ANY EXCESS SULFIDE WITH SODIUM HYPOCHLORITE. NEUTRALIZE THE SOLUTION BEFORE FLUSHING DOWN THE DRAIN.

--- PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE ---

CHEMICAL SAFETY GOGGLES.
LONG RUBBER OR NEOPRENE GAUNTLET GLOVES.
USE ONLY IN A CHEMICAL FUME HOOD.
NIOSH/MSHA-APPROVED RESPIRATOR IN NONVENTILLATED AREAS AND/OR FOR EXPOSURE ABOVE THE ACGIH TLV.
SAFETY SHOWER AND EYE BATH.
DO NOT BREATHE DUST.
DO NOT GET IN EYES, ON SKIN, ON CLOTHING.
AVOID PROLONGED OR REPEATED EXPOSURE.
DO NOT USE IF SKIN IS CUT OR SCRATCHED. WASH THOROUGHLY AFTER HANDLING.
TOXIC.
IRRITANT.
POSSIBLE SENSITIZER.
POSSIBLE MUTAGEN.
KEEP TIGHTLY CLOSED.

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PRODUCT #: 20218-5 NAME: COBALT(II) CHLORIDE HEXAHYDRATE
CAS #: 7791-13-1
MF: CL2CO

--- PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE ---

HYGROSCOPIC
STORE IN A COOL DRY PLACE.

LABEL PRECAUTIONARY STATEMENTS
TOXIC (USA DEFINITION)
HARMFUL (EUROPEAN DEFINITION)
HARMFUL BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
IRRITATING TO EYES, RESPIRATORY SYSTEM AND SKIN.
POSSIBLE RISK OF IRREVERSIBLE EFFECTS.
POSSIBLE MUTAGEN.
POSSIBLE SENSITIZER.
TARGET ORGAN(S):
BLOOD
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
WEAR SUITABLE PROTECTIVE CLOTHING.

REGULATORY INFORMATION
THIS PRODUCT IS SUBJECT TO SARA SECTION 313 REPORTING REQUIREMENTS.

--------- ADDITIONAL PRECAUTIONS AND COMMENTS ---------

ADDITIONAL INFORMATION
MIXTURES OF POTASSIUM AND SODIUM WITH COBALT(II) CHLORIDE ARE SHOCK-SENSITIVE.

THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. ALDRICH SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT. SEE REVERSE SIDE OF INVOICE OR PACKING SLIP FOR ADDITIONAL TERMS AND CONDITIONS OF SALE.

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CUST#: 916003
PO#: 1760753

MATERIAL SAFETY DATA SHEET PAGE 1

IDENTIFICATION

PRODUCT #: 22201-1 NAME: COPPER(II) CHLORIDE, 97%
CAS #:7447-39-4
MF: CL2CU

SYNONYMS
COPPER DICHLORIDE * COPPER(2+) CHLORIDE * COPPER(II) CHLORIDE *
CUPRIC CHLORIDE * CUPRIC DICHLORIDE *

TOXICITY HAZARDS

RTECS NO: GL7000000
COPPER(II) CHLORIDE (1:2)
TOXICITY DATA
IPR-MUS LD50:7400 UG/KG AEPPAE 244,17,62
IVN-MUS LD50:17500 UG/KG EJMCA5 19,425,84
REVIEWS, STANDARDS, AND REGULATIONS
ACGIH TLV-TWA 1 MG(CU)/M3 85INA8 5,146,86
NOES 1983: HZD X9857; NIS 20; TNF 1154; NOS 28; TNE 16759; TFE 9684
EPA GENETOX PROGRAM 1988, NEGATIVE: B SUBTILIS REC ASSAY
EPA TSCA CHEMICAL INVENTORY, JUNE 1990
EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, MARCH 1992

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION

HEALTH HAZARD DATA

ACUTE EFFECTS
HARMFUL IF INHALED OR SWALLOWED.
CAUSES SKIN IRRITATION.
CAUSES EYE IRRITATION.
MATERIAL IS IRRITATING TO MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT.
DEPENDING ON THE INTENSITY AND DURATION OF EXPOSURE, EFFECTS MAY VARY FROM MILD IRRITATION TO SEVERE DESTRUCTION OF TISSUE.
EXPOSURE CAN CAUSE:
GASTROINTESTINAL DISTURBANCES
DAMAGE TO THE EYES
DAMAGE TO THE LIVER
DAMAGE TO THE KIDNEYS
DAMAGE TO THE LUNGS
FIRST AID
IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES.
IN CASE OF CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND COPIOUS

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P.O. Box 355, Milwaukee, Wisconsin 53201 USA

CUST#: 216003
PO#: 1760753

PRODUCT #: 22201-1 NAME: COPPER(II) CHLORIDE, 97%
CAS #: 7447-39-4
MF: CL2CU

---------- HEALTH HAZARD DATA ----------

AMOUNTS OF WATER.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS.
CALL A PHYSICIAN.
WASH CONTAMINATED CLOTHING BEFORE REUSE.

ADDITIONAL INFORMATION
CHRONIC COPPER POISONING IS TYPIFIED BY HEPATIC CIRRHOSIS, BRAIN DAMAGE AND DEMYELINATION, KIDNEY DEFECTS, AND COPPER DEPOSITION IN THE CORNEA AS EXEMPLIFIED BY HUMANS WITH WILSON'S DISEASE. IT HAS ALSO BEEN REPORTED THAT COPPER POISONING HAS LEAD TO HEMOLYTIC ANEMIA AND ACCELERATES ARTERIOSCLEROSIS.

---------- PHYSICAL DATA ----------

MELTING PT: 620 C
SPECIFIC GRAVITY: 3.386
APPEARANCE AND ODOR
BROWN POWDER

---------- FIRE AND EXPLOSION HAZARD DATA ----------

EXTINGUISHING MEDIA
NONCOMBUSTIBLE.
USE EXTINGUISHING MEDIA APPROPRIATE TO SURROUNDING FIRE CONDITIONS.
SPECIAL FIREFIGHTING PROCEDURES
FOR FIRES INVOLVING THIS MATERIAL, DO NOT ENTER ANY ENCLOSED OR CONFINED FIRE SPACE WITHOUT PROPER PROTECTIVE EQUIPMENT. THIS MAY INCLUDE SELF-CONTAINED BREATHING APPARATUS TO PROTECT AGAINST THE HAZARDOUS EFFECTS OF THE NORMAL PRODUCTS OF COMBUSTION OR OXYGEN DEFICIENCY.
UNUSUAL FIRE AND EXPLOSIONS HAZARDS
EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

---------- REACTIVITY DATA ----------

INCOMPATIBILITIES
MOISTURE
ALKALI METALS
HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
TOXIC FUMES OF:

CONTINUED ON NEXT PAGE

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CUST#: 916003
PO#: 1760753

PRODUCT #: 22201-1 NAME: COPPER(II) CHLORIDE, 97%
CAS #: 7447-39-4
MF: CL2CU

---------- REACTIVITY DATA ----------

HYDROGEN CHLORIDE GAS

---------- SPILL OR LEAK PROCEDURES ----------

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
WEAR RESPIRATOR, CHEMICAL SAFETY GOGGLES, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
SWEEP UP, PLACE IN A BAG AND HOLD FOR WASTE DISPOSAL.
AVOID RAISING DUST.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.
WASTE DISPOSAL METHOD
THE MATERIAL SHOULD BE DISSOLVED IN 1) WATER; 2) ACID SOLUTION OR 3) OXIDIZED TO A WATER-SOLUBLE STATE. PRECIPITATE THE MATERIAL AS THE SULFIDE, ADJUSTING THE PH OF THE SOLUTION TO 7 TO COMPLETE PRECIPITATION. FILTER THE INSOLUBLES AND DISPOSE OF THEM IN A HAZARDOUS-WASTE SITE. DESTROY ANY EXCESS SULFIDE WITH SODIUM HYPOCHLORITE. NEUTRALIZE THE SOLUTION BEFORE FLUSHING DOWN THE DRAIN.

--- PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE ---

CHEMICAL SAFETY GOGGLES.
LONG RUBBER OR NEOPRENE GAUNTLET GLOVES.
SAFETY SHOWER AND EYE BATH.
USE ONLY IN A CHEMICAL FUME HOOD.
NIOSH/MSHA-APPROVED RESPIRATOR IN NONVENTILLATED AREAS AND/OR FOR EXPOSURE ABOVE THE ACGIH TLV.
DO NOT GET IN EYES, ON SKIN, ON CLOTHING.
DO NOT BREATHE DUST.
WASH THOROUGHLY AFTER HANDLING.
TOXIC.
IRRITANT.
KEEP TIGHTLY CLOSED.
HYGROSCOPIC
LABEL PRECAUTIONARY STATEMENTS
TOXIC (USA DEFINITION)
HARMFUL (EUROPEAN DEFINITION)
HARMFUL BY INHALATION AND IF SWALLOWED.
IRRITATING TO EYES, RESPIRATORY SYSTEM AND SKIN.
RISK OF SERIOUS DAMAGE TO EYES.
TARGET ORGAN(S):
LIVER

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MATERIAL SAFETY DATA SHEET

CUST#: 916003
PO#: 1760753

PRODUCT #: 22201-1 NAME: COPPER(II) CHLORIDE, 97%
CAS #: 7447-39-4
MF: CL2CU

--- PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE ---

KIDNEYS
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
WEAR SUITABLE PROTECTIVE CLOTHING.

REGULATORY INFORMATION
THIS PRODUCT IS SUBJECT TO SARA SECTION 313 REPORTING REQUIREMENTS.

--------- ADDITIONAL PRECAUTIONS AND COMMENTS ---------

ADDITIONAL INFORMATION
COPPER(II) CHLORIDE REACTS VIOLENTLY WITH POTASSIUM, SODIUM. CONTACT WITH ACETYLENE MAY CAUSE FORMATION OF COPPER ACETYLIDES THAT ARE SHOCK-SENSITIVE.

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SYRACUSE NY 13214

DATE: 05/29/
CUST#: 016003
PO#: 1260753

MATERIAL SAFETY DATA SHEET PAGE 1

IDENTIFICATION

PRODUCT #: 22029-9 NAME: IRON(II) CHLORIDE TETRAHYDRATE, 99%
CAS #:13478-10-9
ME: CL2FE

SYNONYMS
FERROUS CHLORIDE, TETRAHYDRATE * IRON CHLORIDE TETRAHYDRATE * IRON (II) CHLORIDE, TETRAHYDRATE * IRON DICHLORIDE TETRAHYDRATE *

TOXICITY HAZARDS

RTECS NO: NO5600000
IRON(2+) CHLORIDE, TETRAHYDRATE
TOXICITY DATA
[PP-MUS LD50:23 MG/KG AEPPAE 244,17,62
REVIEWS, STANDARDS, AND REGULATIONS
ACGIH TLV-TWA 1 MG/(FE)/M3 85INA8 5,323,86
MSHA STANDARD-AIR:TWA 1 MG(FE)/M3 OTLVS* 3,138,71
NOES 1981: HZD X6271; MIS 1; TNF 7; NOS 1; TNE 1445; TFE 230

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION.

HEALTH HAZARD DATA

ACUTE EFFECTS
HARMFUL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN.
CAUSES EYE IRRITATION.
CAUSES SKIN IRRITATION.
MATERIAL IS IRRITATING TO MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT.
TO THE BEST OF OUR KNOWLEDGE, THE CHEMICAL, PHYSICAL, AND TOXICOLOGICAL PROPERTIES HAVE NOT BEEN THOROUGHLY INVESTIGATED.
CHRONIC EFFECTS
LABORATORY EXPERIMENTS HAVE SHOWN MUTAGENIC EFFECTS.
FIRST AID
IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES.
IN CASE OF CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND COPIOUS AMOUNTS OF WATER.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS. CALL A PHYSICIAN.
ADDITIONAL INFORMATION
OVERDOSE OF IRON COMPOUNDS MAY HAVE A CORROSIVE EFFECT ON THE

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CUST#: 916003
PO#: 1760753

PRODUCT #: 22029-9 NAME: IRON(II) CHLORIDE TETRAHYDRATE, 99%
CAS #:13478-10-9
MF: CL2FE

---------- HEALTH HAZARD DATA ----------

GASTROINTESTINAL MUCOSA AND BE FOLLOWED BY NECROSIS, PERFORATION AND STRICTURE FORMATION. SEVERAL HOURS MAY ELAPSE BEFORE SYMPTOMS THAT CAN INCLUDE EPIGASTRIC PAIN, DIARRHEA, VOMITING, NAUSEA AND HEMATEMESIS OCCUR. AFTER APPARENT RECOVERY A PERSON MAY EXPERIENCE METABOLIC ACIDOSIS, CONVULSIONS AND COMA HOURS OR DAYS LATER. FURTHER COMPLICATIONS MAY DEVELOP LEADING TO ACUTE LIVER NECROSIS THAT CAN RESULT IN DEATH DUE TO HEPATIC COMA.

