RETEC

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REMOVAL ACTION CONSTRUCTION SPECIFICATIONS FOR

RELIEF & GAS HOLDER REMEDIATION

UGI COLUMBIA GAS PLANT SITE
Columbia, Pennsylvania

Prepared for:

PENNSYLVANIA POWER AND LIGHT COMPANY
Two North Ninth Street
Allentown, Pennsylvania 18101-1179

Prepared by:

REMEDIATION TECHNOLOGIES, INC.
9 Pond Lane
Concord, Massachusetts 01742

Project # 3-1612-200

SEPTEMBER 1995

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DIVISION 1

GENERAL REQUIREMENTS OF CONTRACT

1A.01 CONTRACT AND CONTRACT DOCUMENTS

The Instructions to Bidders for Construction Labor, the Specifications and Amendments thereto, the Addenda, the General Conditions of Contract for Construction, and the Purchase Order for the Work shall form part of this Contract and the provisions thereof shall be as binding upon the parties as if they were fully set forth herein. The Table of Contents, titles, headings, running headlines and marginal notes contained herein and in said Documents, are solely to facilitate various provisions of the Contract Documents and in no way affect, limit or cast light upon the interpretations of the provisions to which they refer. Whenever the term "Contract Documents" is used, it shall mean and include the Instructions to Bidders for Construction Labor, the Specifications and Amendments thereto, the Addenda, the General Conditions of Contract for Construction, and the Insurance Certificates.

1A.02 DEFINITIONS

The following definitions will apply to the participants in this project:

Owner	-	P P & L
Supervising Contractor	-	Clean Sites
Engineer	-	RETEC
Contractor	-	Selected Construction Company
Regulatory Agencies:		
Lead	-	PADEP
Support	-	USEPA

1A.03 LOCATIONS AND SCOPE OF WORK

A. The work under this contract is located on property owned by Pennsylvania Power and Light (PP&L) known as the former UGI Manufactured Gas Plant (MGP) Site. The MGP Site is a 1.6-acre parcel located near the Susquehanna River, in Columbia, Pennsylvania. The site is bounded by a railroad right-of-way to the east and Front Street to the west.

B. The project consists of installing an enhanced recovery system to recover subsurface coal tars and remove water within two underground tanks. The system will require earthwork, concrete work, tank farm installation, well installation, water treatment system installation, piping and pump installation and electrical hook-up.

C. This project for which these Contract Documents pertain includes, but may not be limited to, the following:

1. The construction of a subgrade for a concrete tank containment area.

2. The construction of a 22-foot by 49-foot, 12-inch thick bermed concrete tank containment area.

3. The installation and construction of production and injection wells.

4. The installation of a tank farm including one 10,027 gallon tank, one 6,017 gallon tank, one 5,000 gallon tank and one 1,000 gallon tank.

5. The installation of a steam boiler.

6. The installation of two 1,800 pound granular activated carbon units, and one 1,000 gallon water tank, for water treatment.

7. The installation of insulated and heat traced piping and pumps.

8. The installation of electrical conduit and electrical panel.

9. Installation of enclosures over the wellheads.

1A.04 STANDARD SPECIFICATIONS

A. The latest revision of the Pennsylvania Department of Transportation Standard Specifications for Construction and Materials and the latest approved revisions and special provisions are to govern all construction activities.

B. The Standard Specifications are hereby modified for purposes of this contract so that measurement for payment will be as specified herein.

1A.05 USE OF PREMISES, SPECIAL WORKING CONDITIONS

A. The Contractor shall confine his apparatus, storage of materials, supplies and equipment, temporary stockpiles and all other operations to the immediate work areas and not encroach on neighboring properties.

B. The Contractor is advised that materials encountered on the site may display hazardous characteristics. Therefore, health and safety shall be a priority.

1A.06 THE ENGINEER, HIS STATUS AND DECISIONS

A. The Engineer for this work is Remediation Technologies, Inc. (RETEC), 9 Pond Lane, Concord, Massachusetts 01742. The Engineer is an authorized representative of the Owner. The Engineer must be present during construction of all aspects of this project. The Engineer will not change any conditions of this Contract.

B. The Engineer is responsible for construction inspection, sampling, testing, review of shop drawings, and material and equipment which is intended for inclusion in the work as required for the determination of conformance with the Contract Documents.

C. The Engineer shall be authorized to inspect all work performed and materials furnished. Such inspection may extend to all or any part of the work and to the preparation or manufacture of materials to be used or facilities to be used in meeting the requirements of the Contract Documents.

D. The Engineer shall be authorized to sample and test materials, equipment and facilities as provided for in these specifications and as required for the determination of conformance with the Contract Documents. The results of such tests may provide a basis for acceptance or rejection of such materials, equipment and facilities and/or suspension of construction activities. The Contractor's attention is directed to Sections 1B.03 and 1B.04 of the Special Provisions of the Contract dealing with sampling, testing, health and safety and environmental protection. The Engineer shall be authorized to continually monitor air emissions in the vicinity of the work and the perimeter of each site, inspect health and safety procedures being implemented during construction, and to provide a determination of conformance with the requirements of the Contract Documents. The Engineer shall be authorized to require the Contractor to implement procedures for the control of air emissions and the assurance of health and safety measures for the protection of construction workers. The contractor shall provide a Health and Safety plan to the Engineer prior to the start of site activities. The Engineer's Site specific Health and Safety plan will be made available to the contractor upon request.

E. In the case of any dispute arising between the Contractor and the Engineer as to materials furnished or in the manner of performing the work, including safety requirements and health and safety procedures, the Engineer shall have the authority to reject material or suspend the work until the question at issue can be referred to and decided by the Owner. The Engineer is not empowered to revoke, alter, enlarge or relax any requirements of the Contract Documents or to issue instructions contrary to the plans and specifications. Any advice which the Engineer may give the Contractor shall in no way be construed as binding the Owner in any way, nor releasing the Contractor from fulfillment of the terms of the Contract.

1A.07 PLANS AND SPECIFICATIONS AT THE SITE

A. The Contractor shall maintain at the site of the work one copy of all drawings and specifications, addenda, change orders and other modifications, schedules and instructions, in good order and marked to record all changes made during construction. These shall be available at all times to the Owner and Engineer or their authorized representatives, and to U. S. EPA, PADEN and their authorized representatives.

B. At the conclusion of construction, the Contractor shall turn one corrected set over to the Engineer.

1A.08 DRAWINGS FURNISHED

Three copies of the plans and specifications will be provided to the Contractor by the Engineer. If additional copies are requested, the Contractor shall pay the cost of reproduction.

1A.09 CONSTRUCTION SURVEYS AND LAYOUT

A. The Owner has provided the initial baseline to establish all Contract Work Items shown on the drawings. All other survey and stake-out will be the responsibility of the Contractor. The Contractor shall be responsible for preserving all lines, baselines and benchmarks as established by the Owner and, in the case of destruction thereof by the Contractor or resulting from his negligence, the Contractor shall be responsible for all delays, all mistakes and all damages that may be caused by such loss or disturbance of the established lines, baselines and benchmarks. The total cost incurred for relocating survey due to actions of the Contractor shall be at his expense. This shall include all property line stakes and monuments of the Owner and others.

B. The Contractor shall perform all layout work necessary for the satisfactory prosecution of the work as shown on the Contract Drawings at no additional expense to the Owner.

1A.10 EXISTING UTILITIES AND STREETS

A. The Contractor shall be responsible for repairing or replacing all utilities, appurtenances and street pavement damaged during work on this project.

B. The Contractor shall comply with all precautionary measures proscribed by the Engineer and Owner regarding access and equipment weight restrictions.

C. The Contractor shall take all measures necessary to prevent tracking of mud and dirt roadways. Roadways shall be cleared as often as necessary.

1A.11 CONSTRUCTION EQUIPMENT

The Contractor shall furnish and maintain, at his own cost and risk, all tools, apparatus and appliances, hoists and/or cranes and power for same, and all other similar work or materials necessary to ensure speed, convenience and safety in the execution of this Contract. All such items shall comply with OSHA regulations and other applicable codes and statutes.

1A.12 TEMPORARY LIGHT, POWER AND WATER

A. All power for this project will be furnished and paid for by the Owner. The Contractor shall provide and pay for all lighting apparatus.

B. Emergency showers and other temporary water uses as called for in these specifications shall be furnished by the Contractor.

1A.13 TEMPORARY TOILET SERVICE

The Contractor shall provide for the use of all workmen, where directed, adequate temporary sanitary facilities, such as chemical toilets, temporary wash basins and water supply, including service and maintenance once per week, toilet tissue, soap and paper towels.

1A.14 SITE SIGN

The Contractor shall furnish a site sign that identifies the site and displays the Pennsylvania emergency response number (800-812-3782). The sign will have minimum dimensions of 3x2 feet and will be positioned in a highly visible location near the front of the site. The precise wording of the site sign will be determined before construction commences.

1A.15 QUALITY CONTROL, CODES AND SPECIFICATION

A. The Contractor and each subcontractor shall provide sufficient tools, equipment, skilled workmen and supervisory personnel who shall be thoroughly familiar with the type of construction involved and the materials and techniques specified.

B. All references to standard specifications, codes and other regulations made throughout the specifications refer to the latest editions in effect at the date of the proposal. Such references include current addenda and errata, if any, and shall be considered a part of these specifications as much as if the pertinent portion of those standard specifications were printed herein in their entirety.

1A.16 HOURS OF WORK

The hours of work for this Contract shall be as directed by the Owner.

1A.17 PERMITS AND LICENSES

A. The Contractor shall give all notices and comply with all laws, ordinances, rules and regulations relating to the performance of the work.

B. A NPDES permit will be obtained by the engineer for discharge of treated waters to the Susquehanna River. The contractor is responsible for identifying and obtaining all local permits.

1A.18 SEPARATE CONTRACTS

A. Contractors working in the same vicinity shall cooperate with one another and, in case of dispute, the decision by the Owner shall be complied with by all contractors involved.

B. The Contractor shall assume all liability, financial or otherwise, in connection with this contract and shall protect and save harmless the Owner from any and all damages or claims that may arise because of inconvenience or delay which he may cause other contractors. If the Contractor experiences a loss because of the presence and operations of other contractors working adjacent to or within the limits of the same project, then as between the Owner and the Contractor, the Contractor shall bear such loss.

C. Insofar as possible, the Contractor shall arrange his work and shall place and dispose of the materials being used so as not to interfere with the operations of other contractors adjacent to or within the limits of the same project. He shall join his work with that of the others.

1A.19 CLEANING UP

A. The Contractor will regularly and at all times keep the premises free from accumulations of waste material or rubbish caused by his employees or work, or the employees or work of any of his subcontractors.

B. At the completion of the work, the Contractor shall remove all rubbish caused from and about the site of work, and all temporary structures, tools, scaffolding, surplus materials, supplies and equipment which he or any of his subcontractors may have used in the performance of the work.

C. The Engineer will manage any contaminated materials that are encountered throughout construction, (i.e. soil cuttings). The Engineer will be responsible for coordinating the transportation and disposal of these materials, on behalf of the Owner.

D. The Contractor shall provide municipal trash service (roll-off box or dumpster).

1A.20 FIRE PROTECTION

A. Operations including the potential for fire hazards shall be conducted in a manner as to minimize the risk. Non-sparking tools and fire extinguishers shall be used as required. Sources of ignition shall be removed. When necessary, explosion proof instruments and/or bonding and grounding will be used to prevent fire or explosion.

B. Fire fighting equipment to be kept on the site during construction and operations shall include a dry chemical fire extinguisher. The Contractor is responsible for complying with local fire protection regulations.

1B.01 CONTRACT SCHEDULE

A. The contract schedule for this project shall be as follows. The schedule assumes no agency delays.

Item	Date
Contract Award	November 17, 1995
Field mobilization and start-up of field activities	November 27, 1995
Completion of construction	February 9, 1996

B. The date of beginning and the time for completion of the work are essential conditions of the Contract Documents and the work embraced shall be commenced on a date specified in the Notice to Proceed. If for unforeseeable reasons, delay in schedule occur, contractor will provide written notification to the Engineer explaining the reason(s) for the delay and a revised schedule. If the schedule extension is due to agency delays, an explanation will not be required.

The Contractor will proceed with the work at such rate of progress to insure full completion within the Contract Time. It is expressly understood and agreed, by and between the Contractor and the Owner, that the Contract Time for the completion of the work described herein is a reasonable time, taking into consideration the average climatic and economic conditions and other factors prevailing in the locality of the work. If the contractor or their subcontractors delay the project, a penalty of 1% of the total contract price will be imposed for each working day the project is delayed.

1B.02 INSPECTION AND TESTING

A. **General** - All materials and equipment used in the construction of the project shall be subject to adequate inspection and testing in accordance with generally accepted standards.

The Contractor shall provide, at his expense, the necessary testing and inspection services required by the Contract Documents, unless otherwise provided. The Engineer shall provide all other inspection and testing services not required by the Contract Documents.

If the Contract Documents, laws, ordinances, rules, regulations or orders of any public authority having jurisdiction require any work to be specifically inspected, tested, or approved by someone other than the Contractor, the Contractor shall give the Engineer timely notice of readiness. The Contractor shall then furnish the Engineer the required certificates of inspection, testing or approval.

Neither observations by the Engineer or inspections, tests or approvals by persons other than the Contractor shall relieve the Contractor from his obligations to perform the work in accordance with the requirements of the Contract Documents.

The Engineer, the Owner and their representatives shall at all times have access to the work. The Contractor shall provide proper facilities for such access and observation of the work and also for any inspection or testing thereof. PADEN and U.S. EPA shall have access to the work at all times.

If any work is covered contrary to the written request of the Engineer it must, if requested by the Engineer, be uncovered for his observation and replaced at the Contractor's expense.

B. Engineer's Responsibility

Air Emissions - Continuous air emissions monitoring shall be undertaken around the perimeter of the construction site during drilling and excavation activities. Monitoring shall be both qualitative for odor and semi-quantitative for volatile aromatics and other characteristics. A wind sock shall be installed to indicate wind direction and hourly downwind PID readings will be obtained during drilling activities. In the event of an emergency, continuous monitoring will be performed.

Monitoring results shall be evaluated by the Engineer and directives shall be issued to the Contractor for the control of air emissions, if required.

C. **Contractor's Responsibility**

The Contractor shall provide for the services of material testing laboratory for the sampling and testing of various components of the work.

Any testing laboratory(ies) proposed for this work shall be approved by the Engineer.

The Contractor shall pay all costs associated with his responsibility for inspection and testing. Test results shall be provided to the Engineer for approval. If tests do not meet the specifications, then the contractor must repair and retest at no additional charge.

1B.03 HEALTH AND SAFETY REQUIREMENTS

A. The Contractor shall be responsible for conducting the work in compliance with all OSHA regulations, including but not necessarily limited to OSHA Health and Safety Regulations for Hazardous Waste Work (CFR 1910.120).

B. The Contractor shall be prepared to provide level "C" protection under CFR 1910.120 for work conducted during any part of this contract. It is expected, however, that most work performed on site will require level "D" protection under CFR 1910.120. All personal protective equipment requirements are detailed in the Site Specific Health and Safety Plan.

C. The Contractor will be required to submit a Health and Safety Plan before work begins. The Engineer has written a Site Specific Health and Safety Plan which will be made available to the Contractor and must be reviewed by all parties before entering work zones.

1B.04 ODOR CONTROL

The Contractor shall minimize odor emissions by practical means, including but not limited to removing contaminated auger cuttings from the ground surface and enclosing them in drums and/or roll-off boxes throughout the drilling process. Air monitoring at the site perimeter is the Engineer's responsibility. Work zone air monitoring is the Engineer's responsibility.

Exposure of odorous material can be restricted or curtailed by the Health and Safety supervisor, especially when the wind is blowing towards the town. Real-time wind direction shall be determined by a wind sock to be installed by the Contractor in the work area.

1B.05 SCHEDULE OF PAYMENTS

A. Section 731.3 of the General Conditions of Contract is hereby modified to incorporate the provisions of this item.

B. The earned value system for the work shall incorporate methods of measurement and subsequent basis of payments provided for in these specifications. The earned value system shall be coordinated with the Contractor's proposed contract schedule as required to identify project milestones and associated deliverables.

C. Contractor's requests for payments shall be made on a monthly basis in a manner and form approved by the Supervising Contractor. All requests for payment shall be approved by the Engineer prior to submittal to the Supervising Contractor.

1B.06 SUBMITTALS

The Contractor shall submit the following items to the Engineer: survey notes, copies of permits, Health and Safety Plan, test results, and certifications of completeness.

1B.07 DISPOSAL OF MATERIALS

The following table shows materials that will require disposal, the proposed disposal method, and the party responsible for disposal.

Material	Party Responsible for Coordinating Disposal	Disposal Method
Drill Cuttings	RETEC	Roll-off box, transported to permitted landfill.
PPE, Impacted debris	RETEC	Roll-off box, transported to permitted landfill.
Extraneous Site Surface Soils	RETEC	Characterized as necessary and disposed of at an appropriate landfill.
General Refuse	Contractor	Roll-off box or dumpster, transported to municipal landfill.
Decon Water	RETEC	Drummed, pumped into product separation system
Tar/Inorg. sludges	RETEC	Pumped into vac truck, transported to a disposal facility (to be determined)

DIVISION 2
CIVIL CONSTRUCTION

2.0.1 GENERAL

The General Conditions and Special Provisions are made a part of this section.

2.0.2 DESCRIPTION

Provide all labor, materials and equipment required for the movement of personnel and equipment to and from the project site and for the establishment and removal of all field offices, buildings and other facilities necessary to the performance of the work.

2.0.3 METHOD OF MEASUREMENT

This work shall be measured for payment as follows: Fifty percent (50%) of the amount bid for "Mobilization and Demobilization" shall be certified for payment following mobilization; and upon completion of the work, the remainder of the amount bid shall be certified for payment.

2.0.4 BASIS OF PAYMENT

This work shall be paid for at the contract lump sum price for "Mobilization and Demobilization" which shall include the cost of furnishing all materials, equipment, tools, labor, transportation, operations and work incidental thereto required for completion of the work as per this specification.

2.1.1 GENERAL

A. The General Conditions and Special Provisions are made a part of this section.

2.1.2 DESCRIPTION

A. Provide all labor, materials, and equipment required to perform the work called for in this specification and in accordance with the Contract Drawings.

B. Install erosion control fencing along southern three fencelines of the site. The contractor shall provide for appropriate maintenance of the fence throughout operations (Approx. 1 year). The Contractor shall then remove and dispose of all fence materials.

C. Construct the subgrade for the concrete pad that will serve as the floor of the tank farm area.

D. Clear work areas of vegetative debris.

2.1.3 MATERIALS

A. The Contractor shall procure and deliver to the site sufficient length of Mirafi 100x Envirofence (or equivalent) erosion control fencing to prevent site soils from being carried offsite by precipitation events. This geotextile shall meet the specifications found in Schedule 2-1.

Schedule 2-1
Geotextile Specifications

Property	Unit	Test Method	Mirafi 100x
Weight	Oz/SY	ASTM D-3776-85	3.0
Grab Strength	lbs	ASTM D-4632-86	120
Grab Elongation	%	ASTM D-4632-86	30 (max)
Modulus (10% elongation)	lbs	ASTM D-1682-64	-
Trapezoid Tear Strength	lbs	ASTM D-4533-85	65
Mullen Burst Strength	psi	ASTM D-3786-80	280
Puncture Strength	lbs	ASTM D-3787-80	-
Thickness	mils	ASTM D-1777-64	17
Abrasion Resistance	lbs	ASTM D-3884-80 D-	-
Coef of Permeability, k	cm/sec	ASTM D-4491-89	001
Water Flow Rate	gal/min/SF	ASTM D-4491-89	40
Opening Size (EOS)	U.S. Std. Sieve	COE CW02215-77	20-35
Efficiency	%	VTM-51	75
Slurry Flow Rate	g /min/SF	VADOHVTM/51	0.5
UV Stability	%	ASTM G-26 & D-1682-	90

B. The Contractor shall procure, deliver to the site, and stockpile 60 tons of clean, crushed stone to be used for the construction of the concrete pad subgrade. The stone shall be no larger then two inches in longest diameter and shall contain fewer than ten percent fines.

2.1.4 CONSTRUCTION METHODS

A. Prior to any earthwork activities, erosion control fencing will be installed along the three southern-most fencelines of the site. Installation shall be per the manufacturer's instructions. Following completion of work activities, the silt fence will be left in place throughout construction, operation, and demolition activities.

The Contractor will be responsible for removing and disposing of all erosion control fencing materials and for restoring any disturbed areas to their original condition.

B. The Contractor shall clear all work areas of surface debris. These areas include the well gallery, the area around the process control building, the area around the tank farm and the pathways for piping and conduit. All cleared debris will be stockpiled as directed by the Engineer.

C. The Contractor shall excavate a maximum of 1 foot of overburden material from within the proposed tank farm footprint as shown in the Contract Drawings. These materials will be utilized as fill in the areas adjacent to the tank farm if the material is deemed suitable by the Engineer. The Contractor shall procure, deliver to the site, and place the specified fill material in six-inch thick lifts within the lines shown in the construction drawings. Each lift shall be compacted with a minimum of two passes of suitable vibratory compaction equipment. The final grade shall be validated by the Construction Engineer before concrete is placed.

D. Any erosion problems that occur during construction shall be immediately addressed.

2.1.5 METHOD OF MEASUREMENT

Measurement for payment for the items in this section will be as follows:

A. The installation of the Erosion Control Fencing will be measured on a lump sum basis.

B. The concrete slab subgrade construction will be measured by the square footage of subgrade constructed and by tonnage for crushed stone delivered, placed and compacted.

C. Site clearing will be measured as a lump sum task.

2.1.6 BASIS OF PAYMENT

Work under this item, shall be paid at the contract price for "Erosion Control Fencing", "Concrete Slab Subgrade Construction," and "Site Clearing," which should include the cost of furnishing all materials, labor, equipment, tools and incidentals required for completion of the work as per this section.

2.2.1 GENERAL

The General Conditions and Special Provisions are made a part of this section.

2.2.2 DESCRIPTION

A. Provide all labor, materials, and equipment required to perform the work called for in this specification and in accordance with the Contract Drawings.

B. This work shall consist of the construction of a twelve-inch thick concrete containment area consisting of a base slab, berms, a sump, and access ramps.

2.2.3 MATERIALS

The Contractor shall provide approximately 64 cubic yards of ready mix concrete, 1078 square feet of 6-inch by 6-inch 10/10 gauge welded wire mesh (WWM), 1026 feet of #4 rebar, and all forms and accessories necessary for the placement, reinforcing, finishing and curing of the concrete slab.

2.2.4 CONSTRUCTION METHODS

The Contractor shall construct a twelve-inch thick reinforced concrete slab, as shown in the Contract Drawings, to the following specifications:

A. The dimensions of the slab will be 22 feet by 49 feet by 12 inches thick.

B. The slab will have a 30 inch high by 12 inch wide berm at all edges.

C. The purpose of the slab will be as a base for the Tank Farm Area

D. The maximum static loading on the slab will be 10 psi under the full separation vessels.

E. The 6" x 6" WWM reinforcement shall be placed six inches from the top of the slab.

F. Two sets of #4 rebar will be placed continuously within the berm edge as shown in the contract drawings.

G. Five-foot lengths of #4 rebar shall be placed every 12" O.C. within the berms and bent to extend into the bottom slab as shown in the contract drawings.

H. The Contractor shall provide scored seams every 16 feet in both directions.

I. The 28-day strength shall be 3500 psi.

I. The Contractor shall construct a 2-foot deep, 2-foot square, reinforced sump in the Northwest corner of the concrete slab as shown in the construction drawings to provide for a point of collection for liquids within the bermed tank farm area to enhance liquid removal if necessary.

J. The Contractor shall collect and analyze concrete test cylinders as described in ASTM C31, C39, and Section 16 of C94. If the compressive strength of one or more of the cylinders in one strength test is below 75 percent of the required strength, the entire test will be considered as failed.

K. The Contractor shall keep the concrete at a temperature such that curing will occur at a maximum rate.

L. The final slope shall be 0.5% sloping toward the sump as shown in the drawings.

M. The cured concrete shall be coated with a clear sealant. The sealant should project the concrete from penetration of moisture, oils, acids, caustics and oxidizers.

2.2.5 METHOD OF MEASUREMENT

Measurement for payment for the items in this section will be as follows:

The construction of the concrete slab will be measured as a lump sum task.

2.2.6 BASIS OF PAYMENT

Work under this item, shall be paid at the contract price for "Concrete Slab Construction", which should include the cost of furnishing all materials, labor, equipment, tools, and incidentals required for completion of the work as per this section.

2.3.1 GENERAL

A. The General Conditions and Special Provisions are made a part of this section.

2.3.2 DESCRIPTION

A. Provide all labor, materials, and equipment required to perform the work called for in this specification and in accordance with the Contract Drawings. RETEC will provide all well screens.

B. The Work shall consist of installing ten wells and four borings.

2.3.3 CONSTRUCTION METHODS

A. Prior to the construction activities, the drilling contractor shall advance five borings in each of the two holders, for a total of ten borings. Upon completion of the removal action, the drilling contractor shall remobilize to the site and advance ten more boring logs in a similar manner. All borings shall be advanced as follows:

1. Use a hollow stem auger to advance a minimum 5⅝-inch borehole to 14 feet in the gas holder and 26 feet in the relief holder.

2. Perform continuous sampling with a 2-inch or 3-inch split spoon. Samples shall be observed and logged accordingly.

3. The engineer will provide and install thermocouples and piezometers within four of the borings prior to closing the borings.

4. Allow the borehole to reclose upon removal of augers. Place a 3-foot thick layer of gravel and sand to the top of the borehole, then cement the borehole flush with the surface of the concrete slab to fully reseal the borehole.

B. The drilling contractor shall install each of the eight injection wells within the relief holder as follows:

1. Use a fully cased drilling method (i.e. cable tool, Barber rig) to advance an 8-inch borehole to the bottom of the relief holder.

2. Install a 4-inch, galvanized steel well casing string with the bottom 20 feet perforated or slotted, as shown in the Contract Drawings.

3. Place a 5/16-to-3/4-inch diameter gravel pack around the well screen as shown in the Contract Drawings.

4. Place the gravel pack to within 5 feet of the surface as shown in the Contract Drawings.

5. Place 5-foot thick layer of cement grout to the surface as shown in the Contract Drawings.

6. Place 1-foot thick, 4-foot diameter concrete pad, pinned to the existing concrete surface cover.

7. Install 4-inch diameter casing flanges with a 2-inch NPT threaded pass through as shown in the Contract Drawings.

C. The drilling contractor shall install production well PW1 as follows:

1. Use a fully cased drilling method (i.e., cable tool, barber rig) to advance an 18-inch borehole to the bottom of the relief holder.

2. Install a 10-inch, 10 slot, galvanized steel well screen and steel well casing as shown in Contract Drawings.

3. Place a 5/16 to 3/4-inch gravel pack around the well screen as shown in the Contract Drawings.

4. Place the sand pack to within 5 feet of the surface as shown in the Contract Drawings.

5. Place a 5-foot thick layer of cement grout to the surface as shown in the Contract Drawings.

6. Place 1-foot thick, 3-foot diameter concrete pad, pinned to the existing concrete surface cover.

7. Install a 10-inch diameter casing flange with a 2-inch NPT threaded pass through and a 3-inch diameter pass through as shown in the Contract Drawings.

D. The drilling contractor shall install production well PW2 as follows:

1. Use a fully cased drilling method (i.e., cable tool, barber rig) to advance a 14-inch borehole to the bottom of the gas holder.

2. Install a 7-inch, 10 slot, galvanized steel well screen and steel well casing as shown in the Contract Drawings.

3. Place a 5/16 to 3/4 inch gravel pack around the well screen as shown in the Contract Drawings.

4. Place the sand pack to within 4 feet of the surface as shown in the Contract Drawings.

5. Place a 4-foot thick layer of cement grout to the surface as shown in the Contract Drawings.

6. Place 1-foot thick, 3-foot diameter concrete pad, pinned to the existing concrete surface cover.

7. Install a 7-inch diameter casing flange with a 2-inch NPT threaded pass through and a 3-inch diameter pass through as shown in the Contract Drawings.

E. All cuttings from soil borings and all well development water will be collected in drums and/or roll-off boxes and will be handled according to 40 CFR Part 265 Subpart I.

2.3.4 METHOD OF MEASUREMENT

Measurement for payment for the items in this section will be as follows:

All well and boring installation will be measured on a lump sum basis as per the requirements of this section.

2.3.5 BASIS OF PAYMENT

Work under this item shall be paid at the contract unit price for Division 2 - Civil Construction, "Well and Boring Installation", which should include the cost of furnishing all materials, labor, equipment, tools, and incidentals required for completion of the work as per this section.

2.4.1 GENERAL

A. The General Conditions and Special Provisions are made a part of this section.

2.4.2 DESCRIPTION

Immediately after the water is removed from each of the two holders, the holders will be pressure grouted with a flowable fill mixture. The mixture will consist of fly ash, portland cement, and water. The 28-day compressive strength of the mixture shall be greater than 50 psi and less than 100 psi. The compressive strength may be measured with a proctor penetration meter (ASTM-C403) and must exceed 4,000 psi. The mixture shall have good flowability and self-leveling characteristics such that all voids will be filled. The mixture shall be of low enough strength that it may be removed with an excavator after full strength is developed. The flowable fill will be injected into the holders through drilled casings. The casings will be removed as the holder is filled. The flowable fill contractor will attempt to modify the existing wells to use as injection points. All pressure grouting will be performed as quickly as possible to minimize the potential of groundwater seeping into the holders. All injection points will be closed with concrete after the grouting is complete.

The holder contents will be sampled after the flowable fill has reached full strength. All samples must pass a contaminant leaching test as the criteria of success.

2.4.3 METHOD OF MEASUREMENT

Measurement for payment for the items in this section will be as follows:

All pressure grouting will be measured on a lump sum basis as per the requirements of this section.

2.4.4 BASIS OF PAYMENT

Work under this item shall be paid at the contract unit price for Division 2 - Civil Construction, "Flowable Fill", which should include the cost of furnishing all materials, labor, equipment, tools, and incidentals required for completion of the work as per this section.

DIVISION 3

MECHANICAL CONSTRUCTION

3.0.1 GENERAL

The General Conditions and Special Provisions are made a part of this section.

3.0.2 DESCRIPTION

Provide all labor, materials and equipment required for the installation of all piping. *RETEC will supervise the installation of all piping.*

3.0.3 CONSTRUCTION METHODS

Install all piping and insulation as shown in the Contract Drawings. The pipe materials shall be carbon steel and Schedule 40 weld end piping and all connections shall be threaded or welded, respectively. All piping that meets the requirements to be covered under ANSI or ASME Standards for Power piping B - 31.1 and/or chemical plant and petroleum refinery piping B-31.1, shall be installed accordingly. A list of piping materials and approximate lengths is provided in the following section.

3.0.4 MATERIAL

- 15 feet, 4-inch Carbon Steel schedule 40 black pipe threaded with couplings,
- 90 feet, 3-inch Carbon Steel schedule 40 black pipe threaded with couplings,
- 50 feet, 2-inch Carbon Steel schedule 40 black pipe threaded with couplings,
- 150 feet, 1½-inch carbon steel schedule 40 black pipe threaded with couplings,
- 25 feet, 1½-inch PVDF schedule 80 with couplings,
- 5 feet, 4-inch Schedule 40 weld end pipe,

- 20 feet, 3-inch Schedule 40 weld end pipe,
- 220 feet, 2-inch Schedule 40 weld end pipe,
- 1300 feet, 1½-inch PVC (vinyl) tubing with barbed fittings
- 30, 1½-inch PVC drainage valves to be placed every 50 feet along discharge line.
- approximately 30 miscellaneous pipe supports,
- 245 feet surface piping insulation, 2 inch thick fiberglass with metal sheathing,
- 50 feet, ¼ teflon (or equivalent) tubing with barbed fittings.