---------- PHYSICAL DATA ----------

SPECIFIC GRAVITY: 1.930
VAPOR PRESSURE: 10 MM @ 693 C

---------- FIRE AND EXPLOSION HAZARD DATA ----------

EXTINGUISHING MEDIA
NONCOMBUSTIBLE.
USE EXTINGUISHING MEDIA APPROPRIATE TO SURROUNDING FIRE CONDITIONS.
SPECIAL FIREFIGHTING PROCEDURES
WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.
UNUSUAL FIRE AND EXPLOSIONS HAZARDS
EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

---------- REACTIVITY DATA ----------

INCOMPATIBILITIES
STRONG OXIDIZING AGENTS
MAY DECOMPOSE ON EXPOSURE TO AIR.
FORMS EXPLOSIVE MIXTURES WITH:
POTASSIUM
SODIUM
HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
HYDROGEN CHLORIDE GAS

---------- SPILL OR LEAK PROCEDURES ----------

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
SWEEP UP, PLACE IN A BAG AND HOLD FOR WASTE DISPOSAL.

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CUST#: 916003
PO#: 1760753

PRODUCT #: 22089-9 NAME: IRON(II) CHLORIDE TETRAHYDRATE, 99%
CAS #: 13478-10-9
MF: CL2FE

---------- SPILL OR LEAK PROCEDURES ----------

AVOID RAISING DUST.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

WASTE DISPOSAL METHOD
THE MATERIAL SHOULD BE DISSOLVED IN 1) WATER; 2) ACID SOLUTION OR 3) OXIDIZED TO A WATER-SOLUBLE STATE. PRECIPITATE THE MATERIAL AS THE SULFIDE, ADJUSTING THE PH OF THE SOLUTION TO 7 TO COMPLETE PRECIPITATION. FILTER THE INSOLUBLES AND DISPOSE OF THEM IN A HAZARDOUS-WASTE SITE. DESTROY ANY EXCESS SULFIDE WITH SODIUM HYPOCHLORITE. NEUTRALIZE THE SOLUTION BEFORE FLUSHING DOWN THE DRAIN.

--- PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE ---

CHEMICAL SAFETY GOGGLES.
RUBBER GLOVES.
SAFETY SHOWER AND EYE BATH.
MECHANICAL EXHAUST REQUIRED.
SAFETY SHOWER AND EYE BATH.
DO NOT BREATHE DUST.
DO NOT GET IN EYES, ON SKIN, ON CLOTHING.
WASH THOROUGHLY AFTER HANDLING.
IRRITANT.
TOXIC.
POSSIBLE MUTAGEN.
KEEP TIGHTLY CLOSED.
AIR SENSITIVE
HYGROSCOPIC
STORE IN A COOL DRY PLACE.

LABEL PRECAUTIONARY STATEMENTS
TOXIC (USA DEFINITION)
HARMFUL (EUROPEAN DEFINITION)
HARMFUL BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
IRRITATING TO EYES, RESPIRATORY SYSTEM AND SKIN.
POSSIBLE RISK OF IRREVERSIBLE EFFECTS.
POSSIBLE MUTAGEN.
AIR SENSITIVE
HYGROSCOPIC
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
WEAR SUITABLE PROTECTIVE CLOTHING.
DO NOT BREATHE DUST.

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PRODUCT #: 22029-9 NAME: IRON(II) CHLORIDE TETRAHYDRATE, 99%
CAS #:13478-10-9
MF: CL2FE

THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. ALDRICH SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT. SEE REVERSE SIDE OF INVOICE OR PACKING SLIP FOR ADDITIONAL TERMS AND CONDITIONS OF SALE.

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MATERIAL SAFETY DATA SHEET

IDENTIFICATION

PRODUCT #: 20895-7 NAME: MAGNESIUM CHLORIDE HEXAHYDRATE, 98%
CAS #: 7791-18-6
MF: CL2MG

SYNONYMS
CHLORURE DE MAGNESIUM HYDRATE (FRENCH) * CMH * MAGNESIUM DICHLORIDE HEXAHYDRATE *

TOXICITY HAZARDS

RTECS NO: OM2975000
MAGNESIUM CHLORIDE, HEXAHYDRATE
TOXICITY DATA
ORL-RAT LD50:8100 MG/KG AIHAAP 30,470,69
ORL-MUS LD50:7600 MG/KG THERAP 31,471,76
IPR-MUS LD50:775 MG/KG THERAP 31,471,76
REVIEWS, STANDARDS, AND REGULATIONS
NOES 1983: HZD X5653; NIS 14; TNF 1678; NOS 32; TNE 29612; TFE 16245
TARGET ORGAN DATA
BEHAVIORAL (SOMNOLENCE)
BEHAVIORAL (CONVULSIONS OR EFFECT ON SEIZURE THRESHOLD)
BEHAVIORAL (EXCITEMENT)
BEHAVIORAL (COMA)
LUNGS, THORAX OR RESPIRATION (OTHER CHANGES)

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION

HEALTH HAZARD DATA

ACUTE EFFECTS
MAY BE HARMFUL BY INHALATION, INGESTION, OR SKIN ABSORPTION.
CAUSES EYE AND SKIN IRRITATION.
MATERIAL IS IRRITATING TO MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT.
CAN CAUSE CNS DEPRESSION.
EXPOSURE CAN CAUSE:
STOMACH PAINS, VOMITING, DIARRHEA.
TARGET ORGAN(S):
CENTRAL NERVOUS SYSTEM
KIDNEYS
FIRST AID
IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES.
IN CASE OF CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND COPIOUS

CONTINUED ON NEXT PAGE

aldrich chemical co.
P.O. Box 355 Milwaukee Wisconsin 53201 USA

CUST#: 916003
PO#: 1760753

PRODUCT #: 20895-7 NAME: MAGNESIUM CHLORIDE HEXAHYDRATE, 98%
CAS #: 7791-18-6
ME: CL24G

---------- HEALTH HAZARD DATA ----------

AMOUNTS OF WATER.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS. CALL A PHYSICIAN.
WASH CONTAMINATED CLOTHING BEFORE REUSE.

---------- PHYSICAL DATA ----------

SPECIFIC GRAVITY: 1.569
APPEARANCE AND ODOR
WHITE CRYSTALLINE FLAKES

---------- FIRE AND EXPLOSION HAZARD DATA ----------

EXTINGUISHING MEDIA
NONCOMBUSTIBLE.
USE EXTINGUISHING MEDIA APPROPRIATE TO SURROUNDING FIRE CONDITIONS.
SPECIAL FIREFIGHTING PROCEDURES
WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.
UNUSUAL FIRE AND EXPLOSIONS HAZARDS
EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

---------- REACTIVITY DATA ----------

INCOMPATIBILITIES
STRONG OXIDIZING AGENTS
PROTECT FROM MOISTURE.
HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
TOXIC FUMES OF:
HYDROGEN CHLORIDE GAS

---------- SPILL OR LEAK PROCEDURES ----------

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
SWEEP UP, PLACE IN A BAG AND HOLD FOR WASTE DISPOSAL.
AVOID RAISING DUST.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

CONTINUED ON NEXT PAGE

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5221

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MATERIAL SAFETY DATA SHEET

CUST#: 916003
PO#: 1760753

PRODUCT #: 20395-7 NAME: MAGNESIUM CHLORIDE HEXAHYDRATE, 98%
CAS #: 7791-18-6
MF: CL2MG

SPILL OR LEAK PROCEDURES

WASTE DISPOSAL METHOD
FOR SMALL QUANTITIES: CAUTIOUSLY ADD TO A LARGE STIRRED EXCESS OF WATER. ADJUST THE PH TO NEUTRAL, SEPARATE ANY INSOLUBLE SOLIDS OR LIQUIDS AND PACKAGE THEM FOR HAZARDOUS-WASTE DISPOSAL. FLUSH THE AQUEOUS SOLUTION DOWN THE DRAIN WITH PLENTY OF WATER. THE HYDROLYSIS AND NEUTRALIZATION REACTIONS MAY GENERATE HEAT AND FUMES WHICH CAN BE CONTROLLED BY THE RATE OF ADDITION.

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE

CHEMICAL SAFETY GOGGLES.
RUBBER GLOVES.
NIOSH/MSHA-APPROVED RESPIRATOR.
SAFETY SHOWER AND EYE BATH.
MECHANICAL EXHAUST REQUIRED.
DO NOT BREATHE DUST.
DO NOT GET IN EYES, ON SKIN, ON CLOTHING.
WASH THOROUGHLY AFTER HANDLING.
IRRITANT.
KEEP TIGHTLY CLOSED.
HYGROSCOPIC
STORE IN A COOL DRY PLACE.
LABEL PRECAUTIONARY STATEMENTS
IRRITANT
IRRITATING TO EYES, RESPIRATORY SYSTEM AND SKIN.
TARGET ORGAN(S):
CENTRAL NERVOUS SYSTEM
KIDNEYS
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
WEAR SUITABLE PROTECTIVE CLOTHING.

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DATE: 06/01/
CUST#: 916003
PO#: 1760753

MATERIAL SAFETY DATA SHEET PAGE 1

IDENTIFICATION

PRODUCT #: 22127-9 NAME: MANGANESE(II) CHLORIDE TETRAHYDRATE, 98+%, A.C.S. REAGENT
CAS #: 13446-34-9
MF: CL2MN

SYNONYMS
MANGANESE DICHLORIDE TETRAHYDRATE * MANGANOUS CHLORIDE TETRAHYDRATE *

TOXICITY HAZARDS

RTECS NO: OO9650000
MANGANESE(II) CHLORIDE, TETRAHYDRATE
TOXICITY DATA
ORL-RAT LD50:1484 MG/KG EVHPAZ 10,95,75
IPR-RAT LD50:138 MG/KG EVHPAZ 10,95,75
PAR-RAT LD50:225 MG/KG JINCAO 41,1507,79
IPR-MUS LD50:144 MG/KG TXAPA9 53,461,82
REVIEWS, STANDARDS, AND REGULATIONS
ACGIH TLV-TWA 5 MG(MN)/M3 85INA8 5,354(88),86
MSHA STANDARD-AIR:CL 5 MG(MN)/M3 DTLVS* 3,149,71
OSHA PEL:CL 5 MG(MN)/M3 FEREAC 54,2923,89
OSHA PEL FINAL:CL 5 MG(MN)/M3 FEREAC 54,2923,89
NOES 1983: HZD X4985; NIS 3; TNF 110; NOS 5; TNE 3297; TFE 1033
EPA GENETOX PROGRAM 1983, POSITIVE: CELL TRANSFORM.-RLV F344 RAT EMBRYO
TARGET ORGAN DATA
PATERNAL EFFECTS (TESTES, EPIDIDYMIS, SPERM DUCT)
EFFECTS ON FERTILITY (POST-IMPLANTATION MORTALITY)

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION

HEALTH HAZARD DATA

ACUTE EFFECTS
HARMFUL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN.
CAUSES EYE AND SKIN IRRITATION.
MATERIAL IS IRRITATING TO MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT.
CHRONIC EFFECTS
LABORATORY EXPERIMENTS HAVE SHOWN MUTAGENIC EFFECTS.
TARGET ORGAN(S):
NERVES
LUNGS
FIRST AID
IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES WITH COPIOUS AMOUNTS OF

CONTINUED ON NEXT PAGE

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CUST#: 916003
PO#: 1760753

PRODUCT #: 22127-9 NAME: MANGANESE(II) CHLORIDE TETRAHYDRATE, 98+%, A.C.S. REAGENT
CAS #:13446-34-9
ME: CL2MN

---------- HEALTH HAZARD DATA ----------

WATER FOR AT LEAST 15 MINUTES.
IN CASE OF CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND COPIOUS AMOUNTS OF WATER.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS.
CALL A PHYSICIAN.
WASH CONTAMINATED CLOTHING BEFORE REUSE.

ADDITIONAL INFORMATION
MEN EXPOSED TO MANGANESE DUSTS SHOWED A DECREASE IN FERTILITY.
CHRONIC MANGANESE POISONING PRIMARILY INVOLVES THE CENTRAL NERVOUS SYSTEM. EARLY SYMPTOMS INCLUDE LANGUOR, SLEEPINESS AND WEAKNESS IN THE LEGS. A STOLID MASK-LIKE APPEARANCE OF THE FACE, EMOTIONAL DISTURBANCES SUCH AS UNCONTROLLABLE LAUGHTER AND A SPASTIC GAIT WITH TENDENCY TO FALL IN WALKING ARE FINDINGS IN MORE ADVANCED CASES. HIGH INCIDENCE OF PNEUMONIA HAS BEEN FOUND IN WORKERS EXPOSED TO THE DUST OR FUME OF SOME MANGANESE COMPOUNDS.

---------- PHYSICAL DATA ----------

MELTING PT: 58 C
SPECIFIC GRAVITY: 2.010
APPEARANCE AND ODOR
PINK CRYSTALS

---------- FIRE AND EXPLOSION HAZARD DATA ----------

EXTINGUISHING MEDIA
NONCOMBUSTIBLE.
USE EXTINGUISHING MEDIA APPROPRIATE TO SURROUNDING FIRE CONDITIONS.
SPECIAL FIREFIGHTING PROCEDURES
WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.
UNUSUAL FIRE AND EXPLOSIONS HAZARDS
EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

---------- REACTIVITY DATA ----------

INCOMPATIBILITIES
STRONG ACIDS

CONTINUED ON NEXT PAGE

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M A T E R I A L S A F E T Y D A T A S H E E T

CUST#: 916003
PO#: 1760753

PRODUCT #: 22127-9 NAME: MANGANESE(II) CHLORIDE TETRAHYDRATE, 98+%, A.C.S. REAGENT
CAS #:13446-34-9
MF: CL2MN

REACTIVITY DATA

REACTS VIOLENTLY WITH:
SODIUM
POTASSIUM
ZINC
PROTECT FROM MOISTURE.
HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
HYDROGEN CHLORIDE GAS

SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
SWEEP UP, PLACE IN A BAG AND HOLD FOR WASTE DISPOSAL.
AVOID RAISING DUST.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.
WASTE DISPOSAL METHOD
THE MATERIAL CHOULD BE DISSOLVED IN 1) WATER; 2) ACID SOLUTION OR 3) OXIDIZED TO A WATER-SOLUBLE STATE. PRECIPITATE THE MATERIAL AS THE SULFIDE, ADJUSTING THE PH OF THE SOLUTION TO 7 TO COMPLETE PRE-CIPITATION. FILTER THE INSOLUBLES AND DISPOSE OF THEM IN A HAZARDOUS-WASTE SITE. DESTROY ANY EXCESS SULFIDE WITH SODIUM HYPOCHLORITE. NEUTRALIZE THE SOLUTION BEFORE FLUSHING DOWN THE DRAIN.

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE

WEAR APPROPRIATE NIOSH/MSHA-APPROVED RESPIRATOR, CHEMICAL-RESISTANT GLOVES, SAFETY GOGGLES, OTHER PROTECTIVE CLOTHING.
SAFETY SHOWER AND EYE BATH.
USE ONLY IN A CHEMICAL FUME HOOD.
DO NOT BREATHE DUST.
AVOID CONTACT WITH EYES, SKIN AND CLOTHING.
AVOID PROLONGED OR REPEATED EXPOSURE.
WASH THOROUGHLY AFTER HANDLING.
HARMFUL SOLID.
IRRITANT.
POSSIBLE MUTAGEN.
KEEP TIGHTLY CLOSED.
VERY HYGROSCOPIC
REFRIGERATE.
LABEL PRECAUTIONARY STATEMENTS

CONTINUED ON NEXT PAGE

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PRODUCT #: 22127-9 NAME: MANGANESE(II) CHLORIDE TETRAHYDRATE, 98+%, A.C.S. REAGENT
CAS #:13446-34-9
MF: CL2MN

--- PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE ---

HARMFUL
HARMFUL BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
IRRITATING TO EYES AND SKIN.
POSSIBLE RISK OF IRREVERSIBLE EFFECTS.
POSSIBLE MUTAGEN.
TARGET ORGAN(S):
CENTRAL NERVOUS SYSTEM
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
WEAR SUITABLE PROTECTIVE CLOTHING.

REGULATORY INFORMATION
THIS PRODUCT IS SUBJECT TO SARA SECTION 313 REPORTING REQUIREMENTS.

THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. ALDRICH SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT. SEE REVERSE SIDE OF INVOICE OR PACKING SLIP FOR ADDITIONAL TERMS AND CONDITIONS OF SALE.

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PO#: 1760753

MATERIAL SAFETY DATA SHEET

IDENTIFICATION

PRODUCT #: 22338-7 NAME: NICKEL(II) CHLORIDE HEXAHYDRATE
CAS #:7791-20-0
MF: CL2NI

TOXICITY HAZARDS

RTECS NO: QR6480000
NICKEL(II) CHLORIDE, HEXAHYDRATE (1:2:6)
TOXICITY DATA
ORL-RAT LD50:175 MG/KG FDRLI* 7684A,83
IPR-MUS LD50:48 MG/KG AEPPAE 244,17,62
IVN-DOG LD50:40 MG/KG EQSSDX 1,1,75
REVIEWS, STANDARDS, AND REGULATIONS
ACGIH TLV-TWA 0.05 MG(NI)/M3 85INA8 5,422(89),86
ACGIH TLV-CONFIRMED CARCINOGEN 85INA8 5,422(89),86
IARC CANCER REVIEW:ANIMAL LIMITED EVIDENCE IMEMDT 49,257,90
MSHA STANDARD-AIR:TWA 1 MG(NI)/M3 DTLVS* 3,178,71
OSHA PEL:8H TWA 1 MG(NI)/M3 FEREAC 54,2923,89
OSHA PEL FINAL:8H TWA 1 MG(NI)/M3 FEREAC 54,2923,89
NIOSH REL TO NICKEL, INORGANIC-AIR:10H TWA 0.015 MG(NI)/M3 MMWR** 37(S-7),21,88
NOES 1983: HZD X4330; NIS 5; TNF 366; NOS 9; TNE 10406; TFE 3890

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMAT N.

HEALTH HAZARD DATA

ACUTE EFFECTS
HARMFUL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN.
CAUSES EYE AND SKIN IRRITATION.
MATERIAL IS IRRITATING TO MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT.
CAUSES DERMATITIS.
MAY CAUSE ALLERGIC RESPIRATORY REACTION.
EXPOSURE CAN CAUSE:
GASTROINTESTINAL DISTURBANCES
CHRONIC EFFECTS
CARCINOGEN.
TARGET ORGAN(S):
LUNGS
FIRST AID
IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES.
IN CASE OF CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND COPIOUS

CONTINUED ON NEXT PAGE

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CUST#: 916003
PO#: 1760753

PRODUCT #: 22338-7 NAME: NICKEL(II) CHLORIDE HEXAHYDRATE
CAS #:7791-20-0
MF: CL2NI

---------- HEALTH HAZARD DATA ----------

AMOUNTS OF WATER.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS.
CALL A PHYSICIAN.
WASH CONTAMINATED CLOTHING BEFORE REUSE.

---------- PHYSICAL DATA ----------

APPEARANCE AND ODOR
GREEN CRYSTALS

---------- FIRE AND EXPLOSION HAZARD DATA ----------

EXTINGUISHING MEDIA
NONCOMBUSTIBLE.
USE EXTINGUISHING MEDIA APPROPRIATE TO SURROUNDING FIRE CONDITIONS.
SPECIAL FIREFIGHTING PROCEDURES
WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.
UNUSUAL FIRE AND EXPLOSIONS HAZARDS
EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

---------- REACTIVITY DATA ----------

INCOMPATIBILITIES
PEROXIDES
HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
HYDROGEN CHLORIDE GAS
NICKEL/NICKEL OXIDES

---------- SPILL OR LEAK PROCEDURES ----------

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
EVACUATE AREA.
WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
WEAR DISPOSABLE COVERALLS AND DISCARD THEM AFTER USE.
SWEEP UP, PLACE IN A BAG AND HOLD FOR WASTE DISPOSAL.
AVOID RAISING DUST.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

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CUST#: 916003
PO#: 1760753

PRODUCT #: 22338-7 NAME: NICKEL(II) CHLORIDE HEXAHYDRATE
CAS #:7791-20-0
MF: CL2NI

---------- SPILL OR LEAK PROCEDURES ----------

WASTE DISPOSAL METHOD
THE MATERIAL SHOULD BE DISSOLVED IN 1) WATER; 2) ACID SOLUTION OR 3) OXIDIZED TO A WATER-SOLUBLE STATE. PRECIPITATE THE MATERIAL AS THE SULFIDE, ADJUSTING THE PH OF THE SOLUTION TO 7 TO COMPLETE PRECIPITATION. FILTER THE INSOLUBLES AND DISPOSE OF THEM IN A HAZARDOUS-WASTE SITE. DESTROY ANY EXCESS SULFIDE WITH SODIUM HYPOCHLORITE. NEUTRALIZE THE SOLUTION BEFORE FLUSHING DOWN THE DRAIN.

--- PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE ---

WEAR APPROPRIATE NIOSH/MSHA-APPROVED RESPIRATOR, CHEMICAL-RESISTANT GLOVES, SAFETY GOGGLES, OTHER PROTECTIVE CLOTHING.
SAFETY SHOWER AND EYE BATH.
USE ONLY IN A CHEMICAL FUME HOOD.
DO NOT BREATHE DUST.
DO NOT GET IN EYES, ON SKIN, ON CLOTHING.
AVOID PROLONGED OR REPEATED EXPOSURE.
WASH THOROUGHLY AFTER HANDLING.
TOXIC.
CARCINOGEN.
IRRITANT.
SENSITIZER.
KEEP TIGHTLY CLOSED.
HYGROSCOPIC
STORE IN A COOL DRY PLACE.

LABEL PRECAUTIONARY STATEMENTS
TOXIC
MAY CAUSE CANCER.
TOXIC BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
IRRITATING TO EYES, RESPIRATORY SYSTEM AND SKIN.
MAY CAUSE SENSITIZATION BY INHALATION AND SKIN CONTACT.
TARGET ORGAN(S):
LUNGS
DO NOT BREATHE DUST.
IF YOU FEEL UNWELL, SEEK MEDICAL ADVICE (SHOW THE LABEL WHERE POSSIBLE).
WEAR SUITABLE PROTECTIVE CLOTHING, GLOVES AND EYE/FACE PROTECTION.
KEEP CONTAINER TIGHTLY CLOSED IN A COOL WELL VENTILATED PLACE.

REGULATORY INFORMATION
THIS PRODUCT IS SUBJECT TO SARA SECTION 313 REPORTING REQUIREMENTS.

CONTINUED ON NEXT PAGE

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PO#: 1760753

PRODUCT #: 22338-7 NAME: NICKEL(II) CHLORIDE HEXAHYDRATE
CAS #: 7791-20-0
MF: CL2NI

THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. ALDRICH SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT. SEE REVERSE SIDE OF INVOICE OR PACKING SLIP FOR ADDITIONAL TERMS AND CONDITIONS OF SALE.

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Material Safety Data Sheet

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GENIUM PUBLISHING CORP.

No. 033

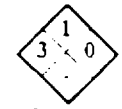
POLYCHLORINATED BIPHENYLS (PCBs)

Issued: November 1988

SECTION 1. MATERIAL IDENTIFICATION

27

Material Name: POLYCHLORINATED BIPHENYLS (PCBs)



Genium

Description (Origin, Uses): Commercial PCBs are mixtures that were once widely manufactured by combining chlorine gas, iron filings, and biphenyls. Their high stability contributes to their intended commercial applications and their accidental, long-term adverse environmental and health effects. PCBs are useful as insulators in electrical equipment because they are electrically nonconductive. Their distribution has been limited since 1976. The Aroclor PCB codes identify PCBs by type. The first two digits of a code indicate whether the PCB contains chlorinated biphenyls (12), chlorinated terphenyls, (54), or both (25, 44); the last two digits indicate the approximate percentage of chlorine. Found in insulating liquid, synthetic rubber, plasticizers, flame retardants, floor tile, printer's ink, paper and fabric coatings, brake linings, paints, automobile body sealants, asphalt, adhesives, electrical capacitors, electrical transformers, vacuum pumps, gas-transmission turbines, heat-transfer fluids, hydraulic fluids, lubricating and cutting oil, copying paper, carbonless copying paper, and fluorescent light ballasts.

Synonym: Chlorodiphenyls

Other Designations (Producer, Trade Name, Nation): Monsanto, Aroclor® (USA, Great Britain); Bayer, Clophen® (German Democratic Republic); Prodelec, Phenoclor®, Pyralene® (France); Kanegafuchi, Kanechlor®; Mitsubishi, Santotherm® (Japan); Caffaro, Fenclor® (It...