3.0.5 METHOD OF MEASUREMENT

All piping installation will be measured on a lump sum basis, including insulation and all fittings and supports.

3.0.6 BASIS OF PAYMENT

Work under this item, shall be paid at the contract price for "Piping", which should include the cost of furnishing all materials, labor, equipment, tools, and incidentals required for completion of the work as per this section.

3.1.1 GENERAL

The General Conditions and Special Provisions are made a part of this section.

3.1.2 DESCRIPTION

Provide all labor and equipment required for the installation of all pumps. RETEC will supervise the installation of all pumps.

3.1.3 CONSTRUCTION METHODS

Provide all labor and equipment for the installation of all pumps and control loops as shown in the Contract Drawings. RETEC will provide all of the pumps and control loops as described in the Pump and Control Loop Data Sheets and listed in Schedules 1-1 and 1-2. All pH and redox control loops must be located a minimum of 10 feet downstream from chemical injection points.

Schedule 1-1

Pump #

1 Submersible pump, high temperature,10-30 gpm normal operating range, pumping against 100 feet of head maximum, 3 hp, 480 volt, 3 phase, off/auto, auto/manual.

2 Submersible pump, 30 gpm, pumping against 100 feet of head maximum, 3 hp, 480 volt, 3 phase, off/auto, auto/manual.

3 Water transfer pump, variable speed (5-30 gpm), 50 psig, 150°F, 1.5 hp, 480 volt, 3 phase, off/auto, manual controller.

4 Acid injection pump, 25 gpd, 1/3 hp, 120 volt, single phase, variable speed, off/auto, manual controller.

5 Caustic injection pump, 50 gpd, 1/3 hp, 120 volt, single phase, variable speed, off/auto, manual controller.

6 Oil transfer pump, 10 gpm, 20 psig, 2 hp, 480 volt, 3 phase, Hand/Off/Auto, On/Off at pump for emergency shutdown in the automatic mode, start/stop in the Hand mode at pump (on/off emergency shutdown must be wired in).

7 Oil transfer pump, 100 gpm, 20 psig, 2hp, 400 volt, 3 phase, manual start/stop at pump.

8 Clean water discharge pump, 10-30 gpm, 20 psig, 150°F, 1.5 hp, 480 volt, 3 phase, off/auto, manual controller.

9 Hydrogen peroxide metering pump, 50 GPD, 1/3 HP, 1-inch diameter, 230 volt, single phase, off auto, manual controller

10 Decant pump, 10 gpm, 1 hp, pumping against 40 feet of head maximum, 480 volt, 3 phase, manual start stop at pump.

The specific pumps are described in further detail in the Pump Data Sheets.

Schedule 1-2

Controller #

1 H_2SO_4pH controller, pH Control Loop - pH measurement probe and controller. Used to vary H_2SO_4 metering pump P-4. Analog input/output, non-isolated. Signet 9030 Intellek-Pro pH controller, and 3-2716 pH electrode or equivalent.

2 N_aOH pH controller - used to vary NaOH metering pump P-5.

3 H_2O_2 Redox controller - Oxidation reduction potential control loop - Redox measurement probe and controller. Used to vary H_2O_2 metering pump P-9. Analog input/output, non-isolated. Signet 9040 Intelek-Pro ORP Controller, and 3-2717 ORP electrode or equivalent.

RETEC

CENTRIFUGAL PUMP DATA SHEET

Project Name:	PP&L	Prepr'd by:	Jason A. Gerrish	Tag No:	P-01
Project No:	3-1612	Chk'd by:		Rev No:	0
Location:	Columbia, PA	Date:	Sep 95	No. Req'd:	1

Service: Transfer oil/water mix from holder to Tank 1

Operating Conditions		Fluid Properties		Pump Performance	
Capacity (Normal/Rated):	Variable 10-30 gpm	Type of Fluid:	oil/water	RPM:	variable speed
Suction Press (Max/Rated):	1 psig	Temp (max):	250 °F	Impeller Dia (Rated/Max/Min):	
Discharge Press:	65 psig	S. G. (@ Max Temp):	1	Rated Power: (BHP) Efficiency:	
Differential Head:	150' H2O	C_p:	1 BTU/(lb.°F)	Min Cont. Flow:	
NPSH (Available):	Flooded	μ (@ Min Temp):	~ 1.0 cP	Max Head Rated Impeller:	
Hydraulic Power:	HP	Vapor Press:	20 mmHG	Max Power Rated Impeller:	
Duty:	continuious	Corrosivity:		NPSH Reqr'd @ Rated Cap:	
		Characteristic:		Suction Specific Speed:	

CONSTRUCTION

CONNECTIONS		MATERIALS		MECHANICAL	
NAME	SIZE	Volute:	Cast Steel	Mounting:	
Suction	NA	Impellar:		Coupling:	
Discharge	2 inch	Shaft:		Shaft Bearings:	
Casing Vent		Baseplate:	Carbon Steel	Impeller Diameter:	
Casing Drain				Max. Impeller Dia.:	
Seal Flush				Number of Stages:	
Seal Drain				Standard:	

SHAFT SEALS

☐ Single	☐ Double	Seal:	[1]	ACCESSORIES:	
☐ Balanced	☐ Unbalanced	Seal Fluid:	[1]	☐Fluid Filter	
☐ Internal	☐ External	Seal Rings:	[1]	☐Pressure Switch	
☐ Flushed	☐ Static	Seal Manufacturer:	[1]	☐Flow Switch	
☐Stuffing Box (if yes, specify packing)		Seal Model:	[1]	☐Fluid Reservoir	
Packing:		Lubricant:	[1]		

MOTOR / DRIVE

Motor Power:		Freq:	60 Hz	Frame:		Enclosure:	TEFC
Voltage:	460, 3 phase	Eff:	90% Min	Insulation:		Service Factor:	
Full Load Amps:		RPM:		Motor Torque:		Service Duty:	Continuous
Coupling:		Bearings:					

COMMENTS

- Vendor to complete pump data sheet.
- Vendor to supply control package to include level element, transmitter, controller, and variable frequency drive.

RETEC

WELL PUMP DATA SHEET

Project Name:	PP&L	Prepr'd by:	C. Laquidara	Tag No:	PW-2
Project No:	3-1612	Chk'd by:		Rev No:	0
Location:	Columbia, PA	Date:	Apr 95	No. Req'd:	1

Service: Grudfos Well Pump or equivilent

Operating Conditions		Fluid Properties		Pump Performance
Capacity (Normal/Rated):	30 GPM	Type of Fluid:	water	RPM:
Suction Press (Max/Rated):	1 psig	Temp (Norm):	Ambient	Impeller Dia (Rated/Max/Min):
Discharge Press:	50 psig	S. G. (@ Max Temp):	1	Rated Power: (BHP) Efficiency:
Differential Head:	50 psig	C_p:	1 BTU/(lb.°F)	Min Cont. Flow:
NPSH (Available):	Flooded	μ (@ Min Temp):	~ 1.1 cP	Max Head Rated Impeller:
Hydraulic Power:	HP	Vapor Press:	20 mmHG	Max Power Rated Impeller:
Duty:	Intermittent	Corrosivity:		NPSH Reqr'd @ Rated Cap:
		Characteristic:		Suction Specific Speed:

CONSTRUCTION

CONNECTIONS		MATERIALS	MECHANICAL
NAME	SIZE	Volute:	Mounting:
Suction		Impellar:	Coupling:
Discharge	inch	Shaft:	Shaft Bearings:
Casing Vent		Baseplate:	Impeller Diameter:
Casing Drain			Max. Impeller Dia.:
Seal Flush			Number of Stages:
Seal Drain			Standard:

SHAFT SEALS

☐ Single	☐ Double	Seal:Teflon	ACCESSORIES:
☐ Balanced	☐ Unbalanced	Seal Fluid: [1]	☐Fluid Filter
☐ Internal	☐ External	Seal Rings: [1]	☐Pressure Switch
☐ Flushed	☐ Static	Seal Manufacturer: [1]	☐Flow Switch
☐Stuffing Box (if yes, specify packing)		Seal Model: [1]	☐Fluid Reservoir
Packing:		Lubricant: [1]	

MOTOR / DRIVE

Motor Power: 460 V, 3 phase	Freq: 60 Hz	Frame:	Enclosure:
Voltage:	Eff: 90% Min	Insulation:	Service Factor:
Full Load Amps:	RPM:	Motor Torque:	Service Duty: Continuous
Coupling:	Bearings:		

COMMENTS

- Vendor to complete pump data sheet.

RETEC

CENTRIFUGAL PUMP DATA SHEET

Project Name:	PP&L	Prepr'd by:		Tag No:	P-03
Project No:	3-1612	Chk'd by:		Rev No:	0
Location:	Columbia, PA	Date:	Apr 95	No. Req'd:	1
Service:	Transfer clarified water to the boiler				

Operating Conditions		Fluid Properties		Pump Performance	
Capacity (Normal/Rated):	Variable 5-30 gpm	Type of Fluid:	water	RPM:	variable speed
Suction Press (Max/Rated):	1 psig	Temp (Norm):	Ambient	Impeller Dia (Rated/Max/Min):	
Discharge Press:	65 psig	S. G. (@ Max Temp):	1	Rated Power: (BHP) Efficiency:	
Differential Head:	150' H2O	C_p:	1 BTU/(lb.°F)	Min Cont. Flow:	
NPSH (Available):	Flooded	μ (@ Min Temp):	~ 1.0 cP	Max Head Rated Impeller:	
Hydraulic Power:	HP	Vapor Press:	20 mmHG	Max Power Rated Impeller:	
Duty:	continuious	Corrosivity:		NPSH Reqr'd @ Rated Cap:	
		Characteristic:		Suction Specific Speed:	

CONSTRUCTION

CONNECTIONS		MATERIALS		MECHANICAL	
NAME	SIZE	Volute:	Cast Steel	Mounting:	
Suction	2 inch	Impellar:		Coupling:	
Discharge	1.5 inch	Shaft:		Shaft Bearings:	
Casing Vent		Baseplate:	Carbon Steel	Impeller Diameter:	
Casing Drain				Max. Impeller Dia.:	
Seal Flush				Number of Stages:	
Seal Drain				Standard:	

SHAFT SEALS

☐ Single	☐ Double	Seal:	[1]	ACCESSORIES:	
☐ Balanced	☐ Unbalanced	Seal Fluid:	[1]	☐Fluid Filter	
☐ Internal	☐ External	Seal Rings:	[1]	☐Pressure Switch	
☐ Flushed	☐ Static	Seal Manufacturer:	[1]	☐Flow Switch	
☐Stuffing Box (if yes, specify packing)		Seal Model:	[1]	☐Fluid Reservoir	
Packing:		Lubricant:	[1]		

MOTOR / DRIVE

Motor Power:		Freq:	60 Hz	Frame:	Enclosure: TEFC
Voltage:	460, 3 phase	Eff:	90% Min	Insulation:	Service Factor:
Full Load Amps:		RPM:		Motor Torque:	Service Duty: Continuous
Coupling:		Bearings:			

COMMENTS

- Vendor to complete pump data sheet.
- Vendor to supply control package to include level element, transmitter, controller, and variable frequency drive.

METERING PUMP DATA SHEET		
Project Name: PP&L	Project No:3-1612	Tag No: P-04
Location: Columbia, PA	Date May 4, 1995	Rev:
Service: Continuous	Unit:	No required: 1
General specifications...	*Capacity Control...*	
Pump classification:	Stroke adjustment: Manual X Automatic ☐	
Pump type: Positive displacement	For automatic control, specify the type:	
Liquid handled: Sulfuric acid	Electronic positioner ☐ See note [1]	
Solids in suspension: No	Pneumatic positioner ☐	
Installation: outdoors	Speed controller ☐	
Corrosion due to: NA	For electronic positioner, specify the input signal:	
Normal flow: <40 GPD	4 - 20 mA ☐ Other ☐	
Liquid physical properties...	For pneumatic positioner specify input signal:	
Pumping Temp (P.T.): Ambient	3 - 15 psig ☐ Other ☐	
Specific gravity @ P.T.:	For speed controller, specify the type:	
Viscosity @ P.T.:		
Vapor pressure @ P.T.:		
Freezing point:		
Performance characteristics...	*Motor specifications...*	
Maximum capacity @ P.T.:	Power supply:110 V, 1 phase	
Turndown ratio:	Horsepower:[1]	
Accuracy:	Motor speed:[1]	
Suction pressure: 0 psig	Enclosure:[2]	
Maximum discharge pressure: 25 psig	Insulation:[2]	
NPSH available @ P.T.:	Service factor:[1]	
Brake Horsepower:	Full load amps:[1]	
Required NPSH:	Mounting:[1]	
Efficiency:		
Relief valve setting:	*Auxiliary equipment...*	
Strokes/minute:	**Pulsation dampener:** Yes ☐ No X	
	Maximum pulsation amplitude:	
Type & material of construction...	Deviation from average pressure:	
Diaphragm material:[3]	Volume:	
Diaphragm type:	Material:	
Liquid end material:	**Calibration columns:** Yes ☐ No X	
Flow control:	Minimum Volume:	
	Calibration units:	
Connections...	**Backpressure valve:** Yes ☐ No X	
Suction-size & rating: 1/2"	Setting pressure:	
Discharge-size & rating: 1/2"	Material of construction:[1]	
	Strainer @ suction line: Yes ☐ No X	
Comments		
[1] By vendor	[2] Suitable for outdoor nonhazardous environment	
[3] Compatable with chemical of interest		

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METERING PUMP DATA SHEET		
Project Name: PP&L	Project No:3-1612	Tag No: P-05
Location: Columbia, PA	Date May 4, 1995	Rev:
Service: Continuous	Unit:	No required: 1
General specifications...	*Capacity Control...*	
Pump classification:	Stroke adjustment: Manual X Automatic ☐	
Pump type: Positive displacement	For automatic control, specify the type:	
Liquid handled: Sodium hhdroxide	Electronic positioner ☐ See note [1]	
Solids in suspension: No	Pneumatic positioner ☐	
Installation: outdoors	Speed controller ☐	
Corrosion due to: NA	For electronic positioner, specify the input signal:	
Normal flow: < 50 gpd	4 - 20 mA ☐ Other ☐	
Liquid physical properties...	For pneumatic positioner specify input signal:	
Pumping Temp (P.T.): Ambient	3 - 15 psig ☐ Other ☐	
Specific gravity @ P.T.:	For speed controller, specify the type:	
Viscosity @ P.T.:		
Vapor pressure @ P.T.:		
Freezing point:		
Performance characteristics...	*Motor specifications...*	
Maximum capacity @ P.T.:	Power supply:110 V, 1 phase	
Turndown ratio:	Horsepower:[1]	
Accuracy:	Motor speed:[1]	
Suction pressure: 0 psig	Enclosure:[2]	
Maximum discharge pressure: 10 psig	Insulation:[2]	
NPSH available @ P.T.:	Service factor:[1]	
Brake Horsepower:	Full load amps:[1]	
Required NPSH:	Mounting:[1]	
Efficiency:		
Relief valve setting:	*Auxiliary equipment...*	
Strokes/minute:	**Pulsation dampener:** Yes ☐ No X	
	Maximum pulsation amplitude:	
Type & material of construction...	Deviation from average pressure:	
Diaphragm material:[3]	Volume:	
Diaphragm type:	Material:	
Liquid end material:	**Calibration columns:** Yes ☐ No X	
Flow control:	Minimum Volume:	
	Calibration units:	
Connections...	**Backpressure valve:** Yes ☐ No X	
Suction-size & rating: 1/2"	Setting pressure:	
Discharge-size & rating: 1/2"	Material of construction:[1]	
	Strainer @ suction line: Yes ☐ No X	
Comments		
[1] By vendor	[2] Suitable for outdoor nonhazardous environment	
[3] Compatable with chemical of interest		

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RETEC

CENTRIFUGAL PUMP DATA SHEET

Project Name:	PP&L	Prepr'd by:	C. Laquidara	Tag No:	P-06
Project No:	3-1612	Chk'd by:		Rev No:	0
Location:	Columbia, PA	Date:	Apr 95	No. Req'd:	1

Service: Transfer coal tar and iron sludge to holding tank

Operating Conditions		Fluid Properties		Pump Performance
Capacity (Normal/Rated):	10 GPM	Type of Fluid:	sludge	RPM:
Suction Press (Max/Rated):	1 psig	Temp (Norm):	Ambient	Impeller Dia (Rated/Max/Min):
Discharge Press:	20 psig	S. G. (@ Max Temp):	1	Rated Power: (BHP) Efficiency:
Differential Head:	20 psig	C_p:	1 BTU/(lb.°F)	Min Cont. Flow:
NPSH (Available):	Flooded	μ (@ Min Temp):	~ 1.1 cP	Max Head Rated Impeller:
Hydraulic Power:	HP	Vapor Press:	20 mmHG	Max Power Rated Impeller:
Duty:	Intermitten	Corrosivity:		NPSH Reqr'd @ Rated Cap:
		Characteristic:	10% soilds	Suction Specific Speed:

CONSTRUCTION

CONNECTIONS		MATERIALS		MECHANICAL
NAME	SIZE	Volute:	Cast Steel	Mounting:
Suction	2 inch	Impellar:		Coupling:
Discharge	2 inch	Shaft:		Shaft Bearings:
Casing Vent		Baseplate:	Carbon Steel	Impeller Diameter:
Casing Drain				Max. Impeller Dia.:
Seal Flush				Number of Stages:
Seal Drain				Standard:

SHAFT SEALS

☐ Single	☐ Double	Seal:	[1]	ACCESSORIES:
☐ Balanced	☐ Unbalanced	Seal Fluid:	[1]	☐Fluid Filter
☐ Internal	☐ External	Seal Rings:	[1]	☐Pressure Switch
☐ Flushed	☐ Static	Seal Manufacturer:	[1]	☐Flow Switch
☐Stuffing Box (if yes, specify packing)		Seal Model:	[1]	☐Fluid Reservoir
Packing:		Lubricant:	[1]	

MOTOR / DRIVE

Motor Power:	Freq: 60 Hz	Frame:	Enclosure: TEFC
Voltage:	Eff: 90% Min	Insulation:	Service Factor:
Full Load Amps:	RPM:	Motor Torque:	Service Duty: Continuous
Coupling:	Bearings:		

COMMENTS

- Vendor to complete pump data sheet.

RETEC

CENTRIFUGAL PUMP DATA SHEET

Project Name:	PP&L	Prepr'd by:	C. Laquidara	Tag No:	P-07
Project No:	3-1612	Chk'd by:		Rev No:	0
Location:	Columbia, PA	Date:	Apr 95	No. Req'd:	1
Service: Transfer coal tar and iron sludge for off-site disposal					

Operating Conditions		Fluid Properties		Pump Performance
Capacity (Normal/Rated):	50 GPM	Type of Fluid:	sludge	RPM:
Suction Press (Max/Rated):	1 psig	Temp (Norm):	Ambient	Impeller Dia (Rated/Max/Min):
Discharge Press:	30 psig	S. G. (@ Max Temp):	1	Rated Power: (BHP) Efficiency:
Differential Head:	30 psig	C_p:	1 BTU/(lb.°F)	Min Cont. Flow:
NPSH (Available):	Flooded	μ (@ Min Temp):	~ 1.1 cP	Max Head Rated Impeller:
Hydraulic Power:	HP	Vapor Press:	20 mmHG	Max Power Rated Impeller:
Duty:	Intermittent	Corrosivity:		NPSH Reqr'd @ Rated Cap:
		Characteristic:	10% soilds	Suction Specific Speed:

CONSTRUCTION

CONNECTIONS		MATERIALS		MECHANICAL
NAME	SIZE	Volute:	Cast Steel	Mounting:
Suction	2 inch	Impellar:		Coupling:
Discharge	1.5 inch	Shaft:		Shaft Bearings:
Casing Vent		Baseplate:	Carbon Steel	Impeller Diameter:
Casing Drain				Max. Impeller Dia.:
Seal Flush				Number of Stages:
Seal Drain				Standard:

SHAFT SEALS

☐ Single	☐ Double	Seal:	[1]	ACCESSORIES:
☐ Balanced	☐ Unbalanced	Seal Fluid:	[1]	☐Fluid Filter
☐ Internal	☐ External	Seal Rings:	[1]	☐Pressure Switch
☐ Flushed	☐ Static	Seal Manufacturer:	[1]	☐Flow Switch
☐Stuffing Box (if yes, specify packing)		Seal Model:	[1]	☐Fluid Reservoir
Packing:		Lubricant:	[1]	

MOTOR / DRIVE

Motor Power: 460 V, 3 phase	Freq: 60 Hz	Frame:	Enclosure: TEFC
Voltage:	Eff: 90% Min	Insulation:	Service Factor:
Full Load Amps:	RPM:	Motor Torque:	Service Duty: Continuous
Coupling:	Bearings:		

COMMENTS

- Vendor to complete pump data sheet.

PUMP.SPC

Print Date: August 16, 1995

RETEC

CENTRIFUGAL PUMP DATA SHEET

Project Name:	PP&L	Prepr'd by:	C. Laquidara	Tag No:	P-08
Project No:	3-1612	Chk'd by:		Rev No:	0
Location:	Columbia, PA	Date:	Apr 95	No. Req'd:	1
Service: Transfer treated water					

Operating Conditions		Fluid Properties		Pump Performance	
Capacity (Normal/Rated):	30 gpm	Type of Fluid:	Water	RPM:	
Suction Press (Max/Rated):	1 psig	Temp (Norm):	Ambient	Impeller Dia (Rated/Max/Min):	
Discharge Press:	45 psig	S. G. (@ Max Temp):	1	Rated Power: (BHP) Efficiency:	
Differential Head:	45 psig	C_p:	1 BTU/(lb.°F)	Min Cont. Flow:	
NPSH (Available):	Flooded	μ (@ Min Temp):	~ 1 cP	Max Head Rated Impeller:	
Hydraulic Power:	HP	Vapor Press:	20 mmHG	Max Power Rated Impeller:	
Duty:	Continuous	Corrosivity:		NPSH Reqr'd @ Rated Cap:	
		Characteristic:		Suction Specific Speed:	

CONSTRUCTION

CONNECTIONS		MATERIALS		MECHANICAL	
NAME	SIZE	Volute:	Cast Steel	Mounting:	
Suction	2 inch	Impellar:		Coupling:	
Discharge	1.5 inch	Shaft:		Shaft Bearings:	
Casing Vent		Baseplate:	Carbon Steel	Impeller Diameter:	
Casing Drain				Max. Impeller Dia.:	
Seal Flush				Number of Stages:	
Seal Drain				Standard:	

SHAFT SEALS

☐ Single ☐ Double	Seal: [1]	ACCESSORIES:	
☐ Balanced ☐ Unbalanced	Seal Fluid: [1]	☐Fluid Filter	
☐ Internal ☐ External	Seal Rings: [1]	☐Pressure Switch	
☐ Flushed ☐ Static	Seal Manufacturer: [1]	☐Flow Switch	
☐Stuffing Box (if yes, specify packing)	Seal Model: [1]	☐Fluid Reservoir	
Packing:	Lubricant: [1]		

MOTOR / DRIVE

Motor Power: 460 V, 3 phase	Freq: 60 Hz	Frame:	Enclosure: TEFC
Voltage:	Eff: 90% Min	Insulation:	Service Factor:
Full Load Amps:	RPM:	Motor Torque:	Service Duty: Continuous
Coupling:	Bearings:		

COMMENTS

- Vendor to complete pump data sheet.

METERING PUMP DATA SHEET		
Project Name: PP&L	Project No:3-1612	Tag No: P-09
Location: Columbia, PA	Date May 4, 1995	Rev:
Service: Continuous	Unit:	No required: 1
General specifications...	*Capacity Control...*	
Pump classification:	Stroke adjustment: Manual X Automatic ☐	
Pump type: Positive displacement	For automatic control, specify the type:	
Liquid handled: Hydrogen peroxide	Electronic positioner ☐ See note [1]	
Solids in suspension: No	Pneumatic positioner ☐	
Installation: outdoors	Speed controller ☐	
Corrosion due to: NA	For electronic positioner, specify the input signal:	
Normal flow: <40 GPD	4 - 20 mA ☐ Other ☐	
Liquid physical properties...	For pneumatic positioner specify input signal:	
Pumping Temp (P.T.): Ambient	3 - 15 psig ☐ Other ☐	
Specific gravity @ P.T.:	For speed controller, specify the type:	
Viscosity @ P.T.:		
Vapor pressure @ P.T.:		
Freezing point:		
Performance characteristics...	*Motor specifications...*	
Maximum capacity @ P.T.:	Power supply:110 V, 1 phase	
Turndown ratio:	Horsepower:[1]	
Accuracy:	Motor speed:[1]	
Suction pressure: 0 psig	Enclosure:[2]	
Maximum discharge pressure: 10 psig	Insulation:[2]	
NPSH available @ P.T.:	Service factor:[1]	
Brake Horsepower:	Full load amps:[1]	
Required NPSH:	Mounting:[1]	
Efficiency:		
Relief valve setting:	*Auxiliary equipment...*	
Strokes/minute:	**Pulsation dampener:** Yes ☐ No X	
	Maximum pulsation amplitude:	
Type & material of construction...	Deviation from average pressure:	
Diaphragm material:[3]	Volume:	
Diaphragm type:	Material:	
Liquid end material:	**Calibration columns:** Yes ☐ No X	
Flow control:	Minimum Volume:	
	Calibration units:	
Connections...	**Backpressure valve:** Yes ☐ No X	
Suction-size & rating: 1/2"	Setting pressure:	
Discharge-size & rating: 1/2"	Material of construction:[1]	
	Strainer @ suction line: Yes ☐ No X	
Comments		
[1] By vendor	[2] Suitable for outdoor nonhazardous environment	
[3] Compatable with chemical of interest		

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RETEC

CENTRIFUGAL PUMP DATA SHEET

Project Name:	PP&L	Prepr'd by:	C. Laquidara	Tag No:	P-10
Project No:	3-1612	Chk'd by:		Rev No:	0
Location:	Columbia, PA	Date:	Apr 95	No. Req'd:	1

Service: Transfer clarified water

Operating Conditions		Fluid Properties		Pump Performance
Capacity (Normal/Rated):	10 GPM	Type of Fluid:	water	RPM:
Suction Press (Max/Rated):	1 psig	Temp (Norm):	Ambient	Impeller Dia (Rated/Max/Min):
Discharge Press:	20 psig	S. G. (@ Max Temp):	1	Rated Power: (BHP) Efficiency:
Differential Head:	20 psig	C_p:	1 BTU/(lb.°F)	Min Cont. Flow:
NPSH (Available):	Flooded	μ (@ Min Temp):	~ 1.1 cP	Max Head Rated Impeller:
Hydraulic Power:	HP	Vapor Press:	20 mmHG	Max Power Rated Impeller:
Duty:	Intermittent	Corrosivity:		NPSH Reqr'd @ Rated Cap:
		Characteristic:		Suction Specific Speed:

CONSTRUCTION

CONNECTIONS		MATERIALS		MECHANICAL
NAME	SIZE	Volute:	Cast Steel	Mounting:
Suction	2 inch	Impellar:		Coupling:
Discharge	1.5 inch	Shaft:		Shaft Bearings:
Casing Vent		Baseplate:	Carbon Steel	Impeller Diameter:
Casing Drain				Max. Impeller Dia.:
Seal Flush				Number of Stages:
Seal Drain				Standard:

SHAFT SEALS

☐ Single	☐ Double	Seal:	[1]	ACCESSORIES:	
☐ Balanced	☐ Unbalanced	Seal Fluid:	[1]	☐Fluid Filter	
☐ Internal	☐ External	Seal Rings:	[1]	☐Pressure Switch	
☐ Flushed	☐ Static	Seal Manufacturer:	[1]	☐Flow Switch	
☐Stuffing Box (if yes, specify packing)		Seal Model:	[1]	☐Fluid Reservoir	
Packing:		Lubricant:	[1]		

MOTOR / DRIVE

Motor Power:	460 V, 3 phase	Freq:	60 Hz	Frame:		Enclosure:	TEFC
Voltage:		Eff:	90% Min	Insulation:		Service Factor:	
Full Load Amps:		RPM:		Motor Torque:		Service Duty:	Continuous
Coupling:		Bearings:					

COMMENTS

- Vendor to complete pump data sheet.

PUMP.SPC

Print Date: August 16, 1995

METERING PUMP DATA SHEET		
Project Name: PP&L	Project No:3-1612	Tag No: P-11
Location: Columbia, PA	Date May 4, 1995	Rev:
Service: Continuous	Unit:	No required: 1
General specifications...	*Capacity Control...*	
Pump classification:	Stroke adjustment: Manual X Automatic ☐	
Pump type: Positive displacement	For automatic control, specify the type:	
Liquid handled: Flocculant	Electronic positioner ☐ See note [1]	
Solids in suspension: No	Pneumatic positioner ☐	
Installation: outdoors	Speed controller ☐	
Corrosion due to: NA	For electronic positioner, specify the input signal:	
Normal flow: < 10 GPD	4 - 20 mA ☐ Other ☐	
Liquid physical properties...	For pneumatic positioner specify input signal:	
Pumping Temp (P.T.): Ambient	3 - 15 psig ☐ Other ☐	
Specific gravity @ P.T.:	For speed controller, specify the type:	
Viscosity @ P.T.:		
Vapor pressure @ P.T.:		
Freezing point:		
Performance characteristics...	*Motor specifications...*	
Maximum capacity @ P.T.:	Power supply:110 V, 1 phase	
Turndown ratio:	Horsepower:[1]	
Accuracy:	Motor speed:[1]	
Suction pressure: 0 psig	Enclosure:[2]	
Maximum discharge pressure: 10 psig	Insulation:[2]	
NPSH available @ P.T.:	Service factor:[1]	
Brake Horsepower:	Full load amps:[1]	
Required NPSH:	Mounting:[1]	
Efficiency:		
Relief valve setting:	*Auxiliary equipment...*	
Strokes/minute:	**Pulsation dampener:** Yes ☐ No X	
	Maximum pulsation amplitude:	
Type & material of construction...	Deviation from average pressure:	
Diaphragm material:[3]	Volume:	
Diaphragm type:	Material:	
Liquid end material:	**Calibration columns:** Yes ☐ No X	
Flow control:	Minimum Volume:	
	Calibration units:	
Connections...	**Backpressure valve:** Yes ☐ No X	
Suction-size & rating: 1/2"	Setting pressure:	
Discharge-size & rating: 1/2"	Material of construction:[1]	
	Strainer @ suction line: Yes ☐ No X	
Comments		
[1] By vendor	[2] Suitable for outdoor nonhazardous environment	
[3] Compatable with chemical of interest		

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RETEC

CENTRIFUGAL PUMP DATA SHEET

Project Name:	PP&L	Prepr'd by:	C. Laquidara	Tag No:	P-12
Project No:	3-1612	Chk'd by:		Rev No:	0
Location:	Columbia, PA	Date:	Apr 95	No. Req'd:	1

Service: Submersible sump pump

Operating Conditions		Fluid Properties		Pump Performance
Capacity (Normal/Rated):	50 GPM	Type of Fluid:	water	RPM:
Suction Press (Max/Rated):	1 psig	Temp (Norm):	Ambient	Impeller Dia (Rated/Max/Min):
Discharge Press:	25 psig	S. G. (@ Max Temp):	1	Rated Power: (BHP) Efficiency:
Differential Head:	25 psig	C_p:	1 BTU/(lb.°F)	Min Cont. Flow:
NPSH (Available):	Flooded	μ (@ Min Temp):	~ 1.1 cP	Max Head Rated Impeller:
Hydraulic Power:	HP	Vapor Press:	20 mmHG	Max Power Rated Impeller:
Duty:	Intermittent	Corrosivity:		NPSH Reqr'd @ Rated Cap:
		Characteristic:	5% soilds	Suction Specific Speed:

CONSTRUCTION

CONNECTIONS		MATERIALS		MECHANICAL
NAME	SIZE	Volute:	Cast Steel	Mounting:
Suction		Impellar:		Coupling:
Discharge	1.5 inch	Shaft:		Shaft Bearings:
Casing Vent		Baseplate:	Carbon Steel	Impeller Diameter:
Casing Drain				Max. Impeller Dia.:
Seal Flush				Number of Stages:
Seal Drain				Standard:

SHAFT SEALS

☐ Single	☐ Double	Seal:	[1]	ACCESSORIES:	
☐ Balanced	☐ Unbalanced	Seal Fluid:	[1]	☐Fluid Filter	
☐ Internal	☐ External	Seal Rings:	[1]	☐Pressure Switch	
☐ Flushed	☐ Static	Seal Manufacturer:	[1]	☐Flow Switch	
☐Stuffing Box (if yes, specify packing)		Seal Model:	[1]	☐Fluid Reservoir	
Packing:		Lubricant:	[1]		

MOTOR / DRIVE

Motor Power:	460 V, 3 phase	Freq:	60 Hz	Frame:		Enclosure:	
Voltage:		Eff:	90% Min	Insulation:		Service Factor:	
Full Load Amps:		RPM:		Motor Torque:		Service Duty:	Continuous
Coupling:		Bearings:					

COMMENTS

- Vendor to complete pump data sheet.