Trade Name	CAS No.	*RTECS* No.	Trade Name	CAS No.	*RTECS* No.
Arochlors	11336-36-3	TQ1350000	Aroclor 1242	53469-21-9	TQ1356000
Aroclor 1016	12674-11-2	TQ1351000	Aroclor 1248	12672-29-6	TQ1358000
Aroclor 1221	11104-28-2	TQ1352000	Aroclor 1254	11097-69-1	TQ1360000
Aroclor 1232	11141-16-5	TQ1354000	Aroclor 1260	11096-82-5	TQ1362000

HMIS	
H 1	R 1
F 1	I 3
R 0	S 1
PPG*	K 1

SECTION 2. INGREDIENTS AND HAZARDS EXPOSURE LIMITS

PCB-42% Chlorine/Aroclor 1242
CAS No. 53469-21-9
OSHA PEL (Skin*)
8-Hr TWA: 1 mg/m³
ACGIH TLV (Skin*), 1988-89
TLV-TWA: 1 mg/m³

PCB-54% Chlorine/Aroclor 1254
CAS No. 11097-69-1
OSHA PEL (Skin*)
8-Hr TWA: 0.5 mg/m³
ACGIH TLV (Skin*), 1988-89
TLV-TWA: 0.5 mg/m³

All PCBs/Aroclors
CAS No. 1336-36-3
NIOSH REL 1977
10-Hour TWA: 0.001 mg/m³
Toxicity Data**
Mouse, Oral, LD_{50}: 1900 mg/kg

*This material can be absorbed through intact skin, which contributes to overall exposure.
**See NIOSH, *RTECS* (Genium ref. 90), at the locations specified in section 1 for additional data with references to tumorigenic, reproductive, mutagenic, and irritative effects.

SECTION 3. PHYSICAL DATA

Boiling Point: Ranges from 527°F (275°C) to 725°F (385°C)
Solubility in Water (%): Insoluble
Pour Point: Ranges from -31°F (-35°C) to 87.8°F (31°C)
% Volatile by Volume: Ranges from 1.2 to 1.6
Molecular Weight (Average): Aroclor 1242: 258 Grams/Mole
Aroclor 1254: 326 Grams/Mole

Appearance and Odor: Clear to light yellow mobile oil to a sticky resin; a sweet "aromatic" odor. As the percentage of chlorine increases, the PCB becomes thicker and heavier: e.g., Aroclor 1254 is more viscous than Aroclor 1242.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point*	Autoignition Temperature: Not Found	LEL: Not Found	UEL: Not Found

Extinguishing Media: Use water spray/fog, carbon dioxide (CO_2), dry chemical, or "alcohol" foam to extinguish fires that involve polychlorinated biphenyls. Although it is very difficult to ignite PCBs, they are often mixed with more flammable materials (oils, solvents, etc.) **Unusual Fire or Explosion Hazards:** If a transformer containing PCBs is involved in a fire, its owner may be required to report the incident to appropriate authorities. Consult and follow all pertinent Federal, state, and local regulations. **Special Fire-fighting Procedures:** Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode; fire fighters must also wear a complete set of protective clothing. **Comments:** The hazards of PCB fires are associated with the possibility of their being released into the environment where they and their products of degeneration can pose serious long-term health risks. These potential problems are heightened by the PCBs' resistance to biological and chemical degradation and by the possibility that they will contaminate underground water systems (see sect. 5)

*Ranges from 284°F (140°C) to 392°F (200°C).

SECTION 5. REACTIVITY DATA

Stability/Polymerization: Polychlorinated biphenyls are very stable materials. Hazardous polymerization cannot occur.
Chemical Incompatibilities: PCBs can react dangerously with sodium or potassium. These reactions are part of an industrial process used to destroy PCBs; however, people have been killed by explosions at PCB treatment, storage, and disposal sites. **Conditions to Avoid:** Limit human exposure to PCBs to the lowest possible level; especially avoid contact with skin. **Hazardous Products of Decomposition:** Thermal-oxidative degradation of PCBs can produce toxic gases such as carbon monoxide, chlorine, chlorinated aromatic fragments, phenolics, aldehydes, and hydrogen chloride. Incomplete combustion of PCBs produces toxic compounds such as polychlorinated dibenzofuran (PCDF, the major product of combustion), and polychlorinated dibenzo-*p*-dioxin (PCDD or dioxin).

SECTION 6. HEALTH HAZARD INFORMATION

Carcinogenicity: The EPA lists PCBs as carcinogens, and the IARC classifies them as probable human carcinogens (group 2B).
Summary of Risks: Effects of accidental exposure to PCBs include acneform eruptions; eye discharge; swelling of the upper eyelids and hyperemia of the conjunctiva; hyperpigmentation of skin, nails, and mucous membrane; chloroacne; distinctive hair follicles; fever; hearing difficulties; limb spasms; headache; vomiting; and diarrhea. PCBs are potent liver toxins that can be absorbed through unbroken skin in hazardous amounts without immediately discernible pain or discomfort. Severe health effects can develop later. In experimental animals, prolonged or repeated exposure to PCBs by any route results in liver damage at levels that are less than those reported to have caused cancer in rodents. **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** Skin, eyes, eyelids, blood, liver. **Primary Entry:** Inhalation, skin contact/absorption. **Acute Effects:** Skin and eye irritation, acneform dermatitis, nausea, vomiting, abdominal pain, jaundice, liver damage. **Chronic Effects:** Possible cancer (evidence of this is inconclusive); reproductive effects (jaundice, excessive secretion of tears, dermal chromopexy); and hepatitis. **FIRST AID:** **Eyes.** Immediately flush eyes, including under the eyelids, gently but thoroughly with flooding amounts of running water for 15 minutes. **Skin.** Rinse exposed skin with flooding amounts of water; wash with soap and water. **Inhalation.** Remove the exposed person to fresh air; restore and/or support breathing as needed. Have qualified medical personnel administer oxygen as required. **Ingestion.** Induce vomiting by sticking your finger to the back of the exposed person's throat. Have him or her drink 1 to 2 glasses of milk or water. **Get medical help (in plant, paramedic, community) for all exposures.** Seek prompt medical assistance for further treatment, observation, and support after first aid. **Note to Physician:** PCBs are poorly metabolized, soluble in lipids, and they accumulate in tissues or organs rich in lipids. Liver function tests can help to determine the extent of body damage in exposed persons. If electrical equipment containing PCBs arcs over, the PCBs or other hydrocarbon dielectric fluids may decompose and give off hydrochloric acid (HCl), a potent respiratory irritant.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: *Treat any accidental release of PCBs as an emergency. An SPCCP (spill-prevention control and countermeasure plan) must be formulated before spills or leaks occur.* PCBs are resistant to biodegradation, soluble in lipids, and chemically stable; as such they have become significant contaminants of global ecosystems. Releases of PCBs require immediate, competent, professional response from trained personnel. *Each release situation is unique and requires a specifically designed cleanup response.* General recommendations include adhering to Federal regulations (40 CFR Part 761). Notify safety personnel, evacuate nonessential personnel, ventilate the spill area, and contain the PCBs. All wastes, residues, and contaminated cleanup equipment from the incident are subject to EPA requirements (40 CFR 761). Consult your attorney or appropriate regulatory officials for information about reporting requirements and disposal procedures. **Waste Disposal:** Contact your hazardous waste disposal firm or a licensed contractor for detailed recommendations, especially when PCBs are unexpectedly discovered. Follow Federal, state, and local regulations. PCBs are biomagnified in the food chain; i.e., their concentration increases at each link. The disposal of PCBs or of PCB-contaminated materials is strictly regulated; violations of applicable laws can result in fines, lawsuits, and negative publicity. **Warning:** Accidental spills of PCBs that may affect water supplies must be reported to Coast Guard personnel at the National Response Center, telephone (202) 426-2675.

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000 Subpart Z).
EPA Designations (40 CFR 302.4)
CERCLA Hazardous Substance, Reportable Quantity: 10 lbs (4.54 kg), per the Clean Water Act (CWA), §§ 311 (b) (4) and 307 (a).

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing of PCBs is possible, wear a full face shield. Follow OSHA eye- and face-protections regulations (29 CFR 1910.133). **Respirator:** Wear a NIOSH-approved respirator per Genium reference 88 for the maximum-use concentrations and/or exposure limits cited in section 2. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (leaks or cleaning reactor vessels and storage tanks), wear an SCBA. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, and gauntlets, etc., to prevent any contact of PCBs with your skin. **Ventilation:** Install and operate general and local maximum, explosion-proof ventilation systems powerful enough to maintain airborne levels of this material below the OSHA PEL standards cited in section 2. Local exhaust ventilation is preferred because it prevents dispersion of the contamination into the general work area by eliminating it at its source. Consult the latest edition of Genium reference 103 for detailed recommendations. **Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work areas. **Contaminated Equipment:** Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Do not wear contact lenses in any work area. Remove contaminated clothing and launder it before wearing it again; clean this material from your shoes and equipment. Heavily soiled clothing must be properly discarded in a manner consistent with applicable regulations. **Comments:** Practice good personal hygiene; always wash thoroughly after using this material and before eating, drinking, smoking, using the toilet, or applying cosmetics. Keep it off your clothing and equipment. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do *not* eat, drink, or smoke in work areas.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage Segregation: Store PCBs in closed containers in a cool, dry, well-ventilated area. Protect containers from physical damage. **Special Handling/Storage:** All storage facilities must have adequate containment systems (dikes; elevated, nonporous holding platforms; retaining walls) to prevent any major release of PCBs into the environment. Carefully design and implement these extra precautions now; do not wait until you have to respond to an accidental release of this material.

Transportation Data (49 CFR 172.101-2; PCBs were the first materials to be directly regulated by Congress by way of TSCA in 1976.)

DOT Shipping Name: Polychlorinated Biphenyls
DOT Hazard Class: ORM-E
ID No. UN 23115
DOT Packaging Requirements: 49 CFR 173.510

IMO Shipping Name: Polychlorinated Biphenyls
IMO Hazard Class: 9
IMDG Packaging Group: II

References: 1, 6, 26, 38, 84-94, 100, 101, 116, 117, 120, 122.

Prepared by PJ Igoe, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD

Technical Review: Northeast Analytical, Inc. (PCB and VOC Specialists), Schenectady, New York, Telephone: (518) 346-4592

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MATERIAL SAFETY DATA SHEET

IDENTIFICATION

PRODUCT #: 34241-6 NAME: POTASSIUM PHOSPHATE, MONOBASIC, 98+%
CAS #:7778-77-0
MF: H2KO4P

TOXICITY HAZARDS

NO TOXICITY DATA AVAILABLE

HEALTH HAZARD DATA

ACUTE EFFECTS
MAY BE HARMFUL BY INHALATION, INGESTION, OR SKIN ABSORPTION.
MAY CAUSE IRRITATION.
FIRST AID
IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES.
IN CASE OF CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND COPIOUS AMOUNTS OF WATER.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS. CALL A PHYSICIAN.
WASH CONTAMINATED CLOTHING BEFORE REUSE.

PHYSICAL DATA

APPEARANCE AND ODOR
WHITE CRYSTALS

FIRE AND EXPLOSION HAZARD DATA

EXTINGUISHING MEDIA
WATER SPRAY.
CARBON DIOXIDE, DRY CHEMICAL POWDER OR APPROPRIATE FOAM.
SPECIAL FIREFIGHTING PROCEDURES
WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.
UNUSUAL FIRE AND EXPLOSIONS HAZARDS
EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

REACTIVITY DATA

INCOMPATIBILITIES
STRONG OXIDIZING AGENTS
PROTECT FROM MOISTURE.

CONTINUED ON NEXT PAGE

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PRODUCT #: 34241-6 NAME: POTASSIUM PHOSPHATE, MONOBASIC, 98+%
CAS #: 7778-77-0
MF: H2KO4P

---------- REACTIVITY DATA ----------

HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
NATURE OF DECOMPOSITION PRODUCTS NOT KNOWN.

---------- SPILL OR LEAK PROCEDURES ----------

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
CHEMICAL SAFETY GOGGLES.
USE PROTECTIVE CLOTHING, GLOVES AND MASK.
SWEEP UP, PLACE IN A BAG AND HOLD FOR WASTE DISPOSAL.
AVOID RAISING DUST.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.
WASTE DISPOSAL METHOD
DISSOLVE IN WATER AND DILUTE TO A 5% SOLUTION. CHECK THE PH AND ADJUST IT TO 7 IF NECESSARY. POUR THE SOLUTION DOWN THE DRAIN WITH RUNNING WATER AND CONTINUE TO FLUSH THE DRAIN SYSTEM FOR 10 MINUTES, PROVIDED THAT RULES AT YOUR PLACE OF EMPLOYMENT OR LOCAL, STATE AND FEDERAL GUIDELINES ALLOW YOU TO DO SO. IF YOU ARE UNABLE TO FLUSH THE SOLUTION DOWN THE DRAIN OR IN DOUBT ABOUT THE SUITABILITY OF THE METHOD USE A LICENSED WASTE DISPOSAL COMPANY.

--- PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE ---

CHEMICAL SAFETY GOGGLES.
COMPATIBLE CHEMICAL-RESISTANT GLOVES.
NIOSH/MSHA-APPROVED RESPIRATOR IN NONVENTILLATED AREAS AND/OR FOR EXPOSURE ABOVE THE ACGIH TLV.
SAFETY SHOWER AND EYE BATH.
MECHANICAL EXHAUST REQUIRED.
DO NOT BREATHE DUST.
DO NOT GET IN EYES, ON SKIN, ON CLOTHING.
WASH THOROUGHLY AFTER HANDLING.
KEEP TIGHTLY CLOSED.
HYGROSCOPIC
STORE IN A COOL DRY PLACE.
LABEL PRECAUTIONARY STATEMENTS
HYGROSCOPIC

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DATE: 06/02/9
CUST#: 916003
PO#: 1760716

MATERIAL SAFETY DATA SHEET PAGE 1

IDENTIFICATION

PRODUCT #: 28296-0 NAME: QUINHYDRONE, 97%
CAS #:106-34-3
MF: C12H10O4

SYNONYMS
P-BENZOQUINONE, COMPD. WITH HYDROQUINONE * CHINHYDRON (CZECH) * 2,5-CYCLOHEXADIENE-1,4-DIONE COMPD. WITH 1,4-BENZENEDIOL (1:1) * GREEN HYDROQUINONE * HYDROQUINONE, COMPD. WITH P-BENZOQUINONE *

TOXICITY HAZARDS

RTECS NO: VA4550000
QUINHYDRONE
TOXICITY DATA
ORL-RAT LD50:225 MG/KG FEPRA7 8,348,49
IVN-RAT LD50:35 MG/KG FEPRA7 8,348,49
REVIEWS, STANDARDS, AND REGULATIONS
EPA TSCA CHEMICAL INVENTORY, JUNE 1990
EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, MARCH 1992

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION

HEALTH HAZARD DATA

ACUTE EFFECTS
HARMFUL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN.
CAUSES EYE AND SKIN IRRITATION.
MATERIAL IS IRRITATING TO MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT.
TO THE BEST OF OUR KNOWLEDGE, THE CHEMICAL, PHYSICAL, AND TOXICOLOGICAL PROPERTIES HAVE NOT BEEN THOROUGHLY INVESTIGATED.
FIRST AID
IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES OR SKIN WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED CLOTHING AND SHOES.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS.
CALL A PHYSICIAN.
WASH CONTAMINATED CLOTHING BEFORE REUSE.

PHYSICAL DATA

MELTING PT: 173 C TO 174 C

CONTINUED ON NEXT PAGE

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MATERIAL SAFETY DATA SHEET

CUST#: 916003
PO#: 1760716

PRODUCT #: 28296-0 NAME: QUINHYDRONE, 97%
CAS #:106-34-3
MF: C12H10O4

PHYSICAL DATA

APPEARANCE AND ODOR
GREEN METALLIC POWDER

FIRE AND EXPLOSION HAZARD DATA

EXTINGUISHING MEDIA
WATER SPRAY.
CARBON DIOXIDE, DRY CHEMICAL POWDER OR APPROPRIATE FOAM.
SPECIAL FIREFIGHTING PROCEDURES
WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.
UNUSUAL FIRE AND EXPLOSIONS HAZARDS
EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

REACTIVITY DATA

INCOMPATIBILITIES
STRONG OXIDIZING AGENTS
LIGHT SENSITIVE
AIR SENSITIVE
HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
TOXIC FUMES OF:
CARBON MONOXIDE, CARBON DIOXIDE

SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
EVACUATE AREA.
WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
SWEEP UP, PLACE IN A BAG AND HOLD FOR WASTE DISPOSAL.
AVOID RAISING DUST.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.
WASTE DISPOSAL METHOD
DISSOLVE OR MIX THE MATERIAL WITH A COMBUSTIBLE SOLVENT AND BURN IN A CHEMICAL INCINERATOR EQUIPPED WITH AN AFTERBURNER AND SCRUBBER.

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE

WEAR APPROPRIATE NIOSH/MSHA-APPROVED RESPIRATOR, CHEMICAL-RESISTANT

CONTINUED ON NEXT PAGE

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MATERIAL SAFETY DATA SHEET

CUST#: 916003
PO#: 1760716

PRODUCT #: 23296-0 NAME: QUINHYDRONE, 97%
CAS #:106-34-3
MF: C12H10O4

--- PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE ---

GLOVES, SAFETY GOGGLES, OTHER PROTECTIVE CLOTHING.
SAFETY SHOWER AND EYE BATH.
USE ONLY IN A CHEMICAL FUME HOOD.
DO NOT BREATHE DUST.
AVOID CONTACT WITH EYES, SKIN AND CLOTHING.
AVOID PROLONGED OR REPEATED EXPOSURE.
WASH THOROUGHLY AFTER HANDLING.
TOXIC.
IRRITANT.
KEEP TIGHTLY CLOSED.
AIR AND LIGHT SENSITIVE
STORE UNDER NITROGEN.
STORE IN A COOL DRY PLACE.

LABEL PRECAUTIONARY STATEMENTS
TOXIC (USA DEFINITION)
HARMFUL (EUROPEAN DEFINITION)
HARMFUL BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
IRRITATING TO EYES, RESPIRATORY SYSTEM AND SKIN.
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
WEAR SUITABLE PROTECTIVE CLOTHING.

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Sheet No. 263
Sodium Bicarbonate

Issued: 8/89

Section 1. Material Identification

Sodium Bicarbonate Description: Prepared from sodium carbonate, water, and carbon dioxide (CO_2). Used to manufacture many sodium salts; as a source of carbon dioxide in fire extinguishers and cleaning compounds; and as an ingredient of baking powder and effervescent salts beverages.

Other Designations: Baking soda; sodium acid carbonate; sodium hydrogen carbonate; monosodium carbonate; bicarbonate of soda; $NaHCO_3$; CAS No. 144-55-8.

Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers Guide* (Genium ref. 73) for a suppliers list.

HMIS
H 1
F 0
R 0
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Sodium bicarbonate, ca 100%

OSHA PEL	ACGIH TLV, 1988-89	NIOSH REL	Toxicity Data*
None established	None established	None established	Infant, oral: TD [illegible] mg/kg Infant, oral: LD, 4220 mg/kg

*See NIOSH, *RTECS* (VZ0950000), for additional data with references to reproductive and irritative effects.

Section 3. Physical Data

Water Solubility: Complete

Molecular Weight: 84 g/mol

pH: *

Appearance and Odor: White crystalline powder or granules; odorless.

* The aqueous solutions of sodium bicarbonate prepared with cold water and no agitation are only slightly alkaline to litmus or phenolphthalein. The alkalinity increases as the temperature rises and as time passes. A freshly prepared 0.1-molar solution of sodium bicarbonate at 77 °F (25 °C) has a pH of 8.3.

Section 4. Fire and Explosion Data

Flash Point: * **Autoignition Temperature:** * **LEL:** * **UEL:** *

Extinguishing Media: * Sodium bicarbonate does not burn. Use extinguishing agents that put out the surrounding fire.

Unusual Fire or Explosion Hazards: None reported.

Special Fire-fighting Procedures: Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode to protect against the effects of the surrounding fire.

Section 5. Reactivity Data

Stability/Polymerization: Sodium bicarbonate is stable at room temperature during routine operations. Hazardous polymerization cannot occur.

Chemical Incompatibilities: Sodium bicarbonate can react dangerously with monoammonium phosphate or a sodium-potassium alloy.

Conditions to Avoid: Sodium bicarbonate decomposes by reaction with acids.

Hazardous Products of Decomposition: Sodium bicarbonate starts to give off carbon dioxide gas at 122 °F (50 °C). At 212 °F (100 °C) the sodium bicarbonate converts to sodium carbonate (Na_2CO_3).

Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists sodium bicarbonate as a carcinogen.
Summary of Risks: Sodium bicarbonate is an alkaline powder that can irritate the tissues it contacts. Dryness, scaling, and alkaline burns of exposed tissue can occur, depending on the exposure's intensity and duration. The alkaline irritant effects of sodium bicarbonate solutions increase as the solution's concentration and strength increase. Sodium bicarbonate's toxicity is low and the FDA has approved its use as a general-purpose food additive.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Skin, eyes, and mucous membranes lining the respiratory system.
Primary Entry: Inhalation, skin contact.
Acute Effects: Irritation, with possible alkaline chemical burns, of the skin, eyes, and the mucous membranes of the respiratory tract. Moist skin probably increases the alkaline irritant effects.
Chronic Effects: None reported.
FIRST AID
Eyes: Immediately flush, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min. Alkaline/basic eye burns are possible. Treatment by competent medical personnel is necessary to prevent permanent eye damage.
Skin: After rinsing affected area with flooding amounts of water, wash it with soap and water.
Inhalation: Remove exposed person to fresh air, and support breathing as needed.
Ingestion: If ingested, have the exposed person drink 1 to 2 glasses of water. If the quantities or concentrations are excessive, induce vomiting by giving an emetic such as Syrup of Ipecac.
After first aid, get appropriate in-plant, paramedic, or community medical attention and support.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety and cleanup personnel of a sodium bicarbonate spill. Cleanup personnel should wear personal protective equipment (Sec. 8) to prevent excessive skin contact or dust inhalation. Do not create dusty conditions during cleanup operations. Shovel, scoop, or vacuum the spilled material into appropriate disposal containers. Never flush to sewers, surface waters, waterways, or watersheds.
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

OSHA Designations
Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed
EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
CERCLA Hazardous Substance (40 CFR 302.4): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Where splashing is possible, wear a full face shield.
Respirator: Wear a NIOSH-approved respirator if necessary. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (spills or cleaning reactor vessels and storage tanks), wear an SCBA.
Warning: Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres.
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact.
Ventilation: Provide general and local ventilation systems to maintain airborne concentrations that protect worker safety/productivity. Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by eliminating it at its source (Genium ref. 103).
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area; soft lenses may absorb, and all lenses concentrate, irritants. Launder contaminated clothing before wearing. Remove this material from your shoes and equipment.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store sodium bicarbonate in closed containers in a cool, dry, well-ventilated area away from acids. Protect these containers from physical damage.

Transportation Data (49 CFR 172.101-2): Not listed

MSDS Collection **References:** 1, 6, 7, 84-94, 100, 116, 117, 119, 120, 122
Prepared by: PJ Igoe, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD

Material Safety Data Sheets Collection

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Sheet No. 743
Sodium Bromide

Issued: 7 91

Section 1. Material Identification

34

Sodium Bromide (NaBr) Description: Occurs naturally in some salt deposits. Prepared commercially by reacting iron with bromine and water, dissolving the resulting ferrosoferric bromide in water, adding sodium carbonate, and filtering and evaporating that solution. Also by adding excess bromine to a sodium hydroxide solution, then evaporating it to dryness and treating it with carbon to reduce the resulting bromate to bromide. Used in photography and preparing bromides, and medicinally as an oral sedative, diuretic, and antiepileptic.

Other Designations: CAS No. 7647-15-6; bromide salt of sodium; Sedoneural;* trisodium tribromide.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

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Genium

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H 2
F 0
R 0
PPG*
* Sec. 8

Cautions: Sodium bromide is moderately toxic by inhalation and ingestion. Its major influence is on the central nervous system (CNS).

Section 2. Ingredients and Occupational Exposure Limits

Sodium bromide, ca 100%

1990 OSHA PEL	1990-91 ACGIH TLV	1990 NIOSH REL	1985-86 Toxicity Data*
None established	None established	None established	Human, estimated oral, LD_{Lo}: 0.5 to 5 g/kg Rat, oral, LD_{50}: 3500 mg/kg; toxic effects not yet reviewed Rabbit, oral, LD_{Lo}: 580 mg/kg; toxic effects not yet reviewed Rat, oral, TD_{Lo}: 338 mg/kg administered for 90 days to pregnant female prior to mating produced maternal effects (ovaries and fallopian tubes)

* See NIOSH, *RTECS* (VZ3150000), for additional reproductive and toxicity data.