3.1.4 METHOD OF MEASUREMENT

All pump installation will be measured on a lump sum basis. The Contractor shall submit a lump sum price for the installation of all pumps.

3.1.5 BASIS OF PAYMENT

Work under this item, shall be paid at the contract price for "Pump Installation", which should include the cost of furnishing all labor, equipment, tools, and incidentals required for completion of the work as per this section.

3.2.1 GENERAL

The General Conditions and Special Provisions are made a part of this section.

3.2.2 DESCRIPTION

Provide all labor and equipment required for the installation of all valves. All valves shall be NACE type valves or equivalent. RETEC will supervise the installation of all valves.

3.2.3 CONSTRUCTION METHODS

Provide all labor and equipment for the installation of all valves as shown in the Contract Drawings. RETEC will provide all of the materials as listed in Schedules 2-1 through 2-2.

Schedule 2-1
Process Valves

Valve #		
1	1½"	Production line #2 control valve
2	1½"	Production line #1 throttle control valve
3		Vacant
4		Vacant
5	1½"	BS-2 bypass valve
6	½"	Acid drum shutoff valve
7		Vacant
8		Vacant
9		Vacant
10		Vacant
11		Vacant
12	2"	Tank 6 tar/iron discharge line shutoff and control valve
13		Vacant
14	1½"	Decant line check valve

15	1½"	Pump 6 check valve
16	1½"	Tar/iron discharge line shutoff and control valve
17	2"	Tank 2 discharge shutoff and control valve
18	1½"	Pump 7 control valve
19	2"	BS-6 bypass valve
20	1½"	Pump 3 check valve
21	½"	Caustic drum shutoff valve
22		Vacant
23		Vacant
24		Vacant
25	1½"	Filter 1 inlet shutoff and control valve
26	1½"	Filter 1 bypass line shutoff valve
27	1½"	Filter 1 outlet shutoff and control valve
28	1½"	Throttle control valve to the CA units
29	1½"	Filter 2 inlet shutoff and control valve
30	1½"	Filter 2 bypass line shutoff and control valve
31	1½"	Filter 2 outlet shutoff control valve
32	1½"	Filter 2 isolation valve
33	1½"	CA 1 inlet shutoff and control valve
34	1½"	Tank 3 inlet shutoff and control valve
35	2"	Tank 3 outlet shutoff and control valve
36	1½"	Pump 8 shutoff valve
37	1½"	Clean water discharge check valve
38	1½"	Boiler feed shutoff valve
39	4"	Boiler outlet control valve
40	4"	Boiler line check valve
41	2"	Boiler offgas line check valve
42		Vacant
43	2"	Injection line 1B drain control valve
44	2"	Injection wellhead 1B shutoff and control valve
45	2"	Injection line drain 1A control valve
46	2"	Injection wellhead 1A shutoff and control valve
47		Vacant
48	2"	Injection line drain 2B control valve
49	2"	Injection wellhead 2B shutoff and control valve

50	2"	Injection line 2A drain
51	2"	Injection wellhead 2A shutoff and control valve
52		Vacant
53	2"	Injection line 3B drain control valve
54	2"	Injection wellhead 3B shutoff and control valve
55	2"	Injection line 3A drain control valve
56	2"	Injection wellhead 3A shutoff and control valve
57	2"	Injection line 4B drain control valve
58	2"	Injection wellhead 4B shutoff and control valve
59	2"	Injection line 4A drain control valve
60	2"	Injection wellhead 4A shutoff and control valve
61		Vacant
62		Vacant
63	1½"	BS-2 bypass shutoff valve
64	1½"	BS-2 bypass shutoff valve
65		Vacant
66		Vacant
67		Vacant
68	2"	Tank 1 tar shutoff valve
69		Vacant
70		Vacant
71		Vacant
72		Vacant
73		Vacant
74		Vacant
75		Vacant
76		Vacant
77	2"	BS-6 bypass shutoff valve
78	2"	BS-6 bypass shutoff valve
79		Vacant
80	1/2"	Peroxide drum shutoff valve
81		Vacant
82		Vacant
83	2"	Vapor Phase Control Valve to CA-3
84	2"	Vapor Phase Check Valve

85	1½	Production Line #2 Check Valve
86	1½	Production Line #2 Throttle Control Valve
87	2"	Tank 2 Decant Shutoff Valve
88	1½	CA-2 Inlet Shutoff Valve
89	1½	Tar/Iron Discharge Check Valve
90	1½	Decant Line Shutoff Valve
91	2"	Tank 8 Tar/iron Shutoff Valve
92	2"	Pump 6 Tar/iron Shutoff Valve
93	1½	Storm Sump Capture Shutoff Valve
94	1½	Storm Sump Discharge Shutoff Valve
95	1½	Filter 3 Inlet Shutoff and Control Valve
96	1½	Filter 3 Bypass Valve
97	1½	Filter 3 Outlet Shutoff and Control Valve
98	1½	Storm Sump Check Valve
99	1½	Production Line #1 Check Valve

Process valves are described in further detail in Schedule 2-2.

Schedule 2-2
Process Valve Details

Valve #	Quantity	Description
44,46,49,51 54,56,58,60	8	2-inch diameter control/throttle valve, manual, globe type, threaded, Crane, Class 150, 250°F, 240 psi non-shock, or equivalent, Pipe Valve and Fitting Co, Denver, CO, phone # 303-289-5811
2, 28, 86	3	1½-inch diameter control/throttle valve manual, globe type, threaded, Crane, Class 150, 250°F, 240 psi non-shock, or equivalent, Pipe Valve and Fitting Co, Denver, CO, phone # 303-289-5811
43,45,48,50 53,55,57,59, 83	8	2-inch diameter gate valve, manual, welded, carbon steel, Max temp: 400^{0}F, VOGT, or equivalent, stock no. SW1211, IPS, phone # 401-847-1452

39	1	4-inch diameter gate valve, manual, welded, carbon steel, Max temp: 400°F, Crane, or equivalent, stock no. 47½ XUF, IPS, phone # 401-847-1452
83	1	2-inch diameter gate valve, manual, threaded, cast iron, max pressure: WOG: 225psi; steam: 150 psi, max temp: 450°F, or equivalent, stock no. 4602K18, McMaster-Carr, phone # 908-329-3200
36, 18	2	1½-inch diameter gate valve, manual, threaded, cast iron, max pressure: WOG: 225psi; steam: 150 psi, max temp: 450°F, or equivalent, stock no. 4602K21, McMaster-Carr, phone # 908-329-3200
12, 17, 19, 35, 68, 77, 78, 87, 91, 92	10	2-inch diameter ball valve, carbon steel, threaded, max pressure: WOG & steam: 150 psi, max temp: 450°F, or equivalent, stock no. 4632K25, McMaster-Carr, phone # 908-329-3200
1, 5, 16, 25, 26, 27 29, 30, 31, 32, 33, 34, 38, 63, 64, 88, 90, 92, 93, 94, 95, 96, 97	23	1½-inch diameter ball valve, carbon steel threaded, max pressure: WOG & steam: 150 psi, max temp: 450°F, or equivalent, stock no. 4632K25, McMaster-Carr, phone # 908-329-3200
40	1	4-inch diameter welded check valve Strataflo No. 300, Strataflo Products, Inc., Ft. Wayne, IN, Phone # 219-744-3313, or equivalent.
21,80	2	½-inch diameter threaded PVC check valve.
6	1	½-inch diameter threaded kynar check valve.
14, 15, 20, 37 85, 89, 98, 99	8	1½-inch diameter threaded check valve, Strataflo No. 400, Strataflo Products, Inc., Ft. Wayne, IN, Phone # 219-744-3313, or equivalent.
41, 90	2	2-inch diameter threaded check valve, Strataflo No. 400, Strataflo Products, Inc., Ft. Wayne, IN, Phone # 219-744-3313, or equivalent.

3.2.4 METHOD OF MEASUREMENT

All valve installation will be measured on a lump sum basis. The Contractor shall submit a lump sum price for the installation of all valves.

3.2.5 BASIS OF PAYMENT

Work under this item, shall be paid at the contract price for "Valve Installation", which should include the cost of furnishing all labor, equipment, tools, and incidentals required for completion of the work as per this section.

3.3.1 GENERAL

The General Conditions and Special Provisions are made a part of this section.

3.3.2 DESCRIPTION

Provide all labor and equipment required for the installation of all tanks. Tanks are divided into three categories; process tanks, chemical tanks and water storage tanks. RETEC will supervise the installation and connections of all tanks.

3.3.3 CONSTRUCTION METHODS

A. Provide all labor and equipment for the installation of all tanks as shown in the Contract Drawings. RETEC will provide all of the tank materials as listed in Schedule 3-1.

Schedule 3-1
Process Tanks

1 10,027 gallon production tank, carbon steel, 0.25-inch wall thickness, 8-foot diameter, 26'- 8" foot height, manway 2-inch bottom inlet, 2-inch bottom outlet, 2-inch bottom outlet, 2-inch top outlet, 2-inch drain, top vent.

2 6,017 gallon oil storage tank, carbon steel, 0.25-inch wall thickness, 8-foot diameter, 16-feet height, manway 2-inch bottom inlet, 2-inch bottom outlet, 2-inch bottom outlet, top vent.

3 1,000 gallon flow equalization tank, polyethylene, 65-inch diameter, 86½-inches long, 10-inch manway, 2-inch bottom inlet, 2-inch bottom outlet, 2-inch bottom outlet, Snyder Industries, Inc., Industrials Products Division, Lincoln, NE, phone (402) 467-5221, or equivalent.

6 5,000 gallon inclined plate clarifier, carbon steel, 18-inch manway, one 4-inch feed inlet, 2-inch water outlet, 2-inch water outlet, one 2-inch sludge outlet, one 3-inch fluid level device opening, one 2-inch vent, mixer, flocculant addition chamber.

8 1,000 gallon water holding tank, carbon steel, 0.25-inch wall thickness, 18-inch manway, one 6-inch feed inlet, 2-inch bottom outlet, 2-inch bottom outlet, one 3-inch level device opening, one 2-inch vent.

NOTE: Addition of appropriate taps to tanks may be required.

B. The Contractor shall install connectors within the tanks for all level measuring devices, level switches, and thermocouples as shown in the Contract Drawings.

C. Additional tank details are presented in the Vessel Specification Sheets.

3.3.4 METHOD OF MEASUREMENT

All tank installation activities will be measured on a lump sum basis. The Contractor shall submit a lump sum price for the installation of all tanks.

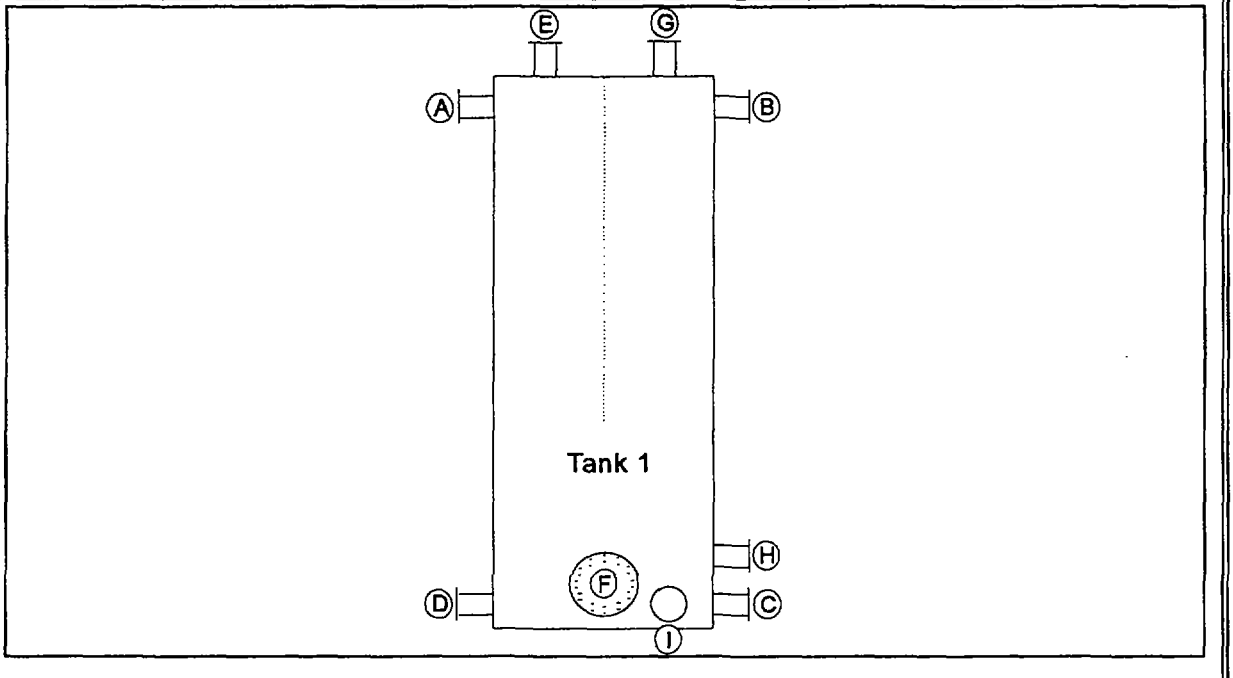
3.3.5 BASIS OF PAYMENT

Work under this item shall be paid at the contract price for "Tank Installation", which should include the cost of furnishing all labor, equipment, tools, and incidentals required for completion of the work as per this section.

REMEDIATION TECHNOLOGIES, INC.

VESSEL SPECIFICATION SHEET

Project Name: PP&L		Project No: 3-1612	Tag No: T-1
Location: Columbia, PA		Rev Date:	Rev No:
Service: Water with coal tar and sulfuric acid		Reason for Rev:	
Objective: Separate coal tar and water [1]		Prpd by: Carl Laquidara	Ckd by:
No. Req'd: 1	Model:	Manufacturer:	Pages: 1



Size: [5]	Orientation: Vertical		Wall Thickness: 0.375 min [2]			Capacity: 10,000 gallons		
DESIGN:	Pressure	Temp.	NOZZLES	Mark	Size	Qty	Rating	Type
Operating	Atm.	70°F	Feed Inlet	A	2"	1	150#	RF
Design	Atm.	140°F	Water Outlet	B	2"	1	150#	RF
Codes			Tar outlet	C	2"	1	150#	RF
COATINGS			Drain	D	2"	1	150#	RF
Exterior			Level	E	3"	1	150#	RF
Interior	epoxy(na if ss)		Manway	F	18x18	1	Bolted Plate	
ACCEPTANCE:			Vent	G	2"	1	150#	RF
Hydro Test			Sump	H	2"	1	150#	RF
Witnesses Test?			Vacant	I	2"	1	150#	RF
MATERIAL	Carbon Steel or SS							
No. Lifting Lugs: 4	same as tank material							
Legs: 4	same as tank material							

COMMENTS

[1] Heated water with emmulsified coal tar

[2] Paint is unnecessary and wall thickness of 0.25" for substituting 304SS or 420SS

[3] Pricing to be FOB Columbia, PA

[4] Bids must include construction schedule: approval drawings; material orders; fabrication; and testing.

[5] 30 GPM, influent

[6] Include flow under baffle.

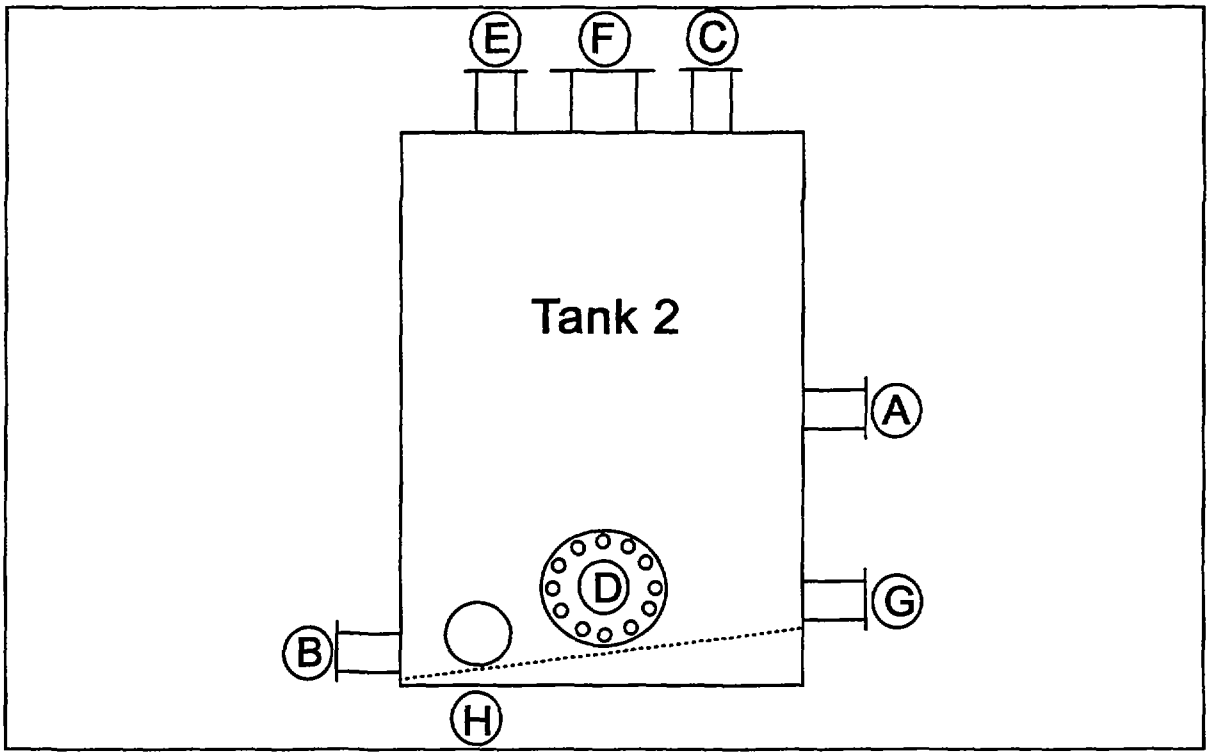
File Name: claquida\T-1.spc

Print Date: August 18, 1995

REMEDIATION TECHNOLOGIES, INC.

VESSEL SPECIFICATION SHEET

Project Name: PP&L	Project No: 3-1612	Tag No: T-2
Location: Columbia, PA	Rev Date:	Rev No:
Service:	Reason for Rev:	
Objective: Store coal tar and iron hydroxide	Prpd by: Carl Laquidara	Ckd by:
No. Req'd: 1 / Model:	Manufacturer:	Pages: 1



Size: [5]	Orientation: Vertical		Wall Thickness: 0.375 min [2]			Capacity: 6000 gallons		
DESIGN:	Pressure	Temp.	NOZZLES	Mark	Size	Qty	Rating	Type
Operating	Atm.	70°F	Feed Inlet	A	2"	1	150#	RF
Design	Atm.	140°F						
Codes			Sludge Outlet	B	2"	1	150#	RF
COATINGS								
Exterior			Level	C	3"	1	150#	RF
Interior	epoxy(na if ss)		Manway	D	18x18	1	Bolted Plate	
ACCEPTANCE:			Vent	E	2"	1	150#	RF
Hydro Test			Heater	F	8"	1	150#	RF
Witnesses Test?			Vacant	G	2"	1	150#	RF
MATERIAL	Carbon steel or ss		Drain	H	2"	1	150#	RF
No. Lifting Lugs: 4	same as tank material							
Legs: 4	same as tank material							

COMMENTS

[1] Paint is unnecessary and wall thickness of 0.25" for substituting 304SS or 420SS

[2] Pricing to be FOB Columbia, PA

[3] Bids must include construction schedule: approval drawings; material orders; fabrication; and testing.

[4] By vendor - sloped bottom - minimize foot print.

[5] Insulate for outdoor service.

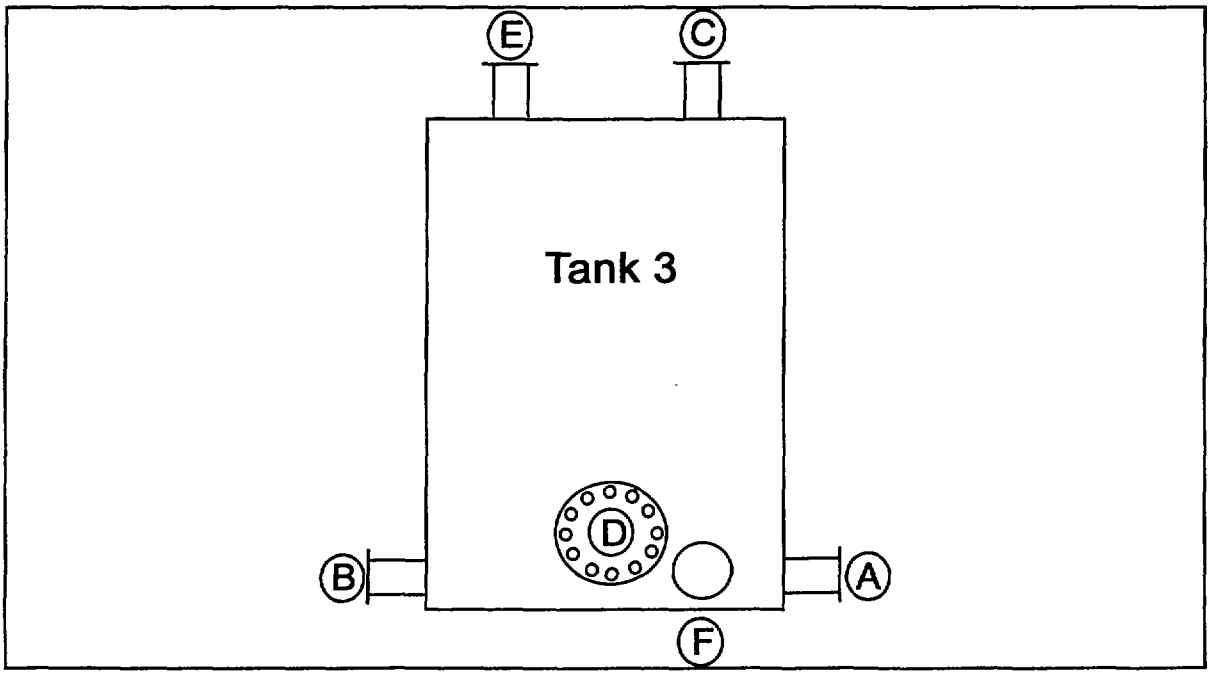
File Name: claquida\T-2.spc

Print Date: August 17, 1995

REMEDIATION TECHNOLOGIES, INC.

VESSEL SPECIFICATION SHEET

Project Name: PP&L	Project No: 3-1612	Tag No: T-3
Location: Columbia, PA	Rev Date:	Rev No:
Service: Water Holding Tank	Reason for Rev:	
Objective: Store clean water	Prpd by: Carl Laquidara	Ckd by:
No. Req'd: 1 / Model:	Manufacturer:	Pages: 1



Size: [1]	Orientation: Vertical		Wall Thickness: [1]			Capacity: 1,000 gallons		
DESIGN:	Pressure	Temp.	NOZZLES	Mark	Size	Qty	Rating	Type
Operating	Atm.	70°F	Feed Inlet	A	2"	1		RF
Design	Atm.	140°F	Water Outlet	B	2"	1		RF
Codes								
COATINGS								
Exterior			Level	C	3"	2		RF
Interior			Manway	D	18x18	1	Bolted Plate	
ACCEPTANCE:			Vent	E	2"	1		RF
Hydro Test			Drain	F	2"	1		RF
Witnesses Test?								
MATERIAL	polyethylene							
No. Lifting Lugs: [1]	same as tank material							
Legs	same as tank material							

COMMENTS
[1] By vendor
[2] Pricing to be FOB Columbia, PA

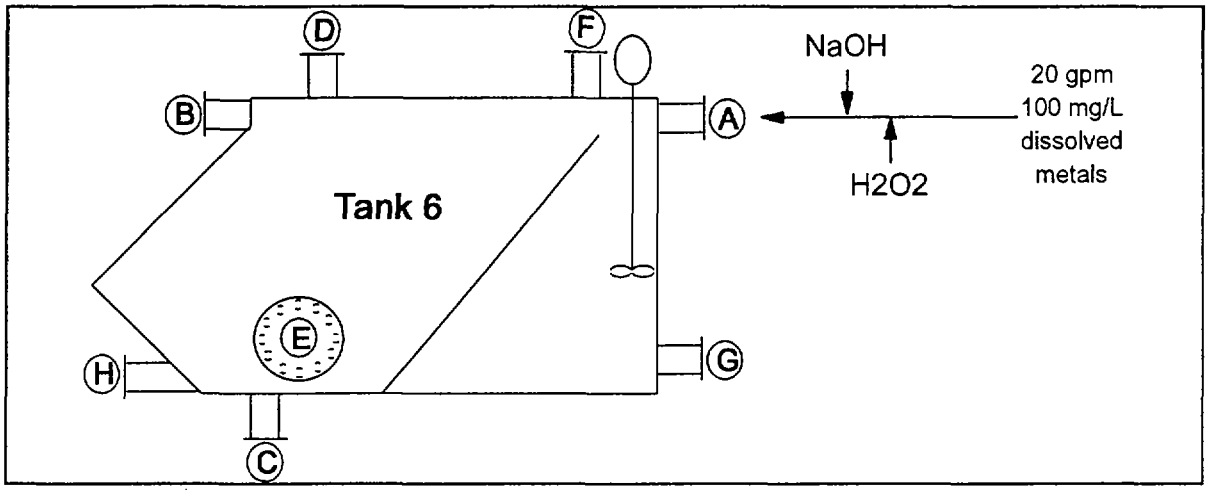
File Name: claquida\t-3.spe

Print Date: August 17, 1995

REMEDIATION TECHNOLOGIES, INC.

VESSEL SPECIFICATION SHEET

Project Name: PP&L		Project No: 3-1612	Tag No: T-6
Location: Columbia, PA		Rev Date:	Rev No:
Service: Water with metal hydroxide sludge		Reason for Rev:	
Objective: Gravity settle suspended solids [1]		Prpd by: Carl Laquidara	Ckd by:
No. Req'd: 1	Model:	Manufacturer:	Pages: 1



Size: [6] Min footprint	Orientation: Vertical		Wall Thickness:[6]			Capacity: 5000 Gal		
DESIGN:	Pressure	Temp.	NOZZLES	Mark	Size	Qty	Rating	Type
Operating	Atm.	70°F	Feed Inlet	A	4"	1	150#	RF
Design	Atm.	140°F	Water Outlet	B	2"	1	150#	RF
Codes			Sludge Outlet	C	2"	1	150#	RF
COATINGS								
Exterior			Level	D	3"	1	150#	RF
Interior	epoxy		Manway	E	18x18	1	Bolted Plate	
ACCEPTANCE:			Vent	F	2"	1	150#	RF
Hydro Test			Vacant	G	2"	1	150#	RF
Witnesses Test?			Drain	H	2"	1	150#	RF
MATERIAL	[2]							
No. Lifting Lugs: [6]	same as tank material							
Legs: [6]	same as tank material							

COMMENTS

[1] Water with trace organics and suspended metals,30 GPM,100 mg/l precipitated metals.

[2] Materials of construction compatable w/ chemicals of interest.

[3] Pricing to be FOB Columbia, PA

[4] Bids must include construction schedule: approval drawings; material orders; fabrication; and testing.

[5] Include provisions for addition of polymer flocculation chamber.

[6] By vendor

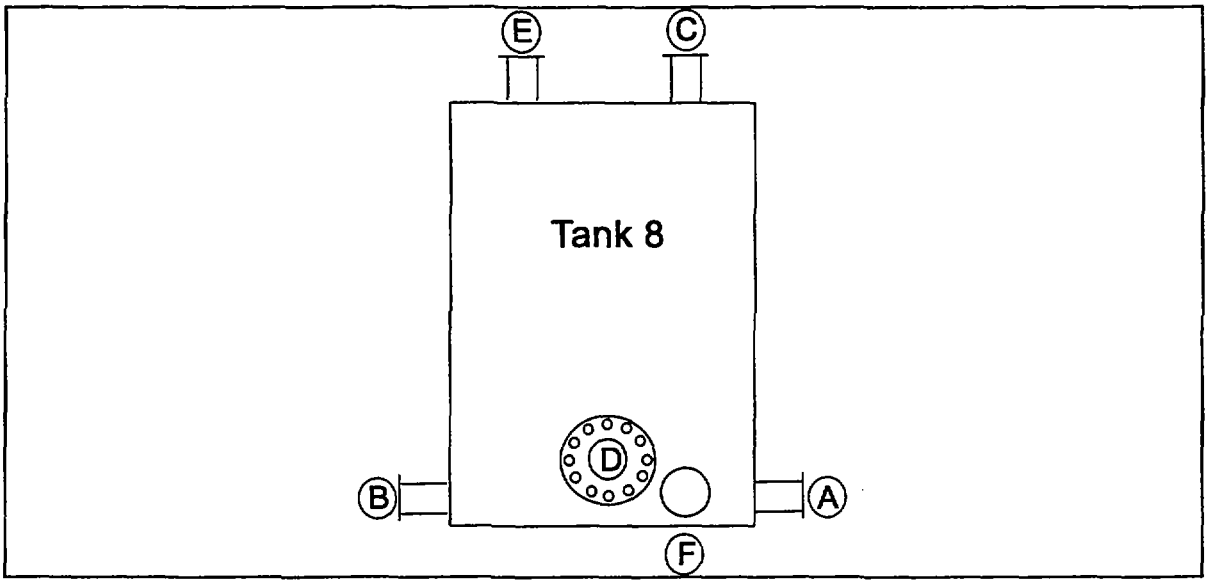
File Name: claquida\T-6.spc

Print Date: August 18, 1995

REMEDIATION TECHNOLOGIES, INC.

VESSEL SPECIFICATION SHEET

Project Name: PP&L		Project No: 3-1612	Tag No: T-8
Location: Columbia, PA		Rev Date:	Rev No:
Service: Water Holding Tank		Reason for Rev:	
Objective: Store clean water		Prpd by: Carl Laquidara	Ckd by:
No. Req'd: 1	Model:	Manufacturer:	Pages: 1



Size: [1]	Orientation: Vertical		Wall Thickness: [1]			Capacity: 1,000 gallons		
DESIGN:	Pressure	Temp.	NOZZLES	Mark	Size	Qty	Rating	Type
Operating	Atm.	70°F	Feed Inlet	A	6"	1		RF
Design	Atm.	140°F	Water Outlet	B	2"	1		RF
Codes								
COATINGS								
Exterior			Level	C	3"	2		RF
Interior			Manway	D	18x18	1	Bolted Plate	
ACCEPTANCE:			Vent	E	2"	1		RF
Hydro Test			Drain	F	2"	1		RF
Witnesses Test?								
MATERIAL	polyethylene							
No. Lifting Lugs: [1]	same as tank material							
Legs	same as tank material							

COMMENTS
[1] By vendor
[2] Pricing to be FOB Columbia, PA

File Name: claquida\t-8.spe

Print Date: August 17, 1995

Schedule 8-2
Water Level Sensor Details

LSL-T3 LSH-T1 LSH-T2 LSH-T3 LSHH-T3 LSH-T8 LSH-P12	7	Mercury-switch actuated liquid level tank controllers, narrow angle, single pole double throw, Magnetek model # 7010-W-4-C-20, E&M Sales, Inc., Englewood, CO phone # 303-761-6202
LSL-1 LSH-1 LSL-2 LSH-2	4	Wire suspension electrodes, for well fluid level control, *Magnetek model # 6013-W5, E&M Sales, Inc.,* Englewood, CO phone # 303-761-6202
LSL-1 LSH-1 LSL-2 LSH-2	4	2" NPT, 3 electrode, holders for well fluid level cable pass through, *Magnetek model # 6012-E3-CI-EP1, E&M Sales, Inc.,* Englewood, CO phone # 303-761-6202
LI-T1, LI-T2, LI-T6	3	Tank fluid level indicator with single float, stainless steel cable and brackets, and mechanical pointer on a graduated scale.
LE/LT/LC-T8	1	Level, element, transmitter and controller to measure tank depth and Transmit analog signal to variable frequency drive.

3.8.3 METHOD OF MEASUREMENT

All water level sensor installation will be measured on a lump sum basis. The Contractor shall submit a lump sum price for the installation of all water level sensors.

3.8.4 BASIS OF PAYMENT

Work under this item, shall be paid at the contract price for "Water Level Sensor Installation", which should include the cost of furnishing all labor, equipment, tools, and incidentals required for completion of the work as per this section.

3.9.1 GENERAL

The General Conditions and Special Provisions are made a part of this section.

3.9.2 DESCRIPTION

Provide all labor and equipment necessary for the installation of all pressure gauges and switches throughout the treatment system as shown in the Contract Drawings. All pressure gages and switches require ¼ shut off valves. RETEC will provide all pressure gauges, switches and valves.

The specifications for the pressure gauges are presented in Schedules 9-1 and 9-2.

Schedule 9-1
Pressure Gauges

Pressure Gauge #	
1	Injection wellhead pressure, 0-100 psig
2	Injection wellhead pressure, 0-100 psig
3	Injection wellhead pressure, 0-100 psig
4	Injection wellhead pressure, 0-100 psig
5	Injection wellhead pressure, 0-100 psig
6	Injection wellhead pressure, 0-100 psig
7	Injection wellhead pressure, 0-100 psig
8	Injection wellhead pressure, 0-100 psig
9	Boiler outlet pressure, 0-100 psig
10	Boiler inlet pressure, 0-100 psig
11	Filter 2 inlet pressure, 0-100 psig
12	Filter 2 outlet pressure, 0-100 psig
13	Filter 1 inlet pressure, 0-100 psig

Schedule 9-2
Pressure Gauge Details

Press. Gauge #	*Qty.*	*Description*
1-13	13	Pressure Gauge, 0-100 psig, liquid filled

3.9.3 METHOD OF MEASUREMENT

All pressure gauge installation will be measured on a lump sum basis. The Contractor shall submit a lump sum price for the installation of all pressure gauges.

3.9.4 BASIS OF PAYMENT

Work under this item, shall be paid at the contract price for "Pressure Gauge Installation", which should include the cost of furnishing all labor, equipment, tools, and incidentals required for completion of the work as per this section.

3.10.1 GENERAL

The General Conditions and Special Provisions are made a part of this section.

3.10.2 DESCRIPTION

Basket stainers, bag filters, and static mixers will be installed throughout the system. RETEC will provide all stainers, filters, and mixers and will supervise installation.

3.10.3 MATERIALS

Schedule 10-1
Strainers

BS-2	Basket strainer for production well #1 pump line. 1½" threaded, cast iron, McMaster Carr 100 part #4454K47, or equivalent.
BS-6	Basket strainer for water line. 2" threaded, cast iron, McMaster Carr 100 part #4454K47, or equivalent.

Schedule 10-2
Bag Filters

F-01 Bag filter and housing for water recycle line. 6" diameter housing, 30" long, 1½" threaded inlet and outlet, carbon steel, McMaster Carr 100 part #5168K345, or equivalent. 15 micron bag, 5.6" x 32", McMaster Carr 100 part #5162K62, or equivalent.

F-02 Bag filter and housing for water discharge line. 6" diameter housing, 30" long, 1½" threaded inlet and outlet, carbon steel, McMaster Carr 100 part # 5168K345, or equivalent. 5 micron bag, 5.6" x 32", McMaster Carr 100 part #5162K61, or equivalent.

F-03 Bag filter and housing for water discharge line. 6" diameter housing, 30" long, 1½" threaded inlet and outlet, carbon steel, McMaster Carr 100 part # 5168K345, or equivalent. 1 micron bag, 5.6" x 32".

Schedule 10-3
Mixers

M-1, 1½-inch, 2 element, stainless steel static mixers, Komax, Wilmington, CA, Model # M020-040-0-002-22, phone # (310) 830-4320.

3.10.4 METHOD OF MEASUREMENT

All strainer and filter installation will be measured on a lump sum basis. The contractor shall submit a lump sum price for the installation of all strainers, filters, and mixers.

3.10.5 BASIS OF PAYMENT

Work under this item, shall be paid at the contract price for "Strainer, Filter and Mixer Installation", which should include the cost of furnishing all labor, equipment, tools, and incidentals required for completion of the work as per this section.

DIVISION 4

ELECTRICAL SPECIFICATIONS

4.0.1 GENERAL

The General Conditions and Special Provisions are made a part of this section.

4.0.2 DESCRIPTION

Provide all labor, materials, and equipment required for the wiring of the entire site. The main feeders will be installed by PP&L. All electrical motors will require power feeds as well as the signal wires depicted on the P&ID. RETEC will supervise the installation of all wiring.

4.0.3 MATERIALS

A. NEMA boxes of sufficient size and quantity. See attached drawings.

B. Aluminum conduit of sufficient size and quantity. See attached drawings.

C. Circuit breakers, motor starters, fuses, hand switches, overload devices, and all other electrical equipment depicted on the attached drawings. Motors, instrumentation, and level switches will be provided by RETEC.

D. Copper wiring of sufficient size and quantity. See attached drawings.

E. Four 120 volt power outlets evenly spaced within the perimeter of the tank farm.

G. Two outdoor high intensity lights. One on each end of the tank farm.

H. All circuits to be GFI protected.

4.0.4 CONSTRUCTION METHODS

Provide all labor and equipment for the installation of all wiring, conduit, junction boxes, and circuit boxes as shown in the contract drawings. Work to be in compliance with all applicable codes.

4.0.4.1 POWER FROM MAIN PANEL

The Contractor shall provide labor and materials to run power from the main panel to the powered devices located at the relief holder, the gas holder, and within the tank farm. This power source will terminate in a junction box.

4.0.4.2 WIRING CONDUIT

The Contractor shall install supports for the wiring conduit. All conduits shall be run over head in areas likely to have pedestrian traffic. Conduits will drop down to terminate at the equipment or within a NEMA box. Supports shall be placed according to all applicable and appropriate standards except when existing piping supports are used that exceed those standards. Instrumentation and Power wiring conduit shall be permanently and clearly marked every ten feet as to the type of material, unless visually identifiable, and a description of the unit area or equipment being serviced by the conduit.

4.0.5 METHOD OF MEASUREMENT

All electrical wiring activities and gas line installation activities will be measured on a lump sum basis. The Contractor shall submit a lump sum price for the performance of the work in accordance with this section.

4.0.6 BASIS OF PAYMENT

Work under this item, shall be paid at the contract price for "Wiring", which should include the cost of furnishing all labor, equipment, tools, and incidentals required for completion of the work as per this section.

4.1.1 GENERAL

The General Conditions and Special Provisions are made a part of this section.

4.1.2 DESCRIPTION

The Test System Logic for the operation of the CROW™ system will proceed as follows:

IF	THEN
LSL-1 Indicates a low level	Shuts off Pump PW-1
LSH-1 Indicates a high level	Shuts off Pumps: PW-1, PW-2, P-3, P-10, P-12
LSH-T1 Indicates a high level	Shuts off Pumps: PW-1, PW-2, P-3, P-10, P-12
LSH-T2 Indicates a high level	Shuts off Pump P-6
LSL-T3 Indicates a low level	Shuts off Pump P-8
LSH-T3 Indicates a high level	Activated Pump P-8
LSHH-T3 Indicates a high level	Shuts off Pumps: PW-1, PW-2, P-3, P-10, P-12
LSL-2 Indicates a low level	Shuts off pump PW-2
LSH-2 Indicates a high level	Activates pump PW-2
LSH-T8 Indicates a high level	Shuts off Pumps: PW-1, PW-2, P-3, P-10, P-12
LSH-P12 Indicates a high level	Shuts off Pumps: PW-1, PW-2, P-3, P-10, P-12

APPENDIX A

CONSTRUCTION STANDARDS

Designation: C 39 – 86ε1

AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 Race St. Philadelphia, Pa 19103
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If not listed in the current combined index, will appear in the next edition.

American Association State
Highway and Transportation Officials Standard
AASHTO No.: T 22

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens[1]

This standard is issued under the fixed designation C 39; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This method has been approved for use by agencies of the Department of Defense and for listing in the DoD Index of Specifications and Standards.

ε1 NOTE—Editorial changes were made throughout in June 1986.

1. Scope

1.1 This test method covers determination of compressive strength of cylindrical concrete specimens such as molded cylinders and drilled cores. It is limited to concrete having a unit weight in excess of 50 lb/ft^3 (800 kg/m^3).

1.2 The values stated in inch-pound units are to be regarded as the standard.

1.3 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 31 Practice for Making and Curing Concrete Test Specimens in the Field[2]

C 42 Test Methods for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete[2]

C 192 Practice for Making and Curing Concrete Test Specimens in the Laboratory[2]

C 617 Practice for Capping Cylindrical Concrete Specimens[2]

C 873 Test Method for Compressive Strength of Concrete Cylinders Cast in Place in Cylindrical Molds[2]

E 4 Practices for Load Verification of Testing Machines[2]

E 74 Practice for Calibration of Force-Measuring Instruments for Verifying the Load Indication of Testing Machines[3]

2.2 *Other:*

Manual of Aggregate and Concrete Testing[2]

3. Summary of Method

3.1 This test method consists of applying a compressive axial load to molded cylinders or cores at a rate which is within a prescribed range until failure occurs. The compressive strength of the specimen is calculated by dividing the maximum load attained during the test by the cross-sectional area of the specimen.

4. Significance and Use

4.1 Care must be exercised in the interpretation of the significance of compressive strength determinations by this test method since strength is not a fundamental or intrinsic property of concrete made from given materials. Values obtained will depend on the size and shape of the specimen, batching, mixing procedures, the methods of sampling, molding, and fabrication and the age, temperature, and moisture conditions during curing.

4.2 This test method may be used to determine compressive strength of cylindrical specimens prepared and cured in accordance with Methods C 31, C 42, and C 192, Practice C 617, and Test Method C 873.

4.3 The results of this test method may be used as a basis for quality control of concrete proportioning, mixing, and placing operations; determination of compliance with specifications; control for evaluating effectiveness of admixtures and similar uses.

5. Apparatus

5.1 *Testing Machine*—The testing machine shall be of a type having sufficient capacity and capable of providing the rates of loading prescribed in 7.5.

5.1.1 Verification of calibration of the testing machines in accordance with Practices E 4 is required under the following conditions:

5.1.1.1 After an elapsed interval since the previous verification of 18 months maximum, but preferably after an interval of 12 months,

5.1.1.2 On original installation or relocation of the machine,

5.1.1.3 Immediately after making repairs or adjustments which may in any way affect the operation of the weighing system or the values displayed, except for zero adjustments that compensate for the weight of tooling, or specimen, or both, or

5.1.1.4 Whenever there is reason to doubt the accuracy of the results, without regard to the time interval since the last verification.

5.1.2 *Design*—The design of the machine must include the following features:

5.1.2.1 The machine must be power operated and must apply the load continuously rather than intermittently, and

[1] This test method is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.03.01 on Methods of Testing Concrete for Strength.

Current edition approved March 27, 1986. Published May 1986. Originally published as C 39 – 21 T. Last previous edition C 39 – 84.

[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 03.01.

without shock. If it has only one loading rate (meeting the requirements of 7.5), it must be provided with a supplemental means for loading at a rate suitable for verification. This supplemental means of loading may be power or hand operated.

5.1.2.2 The space provided for test specimens shall be large enough to accommodate, in a readable position, an elastic calibration device which is of sufficient capacity to cover the potential loading range of the testing machine and which complies with the requirements of Practices E 74.

NOTE 1—The type of elastic calibration device most generally available and most commonly used for this purpose is the circular proving ring.

5.1.3 *Accuracy*—The accuracy of the testing machine shall be in accordance with the following provisions:

5.1.3.1 The percentage of error for the loads within the proposed range of use of the testing machine shall not exceed ±1.0 % of the indicated load.

5.1.3.2 The accuracy of the testing machine shall be verified by applying five test loads in four approximately equal increments in ascending order. The difference between any two successive test loads shall not exceed one third of the difference between the maximum and minimum test loads.

5.1.3.3 The test load as indicated by the testing machine and the applied load computed from the readings of the verification device shall be recorded at each test point. Calculate the error, E, and the percentage of error, E_p, for each point from these data as follows:

$$E = A - B$$
$$E_p = 100(A - B)/B$$

where:

A = load, lbf (or N) indicated by the machine being verified, and

B = applied load, lbf (or N) as determined by the calibrating device.

5.1.3.4 The report on the verification of a testing machine shall state within what loading range it was found to conform to specification requirements rather than reporting a blanket acceptance or rejection. In no case shall the loading range be stated as including loads below the value which is 100 times the smallest change of load that can be estimated on the load-indicating mechanism of the testing machine or loads within that portion of the range below 10 % of the maximum range capacity.

5.1.3.5 In no case shall the loading range be stated as including loads outside the range of loads applied during the verification test.

5.1.3.6 The indicated load of a testing machine shall not be corrected either by calculation or by the use of a calibration diagram to obtain values within the required permissible variation.

5.2 The testing machine shall be equipped with two steel bearing blocks with hardened faces (Note 2), one of which is a spherically seated block that will bear on the upper surface of the specimen, and the other a solid block on which the specimen shall rest. Bearing faces of the blocks shall have a minimum dimension at least 3 % greater than the diameter of the specimen to be tested. Except for the concentric circles described below, the bearing faces shall not depart from a plane by more than 0.001 in. (0.025 mm) in any 6 in. (152 mm) of blocks 6 in. in diameter or larger, or by more than 0.001 in. in the diameter of any smaller block; and new blocks shall be manufactured within one half of this tolerance. When the diameter of the bearing face of the spherically seated block exceeds the diameter of the specimen by more than ½ in. (13 mm), concentric circles not more than 1/32 in. (0.8 mm) deep and not more than 3/64 in. (1.2 mm) wide shall be inscribed to facilitate proper centering.

NOTE 2—It is desirable that the bearing faces of blocks used for compression testing of concrete have a Rockwell hardness of not less than 55 HRC.

5.2.1 Bottom bearing blocks shall conform to the following requirements:

5.2.1.1 The bottom bearing block is specified for the purpose of providing a readily machinable surface for maintenance of the specified surface conditions (Note 3). The top and bottom surfaces shall be parallel to each other. The block may be fastened to the platen of the testing machine. Its least horizontal dimension shall be at least 3 % greater than the diameter of the specimen to be tested. Concentric circles as described in 5.2 are optional on the bottom block.

5.2.1.2 Final centering must be made with reference to the upper spherical block. When the lower bearing block is used to assist in centering the specimen, the center of the concentric rings, when provided, or the center of the block itself must be directly below the center of the spherical head. Provision shall be made on the platen of the machine to assure such a position.

5.2.1.3 The bottom bearing block shall be at least 1 in. (25 mm) thick when new, and at least 0.9 in. (22.5 mm) thick after any resurfacing operations.

NOTE 3—If the testing machine is so designed that the platen itself can be readily maintained in the specified surface condition, a bottom block is not required.

5.2.2 The spherically seated bearing block shall conform to the following requirements:

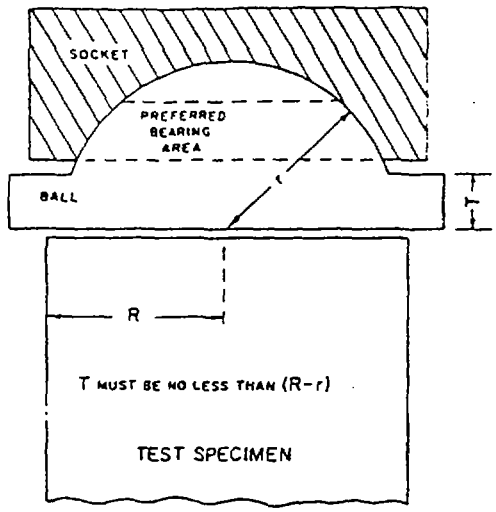
5.2.2.1 The maximum diameter of the bearing face of the suspended spherically seated block shall not exceed the values given below:

Diameter of Test Specimens, in. (mm)	Maximum Diameter of Bearing Face, in. (mm)
2(51)	4(102)
3(76)	5(127)
4(102)	6½(165)
6(152)	10(254)
8(203)	11(279)

NOTE 4—Square bearing faces are permissible, provided the diameter of the largest possible inscribed circle does not exceed the above diameter.

5.2.2.2 The center of the sphere shall coincide with the surface of the bearing face within a tolerance of ±5 % of the radius of the sphere. The diameter of the sphere shall be at least 75 % of the diameter of the specimen to be tested.

5.2.2.3 The ball and the socket must be so designed by the manufacturer that the steel in the contact area does not permanently deform under repeated use, with loads up to 12 000 psi (82.7 MPa) on the test specimen.



NOTE—Provision shall be made for holding the ball in the socket and for holding the entire unit in the testing machine.

FIG. 1 Schematic Sketch of a Typical Spherical Bearing Block

NOTE 5—The preferred contact area is in the form of a ... (described as preferred "bearing" area) as shown on Fig. 1.

5.2.2.4 The curved surfaces of the socket and of the spherical portion shall be kept clean and shall be lubricated with a petroleum-type oil such as conventional motor oil, not with a pressure type grease. After contacting the specimen and application of small initial load, further tilting of the spherically seated block is not intended and is undesirable.

5.2.2.5 If the radius of the sphere is smaller than the radius of the largest specimen to be tested, the portion of the bearing face extending beyond the sphere shall have a thickness not less than the difference between the radius of the sphere and radius of the specimen. The least dimension of the bearing face shall be at least as great as the diameter of the sphere (see Fig. 1).

5.2.2.6 The movable portion of the bearing block shall be held closely in the spherical seat, but the design shall be such that the bearing face can be rotated freely and tilted at least 4° in any direction.

5.3 *Load Indication:*

5.3.1 If the load of a compression machine used in concrete testing is registered on a dial, the dial shall be provided with a graduated scale that can be read to at least the nearest 0.1 % of the full scale load (Note 6). The dial shall be readable within 1 % of the indicated load at any given load level within the loading range. In no case shall the loading range of a dial be considered to include loads below the value that is 100 times the smallest change of load that can be read on the scale. The scale shall be provided with a graduation line equal to zero and so numbered. The dial pointer shall be of sufficient length to reach the graduation marks; the width of the end of the pointer shall not exceed the clear distance between the smallest graduations. Each dial shall be equipped with a zero adjustment that is easily accessible from the outside of the dial case, and with a suitable device that at all times until reset, will indicate to within 1 % accuracy the maximum load applied to the specimen.

NOTE 6—As close as can reasonably be read is considered to be 1/50 in. (0.5 mm) along the arc described by the end of the pointer. Also, one half of a scale interval is about as close as can reasonably be read when the spacing on the load indicating mechanism is between 1/25 in. (1 mm) and 1/16 in. (1.6 mm). When the spacing is between 1/16 in. and 1/8 in. (3.2 mm), one third of a scale interval can be read with reasonable certainty. When the spacing is 1/8 in. or more, one fourth of a scale interval can be read with reasonable certainty.

5.3.2 If the testing machine load is indicated in digital form, the numerical display must be large enough to be easily read. The numerical increment must be equal to or less than 0.10 % of the full scale load of a given loading range. In no case shall the verified loading range include loads less than the minimum numerical increment multiplied by 100. The accuracy of the indicated load must be within 1.0 % for any value displayed within the verified loading range. Provision must be made for adjusting to indicate true zero at zero load. There shall be provided a maximum load indicator that at all times until reset will indicate within 1 % system accuracy the maximum load applied to the specimen.

6. Specimens

6.1 Specimens shall not be tested if any individual diameter of a cylinder differs from any other diameter of the same cylinder by more than 2 %.

NOTE 7—This may occur when single use molds are damaged or deformed during shipment, when flexible single use molds are deformed during molding or when a core drill deflects or shifts during drilling.

6.2 Neither end of compressive test specimens when tested shall depart from perpendicularity to the axis by more than 0.5° (approximately equivalent to 1/8 in. in 12 in. (3 mm in 300 mm)). The ends of compression test specimens that are not plane within 0.002 in. (0.050 mm) shall be capped in accordance with Practice C 617 or they may be sawed or ground to meet that tolerance. The diameter used for calculating the cross-sectional area of the test specimen shall be determined to the nearest 0.01 in. (0.25 mm) by averaging two diameters measured at right angles to each other at about midheight of the specimen.

6.3 The number of individual cylinders measured for determination of average diameter may be reduced to one for each ten specimens or three specimens per day, whichever is greater, if all cylinders are known to have been made from a single lot of reusable or single-use molds which consistently produce specimens with average diameters within a range of 0.02 in. (0.51 mm). When the average diameters do not fall within the range of 0.02 in. or when the cylinders are not made from a single lot of molds, each cylinder tested must be measured and the value used in calculation of the unit compressive strength of that specimen. When the diameters are measured at the reduced frequency, the cross-sectional areas of all cylinders tested on that day shall be computed from the average of the diameters of the three or more cylinders representing the group tested that day.

6.4 The length shall be measured to the nearest 0.05 *D* when the length to diameter ratio is less than 1.8, or more than 2.2, or when the volume of the cylinder is determined from measured dimensions.

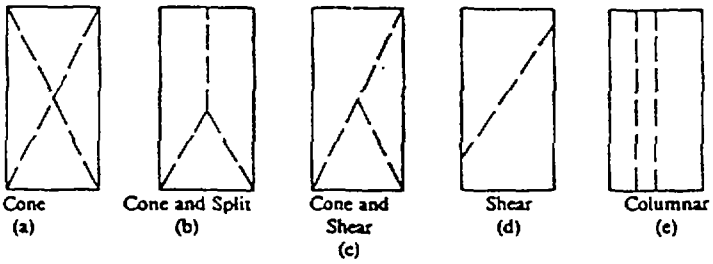


FIG. 2 Sketches of Types of Fracture

7. Procedure

7.1 Compression tests of moist-cured specimens shall be made as soon as practicable after removal from moist storage.

7.2 Test specimens shall be kept moist by any convenient method during the period between removal from moist storage and testing. They shall be tested in the moist condition.

7.3 All test specimens for a given test age shall be broken within the permissible time tolerances prescribed as follows:

Test Age	Permissible Tolerance
24 h	± 0.5 h or 2.1 %
3 days	2 h or 2.8 %
7 days	6 h or 3.6 %
28 days	20 h or 3.0 %
90 days	2 days 2.2 %

7.4 *Placing the Specimen*—Place the plain (lower) bearing block, with its hardened face up, on the table or platen of the testing machine directly under the spherically seated (upper) bearing block. Wipe clean the bearing faces of the upper and lower bearing blocks and of the test specimen and place the test specimen on the lower bearing block. Carefully align the axis of the specimen with the center of thrust of the spherically seated block. As the spherically seated block is brought to bear on the specimen, rotate its movable portion gently by hand so that uniform seating is obtained.

7.5 *Rate of Loading*—Apply the load continuously and without shock.

7.5.1 For testing machines of the screw type, the moving head shall travel at a rate of approximately 0.05 in. (1.3 mm)/min when the machine is running idle. For hydraulically operated machines, the load shall be applied at a rate of movement (platen to crosshead measurement) corresponding to a loading rate on the specimen within the range of 20 to 50 psi/s (0.14 to 0.34 MPa/s). The designated rate of movement shall be maintained at least during the latter half of the anticipated loading phase of the testing cycle.

7.5.2 During the application of the first half of the anticipated loading phase a higher rate of loading shall be permitted.

7.5.3 Make no adjustment in the rate of movement of the platen at any time while a specimen is yielding rapidly immediately before failure.

7.6 Apply the load until the specimen fails, and record the maximum load carried by the specimen during the test. Note the type of failure and the appearance of the concrete.

8. Calculation

8.1 Calculate the compressive strength of the specimen by dividing the maximum load carried by the specimen during the test by the average cross-sectional area determined as described in Section 6 and express the result to the nearest 10 psi (69 kPa).

8.2 If the specimen length to diameter ratio is less than 1.8, correct the result obtained in 8.1 by multiplying by the appropriate correction factor shown in the following table:

L/D:	1.75	1.50	1.25	1.00
Factor:	0.98	0.96	0.93	0.87 (Note 8)

NOTE 8—These correction factors apply to lightweight concrete weighing between 100 and 120 lb/ft³ (1600 and 1920 kg/m³) and to normal weight concrete. They are applicable to concrete dry or soaked at the time of loading. Values not given in the table shall be determined by interpolation. The correction factors are applicable for nominal concrete strengths from 2000 to 6000 psi (13.8 to 41.4 MPa).

9. Report

9.1 The report shall include the following:

9.1.1 Identification number,

9.1.2 Diameter (and length, if outside the range of 1.8*D* to 2.2*D*), in inches or millimetres,

9.1.3 Cross-sectional area, in square inches or square centimetres,

9.1.4 Maximum load, in pounds-force or newtons,

9.1.5 Compressive strength calculated to the nearest 10 psi or 69 kPa,

9.1.6 Type of fracture, if other than the usual cone (see Fig. 2),

9.1.7 Defects in either specimen or caps, and,

9.1.8 Age of specimen.

10. Precision

10.1 The precision of this test method has not yet been determined, but data are being collected, and a precision statement will be included when it is formulated.[4]

[4] See "Concrete Strength in Structures," by D. L. Bloem, *ACI Journal*, March 1968, especially Table 3, p. 185, for possible guidance as to the level of reproducibility of concrete strength measurements that may be expected.

Designation: C 94 – 92a

Standard Specification for Ready-Mixed Concrete[1]

This standard is issued under the fixed designation C 94; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This specification has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This specification covers ready-mixed concrete manufactured and delivered to a purchaser in a freshly mixed and unhardened state as hereinafter specified. Requirements for quality of concrete shall be either as hereinafter specified or as specified by the purchaser. In any case where the requirements of the purchaser differ from these in this specification, the purchaser's specification shall govern. This specification does not cover the placement, consolidation, curing, or protection of the concrete after delivery to the purchaser.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values in parentheses are for information only.

1.3 As used throughout this specification the manufacturer shall be the contractor, subcontractor, supplier, or producer who furnishes the ready-mixed concrete. The purchaser shall be the owner or representative thereof.

2. Referenced Documents

2.1 *ASTM Standards:*

C 31 Practice for Making and Curing Concrete Test Specimens in the Field[2]
C 33 Specification for Concrete Aggregates[2]
C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens[2]
C 109 Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)[3]
C 138 Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete[2]
C 143 Test Method for Slump of Hydraulic Cement Concrete[2]
C 150 Specification for Portland Cement[2,3]
C 172 Practice for Sampling Freshly Mixed Concrete[2]
C 173 Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method[2]
C 191 Test Method for Time of Setting of Hydraulic Cement by Vicat Needle[3]
C 231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method[2]
C 260 Specification for Air-Entraining Admixtures for Concrete[2]
C 330 Specification for Lightweight Aggregates for Structural Concrete[2]
C 494 Specification for Chemical Admixtures for Concrete[2]
C 567 Test Method for Unit Weight of Structural Lightweight Concrete[2]
C 595 Specification for Blended Hydraulic Cements[2,3]
C 618 Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete[2]
C 989 Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars[2]
C 1017 Specification for Chemical Admixtures for Use in Producing Flowing Concrete[2]
C 1064 Test Method for Temperature of Freshly Mixed Portland-Cement Concrete[2]
C 1077 Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation[2]
D 512 Test Methods for Chloride Ion in Water[4]
D 516 Test Method for Sulfate Ion in Water[4]

2.2 *American Concrete Institute Standards:*[6]

CP-2 Concrete Field Testing Technician, Grade I
211.1 Recommended Practice for Selecting Proportions for Normal and Heavyweight Concrete
211.2 Recommended Practice for Selecting Proportions for Structural Lightweight Concrete
301 Specifications for Structural Concrete for Buildings
305R Hot Weather Concreting
306R Cold Weather Concreting
318 Commentary on Building Code Requirements for Reinforced Concrete

2.3 *National Institute of Standards and Technology Document:*[7]

Handbook 44 Specifications, Tolerances, and other Technical Requirements for Commercial Weighing and Measuring Devices

2.4 *Other Documents:*

Bureau of Reclamation Concrete Manual[7]

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[1] This specification is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.40 on Ready-Mixed Concrete.

Current edition approved Oct. 15, 1992. Published December 1992. Originally published as C 94 – 33 T. Last previous edition C 94 – 92.

[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 04.01.

[4] *Annual Book of ASTM Standards*, Vol 11.01.

[5] *Annual Book of ASTM Standards*, Vol 14.02.

[6] Available from American Concrete Institute, P.O. Box 19150, Detroit, MI 48219.

[7] Available from Superintendent of Documents, U. S. Government Printing Office, Washington, DC 20402.

AASHTO T 26 Method of Test for Quality of Water to be Used in Concrete[8]

3. Basis of Purchase

3.1 The basis of purchase shall be the cubic yard or cubic metre of freshly mixed and unhardened concrete as discharged from the mixer.

3.2 The volume of freshly mixed and unhardened concrete in a given batch shall be determined from the total weight of the batch divided by the actual weight per cubic foot of the concrete. The total weight of the batch shall be calculated either as the sum of the weights of all materials, including water, entering the batch or as the net weight of the concrete in the batch as delivered. The weight per cubic foot shall be determined in accordance with Test Method C 138 from the average of at least three measurements, each on a different sample using a ½-ft³ (14 160-cm³) container. Each sample shall be taken from the midpoint of each of three different truck loads by the procedure outlined in Practice C 172.

NOTE 1—It should be understood that the volume of hardened concrete may be, or appear to be, less than expected due to waste and spillage, over-excavation, spreading forms, some loss of entrained air, or settlement of wet mixtures, none of which are the responsibility of the producer.

4. Materials

4.1 In the absence of designated applicable specifications covering requirements for quality of materials, the following specifications shall govern:

4.1.1 *Cement*—Cement shall conform to Specification C 150 or Specification C 595. The purchaser should specify the type or types required, but if no type is specified, the requirements of Type I as prescribed in Specification C 150 shall apply.

NOTE 2—These different cements will produce concretes of different properties and should not be used interchangeably.

4.1.2 *Aggregates*—Aggregates shall conform to Specification C 33 or Specification C 330 if lightweight concrete is specified by the purchaser.

4.1.3 *Water:*

4.1.3.1 The mixing water shall be clear and apparently clean. If it contains quantities of substances which discolor it or make it smell or taste unusual or objectionable or cause suspicion, it shall not be used unless service records of concrete made with it or other information indicates that it is not injurious to the quality of the concrete. Water of questionable quality shall be subject to the acceptance criteria of Table 1.