Section 3. Physical Data

Boiling Point: 2534 °F (1390 °C)
Melting Point: 1377 °F (747 °C)
Index of Refraction: 1.6412
pH: 6.5 to 8.0 (aqueous solution)
Molecular Weight: 102.9
Density/Specific Gravity: 3.203 at 77 °F (25 °C)
Water Solubility: Soluble; 1.16 kg/l water at 122 °F (50 °C), 1.21 kg/l water at 212 °F (100 °C)

Appearance and Odor: White or colorless crystals, granules or powder with a bitter, saline taste. Sodium bromide is hygroscopic (absorbs moisture from air, becoming hard).

Section 4. Fire and Explosion Data

Flash Point: None reported **Autoignition Temperature:** None reported **LEL:** None reported **UEL:** None reported

Extinguishing Media: Sodium bromide is nonflammable. Use extinguishing media suitable for surrounding materials. Use dry chemical, water spray, or regular foam.

Unusual Fire or Explosion Hazards: Sodium bromide may emit toxic bromide and sodium oxide fumes when involved in a fire; use caution. Avoid inhaling fire-produced vapors.

Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Sodium bromide is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. Keep in a dry area since it is hygroscopic, absorbing moisture of any origin.

Chemical Incompatibilities: Acids, alkaloidal and heavy metal salts (lead, silver, manganese, antimony, mercury, etc.), bromine trifluoride, and strong oxidizers (which liberate bromine).

Conditions to Avoid: Avoid contact with moisture, acids, alkaloidal and heavy metal salts and strong oxidizers.

Hazardous Products of Decomposition: Thermal oxidative decomposition of sodium bromide can produce toxic fumes of bromide (Br^-) and sodium oxide (Na_2O).

Section 6. Health Hazard Data

Carcinogenicity: In 1990 reports, the IARC, NTP, and OSHA do not list sodium bromide as a carcinogen.

Summary of Risks: Sodium bromide is moderately toxic by inhalation and ingestion. As of this update, neither OSHA nor ACGIH has set any limits on occupational exposure. All currently available data is on toxicity by ingestion. Acute toxicity is rare since large amounts are needed to produce toxicity and these are usually purged immediately, preventing absorption. Readily absorbed through the lower part of the small intestine, small amounts of bromide salts build up in the body. Maximum accumulation takes about three months. The main effects of systemic poisoning are central nervous system (CNS) disturbances and development of skin rashes.

Medical Conditions Aggravated by Long-Term Exposure: Alcoholism, dehydration, severe depression, preexisting neurological or psychological disorders.

Target Organs: Skin and CNS.

Primary Entry Routes: Ingestion, possibly inhalation.

Acute Effects: When large amounts of sodium bromide are ingested, acute toxicity may occur. Symptoms include listlessness, dizziness, unsteady gait, impaired reflex movements, and profound stupor or coma.

Chronic Effects: Incoordination and psychiatric disturbances such as depression and psychosis.

FIRST AID

Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.

Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.

Inhalation: Remove exposed person to fresh air and support breathing as needed.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: Treatment includes hydration, mild diuresis, and possible hemodialysis. Consider ammonium chloride (10 to 15 g *qd*) in divided doses with diuretic.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel. Isolate area and deny entry. Always stay upwind of spills. Cleanup personnel should protect against dust inhalation and skin contact. Avoid generating dusty conditions. Carefully scoop spilled dry material into appropriate containers for later disposal. For liquid spills, absorb with an inert material and place in appropriate containers for disposal. For large spills, dike far ahead of liquid to contain. Follow applicable OSHA regulations (29 CFR 1910.120).

Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

RCRA Hazardous Waste (40 CFR 261.33): Not listed

CERCLA Hazardous Substance (40 CFR 302.4): Not listed

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

SARA Toxic Chemical (40 CFR 372.65): Not listed

OSHA Designations

Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Since contact lense use in industry is controversial, establish your own policy.

Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator.

Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact.

Ventilation: Provide general and local ventilation systems to maintain airborne concentrations that promote worker safety and productivity. Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Avoid physical damage to containers. Store in a cool, *dry*, well-ventilated area away from acids, alkaloidal and heavy metal salts, and strong oxidizers. *Do not* allow contact with *any* moisture.

Other Precautions: Consider preplacement medical exams for exposed workers that emphasize central nervous system function.

Transportation Data (49 CFR 172.101, .102): Not listed

***MSDS Collection* References:** 73, 101, 103, 124, 126, 127, 132, 136, 159

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DATE: 05/26/92
CUST#: 916003
PO#: 1760753

MATERIAL SAFETY DATA SHEET PAGE 1

IDENTIFICATION

PRODUCT #: 22184-8 NAME: SODIUM MOLYBDATE(VI) DIHYDRATE, 99+%
CAS #:10102-40-6
MF: MONA2O4

SYNONYMS
DISODIUM MOLYBDATE DIHYDRATE * SODIUM MOLYBDATE DIHYDRATE *

TOXICITY HAZARDS

RTECS NO: JA5085000
MOLYBDIC ACID, DISODIUM SALT, DIHYDRATE
TOXICITY DATA
IPR-RAT LD50:520 MG/KG AIPTAK 154,243,65
IPR-MUS LD50:257 MG/KG AIPTAK 154,243,65
REVIEWS, STANDARDS, AND REGULATIONS
ACGIH TLV-TWA 10 MG(MO)/M3 85INA8 5,415,36
NSHA STANDARD-AIR:TWA 10 MG(MO)/M3 OTLVS* 3,173,71
OSHA PEL:8H TWA 15 MG(MO)/M3, TOTAL DUST FEREAC 54,2923,89
OSHA PEL:8H TWA 5 MG(MO)/M3, RESPIRABLE FRACTION FEREAC 54,2923,89
OSHA PEL FINAL:8H TWA 10 MG(MO)/M3, TOTAL DUST FEREAC 54,2923,89
OSHA PEL FINAL:8H TWA 5 MG(MO)/M3, RESPIRABLE FRACTION FEREAC 54,2923, 89
NOES 1983: NZD X1599; NIS 2; TNF 78; NOS 3; TNE 1490; TFE 1059
TARGET ORGAN DATA
BEHAVIORAL (SOMNOLENCE)
BEHAVIORAL (COMA)
MATERNAL EFFECTS (MENSTRUAL CYLCE CHANGES OR DISORDERS)
EFFECTS ON EMBRYO OR FETUS (FETOTOXICITY)

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION.

HEALTH HAZARD DATA

CUTE EFFECTS
MAY BE HARMFUL BY INHALATION, INGESTION, OR SKIN ABSORPTION.
CAUSES EYE IRRITATION.
CAUSES SKIN IRRITATION.
MATERIAL IS IRRITATING TO MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT.
TO THE BEST OF OUR KNOWLEDGE, THE CHEMICAL, PHYSICAL, AND TOXICOLOGICAL PROPERTIES HAVE NOT BEEN THOROUGHLY INVESTIGATED.
IRST AID
IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES.

CONTINUED ON NEXT PAGE

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CUST#: 916003
PO#: 1760753

PRODUCT #: 22184-8 NAME: SODIUM MOLYBDATE(VI) DIHYDRATE, 99+%
CAS #:10102-40-6
MF: MONA2O4

---------- HEALTH HAZARD DATA ----------

IN CASE OF CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND COPIOUS AMOUNTS OF WATER.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS. CALL A PHYSICIAN.

---------- PHYSICAL DATA ----------

SPECIFIC GRAVITY: 3.280
APPEARANCE AND ODOR
WHITE CRYSTALS

---------- FIRE AND EXPLOSION HAZARD DATA ----------

EXTINGUISHING MEDIA
NONCOMBUSTIBLE.
USE EXTINGUISHING MEDIA APPROPRIATE TO SURROUNDING FIRE CONDITIONS.
SPECIAL FIREFIGHTING PROCEDURES
WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.

---------- REACTIVITY DATA ----------

INCOMPATIBILITIES
STRONG OXIDIZING AGENTS
HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
NATURE OF DECOMPOSITION PRODUCTS NOT KNOWN.

---------- SPILL OR LEAK PROCEDURES ----------

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
SWEEP UP, PLACE IN A BAG AND HOLD FOR WASTE DISPOSAL.
AVOID RAISING DUST.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.
WASTE DISPOSAL METHOD
CAUTIOUSLY ACIDIFY A 3% SOLUTION OR A SUSPENSION OF THE MATERIAL TO

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CUST#: 916003
PO#: 1760753

PRODUCT #: 22184-3 NAME: SODIUM MOLYBDATE(VI) DIHYDRATE, 99+%
CAS #:10102-40-6
MF: MONA2O4

---------- SPILL OR LEAK PROCEDURES ----------

PH 2 WITH SULFURIC ACID. GRADUALLY ADD A 50% EXCESS OF AQUEOUS SODIUM BISULFITE WITH STIRRING AT ROOM TEMPERATURE. AN INCREASE IN TEMPERATURE INDICATES THAT A REACTION IS TAKING PLACE. IF NO REACTION IS OBSERVED ON THE ADDITION OF ABOUT 10% OF THE SODIUM BISULFITE SOLUTION INITIATE IT BY CAUTIOUSLY ADDING MORE ACID. IF MANGANESE, CHROMIUM, OR MOLYBDENUM ARE PRESENT ADJUST THE PH OF THE SOLUTION TO 7 AND TREAT WITH SULFIDE TO PRECIPITATE FOR BURIAL AS HAZARDOUS WASTE. DESTROY EXCESS SULFIDE, NEUTRALIZE AND FLUSH THE SOLUTION DOWN THE DRAIN.

--- PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE ---

CHEMICAL SAFETY GOGGLES.
USE PROTECTIVE CLOTHING, GLOVES AND MASK.
SAFETY SHOWER AND EYE BATH.
MECHANICAL EXHAUST REQUIRED.
DO NOT BREATHE DUST.
DO NOT GET IN EYES, ON SKIN, ON CLOTHING.
WASH THOROUGHLY AFTER HANDLING.
IRRITANT.
HARMFUL SOLID.
KEEP TIGHTLY CLOSED.
STORE IN A COOL DRY PLACE.

LABEL PRECAUTIONARY STATEMENTS

HARMFUL
HARMFUL BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
IRRITATING TO EYES, RESPIRATORY SYSTEM AND SKIN.
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
WEAR SUITABLE PROTECTIVE CLOTHING.

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DATE: 05/29/9
CUST#: 916003
PO#: 1760753

M A T E R I A L S A F E T Y D A T A S H E E T PAGE 1

IDENTIFICATION

PRODUCT #: 21448-5 NAME: SODIUM SELENITE, 99%
CAS #:10102-18-8
MF: NA2O3SE

SYNONYMS
DISODIUM SELENITE * NATRIUMSELENIT (GERMAN) * SODIUM SELENITE *
SODIUM SELENITE (DOT) * UN 2630 (DOT) *

TOXICITY HAZARDS

RTECS NO: VS7350000
SELENIOUS ACID, DISODIUM SALT
TOXICITY DATA

ORL-RAT LD50:7 MG/KG	TXAPA9 20,89,71
IVN-RAT LD50:3 MG/KG	EQSSDX 1,1,75
PAR-RAT LD50:6570 UG/KG	CTOXAD 17,171,80
ORL-MUS LD50:7 MG/KG	HYSAAV 35(1-3),176,70
SCU-MUS LD50:13 MG/KG	SAIGBL 17,491,75
IVN-MUS LD50:5 MG/KG	NRTXDN 2,383,81
ICV-MUS LD50:300 UG/KG	NRTXDN 2,383,81
IVN-DOG LD50:1916 UG/KG	PSDAA2 36,173,57
ORL-RBT LD50:2250 UG/KG	HYSAAV 35(1-3),176,70
IMS-RBT LD50:2530 UG/KG	AXVMAW 30,627,76
ORL-GPG LD50:5060 UG/KG	HYSAAV 35(1-3),176,70
ORL-HDR LD50:13 MG/KG	AJVRAH 41,1925,80
IMS-DOM LD50:1533 UG/KG	VHTODE 29,233,87