4.1.3.2 Wash water from mixer washout operations may be used for mixing concrete provided tests of wash water comply with the physical tests of Table 1. Wash water shall be tested at a weekly interval for approximately 4 weeks, and thereafter at a monthly interval provided no single test exceeds the applicable limit (Note 3). Optional chemical tests in Table 2 may be specified by the purchaser when appropriate for the construction. The testing frequency for chemical limits should be as given above or as specified by the purchaser.

NOTE 3—When recycled wash water is used, attention should be given to effects on the dosage rate and batching sequence of air-entraining and other chemical admixtures, and a uniform amount should be used in consecutive batches.

4.1.4 *Admixtures*—Admixtures shall conform to Specifications C 260, C 494, C 618, C 989, and C 1017, if applicable.

NOTE 4—In any given instance, the required dosage of air-entraining, accelerating, and retarding admixtures will vary. Therefore, a range of dosages should be allowed which will permit obtaining the desired effect.

5. Ordering Information

5.1 In the absence of designated applicable general specifications, the purchaser shall specify the following:

5.1.1 Designated size, or sizes, of coarse aggregate,

5.1.2 Slump, or slumps, desired at the point of delivery (see Section 6 for acceptable tolerances),

5.1.3 When air-entrained concrete is specified, the air content of the samples taken at the point of discharge from the transportation unit (see Section 7 and Table 3 for the total air content and tolerances) (Note 4),

5.1.4 Which of Options A, B, or C shall be used as a basis for determining the proportions of the concrete to produce the required quality, and

5.1.5 When structural lightweight concrete is specified, the unit weight as wet weight, air-dry weight, or oven-dry weight (Note 6).

NOTE 5—In selecting the specified air content, the purchaser should consider the exposure conditions to which the concrete will be subjected. Air contents less than shown in Table 3 may not give the required resistance to freezing and thawing, which is the primary purpose of air-entrained concrete. Air contents higher than the levels shown may reduce strength without contributing any further improvement of durability.

NOTE 6—The unit weight of fresh concrete, which is the only unit weight determinable at the time of delivery, is always higher than the air-dry or oven-dry weight. Definitions of, and methods for determining or calculating air-dry and oven-dry weights, are covered by Test Method C 567.

5.2 *Option A:*

5.2.1 When the purchaser requires the manufacturer to assume full responsibility for the selection of the proportions for the concrete mixture (Note 7), the purchaser shall also specify the following:

5.2.1.1 Requirements for compressive strength as determined on samples taken from the transportation unit at the point of discharge evaluated in accordance with Section 17. The purchaser shall specify the requirements in terms of the compressive strength of standard specimens cured under standard laboratory conditions for moist curing (see Section 19). Unless otherwise specified the age at test shall be 28 days.

NOTE 7—The purchaser, in selecting requirements for which he assumes responsibility should give consideration to requirements for workability, placeability, durability, surface texture, and density, in addition to those for structural design. The purchaser is referred to American Concrete Institute Standard 211.1 and American Concrete Institute Standard 211.2 for the selection of proportions that will result in concrete suitable for various types of structures and conditions of

[8] Available from the American Association of State Highway and Transportation Officials, 444 N. Capitol St., NW, Suite 225, Washington, DC 20001.

TABLE 1 Acceptance Criteria for Questionable Water Supplies

	Limits	Test Method
Compressive strength, min % control at 7 days	90	C 109[A]
Time of set, deviation from control, h: min	from 1:00 early to 1:30 later	C 191[A]

[A] Comparisons shall be based on fixed proportions and the same volume of test water compared to control mix using city water or distilled water.

TABLE 2 Chemical Limitations for Wash Water

	Limits	Test Method[A]
Chemical requirements, maximum concentration in mixing water, ppm[B]		
Chloride as Cl, ppm:		D 512
Prestressed concrete or in bridge decks	500[C]	
Other reinforced concrete in moist environments or containing aluminum embedments or dissimilar metals or with stay-in-place galvanized metal forms	1000[C]	
Sulfate as SO_4, ppm	3000	D 516
Alkalies as (Na_2O + 0.658 K_2O), ppm	600	
Total solids, ppm	50 000	AASHTO T26

[A] Other test methods that have been demonstrated to yield comparable results may be used.

[B] Wash water reused as mixing water in concrete may exceed the listed concentrations of chloride and sulfate if it can be shown that the concentration calculated in the total mixing water, including mixing water on the aggregates and other sources does not exceed the stated limits.

[C] For conditions allowing use of $CaCl_2$ accelerator as an admixture, the chloride limitation may be waived by the purchaser.

exposure. The water-cement ratio of most structural lightweight concretes cannot be determined with sufficient accuracy for use as a specification basis.

5.2.2 At the request of the purchaser, the manufacturer shall, prior to the actual delivery of the concrete, furnish a statement to the purchaser, giving the dry weights of cement and saturated surface-dry-weights of fine and coarse aggregate and quantities, type, and name of admixtures (if any) and of water per cubic yard or cubic metre of concrete that will be used in the manufacture of each class of concrete ordered by the purchaser. He shall also furnish evidence satisfactory to the purchaser that the materials to be used and proportions selected will produce concrete of the quality specified.

5.3 *Option B:*

5.3.1 When the purchaser assumes responsibility for the proportioning of the concrete mixture, he shall also specify the following:

5.3.1.1 Cement content in bags or pounds per cubic yard of concrete, or equivalent units,

5.3.1.2 Maximum allowable water content in gallons per cubic yard of concrete, or equivalent units, including surface moisture on the aggregates, but excluding water of absorption (Note 7), and

5.3.1.3 If admixtures are required, the type, name, and dosage to be used. The cement content shall not be reduced when admixtures are used under this option without the written approval of the purchaser.

5.3.2 At the request of the purchaser, the manufacturer shall, prior to the actual delivery of the concrete, furnish a statement to the purchaser giving the sources, specific gravities, and sieve analyses of the aggregates and the dry weights of cement and saturated-surface-dry weights of fine and coarse aggregate and quantities, type and name of admixture (if any) and of water per cubic yard or cubic metre of concrete that will be used in the manufacture of each class of concrete ordered by the purchaser.

5.4 *Option C:*

5.4.1 When the purchaser requires the manufacturer to assume responsibility for the selection of the proportions for the concrete mixture with the minimum allowable cement content specified (Note 7), the purchaser shall also specify the following:

5.4.1.1 Required compressive strength as determined on samples taken from the transportation unit at the point of discharge evaluated in accordance with Section 17. The purchaser shall specify the requirements for strength in terms of tests of standard specimens cured under standard laboratory conditions for moist curing (see Section 19). Unless otherwise specified the age at test shall be 28 days.

5.4.1.2 Minimum cement content in bags or pounds per cubic yard or kilograms per cubic metre of concrete.

5.4.1.3 If admixtures are required, the type, name, and dosage to be used. The cement content shall not be reduced when admixtures are used.

NOTE 8—Option C can be distinctive and useful only if the designated minimum cement content is at about the same level that would ordinarily be required for the strength, aggregate size, and slump specified. At the same time, it must be an amount that will be sufficient to ensure durability under expected service conditions, as well as satisfactory surface texture and density, in the event specified strength is attained with it. For additional information refer to ACI Standards 211.1 and 211.2 referred to in Note 7.

5.4.2 At the request of the purchaser, the manufacturer shall, prior to the actual delivery of the concrete, furnish a statement to the purchaser, giving the dry weights of cement and saturated surface-dry weights of fine and coarse aggregate and quantities, type, and name of admixture (if any) and of water per cubic yard or cubic metre of concrete that will be used in the manufacture of each class of concrete ordered by the purchaser. He shall also furnish evidence satisfactory to the purchaser that the materials to be used and proportions selected will produce concrete of the quality specified. Whatever strengths are attained the quantity of cement used shall not be less than the minimum specified.

5.5 The proportions arrived at by Options A, B, C for each class of concrete and approved for use in a project shall be assigned a designation to facilitate identification of each

TABLE 3 Recommended Total Air Content for Air-Entrained Concrete[A,C]

Exposure Condition[B]	Total Air Content, %						
	Nominal Maximum Sizes of Aggregate, in. (mm)						
	⅜ (9.5)	½ (12.5)	¾ (19.0)	1 (25.0)	1½ (37.5)	2 (50.0)	3 (75.0)
Mild	4.5	4.0	3.5	3.0	2.5	2.0	1.5
Moderate	6.0	5.5	5.0	4.5	4.5	4.0	3.5
Severe	7.5	7.0	6.0	6.0	5.5	5.0	4.5

[A] For air-entrained concrete, when specified.
[B] For description of exposure conditions, refer to ACI 211.1, Section 6.3.3, with attention to accompanying footnotes.
[C] Unless exposure conditions dictate otherwise, air contents recommended above may be reduced by up to 1 % for concretes with specified compressive strength, f'_c, of 5000 psi (34.5 MPa) or above.

concrete mixture delivered to the project. This is the designation required in 16.1.7 and supplies information on concrete proportions when they are not given separately on each delivery ticket as outlined in 16.2. A certified copy of all proportions as established in Options A, B, or C shall be on file at the batch plant.

6. Tolerances in Slump

6.1 Unless other tolerances are included in the project specifications, the following shall apply.

6.1.1 When the project specifications for slump are written as a "maximum" or "not to exceed" requirement:

	Specified slump:	
	If 3 in. (76 mm) or less	If more than 3 in. (76 mm)
Plus tolerance:	0	0
Minus tolerance:	1½ in. (38 mm)	2½ in. (63 mm)

This option is to be used only if one addition of water is permitted on the job provided such addition does not increase the water-cement ratio above the maximum permitted by the specifications.

6.1.2 When the project specifications for slump are *not* written as a "maximum" or "not to exceed" requirement:

Tolerances for Nominal Slumps

For Specified Slump of:	Tolerance
2 in. (51 mm) and less	±½ in. (13 mm)
More than 2 through 4 in. (51 to 102 mm)	±1 in. (25 mm)
More than 4 in. (102 mm)	±1½ in. (38 mm)

6.2 Concrete shall be available within the permissible range of slump for a period of 30 min starting either on arrival at the job site or after the initial slump adjustment permitted in 11.7, whichever is later. The first and last ¼ yd^3 or ¼ m^3 discharged are exempt from this requirement. If the user is unprepared for discharge of the concretes from the vehicle, the producer shall not be responsible for the limitation of minimum slump after 30 min have elapsed starting either on arrival of the vehicle at the prescribed destination or at the requested delivery time, whichever is later.

7. Air-Entrained Concrete

7.1 When air-entrained concrete is desired the purchaser shall specify the total air content of the concrete. See Table 3 for recommended total air contents (Note 4).

7.2 The air content of air-entrained concrete when sampled from the transportation unit at the point of discharge shall be within a tolerance of ± 1.5 of the specified value.

8. Measuring Materials

8.1 Except as otherwise specifically permitted, cement shall be measured by weight. When mineral admixtures (including ground granulated blast furnace slag, fly ash, silica fume, or other pozzolans) are specified in the concrete proportions, they may be weighed cumulatively with cement, but in a weigh hopper and on a scale which is separate and distinct from those used for other materials. Cement shall be weighed before mineral admixtures. When the quantity of cement exceeds 30 % of the full capacity of the scale, the quantity of the cement shall be within ±1 % of the required weight, and the cumulative quantity of cement plus mineral admixtures shall also be within ±1 % of the required weight. For smaller batches to a minimum of 1 yd^3 (1 m^3), the quantity of the cement and the cumulative quantity of cement plus mineral admixture used shall be not less than the required amount nor more than 4 % in excess. Under special circumstances approved by the purchaser, cement may be measured in bags of standard weight (Note 9). No fraction of a bag of cement shall be used unless weighed.

NOTE 9—In the United States the standard weight of a bag of portland cement is 94 lb (42.6 kg) ±3 %.

8.2 Aggregate shall be measured by weight. Batch weights shall be based on dry materials and shall be the required weights of dry materials plus the total weight of moisture (both absorbed and surface) contained in the aggregate. The quantity of aggregate used in any batch of concrete as indicated by the scale shall be within ±2 % of the required weight when weighed in individual aggregate weigh batchers. In a cumulative aggregate weigh batcher, the cumulative weight after each successive weighing shall be within ±1 % of the required cumulative amount when the scale is used in excess of 30 % of its capacity. For cumulative weights for less than 30 % of scale capacity, the tolerance shall be ±0.3 % of scale capacity or ±3 % of the required cumulative weight, whichever is less.

8.3 Mixing water shall consist of water added to the batch, ice added to the batch, water occurring as surface moisture on the aggregates, and water introduced in the form of admixtures. The added water shall be measured by weight or volume to an accuracy of 1 % of the required total mixing water. Added ice shall be measured by weight. In the case of truck mixers, any wash water retained in the drum for use in the next batch of concrete shall be accurately measured; if this proves impractical or impossible the wash water shall be discharged prior to loading the next batch of concrete. Total water (including any wash water) shall be measured or

weighed to an accuracy of ±3 % of the specified total amount.

8.4 Powdered admixtures shall be measured by weight, and paste or liquid admixtures by weight or volume. Accuracy of weighing admixtures shall be within ±3 % of the required weight. Volumetric measurement shall be within an accuracy of ±3 % of the total amount required or plus and minus the volume of dose required for one sack of cement, whichever is greater.

NOTE 10—Admixture dispensers of the mechanical type capable of adjustment for variation of dosage, and of simple calibration, are recommended.

9. Batching Plant

9.1 Bins with adequate separate compartments shall be provided in the batching plant for fine and for each required size of coarse aggregate. Each bin compartment shall be designed and operated so as to discharge efficiently and freely, with minimum segregation, into the weighing hopper. Means of control shall be provided so that, as the quantity desired in the weighing hopper is approached, the material may be shut off with precision. Weighing hoppers shall be constructed so as to eliminate accumulations of tare materials and to discharge fully.

9.2 Indicating devices shall be in full view and near enough to be read accurately by the operator while charging the hopper. The operator shall have convenient access to all controls.

9.3 Scales shall be considered accurate when at least one static load test within each quarter of the scale capacity can be shown to be within ±0.4 % of the total capacity of the scale.

9.4 Scales for batching concrete ingredients shall meet the accuracy criterion of 9.3 and conform to the applicable sections of the current edition of the National Institute of Standards and Technology Handbook 44.

9.5 Adequate standard test weights shall be available for checking accuracy. All exposed fulcrums, clevises, and similar working parts of scales shall be kept clean. Beam scales shall be equipped with a balance indicator sensitive enough to show movement when a weight equal to 0.1 % of the nominal capacity of the scale is placed in the batch hopper. Pointer travel shall be a minimum of 5 % of the net-rated capacity of the largest weigh beam for underweight and 4 % for overweight.

9.6 The device for the measurement of the added water shall be capable of delivering to the batch the quantity required within the accuracy required in 8.3. The device shall be so arranged that the measurements will not be affected by variable pressures in the water supply line. Measuring tanks shall be equipped with outside taps and valves to provide for checking their calibration unless other means are provided for readily and accurately determining the amount of water in the tank.

NOTE 11—The scale accuracy limitations of the National Ready Mixed Concrete Association Plant Certification meet the requirements of this specification.

10. Mixers and Agitators

10.1 Mixers may be stationary mixers or truck mixers. Agitators may be truck mixers or truck agitators.

10.1.1 Stationary mixers shall be equipped with a metal plate or plates on which are plainly marked the mixing speed of the drum or paddles, and the maximum capacity in terms of the volume of mixed concrete. When used for the complete mixing of concrete, stationary mixers shall be equipped with an acceptable timing device that will not permit the batch to be discharged until the specified mixing time has elapsed.

10.1.2 Each truck mixer or agitator shall have attached thereto in a prominent place a metal plate or plates on which are plainly marked the gross volume of the drum, the capacity of the drum or container in terms of the volume of mixed concrete, and the minimum and maximum mixing speeds of rotation of the drum, blades, or paddles. When the concrete is truck mixed as described in 11.5, or shrink mixed as described in 11.4, the volume of mixed concrete shall not exceed 63 % of the total volume of the drum or container. When the concrete is central mixed as described in 11.3, the volume of concrete in the truck mixer or agitator shall not exceed 80 % of the total volume of the drum or container. Truck mixers and agitators shall be equipped with means by which the number of revolutions of the drum, blades, or paddles may be readily verified.

10.2 All stationary and truck mixers shall be capable of combining the ingredients of the concrete within the specified time or the number of revolutions specified in 10.5, into a thoroughly mixed and uniform mass and of discharging the concrete so that not less than five of the six requirements shown in Table A1.1 shall have been met.

NOTE 12—The sequence or method of charging the mixer will have an important effect on the uniformity of the concrete.

10.3 The agitator shall be capable of maintaining the mixed concrete in a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity as defined by Annex A1.

10.4 Slump tests of individual samples taken after discharge of approximately 15 % and 85 % of the load may be made for a quick check of the probable degree of uniformity (Note 13). These two samples shall be obtained within an elapsed time of not more than 15 min. If these slumps differ more than that specified in Annex A1, the mixer or agitator shall not be used unless the condition is corrected, except as provided in 10.5.

NOTE 13—No samples should be taken before 10 % or after 90 % of the batch has been discharged. Due to the difficulty of determining the actual quantity of concrete discharged, the intent is to provide samples that are representative of widely separated portions, but not the beginning and end of the load.

10.5 Use of the equipment may be permitted when operation with a longer mixing time, a smaller load, or a more efficient charging sequence will permit the requirements of Annex A1 to be met.

10.6 Mixers and agitators shall be examined or weighed routinely as frequently as necessary to detect changes in condition due to accumulations of hardened concrete or mortar and examined to detect wear of blades. When such changes are extensive enough to affect the mixer performance, the proof-tests described in Annex A1 shall be performed to show whether the correction of deficiencies is required.

11. Mixing and Delivery

11.1 Ready-mixed concrete shall be mixed and delivered to the point designated by the purchaser by means of one of the following combinations of operations:

11.1.1 *Central-Mixed Concrete.*

11.1.2 *Shrink-Mixed Concrete.*

11.1.3 *Truck-Mixed Concrete.*

11.2 Mixers and agitators shall be operated within the limits of capacity and speed of rotation designated by the manufacturer of the equipment.

11.3 *Central-Mixed Concrete*—Concrete that is mixed completely in a stationary mixer and transported to the point of delivery either in a truck agitator, or a truck mixer operating at agitating speed, or in nonagitating equipment approved by the purchaser and meeting the requirements of Section 12, shall conform to the following: The mixing time shall be counted from the time all the solid materials are in the drum. The batch shall be so charged into the mixer that some water will enter in advance of the cement and aggregate, and all water shall be in the drum by the end of the first one fourth of the specified mixing time.

11.3.1 Where no mixer performance tests are made, the acceptable mixing time for mixers having capacities of 1 yd^3 (0.76 m^3) or less shall be not less than 1 min. For mixers of greater capacity, this minimum shall be increased 15 s for each cubic yard or fraction thereof of additional capacity.

11.3.2 Where mixer performance tests have been made on given concrete mixtures in accordance with the testing program set forth in the following paragraphs, and the mixers have been charged to their rated capacity, the acceptable mixing time may be reduced for those particular circumstances to a point at which satisfactory mixing defined in 11.3.3 shall have been accomplished. When the mixing time is so reduced the maximum time of mixing shall not exceed this reduced time by more than 60 s for air-entrained concrete.

11.3.3 *Sampling for Uniformity Tests of Stationary Mixers*—Samples of concrete for comparative purposes shall be obtained immediately after arbitrarily designated mixing times, in accordance with one of the following procedures:

11.3.3.1 *Alternative Procedure 1*—The mixer shall be stopped, and the required samples removed by any suitable means from the concrete at approximately equal distances from the front and back of the drum, or

11.3.3.2 *Alternative Procedure 2*—As the mixer is being emptied, individual samples shall be taken after discharge of approximately 15 % and 85 % of the load. Any appropriate method of sampling may be used, provided the samples are representative of widely separated portions, but not the very ends of the batch (Note 13).

11.3.3.3 The samples of concrete shall be tested in accordance with Section 19, and differences in test results for the two samples shall not exceed those given in Annex A1. Mixer performance tests shall be repeated whenever the appearance of the concrete or the coarse aggregate content of samples selected as outlined in this section indicates that adequate mixing has not been accomplished.

11.4 *Shrink-Mixed Concrete*—Concrete that is first partially mixed in a stationary mixer, and then mixed completely in a truck mixer, shall conform to the following: The time of partial mixing shall be minimum required to intermingle the ingredients. After transfer to a truck mixer the amount of mixing at the designated mixing speed will be that necessary to meet the requirements for uniformity of concrete as indicated in Annex A1. Tests to confirm such performance may be made in accordance with 11.3.3 and 11.3.3.3. Additional turning of the mixer, if any, shall be at a designated agitating speed.

11.5 *Truck-Mixed Concrete*—Concrete that is completely mixed in a truck mixer, 70 to 100 revolutions at the mixing speed designated by the manufacturer to produce the uniformity of concrete indicated in Annex A1. Concrete uniformity tests may be made in accordance with 11.5.1 and if requirements for uniformity of concrete indicated in Annex A1 are not met with 100 revolutions of mixing, after all ingredients including water, are in the drum, that mixer shall not be used until the condition is corrected, except as provided in 10.5. When satisfactory performance is found in one truck mixer, the performance of mixers of substantially the same design and condition of blades may be regarded as satisfactory. Additional revolutions of the mixer beyond the number found to produce the required uniformity of concrete shall be at a designated agitating speed.

11.5.1 *Sampling for Uniformity of Concrete Produced in Truck Mixers*—The concrete shall be discharged at the normal operating rate for the mixer being tested, with care being exercised not to obstruct or retard the discharge by an incompletely opened gate or seal. Separate samples, each consisting of approximately 2 ft^3 (0.1 m^3 approximately) shall be taken after discharge of approximately 15 % and 85 % of the load (Note 13). These samples shall be obtained within an elapsed time of not more than 15 min. The samples shall be secured in accordance with Practice C 172, but shall be kept separate to represent specific points in the batch rather than combined to form a composite sample. Between samples, where necessary to maintain slump, the mixer may be turned in mixing direction at agitating speed. During sampling the receptacle shall receive the full discharge of the chute. Sufficient personnel must be available to perform the required tests promptly. Segregation during sampling and handling must be avoided. Each sample shall be remixed the minimum amount to ensure uniformity before specimens are molded for a particular test.

11.6 When a truck mixer or truck agitator is used for transporting concrete that has been completely mixed in a stationary mixer, any turning during transportation shall be at the speed designated by the manufacturer of the equipment as agitating speed.

11.7 When a truck mixer or agitator is approved for mixing or delivery of concrete, no water from the truck water system or elsewhere shall be added after the initial introduction of mixing water for the batch except when on arrival at the job site the slump of the concrete is less than that specified. Such additional water to bring the slump within required limits shall be injected into the mixer under such pressure and direction of flow that the requirements for uniformity specified in Annex A1 are met. The drum or blades shall be turned an additional 30 revolutions or more if necessary, at mixing speed, until the uniformity of the concrete is within these limits. Water shall not be added to the batch at any later time. Discharge of the concrete shall be completed within 1½ h, or before the drum has revolved 300

revolutions, whichever comes first, after the introduction of the mixing water to the cement and aggregates or the introduction of the cement to the aggregates. These limitations may be waived by the purchaser if the concrete is of such slump after the 1½-h time or 300-revolution limit has been reached that it can be placed, without the addition of water, to the batch. In hot weather, or under conditions contributing to quick stiffening of the concrete, a time less than 1½ h may be specified by the purchaser.

11.8 Concrete delivered in cold weather shall have the applicable minimum temperature indicated in the following table. (The purchaser shall inform the producer as to the type of construction for which the concrete is intended.)

Minimum Concrete Temperature as Placed

Section Size, in. (mm)	Temperature, min °F (C)
<12 (<300)	55 (13)
12–36 (300–900)	50 (10)
36–72 (900–1800)	45 (7)
>72 (>1800)	40 (5)

The maximum temperature of concrete produced with heated aggregates, heated water, or both, shall at no time during its production or transportation exceed 90°F (32°C).

NOTE 14—When hot water is used rapid stiffening may occur if hot water is brought in direct contact with the cement. Additional information on cold weather concreting is contained in ACI 306R.

11.9 The producer shall deliver the ready mixed concrete during hot weather at concrete temperatures as low as practicable, subject to the approval of the purchaser.

NOTE 15—In some situations difficulty may be encountered when concrete temperatures approach 90°F (32°C). Additional information may be found in the Bureau of Reclamation Concrete Manual and in ACI 305R.

12. Use of Nonagitating Equipment

12.1 Central-mixed concrete may be transported in suitable nonagitating equipment approved by the purchaser. The proportions of the concrete shall be approved by the purchaser and the following limitations shall apply:

12.2 Bodies of nonagitating equipment shall be smooth, watertight, metal containers equipped with gates that will permit control of the discharge of the concrete. Covers shall be provided for protection against the weather when required by the purchaser.

12.3 The concrete shall be delivered to the site of the work in a thoroughly mixed and uniform mass and discharged with a satisfactory degree of uniformity as prescribed in Annex A1.

12.4 Slump tests of individual samples taken after discharge of approximately 15 % and 85 % of the load may be made for a quick check of the probable degree of uniformity (Note 13). These two samples shall be obtained within an elapsed time of not more than 15 min. If these slumps differ more than that specified in Table A1.1, the nonagitating equipment shall not be used unless the conditions are corrected as provided in 12.5.

12.5 If the requirements of Annex A1 are not met when the nonagitating equipment is operated for the maximum time of haul, and with the concrete mixed the minimum time, the equipment may still be used when operated using shorter hauls, or longer mixing times, or combinations thereof that will result in the requirements of Annex A1 being met.

13. Inspection: Materials, Production, Delivery

13.1 The manufacturer shall afford the inspector all reasonable access, without charge, for making necessary checks of the production facilities and for securing necessary samples to determine if the concrete is being produced in accordance with this specification. All tests and inspection shall be so conducted as not to interfere unnecessarily with the manufacture and delivery of the concrete.

14. Inspection of Fresh Concrete and Sampling

14.1 The contractor shall afford the inspector all reasonable access and assistance, without charge, for the procurement of samples of fresh concrete at time of placement to determine conformance of it to this specification.

14.2 Samples of concrete shall be obtained in accordance with Practice C 172, except when taken to determine uniformity of slump within any one batch or load of concrete (10.4, 11.3.3, 11.5.1, and 12.4).

14.3 Tests of concrete required to determine compliance with this specification shall be made by a certified ACI Concrete Field Testing Technician, Grade I or equivalent. Equivalent personnel certification programs shall include both written and performance examinations.

14.4 When the strength of concrete is used as a basis for acceptance, the manufacturer shall be entitled to copies of all test reports.

14.5 Laboratory reports of concrete test results used to determine compliance with this specification shall include a statement that all tests performed by laboratory personnel were in accordance with the applicable test methods or shall note all known deviations from the prescribed procedures (Note 16). The reports shall also list any part of the test methods not performed by the laboratory.

NOTE 16—Deviation from standard test methods may adversely affect test results.

15. Slump and Air Content

15.1 Slump, air-content, and temperature tests shall be made at the time of placement at the option of the inspector as often as is necessary for control checks. In addition, these tests shall be made when specified and always when strength specimens are made (17.2).

15.2 If the measured slump or air content falls outside the specified limits, a check test shall be made immediately on another portion of the same sample. In the event of a second failure, the concrete shall be considered to have failed the requirements of the specification.

16. Batch Ticket Information

16.1 The manufacturer of the concrete shall furnish to the purchaser with each batch of concrete before unloading at the site, a delivery ticket on which is printed, stamped, or written, information concerning said concrete as follows:

16.1.1 Name of ready-mix batch plant,

16.1.2 Serial number of ticket,

16.1.3 Date,

16.1.4 Truck number,

16.1.5 Name of purchaser,

16.1.6 Specific designation of job (name and location),

16.1.7 Specific class or designation of the concrete in conformance with that employed in job specifications,

16.1.8 Amount of concrete in cubic yards (or cubic metres),

16.1.9 Time loaded or of first mixing of cement and aggregates, and

16.1.10 Water added by receiver of concrete and his initials.

16.2 Additional information for certification purposes as designated by the purchaser and required by the job specifications shall be furnished when requested; such information may include:

16.2.1 Reading of revolution counter at the first addition of water,

16.2.2 Type and brand, and amount of cement,

16.2.3 Type and brand, and amount of admixtures,

16.2.4 Information necessary to calculate the total mixing water added by the producer. Total mixing water includes free water on the aggregates, water, and ice batched at the plant, and water added by the truck operator from the mixer tank,

16.2.5 Maximum size of aggregate,

16.2.6 Weights of fine and coarse aggregate,

16.2.7 Ingredients certified as being previously approved, and

16.2.8 Signature or initials of ready-mix representative.

17. Strength

17.1 When strength is used as a basis for acceptance of concrete, standard specimens shall be made in accordance to Practice C 31. The specimens shall be cured under standard moisture and temperature conditions in accordance with the applicable provisions of Practice C 31 (see Section 19).

17.2 Strength tests as well as slump, temperature, and air content tests shall generally be made with a frequency of not less than one test for each 150 yd^3 (115 m^3). Each test shall be made from a separate batch. On each day concrete is delivered, at least one strength test shall be made for each class of concrete.

TABLE 4 Overdesign Necessary to Meet Strength Requirements[A]

Number of Tests[B]	Standard Deviation, psi					Unknown
	300	400	500	600	700	
15	466	622	851	1122	1392	C
20	434	579	758	1010	1261	C
30 or more	402	526	665	898	1131	C
	Standard Deviation, MPa					
	2.0	3.0	4.0	5.0	Unknown	
15	3.1	4.7	7.3	10.0	C	
20	2.9	4.3	6.6	9.1	C	
30 or more	2.7	4.0	5.8	8.2	C	

[A] Add the tabulated amounts to the specified strength to obtain the required average strengths.

[B] Number of tests of a concrete mixture used to estimate the standard deviation of a concrete production facility. The mixture used must have a strength within 1000 psi (7.0 MPa) of that specified and be made with similar materials. See ACI 318.

[C] If less than 15 prior tests are available, the overdesign should be 1000 psi (7.0 MPa) for specified strength less than 3000 psi (20 MPa), 1200 psi (8.5 MPa) for specified strengths from 3000 to 5000 psi (20 to 35 MPa) and 1400 psi (10.0 MPa) for specified strengths greater than 5000 psi (35 MPa).

17.3 For a strength test, at least two standard test specimens shall be made from a composite sample secured as required in Section 14. A test shall be the average of the strengths of the specimens tested at the age specified in 5.3.1.1 or 5.4.1.1 (Note 17). If a specimen shows definite evidence other than low strength, of improper sampling, molding, handling, curing, or testing, it shall be discarded and the strength of the remaining cylinder shall then be considered the test result.

NOTE 17—Additional tests may be made at other ages to obtain information for determining form removal time or when a structure may be put in service. Specimens should be cured in accordance with the applicable provisions of Practice C 31.

17.4 The representative of the purchaser shall ascertain and record the delivery-ticket number for the concrete and the exact location in the work at which each load represented by a strength test is deposited.

17.5 To conform to the requirements of this specification, strength tests representing each class of concrete must meet the following two requirements (Note 18):

17.5.1 The average of any three consecutive strength tests shall be equal to, or greater than, the specified strength, f'_c, and

17.5.2 No individual strength test shall be more than 500 psi (3.4 MPa) below the specified strength, f'_c.

NOTE 18—Due to variations in materials, operations and testing, the average strength necessary to meet these requirements will be substantially higher than the specified strength. The amount higher depends upon the standard deviation of the test results and the accuracy with which that value can be estimated from prior data as explained in ACI 318 and ACI 301. Pertinent data is given in Table 4.

18. Failure to Meet Strength Requirements

18.1 In the event that concrete tested in accordance with the requirements of Section 17 fails to meet the strength requirements of this specification, the manufacturer of the ready-mixed concrete and the purchaser shall confer to determine whether agreement can be reached as to what adjustment, if any, shall be made. If an agreement on a mutually satisfactory adjustment cannot be reached by the manufacturer and the purchaser, a decision shall be made by a panel of three qualified engineers, one of whom shall be designated by the purchaser, one by the manufacturer, and the third chosen by these two members of the panel. The question of responsibility for the cost of such arbitration shall be determined by the panel. Its decision shall be binding, except as modified by a court decision.

19. Sampling and Test Methods

19.1 Test ready-mixed concrete in accordance with the following methods:

19.1.1 *Compression Test Specimens*—Practice C 31, using standard moist curing in accordance with the applicable provisions of Practice C 31.

19.1.2 *Compression Tests*—Test Method C 39.

19.1.3 *Yield, Weight per Cubic Foot*—Test Method C 138.

19.1.4 *Air Content*—Test Method C 138; Test Method C 173 or Test Method C 231.

19.1.5 *Slump*—Test Method C 143.

19.1.6 *Sampling Fresh Concrete*—Method C 172.

19.1.7 *Temperature*—Test Method C 1064.

19.2 The testing laboratory performing acceptance tests of concrete shall meet the requirements of Practice C 1077.

20. Keywords

20.1 accuracy; certification; ready-mixed concrete; scales; testing

ANNEX

(Mandatory Information)

A1. CONCRETE UNIFORMITY REQUIREMENTS

A1.1 The variation within a batch as provided in Table A1.1 shall be determined for each property listed as the difference between the highest value and the lowest value obtained from the different portions of the same batch. For this specification the comparison will be between two samples, representing the first and last portions of the batch being tested. Test results conforming to the limits of five of the six tests listed in Table A1.1 shall indicate uniform concrete within the limits of this specification.

A1.2 *Coarse Aggregate Content*, using the washout test, shall be computed from the following relations:

$$P = (c/b) \times 100$$

where:

P = weight % of coarse aggregate in concrete,

c = saturated surface-dry-weight in lb (kg) of aggregate retained on the No. 4 (4.75-mm) sieve, resulting from washing all material finer than this sieve from the fresh concrete, and

b = weight of sample of fresh concrete in unit weight container, lb (kg).

A1.3 *Unit Weight of Air Free Mortar* shall be calculated as follows:

Inch-pound units:

$$M = \frac{b - c}{V - \left(\frac{V \times A}{100} + \frac{c}{G \times 62.4}\right)}$$

Metric units:

$$M = \frac{b - c}{V - \left(\frac{V \times A}{100} + \frac{c}{1000G}\right)}$$

where:

M = unit weight of air-free mortar, lb/ft^3 (kg/m^3),

b = weight of concrete sample in unit weight container, lb (kg),

c = saturated surface-dry-weight of aggregate retained on No. 4 (4.75-mm) sieve, lb (kg),

V = volume of unit weight container, ft^3 (m^3),

A = air content of concrete, %, measured in accordance with 19.1.4 on the sample being tested, and

G = specific gravity of coarse aggregate (SSD).

TABLE A1.1 Requirements for Uniformity of Concrete

Test	Requirement, Expressed as Maximum Permissible Difference in Results of Tests of Samples Taken from Two Locations in the Concrete Batch
Weight per cubic foot (weight per cubic metre) calculated to an air-free basis, lb/ft^3 (kg/m^3)	1.0 (16)
Air content, volume % of concrete	1.0
Slump:	
If average slump is 4 in. (102 mm) or less, in. (mm)	1.0 (25)
If average slump is 4 to 6 in. (102 to 152 mm), in. (mm)	1.5 (38)
Coarse aggregate content, portion by weight of each sample retained on No. 4 (4.75-mm) sieve, %	6.0
Unit weight of air-free mortar[A] based on average for all comparative samples tested, %.	1.6
Average compressive strength at 7 days for each sample,[B] based on average strength of all comparative test specimens, %	7.5[C]

[A] "Test for Variability of Constituents in Concrete," Designation 26, *Bureau of Reclamation Concrete Manual*, 7th Edition. Available from Superintendent of Documents, U. S. Government Printing Office, Washington, DC 20402.

[B] Not less than 3 cylinders will be molded and tested from each of the samples.

[C] Tentative approval of the mixer may be granted pending results of the 7-day compressive strength tests.

Designation: C 150 – 92

Standard Specification for Portland Cement[1]

This standard is issued under the fixed designation C 150; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This specification covers eight types of portland cement, as follows (see Note):

1.1.1 *Type I*—For use when the special properties specified for any other type are not required.

1.1.2 *Type IA*—Air-entraining cement for the same uses as Type I, where air-entrainment is desired.

1.1.3 *Type II*—For general use, more especially when moderate sulfate resistance or moderate heat of hydration is desired.

1.1.4 *Type IIA*—Air-entraining cement for the same uses as Type II, where air-entrainment is desired.

1.1.5 *Type III*—For use when high early strength is desired.

1.1.6 *Type IIIA*—Air-entraining cement for the same use as Type III, where air-entrainment is desired.

1.1.7 *Type IV*—For use when a low heat of hydration is desired.

1.1.8 *Type V*—For use when high sulfate resistance is desired.

1.2 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

C 33 Specification for Concrete Aggregates[2]

C 109 Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)[3]

C 114 Test Methods for Chemical Analysis of Hydraulic Cement[3]

C 115 Test Method for Fineness of Portland Cement by the Turbidimeter[3]

C 151 Test Method for Autoclave Expansion of Portland Cement[3]

C 183 Practice for Sampling and the Amount of Testing of Hydraulic Cement[3]

C 185 Test Method for Air Content of Hydraulic Cement Mortar[3]

C 186 Test Method for Heat of Hydration of Hydraulic Cement[3]

C 191 Test Method for Time of Setting of Hydraulic Cement by Vicat Needle[3]

C 204 Test Method for Fineness of Portland Cement by Air Permeability Apparatus[3]

C 226 Specification for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Portland Cement[3]

C 266 Test Method for Time of Setting of Hydraulic Cement Paste by Gillmore Needles[3]

C 451 Test Method for Early Stiffening of Portland Cement (Paste Method)[3]

C 452 Test Method for Potential Expansion of Portland Cement Mortars Exposed to Sulfate[3]

C 465 Specification for Processing Additions for Use in the Manufacture of Hydraulic Cements[3]

C 563 Test Method for Optimum SO_3 in Portland Cement[3]

C 1038 Test Method for Expansion of Portland Cement Mortar Bars Stored in Water[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *portland cement*—a hydraulic cement produced by pulverizing clinker consisting essentially of hydraulic calcium silicates, usually containing one or more of the forms of calcium sulfate as an interground addition.

3.1.2 *air-entraining portland cement*—a hydraulic cement produced by pulverizing clinker consisting essentially of hydraulic calcium silicates, usually containing one or more of the forms of calcium sulfate as an interground addition, and with which there has been interground an air-entraining addition.

4. Ordering Information

4.1 Orders for material under this specification shall include the following:

4.1.1 This specification number and date,

4.1.2 Type or types allowable. If no type is specified, Type I shall be supplied,

4.1.3 Any optional chemical requirements from Table 2, if desired,

4.1.4 Type of setting-time test required, Vicat or Gillmore. If not specified, the Vicat shall be used,

4.1.5 Any optional physical requirements from Table 4, if desired.

NOTE—Attention is called to the fact that cements conforming to the requirements for all types may not be carried in stock in some areas. In advance of specifying the use of other than Type I cement, it should be determined whether the proposed type of cement is or can be made available.

[1] This specification is under the jurisdiction of ASTM Committee C-1 on Cement and is the direct responsibility of Subcommittee C01.10 on Portland Cement.

Current edition approved March 15, 1992. Published May 1992. Originally published as C 150 – 40 T. Last previous edition C 150 – 89.

[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 04.01.

TABLE 1 Standard Chemical Requirements

Cement Type [A]	I and IA	II and IIA	III and IIIA	IV	V
Silicon dioxide (SiO_2), min, %	...	20.0	...	...	...
Aluminum oxide (Al_2O_3), max, %	...	6.0	...	...	...
Ferric oxide (Fe_2O_3), max, %	...	6.0	...	6.5	...
Magnesium oxide (MgO), max, %	6.0	6.0	6.0	6.0	6.0
Sulfur trioxide (SO_3), [B] max, %					
When (C_3A) [C] is 8 % or less	3.0	3.0	3.5	2.3	2.3
When (C_3A) [C] is more than 8 %	3.5	[D]	4.5	[D]	[D]
Loss on ignition, max, %	3.0	3.0	3.0	2.5	3.0
Insoluble residue, max, %	0.75	0.75	0.75	0.75	0.75
Tricalcium silicate (C_3S) [C] max, %	...	...	...	35 [E]	...
Dicalcium silicate (C_2S) [C] min, %	...	...	...	40 [E]	...
Tricalcium aluminate (C_3A) [C] max, %	...	8	15	7 [E]	5 [F]
Tetracalcium aluminoferrite plus twice the tricalcium aluminate [C] $(C_4AF + 2(C_3A))$, or solid solution $(C_4AF + C_2F)$, as applicable, max, %	...	...	...	...	25 [F]

[A] See Note.

[B] There are cases where optimum SO_3 (using Test Method C 563) for a particular cement is close to or in excess of the limit in this specification. In such cases where properties of a cement can be improved by exceeding the SO_3 limits stated in this table, it is permissible to exceed the values in the table, provided it has been demonstrated by Test Method C 1038 that the cement with the increased SO_3 will not develop expansion in water exceeding 0.020 % at 14 days. When the manufacturer supplies cement under this provision, he shall, upon request, supply supporting data to the purchaser.

[C] The expressing of chemical limitations by means of calculated assumed compounds does not necessarily mean that the oxides are actually or entirely present as such compounds.

When expressing compounds, C = CaO, S = SiO_2, A = Al_2O_3, F = Fe_2O_3. For example, $C_3A = 3CaO \cdot Al_2O_3$.

Titanium dioxide and phosphorus pentoxide (TiO_2 and P_2O_5) shall be included with the Al_2O_3 content. The value historically and traditionally used for Al_2O_3 in calculating potential compounds for specification purposes is the ammonium hydroxide group minus ferric oxide ($R_2O_3 - Fe_2O_3$) as obtained by classical wet chemical methods. This procedure includes as Al_2O_3 the TiO_2, P_2O_5 and other trace oxides which precipitate with the ammonium hydroxide group in the classical wet chemical methods. Many modern instrumental methods of cement analysis determine aluminum or aluminum oxide directly without the minor and trace oxides included by the classical method. Consequently, for consistency and to provide comparability with historic data and among various analytical methods, when calculating potential compounds for specification purposes, those using methods which determine Al or Al_2O_3 directly should add to the determined Al_2O_3 weight quantities of P_2O_5, TiO_2 and any other oxide except Fe_2O_3 which would precipitate with the ammonium hydroxide group when analyzed by the classical method and which is present in an amount of 0.05 weight % or greater. The weight percent of minor or trace oxides to be added to Al_2O_3 by those using direct methods may be obtained by actual analysis of those oxides in the sample being tested or estimated from historical data on those oxides on cements from the same source, provided that the estimated values are identified as such.

When the ratio of percentages of aluminum oxide to ferric oxide is 0.64 or more, the percentages of tricalcium silicate, dicalcium silicate, tricalcium aluminate, and tetracalcium aluminoferrite shall be calculated from the chemical analysis as follows:

Tricalcium silicate = $(4.071 \times \%\ CaO) - (7.600 \times \%\ SiO_2) - (6.718 \times \%\ Al_2O_3) - (1.430 \times \%\ Fe_2O_3) - (2.852 \times \%\ SO_3)$

Dicalcium silicate = $(2.867 \times \%\ SiO_2) - (0.7544 \times \%\ C_3S)$

Tricalcium aluminate = $(2.650 \times \%\ Al_2O_3) - (1.692 \times \%\ Fe_2O_3)$

Tetracalcium aluminoferrite = $3.043 \times \%\ Fe_2O_3$

When the alumina-ferric oxide ratio is less than 0.64, a calcium aluminoferrite solid solution (expressed as $ss(C_4AF + C_2F)$) is formed. Contents of this solid solution and of tricalcium silicate shall be calculated by the following formulas:

$ss(C_4AF + C_2F) = (2.100 \times \%\ Al_2O_3) + (1.702 \times \%\ Fe_2O_3)$

Tricalcium silicate = $(4.071 \times \%\ CaO) - (7.600 \times \%\ SiO_2) - (4.479 \times \%\ Al_2O_3) - (2.859 \times \%\ Fe_2O_3) - (2.852 \times \%\ SO_3)$.

No tricalcium aluminate will be present in cements of this composition. Dicalcium silicate shall be calculated as previously shown.

In the calculation of all compounds the oxides determined to the nearest 0.1 % shall be used.

All values calculated as described in this note shall be reported to the nearest 1 %.

[D] Not applicable.

[E] Does not apply when the heat of hydration limit in Table 4 is specified.

[F] Does not apply when the sulfate resistance limit in Table 4 is specified.

5. Additions

5.1 The cement covered by this specification shall contain no addition except as follows:

5.1.1 Water or calcium sulfate, or both, may be added in amounts such that the limits shown in Table 1 for sulfur trioxide and loss-on-ignition shall not be exceeded.

5.1.2 At the option of the manufacturer, processing additions may be used in the manufacture of the cement, provided such materials in the amounts used have been shown to meet the requirements of Specification C 465.

5.1.3 Air-entraining portland cement shall contain an interground addition conforming to the requirements of Specification C 226.

6. Chemical Composition

6.1 Portland cement of each of the eight types shown in Section 1 shall conform to the respective standard chemical requirements prescribed in Table 1. In addition, optional chemical requirements are shown in Table 2.

7. Physical Properties

7.1 Portland cement of each of the eight types shown in Section 1 shall conform to the respective standard physical requirements prescribed in Table 3. In addition, optional physical requirements are shown in Table 4.

8. Sampling

8.1 When the purchaser desires that the cement be sampled and tested to verify compliance with this specification, sampling and testing should be performed in accordance with Practice C 183.

8.2 Practice C 183 is not designed for manufacturing quality control and are not required for manufacturer's certification.

9. Test Methods

9.1 Determine the applicable properties enumerated in this specification in accordance with the following test methods:

9.1.1 *Air Content of Mortar*—Test Method C 185.

TABLE 2 Optional Chemical Requirements[A]

Cement Type	I and IA	II and IIA	III and IIIA	IV	V	Remarks
Tricalcium aluminate (C_3A),[B] max, %	...	...	8	...	...	for moderate sulfate resistance
Tricalcium aluminate (C_3A),[B] max, %	...	...	5	...	...	for high sulfate resistance
Sum of tricalcium silicate and tricalcium aluminate,[B] max, %	...	58[C]	...	...	...	for moderate heat of hydration
Alkalies ($Na_2O + 0.658K_2O$), max, %	0.60[D]	0.60[D]	0.60[D]	0.60[D]	0.60[D]	low-alkali cement

[A] These optional requirements apply only if specifically requested. Availability should be verified. See note in Section 4.

[B] The expressing of chemical limitations by means of calculated assumed compounds does not necessarily mean that the oxides are actually or entirely present as such compounds.

When expressing compounds, C = CaO, S = SiO_2, A = Al_2O_3, F = Fe_2O_3. For example, $C_3A = 3CaO \cdot Al_2O_3$.

Titanium dioxide and phosphorus pentoxide (TiO_2 and P_2O_5) shall be included with the Al_2O_3 content. The value historically and traditionally used for Al_2O_3 in calculating potential compounds for specification purposes is the ammonium hydroxide group minus ferric oxide ($R_2O_3 - Fe_2O_3$) as obtained by classical wet chemical methods. This procedure includes as Al_2O_3 the TiO_2, P_2O_5 and other trace oxides which precipitate with the ammonium hydroxide group in the classical wet chemical methods. Many modern instrumental methods of cement analysis determine aluminum or aluminum oxide directly without the minor and trace oxides included by the classical method. Consequently, for consistency and to provide comparability with historic data and among various analytical methods, when calculating potential compounds for specification purposes, those using methods which determine Al or Al_2O_3 directly should add to the determined Al_2O_3 weight quantities of P_2O_5, TiO_2 and any other oxide except Fe_2O_3 which would precipitate with the ammonium hydroxide group when analyzed by the classical method and which is present in an amount of 0.05 weight % or greater. The weight percent of minor or trace oxides to be added to Al_2O_3 by those using direct methods may be obtained by actual analysis of those oxides in the sample being tested or estimated from historical data on those oxides on cements from the same source, provided that the estimated values are identified as such.

When the ratio of percentages of aluminum oxide to ferric oxide is 0.64 or more, the percentages of tricalcium silicate, dicalcium silicate, tricalcium aluminate and tetracalcium aluminoferrite shall be calculated from the chemical analysis as follows:

Tricalcium silicate = $(4.071 \times \%\ CaO) - (7.600 \times \%\ SiO_2) - (6.718 \times \%\ Al_2O_3) - (1.430 \times \%\ Fe_2O_3) - (2.852 \times \%\ SO_3)$

Dicalcium silicate = $(2.867 \times \%\ SiO_2) - (0.7544 \times \%\ C_3S)$

Tricalcium aluminate = $(2.650 \times \%\ Al_2O_3) - (1.692 \times \%\ Fe_2O_3)$

Tetracalcium aluminoferrite = $3.043 \times \%\ Fe_2O_3$

When the alumina-ferric oxide ratio is less than 0.64, a calcium aluminoferrite solid solution (expressed as ss ($C_4AF + C_2F$)) is formed. Contents of this solid solution and of tricalcium silicate shall be calculated by the following formulas:

$ss(C_4AF + C_2F) = (2.100 \times \%\ Al_2O_3) + (1.702 \times \%\ Fe_2O_3)$

Tricalcium silicate = $(4.071 \times \%\ CaO) - (7.600 \times \%\ SiO_2) - (4.479 \times \%\ Al_2O_3) - (2.859 \times \%\ Fe_2O_3) - (2.852 \times \%\ SO_3)$.

No tricalcium aluminate will be present in cements of this composition. Dicalcium silicate shall be calculated as previously shown.

In the calculation of all compounds the oxides determined to the nearest 0.1 % shall be used.

All values calculated as described in this note shall be reported to the nearest 1 %.

[C] The optional limit for heat of hydration in Table 4 shall not be requested when this optional limit is requested.

[D] This limit may be specified when the cement is to be used in concrete with aggregates that may be deleteriously reactive. Reference should be made to Specification C 33 for suitable criteria of deleterious reactivity.

9.1.2 *Chemical Analysis*—Test Methods C 114.

9.1.3 *Strength*—Test Method C 109.

9.1.4 *False Set*—Test Method C 451.

9.1.5 *Fineness by Air Permeability*—Test Method C 204.

9.1.6 *Fineness by Turbidimeter*—Test Method C 115.

9.1.7 *Heat of Hydration*—Test Method C 186.

9.1.8 *Autoclave Expansion*—Test Method C 151.

9.1.9 *Time of Setting by Gillmore Needles*—Test Method C 266.

9.1.10 *Time of Setting by Vicat Needles*—Test Method C 191.

9.1.11 *Sulfate Resistance*—Test Method C 452 (sulfate expansion).

9.1.12 *Calcium Sulfate (expansion of) Mortar*—Test Method C 1038.

9.1.13 *Optimum SO_3*—Test Method C 563.

10. Inspection

10.1 Inspection of the material shall be made as agreed upon by the purchaser and the seller as part of the purchase contract.

11. Rejection

11.1 The cement may be rejected if it fails to meet any of the requirements of this specification.

11.2 Cement remaining in bulk storage at the mill, prior to shipment, for more than 6 months, or cement in bags in local storage in the hands of a vendor for more than 3 months, after completion of tests, may be retested before use and may be rejected if it fails to conform to any of the requirements of this specification.

11.3 Packages shall identify the weight as net weight. Packages more than 2 % below the weight marked thereon may be rejected; and if the average weight of packages in any shipment, as shown by weighing 50 packages taken at random, is less than that marked on the packages, the entire shipment may be rejected.

12. Manufacturer's Statement

12.1 At the request of the purchaser, the manufacturer shall state in writing the nature, amount, and identity of the air-entraining agent used, and of any processing addition that may have been used, and also, if requested, shall supply test data showing compliance of such air-entraining addition with the provisions of Specification C 226, and of any such processing addition with Specification C 465.

13. Packaging and Package Marking

13.1 When the cement is delivered in packages, the words "Portland Cement," the type of cement, the name and brand of the manufacturer, and the weight of the cement contained therein shall be plainly marked on each package. When the cement is an air-entraining type, the words "air-entraining" shall be plainly marked on each package. Similar information shall be provided in the shipping documents accompanying the shipment of packaged or bulk cement. All packages shall be in good condition at the time of inspection.

TABLE 3 Standard Physical Requirements

Cement Type [A]	I	IA	II	IIA	III	IIIA	IV	V
Air content of mortar, [B] volume %:								
max	12	22	12	22	12	22	12	12
min	...	16	...	16	...	16	...	...
Fineness, [C] specific surface, m^2/kg (alternative methods):								
Turbidimeter test, min	160	160	160	160	...	...	160	160
Air permeability test, min	280	280	280	280	...	...	280	280
Autoclave expansion, max, %	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Strength, not less than the values shown for the ages indicated below: [D]								
Compressive strength, psi (MPa):								
1 day	...	...	...	...	1800 (12.4)	1450 (10.0)	...	...
3 days	1800 (12.4)	1450 (10.0)	1500 (10.3) 1000 [F] (6.9) [F]	1200 (8.3) 800 [F] (5.5) [F]	3500 (24.1)	2800 (19.3)	...	1200 (8.3)
7 days	2800 (19.3)	2250 (15.5)	2500 (17.2) 1700 [F] (11.7) [F]	2000 (13.8) 1350 [F] (9.3) [F]	...	...	1000 (6.9)	2200 (15.2)
28 days	...	...	...	...	...	...	2500 (17.2)	3000 (20.7)
Time of setting (alternative methods): [E]								
Gillmore test:								
Initial set, min, not less than	60	60	60	60	60	60	60	60
Final set, min, not more than	600	600	600	600	600	600	600	600
Vicat test: [G]								
Time of setting, min, not less than	45	45	45	45	45	45	45	45
Time of setting, min, not more than	375	375	375	375	375	375	375	375

[A] See Note.
[B] Compliance with the requirements of this specification does not necessarily ensure that the desired air content will be obtained in concrete.
[C] Either of the two alternative fineness methods may be used at the option of the testing laboratory. However, when the sample fails to meet the requirements of the air-permeability test, the turbidimeter test shall be used, and the requirements in this table for the turbidimetric method shall govern.
[D] The strength at any specified test age shall be not less than that attained at any previous specified test age.
[E] The purchaser should specify the type of setting-time test required. In case he does not so specify, the requirements of the Vicat test only shall govern.
[F] When the optional heat of hydration or the chemical limit on the sum of the tricalcium silicate and tricalcium aluminate is specified.
[G] The time of setting is that described as initial setting time in Test Method C 191.

TABLE 4 Optional Physical Requirements [A]

Cement Type	I	IA	II	IIA	III	IIIA	IV	V
False set, final penetration, min, %	50	50	50	50	50	50	50	50
Heat of hydration:								
7 days, max, cal/g (kJ/kg)	...	...	70 (290) [B]	70 (290) [B]	...	...	60 [C] (250)	...
28 days, max, cal/g (kJ/kg)	...	...	...	...	...	...	70 [C] (290)	...
Strength, not less than the values shown:								
Compressive strength, psi (MPa)								
28 days	4000 (27.6)	3200 (22.1)	4000 (27.6) 3200 [B] (22.1) [B]	3200 (22.1) 2560 [B] (17.7) [B]	...	...	...	...
Sulfate resistance, [D] 14 days, max, % expansion	...	...	...	...	...	...	...	0.040

[A] These optional requirements apply only if specifically requested. Availability should be verified. See Note in Section 4.
[B] The optional limit for the sum of the tricalcium silicate and tricalcium aluminate in Table 2 shall not be requested when this optional limit is requested. These strength requirements apply when either heat of hydration or the sum of tricalcium silicate and tricalcium aluminate requirements are requested.
[C] When the heat of hydration limit is specified, it shall be instead of the limits of C3S, C2S, and C3A listed in Table 1.
[D] When the sulfate resistance is specified, it shall be instead of the limits of C_3A and $C_4AF + 2\ C_3A$ listed in Table 1.

14. Storage

14.1 The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment, and in a suitable weather-tight building that will protect the cement from dampness and minimize warehouse set.

15. Manufacturer's Certification

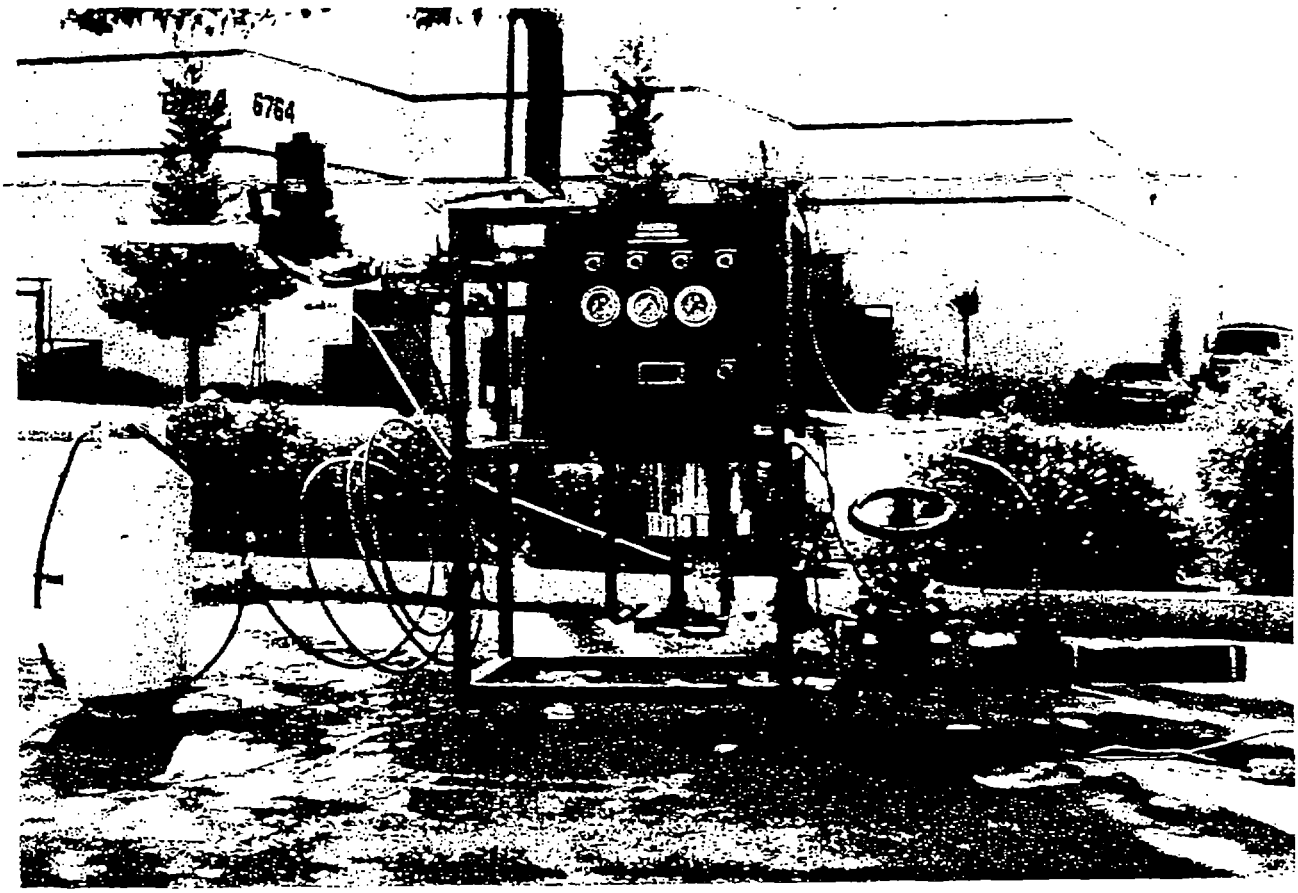
15.1 Upon request of the purchaser in the contract or order, a manufacturer's report shall be furnished at the time of shipment stating the results of tests made on samples of the material taken during production or transfer and certifying that the cement conforms to applicable requirements of this specification.

APPENDIX B

BOILER LITERATURE

NATIONAL VAPOR INDUSTRIES, INC.

Manufacturer of superior steam generator systems



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- Continues in full operation for duration of project

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- No lost time in maintenance shut-downs
- No lost temperature to maintenance shut-downs

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- Auto safety shut-off / recycle design
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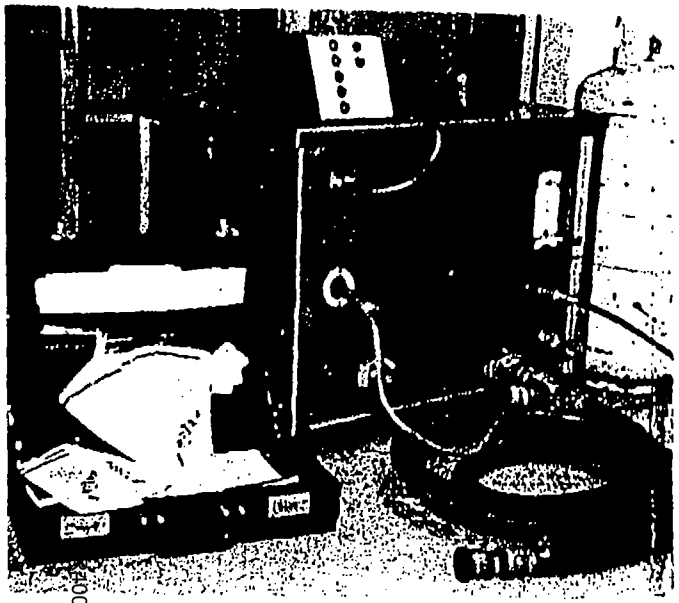

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- DE GREASERS
- PESTICIDES
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RETEC

Final SJO

REMOVAL ACTION CONTINGENCY PLAN

RELIEF AND GAS HOLDER REMEDIATION

UGI COLUMBIA GAS PLANT SITE
Columbia, Pennsylvania

Prepared for:

PENNSYLVANIA POWER & LIGHT COMPANY
Two North Ninth Street
Allentown, Pennsylvania 18101-1179

Prepared by:

REMEDIATION TECHNOLOGIES, INC.
9 Pond Lane
Concord, Massachusetts 01742

Project No. 3-1612-200

NOVEMBER 1995

ORIGINAL (Red)

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Reviewed by: _____

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NOVEMBER 1995

ORIGINAL (Red)

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1.0 INTRODUCTION

The UGI Gas Plant site in Columbia, Pennsylvania was placed on the National Priorities List in June 1994. The process of site remediation has been initiated under the Superfund Accelerated Cleanup Model (SACM) as a non-time critical removal action. RETEC prepared an Engineering Evaluation/Cost Analysis (EE/CA) for the relief and gas holders at the site. The results of the EE/CA showed that the selected remedy for the relief holder should be enhanced recovery using steam injection. The selected remedy for the gas holder should be conventional pumping. The final step will be to remove residual liquids from both holders and grout them closed. The Electric Power Research Institute (EPRI) and Pennsylvania Power and Light Company (PP&L) have entered into a Tailored Collaboration to remediate the relief and gas holders at the site.