REVIEWS, STANDARDS, AND REGULATIONS
ACGIH TLV-TWA 0.2 MG(SE)/M3 85INA8 5,517,86
IARC CANCER REVIEW:ANIMAL INADEQUATE EVIDENCE IMEMDT 9,245,75
IARC CANCER REVIEW:GROUP 3 IMSUDL 7,56,87
MSHA STANDARD-AIR:TWA 0.2 MG(SE)/M3 OTLVS* 3,224,71
OSHA PEL:8H TWA 0.2 MG(SE)/M3 FEREAC 54,2923,89
OSHA PEL FINAL:8H TWA 0.2 MG(SE)/M3 FEREAC 54,2923,89
NOHS 1974: HZD 94379; NIS 5; TNF 480; NOS 5; TNE 1198
NOES 1983: HZD 34379; NIS 7; TNF 741; NOS 19; TNE 10544; TFE 3736
EPA GENETOX PROGRAM 1988, POSITIVE: HISTIDINE REVERSION-AMES TEST
EPA GENETOX PROGRAM 1988, POSITIVE/DOSE RESPONSE: IN VITRO SCE-HUMAN LYMPHOCYTES
EPA GENETOX PROGRAM 1988, POSITIVE/DOSE RESPONSE: IN VITRO SCE-HUMAN
EPA GENETOX PROGRAM 1988, POSITIVE/DOSE RESPONSE: IN VITRO UDS-HUMAN FIBROBLAST
EPA TSCA CHEMICAL INVENTORY, JUNE 1990
EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, MARCH 1992
NTP CARCINOGENESIS STUDIES;TEST COMPLETED (PEER REVIEW), JANUARY 1992
TARGET ORGAN DATA
BRAIN AND COVERINGS (RECORDINGS FROM SPECIFIC AREAS OF CNS)

CONTINUED ON NEXT PAGE

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CUST#: 916003
PO#: 1760753

PRODUCT #: 21448-5 NAME: SODIUM SELENITE, 99%
CAS #: 10102-18-8
MF: NA2O3SE

---------- TOXICITY HAZARDS ----------

PERIPHERAL NERVE AND SENSATION (FLACCID PARALYSIS WITHOUT ANESTHESIA)
SENSE ORGANS AND SPECIAL SENSES (OTHER OLFACTION EFFECTS)
BEHAVIORAL (SOMNOLENCE)
BEHAVIORAL (CONVULSIONS OR EFFECT ON SEIZURE THRESHOLD)
BEHAVIORAL (CHANGE IN MOTOR ACTIVITY)
BEHAVIORAL (MUSCLE CONTRACTION OR SPASTICITY)
CARDIAC (ARRYTHMIAS)
CARDIAC (PULSE RATE INCREASED WITHOUT FALL IN BP)
CARDIAC (OTHER CHANGES)
LUNGS, THORAX OR RESPIRATION (ACUTE PULMONARY EDEMA)
LUNGS, THORAX OR RESPIRATION (DYSPNAE)
LUNGS, THORAX OR RESPIRATION (CYANOSIS)
LUNGS, THORAX OR RESPIRATION (RESPIRATORY STIMULATION)
LUNGS, THORAX OR RESPIRATION (OTHER CHANGES)
GASTROINTESTINAL (HYPERMOTILITY, DIARRHEA)
ENDOCRINE (HYPOGLYCEMIA)
MATERNAL EFFECTS (UTERUS, CERVIX, VAGINA)
EFFECTS ON FERTILITY (POST-IMPLANTATION MORTALITY)
EFFECTS ON FERTILITY (LITTER SIZE)
EFFECTS ON EMBRYO OR FETUS (EXTRA EMBRYONIC STRUCTURES)
EFFECTS ON EMBRYO OR FETUS (FETOTOXICITY)
EFFECTS ON NEWBORN (LIVE BIRTH INDEX)
EFFECTS ON NEWBORN (VIABILITY INDEX)
EFFECTS ON NEWBORN (WEANING OR LACTATION INDEX)
EFFECTS ON NEWBORN (GROWTH STATISTICS)
NUTRITIONAL AND GROSS METABOLIC (WEIGHT LOSS OR DECREASED WEIGHT GAIN)

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION

---------- HEALTH HAZARD DATA ----------

ACUTE EFFECTS
MAY BE FATAL IF INHALED, SWALLOWED, OR ABSORBED THROUGH SKIN.
CAUSES EYE AND SKIN IRRITATION.
MATERIAL IS IRRITATING TO MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT.
EXPOSURE CAN CAUSE:
NAUSEA, DIZZINESS AND HEADACHE
CHRONIC EFFECTS
LABORATORY EXPERIMENTS HAVE SHOWN MUTAGENIC EFFECTS.

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CUST#: 916003
PO#: 1760753

PRODUCT #: 21448-5 NAME: SODIUM SELENITE, 99%
CAS #:10102-18-3
MF: NA2O3SE

---------- HEALTH HAZARD DATA ----------

TARGET ORGAN(S):
LIVER

FIRST AID
IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES OR SKIN WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED CLOTHING AND SHOES.
ASSURE ADEQUATE FLUSHING OF THE EYES BY SEPARATING THE EYELIDS WITH FINGERS.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS. CALL A PHYSICIAN IMMEDIATELY.
WASH CONTAMINATED CLOTHING BEFORE REUSE.

---------- PHYSICAL DATA ----------

APPEARANCE AND ODOR
WHITE POWDER

---------- FIRE AND EXPLOSION HAZARD DATA ----------

EXTINGUISHING MEDIA
NONCOMBUSTIBLE.
USE EXTINGUISHING MEDIA APPROPRIATE TO SURROUNDING FIRE CONDITIONS.

SPECIAL FIREFIGHTING PROCEDURES
WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.

UNUSUAL FIRE AND EXPLOSIONS HAZARDS
EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

---------- REACTIVITY DATA ----------

INCOMPATIBILITIES
STRONG ACIDS
PROTECT FROM MOISTURE.

HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
SELENIUM/SELENIUM OXIDES

---------- SPILL OR LEAK PROCEDURES ----------

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
EVACUATE AREA.

CONTINUED ON NEXT PAGE

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CUST#: 916003
PO#: 1760753

PRODUCT #: 21448-5 NAME: SODIUM SELENITE, 99%
CAS #:10102-18-8
MF: NA2O3SE

---------- SPILL OR LEAK PROCEDURES ----------

WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
SWEEP UP, PLACE IN A BAG AND HOLD FOR WASTE DISPOSAL.
AVOID RAISING DUST.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

WASTE DISPOSAL METHOD
BURY IN A LANDFILL SITE APPROVED FOR THE DISPOSAL OF CHEMICAL AND HAZARDOUS WASTES.

--- PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE ---

WEAR APPROPRIATE NIOSH/MSHA-APPROVED RESPIRATOR, CHEMICAL-RESISTANT GLOVES, SAFETY GOGGLES, OTHER PROTECTIVE CLOTHING.
SAFETY SHOWER AND EYE BATH.
USE ONLY IN A CHEMICAL FUME HOOD.
DO NOT BREATHE DUST.
DO NOT GET IN EYES, ON SKIN, ON CLOTHING.
AVOID PROLONGED OR REPEATED EXPOSURE.
WASH THOROUGHLY AFTER HANDLING.
HIGHLY TOXIC.
IRRITANT.
POSSIBLE MUTAGEN.
KEEP TIGHTLY CLOSED.
MOISTURE SENSITIVE
STORE IN A COOL DRY PLACE.

LABEL PRECAUTIONARY STATEMENTS
HIGHLY TOXIC (USA DEFINITION)
VERY TOXIC (EUROPEAN DEFINITION)
VERY TOXIC BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
IRRITATING TO EYES, RESPIRATORY SYSTEM AND SKIN.
POSSIBLE RISK OF IRREVERSIBLE EFFECTS.
POSSIBLE CARCINOGEN.
POSSIBLE MUTAGEN.
IF YOU FEEL UNWELL, SEEK MEDICAL ADVICE (SHOW THE LABEL WHERE POSSIBLE).
WEAR SUITABLE PROTECTIVE CLOTHING, GLOVES AND EYE/FACE PROTECTION.
DO NOT BREATHE DUST.

REGULATORY INFORMATION
THIS PRODUCT IS SUBJECT TO SARA SECTION 313 REPORTING REQUIREMENTS.

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MATERIAL SAFETY DATA SHEET

CUST#: 916003
PO#: 1760753

PRODUCT #: 21448-5 NAME: SODIUM SELENITE, 99%
CAS #: 10102-18-8
MF: NA2O3SE

THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. ALDRICH SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT. SEE REVERSE SIDE OF INVOICE OR PACKING SLIP FOR ADDITIONAL TERMS AND CONDITIONS OF SALE.

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Material Safety Data Sheets Collection:

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Sheet No. 294
Sodium Sulfide

Issued: 4/90

Section 1. Material Identification

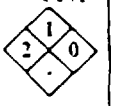
31

Sodium Sulfide Description: Best prepared from the elements in liquid ammonia. Also obtained by dehydrating sodium sulfide nonahydrate. Used in manufacturing rubber and sulfur dyes; in metal refining, cotton printing, dehairing hides, wool pulling, engraving, ore flotation, paper-pulping process, and desulfurizing viscose rayon; as a photographic reagent, a chemical intermediate, and a laboratory reagent.

Other Designations: CAS No. 1313-82-2; Na_2S; sodium monosulfide; sodium sulfuret; sodium sulphide.

Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*™ for a suppliers list.

NFPA
R 3
I -
S 3
K -



HMIS
H 2
F 0
R 0
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Sodium sulfide, ca 100%

OSHA PEL	ACGIH TLV, 1989-90	NIOSH REL, 1987	Toxicity Data*
None established	None established	None established	None listed

*Monitor NIOSH, *RTECS* (WE1905000), for future toxicity data.

Section 3. Physical Data

Melting Point: 2156 °F/1180 °C
Molecular Weight: 78.04 g/mol
Specific Gravity (H_2O = 1 at 39 °F/4 °C): 1.856 at 57 °F/14 °C
Water Solubility: Soluble

Appearance and Odor: Yellow-pink or white, deliquescent crystals.

Section 4. Fire and Explosion Data

Flash Point: None reported **Autoignition Temperature:** None reported **LEL:** None reported **UEL:** None reported

Extinguishing Media: Use dry chemical, CO_2, Halon, water spray, or standard foam to fight fires involving sodium sulfide.

Unusual Fire or Explosion Hazards: Sodium sulfide is a moderately flammable solid when exposed to heat or flame. It can explode with rapid heating or percussion. When it contacts acids, this material yields flammable hydrogen sulfide. When burned, it yields sulfur dioxide. Finely divided sodium sulfide forms explosive mixtures in air.

Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Although stable at room temperature in closed containers under normal storage and handling conditions, sodium sulfide is unstable and can explode with rapid heating or percussion. This material is extremely hygroscopic (absorbs moisture from the air) and discolors upon exposure to the air. Hazardous polymerization cannot occur.

Chemical Incompatibilities: This material reacts violently with water, carbon, diazonium salts, *o*-nitroaniline diazonium salt, n,n-dichloromethylamine, acids, and oxidizing materials.

Conditions to Avoid: Avoid contact with heat or any ignition source.

Hazardous Products of Decomposition: Thermal oxidative decomposition of sodium sulfide can produce toxic fumes of sulfur oxides (SO_x) and sodium oxide (Na_2O).

Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists sodium sulfide as a carcinogen.
Summary of Risks: Sodium sulfide is a strong irritant to skin and tissue. It yields toxic sulfur dioxide when burning and toxic hydrogen sulfide on contact with acids. High concentrations (500 to 1000 ppm) of hydrogen sulfide (*MSDS Collection*, No. 52) can cause systemic poisoning symptomized by respiratory paralysis and unconsciousness, followed by death. Sulfur dioxide (*MSDS Collection*, No. 50) affects the respiratory tract, causing bronchial irritation, difficulty in breathing, pulmonary edema, and at high levels, possible respiratory paralysis. Short-term exposures above 400 to 500 ppm are immediately life threatening.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Skin, eyes, respiratory tract.
Primary Entry Routes: Inhalation, skin or tissue contact.
Acute Effects: Direct contact with sodium sulfide irritates the skin and other tissue. Eye contact may cause painful conjunctivitis, colored halo effects on vision, and lid spasm.
Chronic Effects: None reported.
FIRST AID
Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
Skin: Remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have a *conscious* person drink 1 to 2 glasses of water, then induce repeated vomiting until vomit is clear.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Eye exposure may result in fundoscopic and retinal changes that usually resolve within 72 hr. All eye exposures should have baseline and follow-up fundoscopic evaluation. If exposure is significant, nitrate-induced methemoglobinemia has been advocated as treatment on the basis that methemoglobin bind the toxic hydrosulfide anion, forming sulfmethemoglobin. Inhaling amyl nitrate or intravenous sodium nitrite is recommended. Do not use thiosulfate.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel and immediately remove all heat and ignition sources. Cleanup crew should protect against vapor inhalation and direct skin or eye contact. Do not handle with bare hands! Using nonsparking tools, scoop spilled material into appropriate disposal containers. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
CERCLA Hazardous Substance (40 CFR 302.4): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed
OSHA Designations
Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.
Warning: Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres.
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact.
Ventilation: Provide general and local explosion-proof ventilation systems to control airborne concentrations. Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, dry area away from all possible ignition sources and incompatibilities (Sec. 5), especially liquid acids. Protect containers against physical damage. Store in glass bottles, cans, and steel drums.
Engineering Controls: Avoid direct contact with skin and tissue. Do not handle with bare hands! Practice good personal hygiene. Do not expose sodium sulfide to any heat or ignition sources. Do not allow sodium sulfide to contact acids since their reaction evolves toxic hydrogen sulfide.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Sodium sulfide, anhydrous, *or* Sodium sulfide with less than 30% water of crystallization
DOT Hazard Class: Flammable solid
ID No.: UN1385
DOT Label: Flammable solid
DOT Packaging Requirements: 173.207
DOT Packaging Exceptions: 173.153

IMO Shipping Name: Sodium sulphide, anhydrous, *or* Sodium sulphide with less than 30% water of crystallization
IMO Hazard Class: 4.2
IMO Label: Spontaneously combustible
IMDG Packaging Group: II
ID No.: UN1385

MSDS Collection **References:** 7, 73, 84, 85, 103, 123, 124, 126, 127, 136
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD

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DATE: 05/29/
CUST#: 916003
PO#: 1760753

MATERIAL SAFETY DATA SHEET PAGE 1

IDENTIFICATION

PRODUCT #: 20303-6 NAME: ZINC CHLORIDE, 98+%
CAS #: 7646-85-7
MF: CL2ZN

SYNONYMS
BUTTER OF ZINC * CHLORURE DE ZINC (FRENCH) * TINNING FLUX (DOT) * UN 1840 (DOT) * UN 2331 (DOT) * ZINC BUTTER * ZINC CHLORIDE (ACGIH,OSHA) * ZINC CHLORIDE, ANHYDROUS (DOT) * ZINC CHLORIDE, SOLUTION (DOT) * ZINC (CHLORURE DE) (FRENCH) * ZINC DICHLORIDE * ZINC MURIATE, SOLUTION (DOT) * ZINCO (CLORURO DI) (ITALIAN) * ZINKCHLORID (GERMAN) * ZINKCHLORIDE (DUTCH) *

TOXICITY HAZARDS

RTECS NO: ZH1400000
ZINC CHLORIDE
TOXICITY DATA
ORL-RAT LD50:350 MG/KG FOREAF 7,313,42
IPR-RAT LD50:53 MG/KG VHTODE 30,224,88
ORL-MUS LD50:350 MG/KG FOREAF 7,313,42
IPR-MUS LD50:24 MG/KG TXAPA9 63,461,82
SCU-MUS LD50:330 MG/KG OYYAA2 8,1067,74
ORL-GPG LD50:200 MG/KG FOREAF 7,313,42
REVIEWS, STANDARDS, AND REGULATIONS
ACGIH TLV-TWA 1 MG/M3; STEL 2 MG/M3 (VAPOR) 35INA8 5,643,86
EPA FIFRA 1988 PESTICIDE SUBJECT TO REGISTRATION OR RE-REGISTRATION FEREAC 54,4388,89
MSHA STANDARD-AIR:TWA 1 MG/M3 (FUME) OTLVS* 3,283,71
OSHA PEL:8H TWA 1 MG/M3, FUME FEREAC 54,2923,89
OSHA PEL FINAL:8H TWA 1 MG/M3;STEL 2 MG/M3, FUME FEREAC 54,2923,89
NOHS 1974: HZD 77150; NIS 192; TNF 20416; NOS 84; TNE 185570
NOES 1983: HZD 77150; NIS 172; TNF 22612; NOS 115; TNE 353004; TFE 87750
EPA GENETOX PROGRAM 1988, POSITIVE: CELL TRANSFORM.-SA7/SHE; HOST-MEDIATED ASSAY
EPA GENETOX PROGRAM 1988, POSITIVE: HISTIDINE REVERSION-AMES TEST
EPA GENETOX PROGRAM 1988, NEGATIVE: IN VITRO CYTOGENETICS-HUMAN LYMPHOCYTE
EPA GENETOX PROGRAM 1988, NEGATIVE: B SUBTILIS REC ASSAY; SPERM MORPHOLOGY-MOUSE
EPA TSCA CHEMICAL INVENTORY, JUNE 1990
EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, MARCH 1992
OSHA ANALYTICAL METHOD #ID-125G
TARGET ORGAN DATA
SENSE ORGANS AND SPECIAL SENSES (MIOSIS)

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MATERIAL SAFETY DATA SHEET

CUST#: 916003
PO#: 1760753

PRODUCT #: 20308-6 NAME: ZINC CHLORIDE, 98+%
CAS #: 7646-85-7
MF: CL2ZN

TOXICITY HAZARDS

VASCULAR (BP ELEVATION NOT CHARACTERIZED IN AUTONOMIC SECTION)
GASTROINTESTINAL (COLON TUMORS)
ENDOCRINE (CHANGE IN LH)
ENDOCRINE (CHANGE IN GONADOTROPINS)
PATERNAL EFFECTS (OTHER EFFECTS ON MALE)
EFFECTS ON FERTILITY (FEMALE FERTILITY INDEX)
EFFECTS ON FERTILITY (POST-IMPLANTATION MORTALITY)
SPECIFIC DEVELOPMENTAL ABNORMALITIES (MUSCULOSKELETAL SYSTEM)
TUMORIGENIC EFFECTS (TESTICULAR TUMORS)
NUTRITIONAL AND GROSS METABOLIC (WEIGHT LOSS OR DECREASED WEIGHT GAIN)
TUMORIGENIC (EQUIVOCAL TUMORIGENIC AGENT BY RTECS CRITERIA)

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION.

HEALTH HAZARD DATA

ACUTE EFFECTS
HARMFUL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN.
MATERIAL IS EXTREMELY DESTRUCTIVE TO TISSUE OF THE MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT, EYES AND SKIN.
INHALATION MAY BE FATAL AS A RESULT OF SPASM, INFLAMMATION AND EDEMA OF THE LARYNX AND BRONCHI, CHEMICAL PNEUMONITIS AND PULMONARY EDEMA.
SYMPTOMS OF EXPOSURE MAY INCLUDE BURNING SENSATION, COUGHING, WHEEZING, LARYNGITIS, SHORTNESS OF BREATH, HEADACHE, NAUSEA AND VOMITING.

CHRONIC EFFECTS
LABORATORY EXPERIMENTS HAVE SHOWN MUTAGENIC EFFECTS.
TO THE BEST OF OUR KNOWLEDGE, THE CHEMICAL, PHYSICAL, AND TOXICOLOGICAL PROPERTIES HAVE NOT BEEN THOROUGHLY INVESTIGATED.

FIRST AID
IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES OR SKIN WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED CLOTHING AND SHOES.
ASSURE ADEQUATE FLUSHING OF THE EYES BY SEPARATING THE EYELIDS WITH FINGERS.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS. CALL A PHYSICIAN.
WASH CONTAMINATED CLOTHING BEFORE REUSE.

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PRODUCT #: 20808-6 NAME: ZINC CHLORIDE, 98+%
CAS #: 7646-85-7
MF: CL2ZN

---------- HEALTH HAZARD DATA ----------

DISCARD CONTAMINATED SHOES.

ADDITIONAL INFORMATION
ZINC CHLORIDE AND ITS AQUEOUS SOLUTIONS ARE CORROSIVE TO THE EYES AND SKIN. THEY CAUSE CONJUNCTIVITIS AND CORNEAL BURNS IN THE EYE AND PRODUCE CHEMICAL BURNS, PARTICULARLY ON AREAS WHERE THE SKIN IS BROKEN. INGESTION PRODUCES A CORROSIVE ACTION TO THE MOUTH, THROAT AND DIGESTIVE TRACT WHICH CAN INCLUDE SYMPTOMS OF STOMACH PAIN, NAUSEA, VOMITING, BLOODY DIARRHEA, SWELLING OF THE THROAT, BLOOD IN THE URINE AND SHOCK. INHALATION IRRITATES THE NOSE AND THROAT PRODUCING COUGH, CHEST PAIN, BLUISH SKIN, FEVER, NAUSEA AND VOMITING, SHORTNESS OF BREATH, DIFFICULTY IN BREATHING (ONSET MAY BE DELAYED BY SEVERAL HOURS) AND PNEUMONIA. FATALITIES HAVE OCCURRED BY INHALATION AND INGESTION.

---------- PHYSICAL DATA ----------

MELTING PT: 293 C
SPECIFIC GRAVITY: 2.910
VAPOR PRESSURE: 1 MM @ 428 C

APPEARANCE AND ODOR
WHITE OR OFF-WHITE POWDER

---------- FIRE AND EXPLOSION HAZARD DATA ----------

EXTINGUISHING MEDIA
NONCOMBUSTIBLE.
USE EXTINGUISHING MEDIA APPROPRIATE TO SURROUNDING FIRE CONDITIONS.

SPECIAL FIREFIGHTING PROCEDURES
WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.

UNUSUAL FIRE AND EXPLOSIONS HAZARDS
EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

---------- REACTIVITY DATA ----------

INCOMPATIBILITIES
STRONG OXIDIZING AGENTS
PROTECT FROM MOISTURE.

HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
HYDROGEN CHLORIDE GAS
METAL OXIDES

---------- SPILL OR LEAK PROCEDURES ----------

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
EVACUATE AREA.

CONTINUED ON NEXT PAGE

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MATERIAL SAFETY DATA SHEET

CUST#: 916003
PO#: 1760753

PRODUCT #: 20308-6 NAME: ZINC CHLORIDE, 98+%
CAS #: 7646-85-7
MF: CL2ZN

SPILL OR LEAK PROCEDURES

WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
COVER WITH DRY LIME OR SODA ASH, PICK UP, KEEP IN A CLOSED CONTAINER AND HOLD FOR WASTE DISPOSAL.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

WASTE DISPOSAL METHOD
THE MATERIAL SHOULD BE DISSOLVED IN 1) WATER; 2) ACID SOLUTION OR 3) OXIDIZED TO A WATER-SOLUBLE STATE. PRECIPITATE THE MATERIAL AS THE SULFIDE, ADJUSTING THE PH OF THE SOLUTION TO 7 TO COMPLETE PRECIPITATION. FILTER THE INSOLUBLES AND DISPOSE OF THEM IN A HAZARDOUS-WASTE SITE. DESTROY ANY EXCESS SULFIDE WITH SODIUM HYPOCHLORITE. NEUTRALIZE THE SOLUTION BEFORE FLUSHING DOWN THE DRAIN.

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE

WEAR APPROPRIATE NIOSH/MSHA-APPROVED RESPIRATOR, CHEMICAL-RESISTANT GLOVES, SAFETY GOGGLES, OTHER PROTECTIVE CLOTHING.
SAFETY SHOWER AND EYE BATH.
USE ONLY IN A CHEMICAL FUME HOOD.
FACESHIELD (8-INCH MINIMUM).
DO NOT BREATHE DUST.
DO NOT GET IN EYES, ON SKIN, ON CLOTHING.
AVOID PROLONGED OR REPEATED EXPOSURE.
WASH THOROUGHLY AFTER HANDLING.
CORROSIVE.
TOXIC.
POSSIBLE MUTAGEN.
KEEP TIGHTLY CLOSED.
HYGROSCOPIC
STORE IN A COOL DRY PLACE.

LABEL PRECAUTIONARY STATEMENTS
CORROSIVE
CAUSES BURNS.
TOXIC BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
POSSIBLE RISK OF IRREVERSIBLE EFFECTS.
POSSIBLE MUTAGEN.
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
TAKE OFF IMMEDIATELY ALL CONTAMINATED CLOTHING.
IF YOU FEEL UNWELL, SEEK MEDICAL ADVICE (SHOW THE LABEL WHERE POSSIBLE).

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PRODUCT #: 20808-6 NAME: ZINC CHLORIDE, 98+%
CAS #: 7646-85-7
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--- PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE ---

KEEP CONTAINER TIGHTLY CLOSED IN A COOL WELL VENTILATED PLACE.

REGULATORY INFORMATION

THIS PRODUCT IS SUBJECT TO SARA SECTION 313 REPORTING REQUIREMENTS.

THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. ALDRICH SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT. SEE REVERSE SIDE OF INVOICE OR PACKING SLIP FOR ADDITIONAL TERMS AND CONDITIONS OF SALE.

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