The work to be performed at the site includes removing MGP residuals from two former holders, a relief holder (60 feet diameter, 27 feet deep) and a gas holder (40 feet diameter, 17 feet deep). The relief holder is filled with soil and debris and is saturated with tar and water. The gas holder is also filled with soil and debris and is saturated with water and aqueous tar constituents. The selected remedy for removing the MGP residuals from the relief holder is an enhanced recovery process. The enhanced recovery process involves injecting steam into the holder, pumping tar and water out of the holder, separating the tar from the water, disposing of the tar, heating the water and recycling it back through the holder as low quality steam. Once all separable tar has been removed from the holder, the remaining water will be pumped from the holder, treated in an on site water treatment system, and discharged to the Susquehanna River. The selected remedy for the gas holder involves pumping the liquids out of the holder, treating with the on site water treatment system and discharging them to the river.

Many industrial activities have the potential for causing environmental degradation or endangerment of public health and safety through accidental releases of toxic, hazardous, or other pollutional materials. In Pennsylvania, industrial and commercial installations which have the potential for causing accidental pollution of air, land, or water, or the endangerment of public health and safety are required to develop and implement Preparedness, Preventing, and Contingency (PPC) Plans. Also, manufacturing or commercial installations which generate hazardous waste, or which involve treatment, storage, or disposal of hazardous waste must develop PPC plans in conformance with Chapter 262, 264, and 265 of the Pennsylvania Department of Environmental Protection's (PADEP) regulations.

Remediation Technologies (RETEC), Inc., on behalf of Pennsylvania Power and Light (PP&L), has prepared this Contingency Plan, in accordance with PADEP guidance, to present response measures that will be implemented if an emergency situation arises.

This Contingency Plan focuses on the emergency response procedures to be implemented in the case of an emergency while the remedial action is being implemented at the former MGP Site in Columbia, Pennsylvania. It develops response measures in the event of accidents, leaks, or other emergencies. The site Contingency Plan includes the following information:

- identification of person responsible for responding in the event of an emergency incident;
- first aid and medical information including a clearly marked map with the locations of medical facilities;
- all necessary emergency phone numbers; and
- a spill prevention and countermeasures plan.

Implementing the appropriate emergency and contingency measures outlined in this Plan will increase the safety of site personnel and the safety of nearby residents. The controls will aid in the effective preparedness for site emergencies.

A copy of the Contingency Plan will be provided to local police departments, fire departments, hospitals, employed contractors, and state and local emergency response teams. A copy of the Contingency Plan will also be kept on site. PADEP and EPA Region III will be notified prior to the commencement of any work activities.

2.0 DESCRIPTION OF FACILITY

The UGI Columbia Gas Plant site is located along Front Street in the Borough of Columbia, Lancaster County, Pennsylvania. The property encompasses approximately 1.6 acres, and is enclosed by a chain-link fence. The site can be located on the United States Geological Survey (U.S.G.S.) Columbia East, Pennsylvania 7.5 minute series quadrangle at 40° 01' 37" north latitude and 76° 30' 01" west longitude or 0.05 inch east and 4.9 inches north of the southwestern corner of the quadrangle. Figure 2-1 presents the location of the site.

2.1 Description of the Industrial or Commercial Activity

The site was operated as a gas manufacturing facility from approximately 1853 to 1948. Figure 2-2 presents a map of the site. Prior reports indicate the Columbia Gas Company, which was organized in 1851, was the first to operate the site as a gas manufacturing facility. The property was owned and operated by Columbia Gas until 1935, when the property was transferred to the Pennsylvania Power and Light Company (PP&L).

In 1949, the property was transferred to the Lancaster County Gas Company, which later merged into UGI Corporation. Thomas Crouse purchased the property in 1976 from UGI Corporation. In October 1979, George Roach purchased two-thirds of the property from UGI and began operating the site as a boat dealership. The site was repurchased by PP&L on January 27, 1994.

2.1.1 Facility Operations

The Columbia Gas Company originated in 1851 with the prospect of supplying the Borough of Columbia, Pennsylvania with manufactured gas. Previous investigations indicate that manufactured gas was originally generated from wood. These investigations also indicate that there is no other information concerning operations at the site prior to 1910.

The manufactured gas process began with the transport of gas from two gas generating sets through a washbox, condenser, washer cooler, and stored in a relief holder. From the relief holder, the gas proceeded through a tar separator, a purifier, and finally distributed to a holder for distribution to the city.

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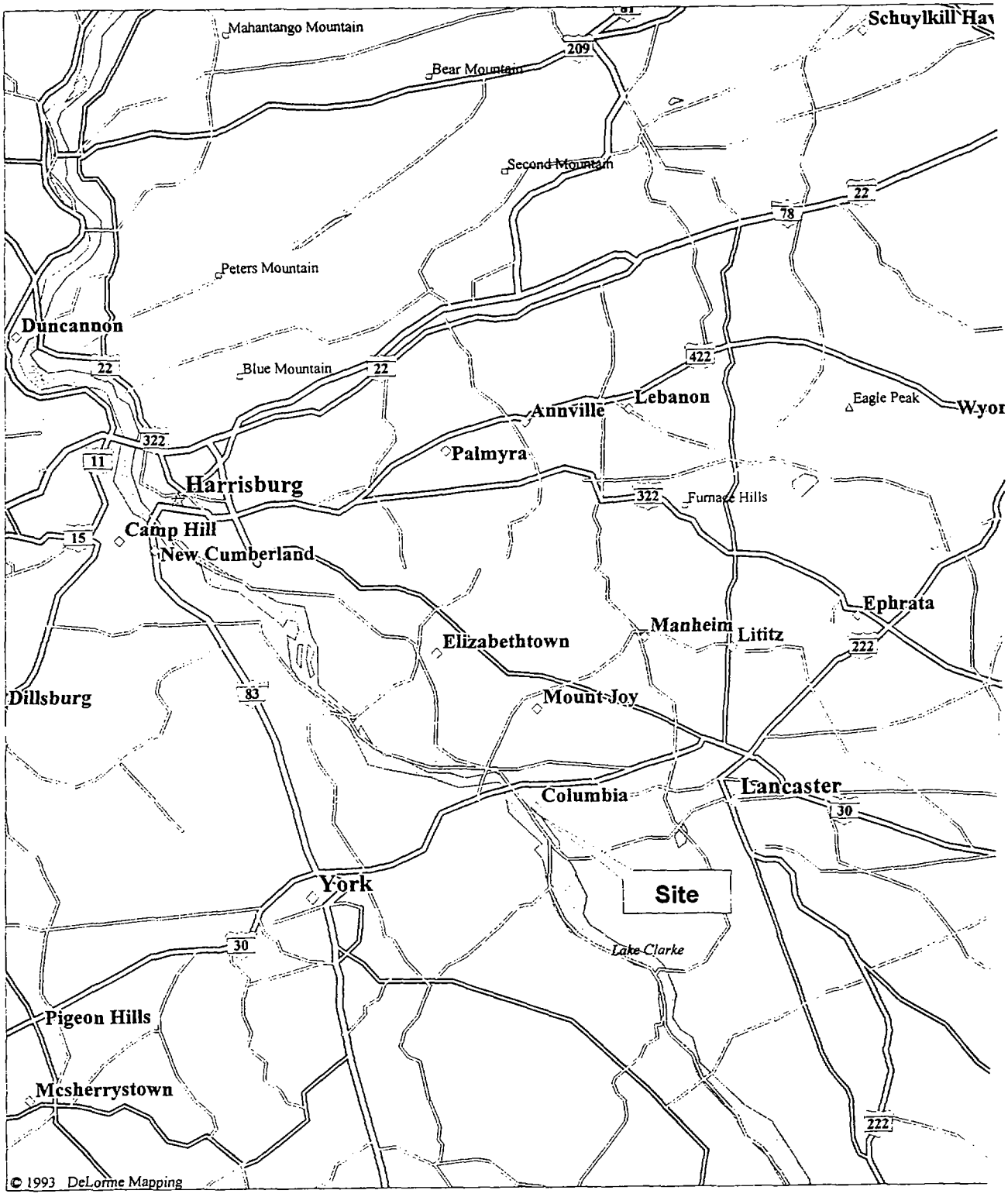
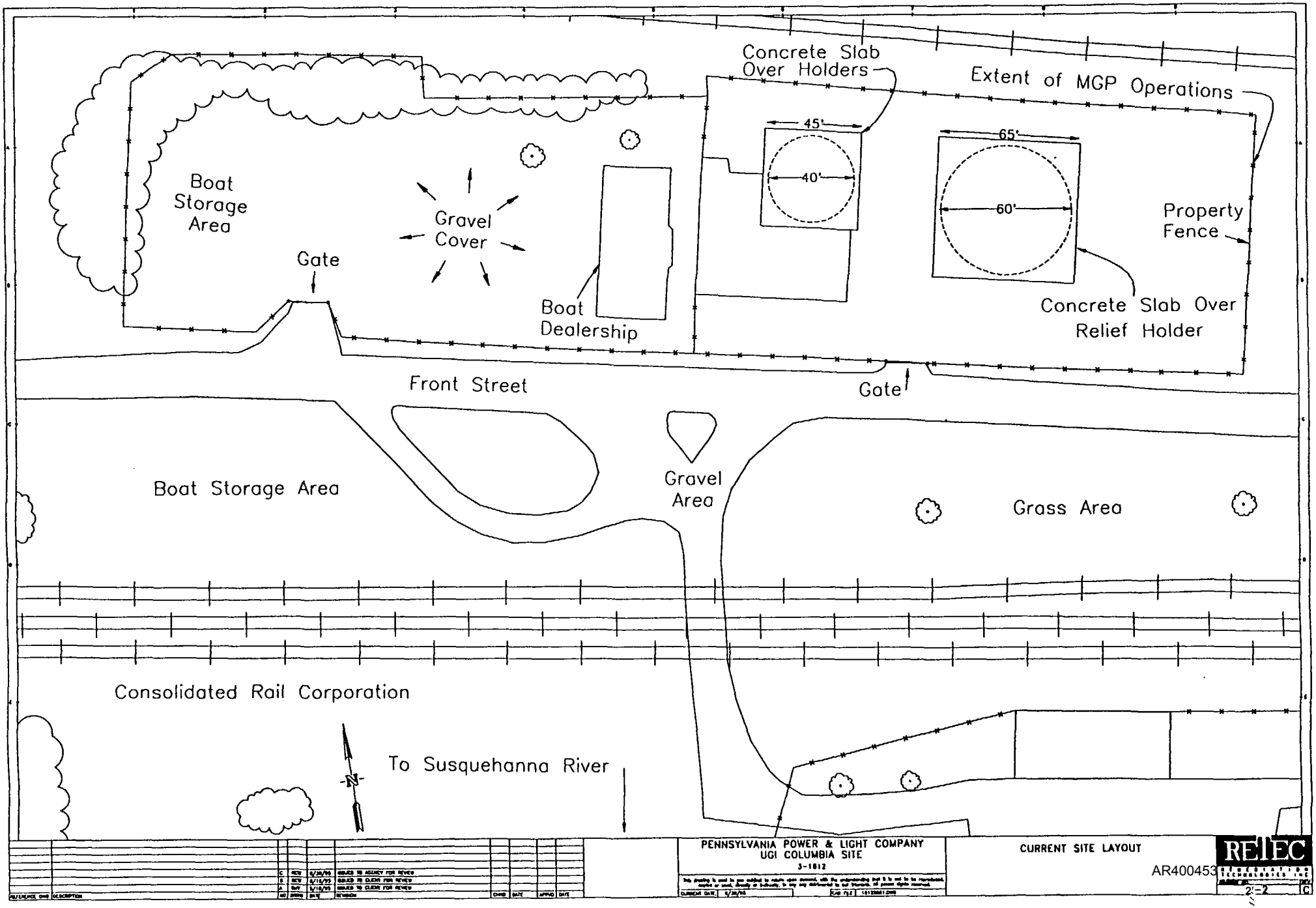


Site Location Map

FIGURE 2-1



PENNSYLVANIA POWER & LIGHT COMPANY
UGI COLUMBIA SITE
3-1812

CURRENT SITE LAYOUT

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2-2

2.1.2 Physical Description

In 1910, the plant was completely rebuilt, with the exception of two gas holders and one boiler. The reconstruction included new buildings on former building foundations, a tar separator, water gas sets, and a double unit purifier. Old plans reveal the presence of an artesian well. Attempts to locate this well have been unsuccessful. However, post-1910 operations used city water. A site layout map of the plant, dated 1935 [TRC, 1986], revealed the structures present during operation. They include the following:

- 60 foot diameter relief holder;
- 40 foot diameter gas holder;
- oil tank;
- cooler tank;
- tar separator;
- tar tanks;
- meter house;
- boiler and generating house;
- brick room; and
- purifier house.

The gas holder, also known as the city or distribution holder pit, was located near the center of the property, east of the larger of the two on-site buildings. The gas holder was used to store gas prior to distribution. The 40 foot diameter structure was a brick-lined cylindrical pit with a concrete base. A more extensive investigation of the gas holder was performed in December 1993 by Remediation Technologies, Inc. to determine its contents.

The relief holder was constructed of riveted steel plates and was contained within a pit that was approximately 26 feet deep. Tars were stored inside the relief holder during the plants operation in order to allow for the separation of tar/water emulsion. In 1947, the relief holder had a structural failure. However, the relief pit remained in use as a separator. Tar of good quality was sold and the remaining tar was left in the pit. Once operation of the plant ceased, the pit was filled with general refuse, construction fill, and soil.

After Mr. Roach purchased the property in October 1979, he observed tar oozing up through the parking lot area, which subsequently resulted in the regrading of the property. The former relief holder foundation was found to be filled with refuse, construction debris, and fill.

During the regrading, tars within the relief holder were displaced and reportedly released to the surface soils in the immediate area. The tars were then forced into a former pedestrian tunnel/underpass located on the property and enclosed within the underpass through the construction of a small dike. The total volume of tar contained within the tunnel was estimated at 7,500 gallons during the 1985 site investigation.

Currently, there are two unoccupied buildings on the property. Two concrete pads, one 45 by 45 feet and one 65 by 65 feet, are located southeast of the buildings. These pads cover the former relief and gas holders. Conrail railroad tracks run adjacent to the site on the northeastern side. The former pedestrian tunnel which passes under the tracks, has since been blocked off at the eastern end due to the expansion of the railroad track. The remainder of the site is covered with gravel.

Investigations have revealed that coal tar is present outside the holders. This has led to soil contamination and coal tar penetration into fractured bedrock. Groundwater moving through the site has subsequently become contaminated with coal tar constituents. Halliburton NUS (1993) performed a hazardous ranking for the site which has led to a recommendation that the site be placed on the National Priorities List (NPL).

2.2 Description of Existing Emergency Response Plans

The Site-Specific Health and Safety Plan (HASP) (RETEC, 1995) was prepared for the UGI Columbia Gas Plant site in September 1995. The plan describes the Health and Safety (H&S) protocols developed for the site and was designed to protect on-site personnel, visitors, and the public from known or suspected health and safety hazards during design and removal action activities. The Site-Specific HASP was prepared for the Non-Time Critical Removal activities in accordance with OSHA regulations (29 CFR 1910.120). The procedures and guidelines contained in the HASP are based on the most up-to-date information available at the time of the drafting of the document. Specific sections of the HASP and this plan will be changed or revised if or when additional information is received or when conditions at the site change. Any changes or revisions to the HASP will be by a written amendment which will become a permanent part of the plan.

2.3 Material and Waste Inventory

Previous sampling and analytical data, investigations, and site history have indicated that the chemical hazards, presented in Table 2-1, exist at the site. Detailed hazard information for these chemicals is available through MSDS sheets in Appendix A.

Primary chemical hazards will be volatile compounds. Benzene, although not expected in high concentrations, is a highly volatile compound that can be noted by its gasoline-like odor. Benzene is considered a carcinogen and therefore immediately dangerous to life and health at any detectable concentration. Respiratory protection should include the use of an air-purifying respirator with organic vapor cartridges when required according to the Health and Safety Plan. Naphthalene will be expected in higher concentrations than benzene. Naphthalene is also volatile but not considered carcinogenic and can be easily detected by its mothball-like odor. An air-purifying respirator with combination organic vapor/dust, mist cartridges should also be used in the presence of naphthalene. Although coal tar contains many carcinogenic compounds, most are only slightly volatile and pose hazards primarily through dermal or eye contact and ingestion.

Contact with coal tar constituents is not likely to be significant. However, there are certain phases of the project that are more likely to expose a worker to coal tar. If exposure is likely to occur, workers will be required to wear, at a minimum, full level D with eye protection, tyvek and any other personal protective equipment specified in the Site-Specific Health and Safety Plan.

2.3.1 Treatment Chemicals

Chemicals associated with the designed recovery process include hydrogen peroxide (H_2O_2), liquid caustic soda (NaOH), sulfuric acid (H_2SO_4), activated carbon, and Drewfloc 2270 (polyacrylic acid, anionic flocculent). MSDS's for these chemicals are included in Appendix A.

H_2O_2, NaOH, and H_2SO_4 will be delivered to the site as needed for the recovery process. Textile Chemical Company (P.O. Box 13788, Reading PA 19612-3788, phone: 800-422-8160) will provide 55-gallon poly-drums of each chemical. Delivery is provided by Textile Chemical Company and is done using liftgate service. A detailed explanation of the procedure to be used during chemical delivery is presented in the Operations and Maintenance Plan (RETEC, 1995).

TABLE 2-1

Potential Site Chemical Hazards

CONTAMINANT	SKIN HAZ.	PEL [1]	TLV [2]	REL [3]	STEL[4]	IDLH[5]	ODOR THRES-HOLD	IP[6]
Coal Tar	No	0.2	0.2	0.1	N/A	700CA	0.1-0.2	N/A
Benzene	Yes	1	0.10	0.1	5	3000CA	34-119	9.24
Toluene	Yes	100	50	100	150	2000	0.16-37	8.82
Ethylbenzene	No	100	100	100	125	2000	0.092-.060	8.76
Xylene	No	100	100	100	150	1000	20	8.5
Naphthalene	No	10	10	10	15	500	0.038	8.12
Activated Carbon	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cyanide	Yes	5	N/A	5	N/A	50	N/A	N/A

NOTE:

[1] All Concentrations in mg/m^3 (ppm)
[2] ACGIH Threshold Limit Value (TLV)
[3] NIOSH Recommended Exposure Limit (REL)
USE LOWEST FIGURE OF THE THREE LIMITS.
[4] Short-Term Exposure Limit (STEL)
[5] Immediately Dangerous to Life and Health (IDLH)
[6] Ionization Potential (IP)
[7] OSHA Permissible Exposure Limit (PEL)
[8] CA = Carcinogenic

2.3.1.1 Hydrogen Peroxide

55-gallon poly-drums of 50% hydrogen peroxide solution will be metered into the process water to oxidize dissolved iron. H_2O_2 drums will be stored and contained within the tankfarm. Because of potential reactions between the H_2O_2 and activated carbon, the drums of activated carbon will be stored separately inside the on-site building. Drums of H_2O_2 do not need to be separated from drums of NaOH or $H2SO_4$.

2.3.1.2 Liquid Caustic Soda

55-gallon poly-drums of 25% sodium hydroxide (liquid caustic soda) solution will be metered into the process water to raise the pH for iron oxidation. NaOH drums will be stored and contained within the tankfarm. Due to the potential for a reaction between acids and bases, the NaOH will be stored, within the tankfarm, at a safe distance from the H_2SO_4. The NaOH drums may be kept in close proximity to H_2O_2 due to the lack of potential reactions between the two chemicals.

2.3.1.3 Sulfuric Acid

55-gallon poly-drums of 93-94% sulfuric acid solution will be metered into the process water to lower the pH for coal tar emulsion "cracking". H_2SO_4 drums will be stored and contained within the tankfarm. Due to the potential for a reaction between acids and bases, the H_2SO_4 will be stored, within the tankfarm, at a safe distance from the NaOH. The H_2SO_4 drums may be kept in close proximity to H_2O_2 due to the lack of potential reactions between the two chemicals.

2.3.1.4 Activated Carbon

200-pound, 55-gallon activated carbon absorption (CA) units will be used to polish discharge water to the Susquehanna River. Calgon Carbon Corporation (P.O. Box 717 Pittsburgh, PA 15230-0717, phone: 412-787-6700) will supply the CA units. CA units will be stored inside the on-site building and, therefore, will be kept separately from the other chemicals stored within the tankfarm. The potential reaction between the activated carbon and H_2O_2 is eliminated by their physical separation.

2.3.1.5 Drewfloc 2270

A 5-gallon container of Drewfloc 2270 (polyacrylic acid, anionic flocculent) will be stored in the on-site building. Drewfloc 2270 is an inert, very high molecular weight, highly anionic, single component, emulsion polymer. Drewfloc 2270 is highly effective in water clarification applications with typical addition levels ranging between 0.2-0.5 parts per million (ppm). Because the flocculant is inert, storage considerations are minimal. Drewfloc 2270 should be stored where temperature conditions are between 40-95°F.

2.4 Pollution Incident History

A pollution incident history is not entirely applicable or appropriate for this site. Accurate records of pollution incidents are not available due to the fact that facility operations occurred and were discontinued prior to requirements for this type of record keeping.

2.5 Implementation Schedule for Plan Elements Not Currently in Place

This document does not contain any missing or incomplete elements of a PPC plan. Therefore, an implementation schedule for plan elements not currently in place is not appropriate.

3.0 DESCRIPTION OF HOW PLAN IS IMPLEMENTED BY ORGANIZATION

3.1 Organizational Structure of Facility for Implementation

An organizational structure concerning implementation of this PPC plan is not applicable because this facility will have a single operator responsible for developing and implementing the plan. The operator of this site has been given both the responsibility and authority, by management, for developing, implementing, and maintaining this PPC plan.

The responsibilities of the operator include:

- identifying all handled wastes and materials;
- keeping an updated inventory of all handled wastes and materials;
- identifying potential spill sources;
- conducting visual inspections;
- reviewing past incidents and the countermeasures utilized;
- coordinating or plan implementation;
- coordination of spill cleanup activities; and
- notification of authorities when necessary.

3.2 List of Emergency Coordinators

A list of emergency coordinators for the implementation of this PPC plan is not applicable because this facility will have a single operator responsible for implementing the plan. The operator of this site has been given both the resposibility and authority to be the single emergency coordinator in the event of an emergency.

The operator will be available, at all times, to act as the emergency coordinator. The operator will be thoroughly familiar with all aspects of the plan, all operations and activities, the location and characteristics of all materials handled, the location of all records, and the layout of the facility. In addition, this individual will have the authority to commit the resources necessary to carry out the plan.

3.3 Duties and Responsibilities of the Coordinator

This section presents the duties and responsibilities of the emergency coordinator, specific to this installation, in the event of and imminent or actual emergency.

Whenever there is an emission or discharge, fire or explosion, the emergency coordinator must immediately identify the character, exact source, amount and areal extent of emitted or discharged materials. He may do this by observation or review of records and, if necessary, by chemical analysis.

Concurrently, the emergency coordinator must assess possible hazards to human health or the environment that may result from the emission, discharge, fire, or explosion. This assessment must consider both direct and indirect effects of the emission, discharge, fire, or explosion.

If the emergency coordinator determines that the installation has had an emission, discharge, fire, or explosion which would threaten human health or the environment, he must immediately notify the applicable local authorities including the county emergency management agency and indicate if the evacuation of local areas may be advisable; and immediately notify the Pennsylvania Department of Environmental Protection (PADEP) in accordance with Appendix IV; the National Response Center at (800) 424-8802; the Pennsylvania Emergency Management Agency at (717) 783-8150; and report the following:

1. Name of the person reporting the incident.
2. Name and location of the installation.
3. Phone number where the person reporting the spill can be reached.
4. Date, time, and location of the incident.
5. A brief description of the incident, nature of the materials or wastes involved, extent of any injuries, and possible hazards to human health or the environment.
6. The estimated quantity of the materials or wastes spilled.
7. The extent of contamination of land, water, or air, if known.

During an emergency, the emergency coordinator must take all reasonable measures necessary to ensure that fire, explosion, emission, or discharge do not occur, reoccur, or spread to other materials or wastes at the facility. These measures shall include, where applicable, stopping manufacturing processes and operations, collecting and containing released materials or wastes, and removing or isolating containers.

If the facility stops operation in response to a fire, explosion, emission, or discharge, the emergency coordinator must ensure that adequate monitoring is conducted for leaks, pressure buildup, gas generation, or ruptures in valves, pipes, or other equipment, wherever this is appropriate.

Immediately after an emergency, the emergency coordinator, with PADEP's approval, must provide for treating, storing, or disposing, of residues, contaminated soil, etc., from an emission, discharge, fire, or explosion at the facility. The emergency coordinator must insure that in the affected areas of the facility, no material or waste incompatible with the emitted or discharged residues is processed, stored, treated, or disposed of until cleanup procedures are completed; and, all emergency equipment listed in the plan is cleaned and fit for its intended use before operations are resumed.

Within 15 days after the incident, the emergency coordinator must submit a written report on the incident to PADEP. The report must include the following:

1. Name, address, and telephone number of the individual filing the report.
2. Name, address, and telephone number of the facility.
3. Data, time, and location of the incident.
4. A brief description of the circumstances causing the accident.
5. Description and estimated quantity by weight or volume of materials or wastes involved.
6. An assessment of any contamination of land, water, or air that has occurred due to the incident.
7. Estimated quantity and disposition of recovered materials or wastes that resulted from the incident.
8. A description of what actions the facility intends to take to prevent a similar occurrence in the future.

3.4 Chain of Command

In the event of an emergency or spill, the on-duty emergency coordinator should contact the people in the following list. This list, along with the notification procedure, should be posted on bulletin boards or other conspicuous locations around the site. Because the site will have more

than one emergency coordinator (operator), RETEC will ensure that all emergency coordinators are thoroughly familiar with all necessary procedures.

1. Mark W. Moeller, PE
   Project Manager
   Remediation Technologies, Inc.
   9 Pond Lane
   Concord, MA 01742
   Work- (508) 371-1422
   Home- (508) 836-4634

2. Jason A. Gerrish
   Environmental Scientist
   Remediation Technologies, Inc.
   9 Pond Lane
   Concord, MA 01742
   Work- (508) 371-1422
   Home- (508) 448-0406

4.0 SPILL LEAK PREVENTION AND RESPONSE

4.1 *Pre-release Planning*

Spills of chemicals or recovered materials will be contained within the tankfarm. The tankfarm has been designed to contain, at a minimum, 1.5 times the volume of the largest tankfarm vessel plus a reasonable allowance for precipitation. The tankfarm is sufficiently impervious to contain spilled materials or chemicals. The tankfarm grade has been designed to slope towards the sump so that liquids falling at any point within the tankfarm will ultimately drain into the sump. The sump requires manual operation to prevent discharge of spilled process liquids or chemicals.

Although spills within the tankfarm will be contained, pollution incident prevention practices should be used by the operator to safeguard human health and the surrounding community. Pollution incident prevention practices can be divided into the following four categories: prevention, containment, mitigation, and ultimate disposition.

4.1.1 Prevention

As a preventative measure, the operator should make frequent visual observations of storage vessels, transfer pipelines, loading and unloading areas, and waste handling and storage areas. Also, the operator should make a daily inspection of:

- pipes, pumps, valves, and fittings for leaks;
- tanks for corrosion (internal and external);
- tank foundation for deterioration;
- walls for stains;
- areas around tanks for evidence of spilled materials;
- primary or secondary containment for deterioration;
- housekeeping practices;
- chemical containers for damage;
- chemical injection systems for leaks, spills, or overflows;
- integrity of stormwater collection system; and
- waste storage, treatment, or disposal sites for leaks, seeps, and overflows.

The operator should also monitor, on a daily basis:

- liquid level detectors;
- alarm systems;
- pressure and temperature gauges;
- analytical testing instrumentation;
- flow meters;
- valve positions;
- equipment operational lights; and
- site operation records.

4.1.2 Containment

The operator should make daily inspection of containment units to ensure their structural integrity. Containment units at the UGI Columbia Gas Plant site include the tankfarm and the tankfarm sump. These units should be inspected for leaks, cracks, physical breakdown, and failures.

4.1.3 Mitigation

The operator should attempt to keep the site clean and orderly by insuring that:

- proper labeling procedures are to be used for tanks and pipelines;
- warning signs are posted in appropriate locations;
- designated loading and unloading areas are free of obstructions;
- required inspections are performed;
- equipment that needs upgrading, repair, or replacement is identified;
- equipment is properly adjusted;
- chemicals are stored in a neat and orderly fashion;
- small spills are promptly removed;
- garbage is regularly removed and disposed;
- proper spacing is maintained, between containers, for walkways;
- operational records are complete and up-to-date; and
- health and safety equipment is available and functional.

4.1.4 Ultimate Disposition

In the event of a release that requires the disposition of recovered materials, proper procedures shall be followed and appropriate disposal practices will be used.

4.2 Material Compatibility

The materials of construction for this remedial action have been chosen due to their weatherability and compatibility with wastes and process chemicals. Due to material compatibilities with coal tar, carbon steel piping and tanks will be used throughout the system excluding the chemical injection systems. Polypropylene and PVC piping and tubing will be used with the H_2O_2 and NaOH injection systems and PVDF and PVC piping and tubing will be used with the H_2SO_4 injection system. The flocculent injection system will require only PVC piping and tubing.

4.3 Inspection and Monitoring Program

The operator will inspect and monitor the entire system on a daily basis. The operator will keep detailed records of all inspection activities in either the Site Logbook or the Site Notebook. The information in the Notebook will provide reference to system events and parameters. The Notebook is a less formal information log that is to be used in common by each of the site operators. The Logbook will present field gathered information and a record of when specific maintenance tasks were performed. The Logbook will contain formal documentation of all parameters of the recovery system. These books will remain on-site at all times and will be available for review.

4.3.1 Operator's Notebook

The operator will possess a Site Notebook to be used for all note taking concerning system operations. The notes should include all pertinent information including:

- tank levels;
- temperatures;
- flowrates;

- pressures;
- pH's;
- Iron concentrations;
- repairs performed;
- maintenance activities;
- site activities;
- visitor information;
- intervals the operator is on-site;
- modifications in system operation; and
- additional consequential events.

4.3.2 Operator's Logbook

The Site Logbook will contain forms and checklists including:

- Flowmeter Daily Checklist (Figure 4-1)
- Visitor's Sign-In Sheet (Figure 4-2)
- Daily Leak Detection Checklist (Figure 4-3)
- Chemical Management Checklist (Figure 4-4)
- Well Flowrates Daily Checklist (Figure 4-5)
- Temperature Sensor Daily Checklist (Figure 4-6)
- Pressure Gage Daily Checklist (Figure 4-7)

The Operator is responsible for completing all checklists within the time periods specified in the logbook and this manual. If checklist pages need to be removed from the logbook, they will be stored on-site in a designated location.

4.4 Preventative Maintenance

If the operator ever discovers conditions signifying the potential for failure of a piece of equipment, he/she should immediately correct those conditions by adjustments, repairs, or replacements. The system components requiring maintenance and their proper maintenance procedures are presented in the Operations and Maintenance (O&M) Plan (RETEC, 1995). Readers interested in this information should consult the O&M Plan.

RETEC

UGI Columbia Gas Plant Site
Flowmeter
Daily Checklist

Date	Flowrate in GPM								
	PW1 FM1	Oil Line FM2 (Total)	Post Tank 8 FM3	Boiler Feed FM4	PW2 FM5	IW 1A + 1B OM1	IW 2A + 2B OM2	IW 3A + 3B OM3	IW 4A + 4 B OM4

RETEC

IGI Columbia Gas Plant Site
Visitors Log

Name	Representing	Date/Time In	Date/Time Out

REIEC

UGI Columbia Gas Plant Site

System Leak Detection

Daily Checklist

DATE	Oil Lines	Heat Exchanger	Boiler	CA Units & Assoc. Pipes	Discharge Piping	Production Wellheads	Injection Wellheads	Production Pumpline	Injection Pumpline	Tankfarm Tanks	Tankfarm Piping	Bag Filters	Chemical Lines

RE|TEC

UGI Columbia Gas Plant Site
Chemical Management
Daily Checklist

Date	pH					Dissolved Fe Conc. (ppm)			Chemical Pump Rates					
									H2SO4		NaOH		H2O2	
	Pre Acid SP3	Post Acid SP4	Pre Caustic SP5	Post Caustic SP6	Post Tank 8 SP7	Pre Tank 1 SP3	Post H2O2 SP6	Post Tank 8 SP7	Strk Length	Strk Rate	Strk Length	Strk Rate	Strk Length	Strk Rate

RETEC

UGI Columbia Gas Plant Site
Well Flowrates
Daily Checklist

Date	Flowrate in GPM									
	PW1	PW2	IW1A	IW1B	IW2A	IW2B	IW3A	IW3B	IW4A	IW4B

RETEC

UGI Columbia Gas Plant Site
Temperature Sensor
Daily Checklist

Date	Temperature													
	PW1 TI1	Post PW1 TI2	Post Heat Exch. TI3	Clarifier TI4	Tank 2 TI5	Post Boiler TI6	IW1A TI7	IW1B TI8	IW2A TI9	IW2B TI10	IW3A TI11	IW3B TI12	IW4A TI13	IW4B TI14

RETEC

UGI Columbia Gas Plant Site
Pressure Gage
Daily Checklist

Date	Pressure in psi									
	Pre Boiler PI10	Post Boiler PI9	IW1A PI1	IW1B PI2	IW2A PI3	IW2B PI4	IW3A PI5	IW3B PI6	IW4A PI7	IW4B PI8

4.5 Housekeeping Program

Due to the deficiency of open space and the closeness of site features, improperly or precariously placed materials may be unsafe to site personnel or may obstruct evacuation routes. Operators are responsible for keeping materials in their proper locations and, in general, maintaining site order and cleanliness. In addition, all walkways should be kept free from obstructions, trash, and debris.

4.6 Security

Access to the site area will be restricted to persons having read the Site-Specific Health and Safety Plan and having attended a safety indoctrination meeting. Signs will be posted at the entrance to the site stating, "DANGER - AUTHORIZED PERSONNEL ONLY", "PROTECTIVE EQUIPMENT REQUIRED BEYOND THIS POINT". Both the Site Security Plan and Section 5.0 of the Site-Specific Health and Safety Plan (RETEC, 1995) discuss procedures for maintaining site control and security in order to not only protect site workers but visitors and the general public. All lines containing hot water will be labeled every twenty feet. All process tanks will be enclosed within a six-foot-high chain-link fence with barbed wire on top. Access to this area will be limited to personnel who must perform specific tasks within the tankfarm area.

The site will be kept secure by a currently existing security fence and wall that surround the site. Whenever personnel are to be absent from the site for extended periods or overnight, the Operator will secure the site by locking the gate with a padlock.

The Operator will verify that every person entering the exclusion zone has read and signed the Site Specific Health and Safety Plan and familiarized themselves with all potential hazards associated with the site. Also, individuals must have successfully completed an OSHA 40-hour training course to be allowed into the exclusion zone. No person may enter the exclusion zone without the Operator's knowledge and authorization.

4.7 External Factor Planning

Natural disasters and problems such as power outages are not expected to effect public health and safety or the environment. Natural disasters do have the potential to damage

equipment, but interruptions in system operations will not have negative impacts on the public or environment.

4.8 Employee Training Program

An initial safety meeting and training session, as outlined in the Site Health and Safety Plan, will be attended by all employees working at the site involved with the remedial action. The meeting will be run by the RETEC safety officer or the RETEC site manager and will discuss pertinent issues associated with system operation and the Health and Safety Plan. The following items will be covered:

- hazards associated with coal tar;
- dangers and indications of cold stress;
- dangers and indications of heat stress;
- location of hospital and maps to hospital;
- location of emergency contacts and phone numbers;
- location of first aid kit and its contents;
- proper dress and personal protective equipment required for on-site work;
- dangers associated with working around railroad tracks and trains;
- dangers associated with working around steam injection and recovery equipment;
- dangers associated with working around heavy equipment;
- proper drum handling procedures;
- decontamination procedures;
- system operation;
- component maintenance;
- contingency procedures; and
- spill response procedures.

In addition to an initial safety meeting, a briefing will be given to local fire and police chiefs before work begins.

5.0 COUNTERMEASURES

5.1 Countermeasures to be Undertaken by Facility

In the event of a leak in any piping resulting in a spill, site personnel will locate the source of the spillage and stop the flow by shutting off the pumps associated with that flow stream, if it can be done safely, and begin containment and recovery of the spilled material. There are four different types of piping systems based on the type of liquid flowing through them. They are:

- pipes running from the recycle water tank to the boiler which carry water;
- pipes running from production tanks to the oil storage tanks which carry coal tar;
- pipes running from the boiler to the injection wells carrying steam; and
- piping from the recovery wells to the production tanks carrying coal tar contaminated water.

The most caution should be used around the pipes carrying steam, contaminated water and coal tar. A leak from a steam pipe will require pumps to be shut off and the leak repaired. A leak in a pipe carrying contaminated water will be handled by shutting off the necessary pumps and collecting coal tar with sorbent pads. The affected area will be surrounded by sorbent booms to prevent spreading of the contamination. A leak in a pipe carrying coal tar will be contained within the tankfarm. Any spilled coal tar will be collected using sorbent pads. Any sorbent pads or booms used during spill clean-up will be placed in 55-gallon drums and stored until being properly disposed.

5.1.1 Oil Transfer Spill Prevention

Any recovered coal tar will be properly manifested during its removal from the site. The company responsible for transporting the recovered coal tar to its final place of disposal will be responsible for any necessary spill prevention control and countermeasures during transportation.

Any spill of coal tar during transfer from the storage tank to the transporting vehicle will be collected using sorbent pads. If a leak has occurred in the transfer piping, the transfer process will be stopped until the leak has been repaired. Any soiled sorbent pads or booms will also be placed in 55-gallon drums for proper disposal.

5.1.2 Drum Spill Contingency Plan

In the event that a drum fails or spills its contents, it shall be contained within the tankfarm area. Chemical spills will be diluted with water and washed towards the sump, where it will be collected in 55-gallon drums. The drums will be stored in the tankfarm until proper disposal arrangements are made. Water will be available at all times via a hose connected to the on-site building.

5.1.3 Process Control Building Spill Contingency Plan

In the event that a spill occurs within the process control building, site personnel will locate the source of the spillage and stop the flow by shutting off the pumps associated with that flow stream, if it can be done safely, and begin containment and recovery of the spilled material. Recovery will involve using sorbent pads and booms, which will subsequently be stored in 55-gallon drums, in the decontamination area, until proper disposal is arranged.

5.1.4 Air Monitoring

In the event of a spill of contaminated process water or coal tar, air monitoring will be performed continuously at the site entrance and hourly downwind for a period of 24 hours or until levels drop below those specified in the Site-Specific Health and Safety Plan (RETEC, 1995). A wind sock will be installed, on site, to identify wind direction. Monitoring will be continuous for the following:

- if abnormal odors are detected;
- if there is an emergency such as a tank failure; or
- if hourly readings exceed background levels.

The air monitoring will be performed with a PID meter. If coal tar is being handled, the readings will be taken in the area of the handling operation in the breathing zone. If the PID maintains a reading of greater than 5 parts per million (ppm) for fifteen minutes, the EPA Project Manager will be notified and respirators with organic cartridges will be worn until the operation causing the presence of volatiles is completed or the levels drop below 5 ppm on the PID. If the PID ever reads greater than 100 ppm or maintains a reading above 50 ppm for more than fifteen minutes in the ambient air, the site will be immediately evacuated.

Weekly monitoring will be performed for elevated organic concentrations using a PID meter at all locations where potential elevated organic concentrations may occur. Should any reading above 10,000 ppm be found, a leak is considered to have occurred.

Immediately following a leak detection, attempts will be made to seal the leaking component, the EPA Regional Administrator will be notified within 24 hours and a report will be submitted to him within 30 days. If immediate control measures fail, alternate control measures, such as component replacement, will be applied.

(Section 4.0 of the Site-Specific Health & Safety Plan discusses air monitoring procedures in more detail.)

5.2 Countermeasures to be Undertaken by Contractors

Arrangements will be made, prior to the beginning of work activities, to notify local emergency response agencies, and hospitals concerning the types of wastes handled at the facility and the potential need for services. Also, prior to start-up activities, efforts will be made to familiarize police, fire departments, emergency response teams, and the County Emergency Management Coordinator with the layout of the facility, the properties and dangers associated with hazardous materials handled, places where personnel would normally be working, entrances to roads inside the facility, and the possible evacuation routes.

The following agencies will be contacted and given all necessary and pertinent information:

- Columbia Police Department;
- Columbia Fire Department;
- Columbia Ambulance Service; and
- Columbia Hospital.

5.3 Internal and External Communications and Alarm Systems

Because the system will be operated by one operator, internal communication systems are not appropriate. The operator will have a telephone that can be used to summon emergency assistance from local agencies.

5.4 Evacuation Plan for Installation Personnel

If the Emergency Coordinator determines that the facility has had a release, fire, or explosion which could threaten facility personnel, site evacuation will commence. The Emergency Coordinator will locate and verbally instruct any personnel on-site to evacuate. Evacuation will involve moving all personnel outside of the work zone to a distance deemed safe by the Emergency Coordinator. All personnel will refrain from approaching the facility until instructed to do so by the Emergency Coordinator. Should it be necessary that site personnel evacuate without Emergency Coordinator instruction, all personnel shall evacuate the site via the following routes:

- From the Well Area

  Any personnel evacuating from the well field area shall exit the site by walking across the street towards the Susquehanna River until they have reached safety. Personnel shall not re-enter the site until instructed to do so.

- From the Process Control Building

  Any personnel evacuating from the process control building shall exit through the nearest/safest exit door and proceed to move off-site and away from the source of danger. Personnel shall not re-enter the site until instructed to do so.

- From the Tankfarm

  Any personnel evacuating from the tankfarm will exit through the tankfarm entrance gate and proceed across the road towards the Susquehanna River until they have reached safety. Personnel shall not re-enter the site until instructed to do so.

5.5 Emergency Equipment Available for Response

All operators will be instructed in the use of on-site emergency equipment. Emergency equipment will consist of an eye wash station, first-aid kit, burn kit, emergency blanket, and fire extinguisher. The operator will be responsible for ensuring that emergency equipment is in proper working condition and available for use.

Several items of emergency equipment will be available to site personnel for use in the event of an emergency. Two sets of the following items shall be available with one located within the office of the on-site building and the other in an area not yet determined.

(1) Fire extinguisher
- capable of extinguishing type A, B, and C fires.

(2) Emergency eye wash station
- to be used for cleansing chemicals or foreign objects from eyes.

(3) Burn treatment kit
- treatment of minor burns, temporary treatment of major burns.

(4) First-aid kit
- treatment of minor cuts, scrapes, and burns and temporary treatment of major cuts, scrapes, and burns.

(5) Blankets
- to be used for warmth for an injured person.

(6) Stretcher
- capable of safe removal of injured personnel from dangerous areas.

(7) Sorbent Pads and Booms
- capable of absorbing spilled liquids.

6.0 EMERGENCY SPILL CONTROL NETWORK

6.1 Arrangements with Local Emergency Response Agencies and Hospitals

Arrangements will be made, prior to the beginning of work activities, to notify local emergency response agencies, and hospitals concerning the types of wastes handled at the facility and the potential need for services. Also, prior to start-up activities, efforts will be made to familiarize police, fire departments, emergency response teams, and the County Emergency Management Coordinator with the layout of the facility, the properties and dangers associated with hazardous materials handled, places where personnel would normally be working, entrances to roads inside the facility, and the possible evacuation routes.

The following agencies will be contacted and given all necessary and pertinent information:

- Columbia Police Department
  308 Locust Street
  Columbia, PA 17512
  Phone: (717) 684-7735 or 911

- Columbia Fire Department
  137 South Braid Street
  Columbia, PA 17512
  Phone: (717) 684-5100 or 911

- Columbia Ambulance Service
  Phone: (717) 684-2400 or 911

- Columbia Hospital
  631 Poplar Road
  Columbia, PA 17512
  Phone: (717) 684-2841

6.2 Notification Lists

Table 6-1 contains phone number of agencies and contacts that must be contacted in the event of an emergency or spill.

6.3 Downstream Notification Requirement for Storage Tanks

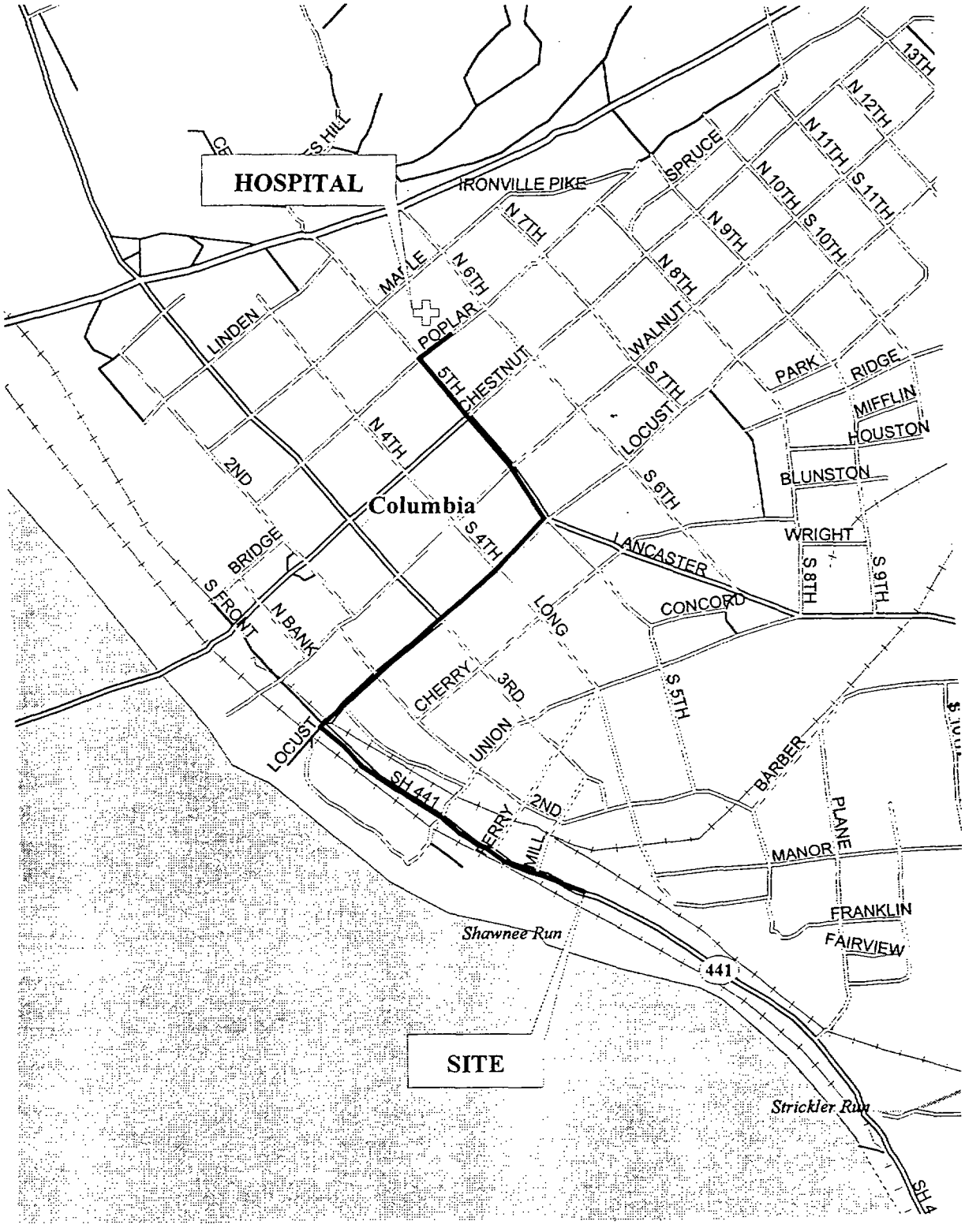
This notification requirement is applicable to storage tank facilities with aggregate aboveground storage >21,000 gallons of regulated substances. Therefore, it is not applicable to this particular site.

TABLE 6-1

Emergency Contacts

FIRE:	911	
POLICE:	911	
AMBULANCE:	911	
Capable of Transporting Contaminated Personnel?	YES: X	NO:
HOSPITAL: Columbia Hospital		(717) 684 - 2841
Address: 631 Poplar Road Columbia, PA 17512		
Chemical Trauma Capabilities?	YES: X	NO:
Decontamination Capabilities?	YES: X	NO:
Directions From Site to Hospital: Exit site on Front St. at Locust St., take right to 3rd light, (about 4 blocks), this intersection is Locust & Fifth St.; take left. Go 3 blocks to watch tower, take a right. Go to stop sign, hospital on left.		
NOTE: See Figure 6-1 for route to hospital. The route to the hospital was verified by: Jason A. Gerrish Distance from the site to the hospital is: 1 (miles) The approximate driving time is: 5 minutes		
POISON CONTROL CENTER:		(215) 433 - 3211
ELECTRIC COMPANY: PP&L		(800) 342 - 5775
Metropolitan Edison		(800) 545 - 7750
PP & L EMERGENCY HOTLINE		(610) 774 - 5566
GAS COMPANY: Columbia Gas Transmission Corp.		(717) 529 - 2248
WATER COMPANY: Columbia Water Company		(717) 684 - 2188
AIRPORT: Lancaster Airport		(717) 569 - 1221
NATIONAL EMERGENCY RESPONSE CENTER:		(800) 424 - 8802
CENTER FOR DISEASE CONTROL:		(404) 488 - 4100 (24-hour)
AT&F (explosion information)		(800) 424 - 9555
CHEMTREC:		(800) 424 - 9300
STATE ENVIRONMENTAL AGENCY: PADEP - Anthony Martinelli		(717) 657 - 4592
STATE EMERGENCY RESPONSE NUMBER		(800) 812 - 3782
Pennsylvania Emergency Management Agency (PEMA)		(717) 783 - 5082
U.S. EPA REGION: III - Mr. Steven Donohue		(215) 597 - 3166
U.S. EPA REGION III PENNSYLVANIA SPILL REPORTING NUMBER		(215) 597- 9898
RETEC CORPORATE OFFICE:	Ms. Dawn Dearborn	(508) 371 - 1422
RETEC PERSONNEL OFFICE (local):		
RETEC CORPORATE HEALTH AND SAFETY OFFICER:	Mr. William A. Odenthal	(412) 823 - 3340
CROZER-CHESTER MEDICAL BURN CENTER		(610) 447 - 2000
RETEC MEDICAL CONSULTANT	Shady Hospital (412) 623-1070	
RETEC PERSONNEL MEDICAL CONSULTANT (local)		
RETEC PROJECT MANAGER:	Mark W. Moeller	(617) 371 - 1422
CLIENT CONTACT: (PP & L)	Brad Wise	(610) 774 - 6508
CLEAN SITES CONTACT:	Douglas McClure	(703) 739 - 1279
SUPERVISING CONTRACTOR: To be determined		

RETEC



Route From Site To Hospital

FIGURE 6-1

AR400485

7.0 REFERENCES

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APPENDIX A

MSDSs

Occupational Health Guideline for Phosphoric Acid

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: H_3PO_4
- Synonyms: White phosphoric acid; ortho-phosphoric acid; 85% phosphoric acid; meta-phosphoric acid
- Appearance and odor: Viscous, colorless, odorless liquid which can solidify at temperatures below 21 C (70 F).

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for phosphoric acid is 1 milligram of phosphoric acid per cubic meter of air (mg/m^3) averaged over an eight-hour work shift.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Phosphoric acid can affect the body if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if it is swallowed.

- **Effects of overexposure**

1. Short-term Exposure: Solid phosphoric acid or its solutions may cause skin burns. Contact with the eyes may produce irritation and eye burns. Exposure to phosphoric acid vapor or mist may cause irritation of the eyes, nose, and throat.

2. Long-term Exposure: Repeated or prolonged exposure may cause irritation of the skin.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to phosphoric acid.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to phosphoric acid at potentially hazardous levels:

1. Initial Medical Screening: Employees should be screened for history of certain medical conditions (listed below) which might place the employee at increased risk from phosphoric acid exposure.

—Chronic respiratory disease: In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of phosphoric acid dust or mist might cause exacerbation of symptoms due to its irritant properties.

—Skin disease: Phosphoric acid dust, mist, or solutions may cause dermatitis. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

2. Periodic Medical Examination: Any employee developing the above-listed conditions should be referred for further medical examination.

- **Summary of toxicology**

Phosphoric acid mist is an irritant to the eyes, upper respiratory tract, and skin. The solid is especially irritating to skin in the presence of moisture. Unacclimated workers could not endure exposure to fumes of phosphorus pentoxide (the anhydride of phosphoric acid) at a concentration of 100 mg/m^3; exposure to concentrations between 3.6 and 11.3 mg/m^3 produced coughing. Concentrations of 0.8 to 5.4 mg/m^3 were noticeable but not uncomfortable. There is no evidence that phosphorus poisoning can result from contact with phosphoric acid. The risk of pulmonary edema resulting from the inhalation of mist or spray is remote. A dilute solution buffered to pH 2.5 caused a moderate brief stinging sensation but no injury when dropped in the human eye. A 75% solution will cause severe skin burns.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 98

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2. Boiling point (760 mm Hg): 260 C (500 F)
3. Specific gravity (water = 1): 1.7
4. Vapor density (air = 1 at boiling point of phosphoric acid): 3.4
5. Melting point: 21 C (70 F)
6. Vapor pressure at 20 C (68 F): 0.0285 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Miscible in all proportions
8. Evaporation rate (butyl acetate = 1): Not applicable

• **Reactivity**

1. Conditions contributing to instability: None
2. Incompatibilities: Contact with strong caustics can cause liberation of much heat and violent spattering. Contact with most metals causes formation of flammable and explosive hydrogen gas.
3. Hazardous decomposition products: Toxic gases and vapors (such as phosphoric acid fume) may be released when phosphoric acid decomposes.
4. Special precautions: Liquid phosphoric acid will attack some forms of plastics, rubber, and coatings.

• **Flammability**

1. Not combustible

• **Warning properties**

Phosphoric acid mist can cause irritation of the eyes and respiratory tract, according to the *Hygienic Guide*. No quantitative information is given, however. Deichmann and Gerarde note that since phosphoric acid "has a low vapor pressure at room temperature, it is not irritating to the eyes or respiratory tract, unless introduced into the atmosphere as a spray or mist."

MONITORING AND MEASUREMENT PROCEDURES

• **General**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• **Method**

Sampling and analyses may be performed by collection of phosphoric acid on a cellulose membrane filter, followed by leaching with hot water, chemical reaction, and spectrophotometric analysis. An analytical method for phosphoric acid is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with solid or liquid phosphoric acid or solutions containing greater than 1.6% ortho-phosphoric acid by weight or any concentration of meta-phosphoric acid.

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with solutions containing 1.6% or less ortho-phosphoric acid by weight.

• If employees' clothing may have become contaminated with solid phosphoric acid, employees should change into uncontaminated clothing before leaving the work premises.

• Clothing contaminated with phosphoric acid should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of phosphoric acid from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the phosphoric acid, the person performing the operation should be informed of phosphoric acid's hazardous properties.

• Where there is any possibility of exposure of an employee's body to solid or liquid phosphoric acid or solutions containing phosphoric acid, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

• Non-impervious clothing which becomes contaminated with phosphoric acid should be removed immediately and not reworn until the phosphoric acid is removed from the clothing.

• Employees should be provided with and required to use dust- and splash-proof safety goggles where there is any possibility of solid or liquid phosphoric acid or solutions containing phosphoric acid contacting the eyes.

• Where there is any possibility that employees' eyes may be exposed to solid or liquid phosphoric acid or solutions containing more than 1.6% ortho-phosphoric acid by weight, or any concentration of meta-phosphoric acid, an eye-wash fountain should be provided within the immediate work area for emergency use.

SANITATION

• Skin that becomes contaminated with phosphoric acid should be immediately washed or showered to remove any phosphoric acid.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to phosphoric acid may occur and control methods which may be effective in each case:

Operation	Controls
Use in manufacture of aluminum products in bright dipping operations; use in cleaning, electropolishing, and pickling in manufacture of steel, brass, bronze, and copper during surface treatment and rust-proofing operations	Process enclosure; local exhaust ventilation; personal protective equipment
Use in synthesis of intermediates in manufacture of soil fertilizers; use in manufacture of livestock and poultry feed	Process enclosure; local exhaust ventilation; personal protective equipment
Use during synthesis of detergent and soap builders and water-treatment chemicals; use as an acidulant and flavor agent in manufacture of carbonated beverages and jellies and preserves	Process enclosure; personal protective equipment
Use in manufacture of food products, intermediates, and food additives; use as an antioxidant and preservative; use in wood, textile, polyurethane foam flame-retardant processing and production of flame-retardant agents	Process enclosure; personal protective equipment
Use in manufacture of cleaning preparations and disinfectants	Process enclosure; personal protective equipment
Use as a bonding agent in manufacture of refactory bricks; use during lithography and photoengraving operations	Process enclosure; personal protective equipment
Use as a catalyst in synthesis of other chemicals; use in synthesis of textile and leather processing chemicals, clays, ceramics, cements, and clay-thinning agents for drilling mud formulations	Process enclosure; personal protective equipment
Use in synthesis of pharmaceuticals and pharmaceutical intermediates and in the extraction of penicillin; use as a laboratory reagent	Process enclosure; personal protective equipment
Use during manufacture of opal glass; during manufacture of dental cements and dentrifice adhesives, adhesive gums, and synthetic rubber; and in the manufacture of electric lights	Process enclosure; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If phosphoric acid gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

• **Skin Exposure**

If phosphoric acid gets on the skin, immediately flush the contaminated skin with water. If phosphoric acid soaks through the clothing, remove the clothing immediately and flush the skin with water.

• **Breathing**

If a person breathes in large amounts of phosphoric acid, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When phosphoric acid has been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If phosphoric acid is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill or leak.
2. If in the solid form, collect spilled material in the most convenient and safe manner for reclamation or for disposal in a secured sanitary landfill.
3. If in the liquid form, collect for reclamation or absorb in vermiculite, dry sand, earth, or a similar material.

• Waste disposal method:

Liquid phosphoric acid may be disposed of by absorbing in vermiculite, dry sand, earth, or a similar material and diposing in a secured sanitary landfill.

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RESPIRATORY PROTECTION FOR PHOSPHORIC ACID

Condition	Minimum Respiratory Protection* Required Above 1 mg/m³
Particulate or Vapor Concentration	
50 mg/m³ or less	A high efficiency particulate filter respirator with a full facepiece. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
2000 mg/m³ or less	A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode.
Greater than 2000 mg/m³ or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Occupational Health Guideline for Sulfuric Acid

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: H_2SO_4
- Synonyms: Oil of vitriol
- Appearance and odor: Colorless to dark brown, oily, odorless liquid.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for sulfuric acid is 1 milligram of sulfuric acid per cubic meter of air (mg/m³) averaged over an eight-hour work shift. NIOSH has recommended a permissible exposure limit of 1 mg/m³ averaged over a work shift of up to 10 hours per day, 40 hours per week. The NIOSH Criteria Document for Sulfuric Acid should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Sulfuric acid can affect the body if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if it is swallowed.

- **Effects of overexposure**

1. Short-term Exposure: Sulfuric acid may cause irritation of the eyes, nose, and throat. Breathing in the mist or vapor may cause teeth erosion or the mouth to become sore and also difficulty in breathing. Splashes in the eyes or on the skin will cause severe skin burns.
2. Long-term Exposure: Repeated or prolonged exposure to dilute solutions of sulfuric acid may cause irritation of the skin. Repeated or prolonged exposure to mists or vapors of sulfuric acid may cause erosion of the teeth, chronic irritation of the eyes, or chronic inflammation of the nose, throat, and bronchial tubes.
3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to sulfuric acid.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to sulfuric acid at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the respiratory system, eyes, and teeth should be stressed. The skin should be examined for evidence of chronic disorders.

—14" x 17" chest roentgenogram: Sulfuric acid may cause acute lung damage. Surveillance of the lungs is indicated.

—FVC and FEV (1 sec): Sulfuric acid is reported to cause pulmonary function impairment. Periodic surveillance is indicated.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis, except that an x-ray is considered necessary only when indicated by the results of pulmonary function testing.

- **Summary of toxicology**

Sulfuric acid mist severely irritates the eyes, respiratory tract, and skin. Concentrated sulfuric acid destroys tissue due to its severe dehydrating action, whereas the dilute form acts as a milder irritant due to acid properties. The LC50 of mist of 1-micron particle size for an 8 hour exposure was 50 mg/m³ for adult guinea pigs and 18 mg/m³ for young animals. Continuous exposure of guinea pigs to 2 mg/m³ for 5 days caused pulmonary edema and thickening of the alveolar walls; exposure of guinea pigs to 2 mg/m³ for 1 hour caused an increase in

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pulmonary airway resistance from reflex bronchoconstriction. A worker sprayed in the face with liquid fuming sulfuric acid suffered skin burns of the face and body, as well as pulmonary edema from inhalation. Sequelae were pulmonary fibrosis, residual bronchitis, and pulmonary emphysema; in addition, necrosis of the skin resulted in marked scarring. In human subjects, concentrations of about 5 mg/m³ were objectionable, usually causing cough, an increase in respiratory rate, and impairment of ventilatory capacity. Workers exposed to concentrations of 12.6 to 35 mg/m³ had a markedly higher incidence of erosion and discoloration of teeth than was noted in unexposed individuals. Splashed in the eye, the concentrated acid causes extremely severe damage, often leading to blindness, whereas dilute acid produces more transient effects from which recovery may be complete. Repeated exposure of workers to the mist causes chronic conjunctivitis, tracheobronchitis, stomatitis, and dermatitis, as well as dental erosion. While ingestion of the liquid is unlikely in ordinary industrial use, the highly corrosive nature of the substance may be expected to produce serious mucous membrane burns of the mouth and esophagus.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 98
2. Boiling point (760 mm Hg): 270 C (518 F)
3. Specific gravity (water = 1): 1.84
4. Vapor density (air = 1 at boiling point of sulfuric acid): 3.4
5. Melting point: 3 C (37 F)
6. Vapor pressure at 20 C (68 F): Less than 0.001 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Miscible in all proportions
8. Evaporation rate (butyl acetate = 1): Data not available

- **Reactivity**

1. Conditions contributing to instability: None
2. Incompatibilities: Contact of acid with organic materials (such as chlorates, carbides, fulminates, and picrates) may cause fires and explosions. Contact of acid with metals may form toxic sulfur dioxide fumes and flammable hydrogen gas.
3. Hazardous decomposition products: Toxic gases and vapors (such as sulfuric acid fume, sulfur dioxide, and carbon monoxide) may be released when sulfuric acid decomposes.
4. Special precautions: Liquid sulfuric acid will attack some forms of plastics, rubber, and coatings.

- **Flammability**

1. Sulfuric acid is not combustible by itself, but is highly reactive and capable of igniting finely divided combustible materials on contact. Fires involving small amounts of combustibles may be smothered with dry chemical. Water applied directly to sulfuric acid causes evolution of heat and splattering.

- **Warning properties**

The International Labour Office (ILO) reports that sulfuric acid, in liquid or vapor form, can cause eye irritation, but no quantitative information is given. The NIOSH criteria document for sulfuric acid states that Bushtueva exposed 10 human subjects to different concentrations of sulfuric acid aerosol. At a concentration of 1.1 to 2.4 mg/m³, 40% of the subjects experienced eye irritation.

MONITORING AND MEASUREMENT PROCEDURES

- **General**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Method**

Sampling and analyses may be performed by collection of sulfuric acid on a cellulose membrane filter, followed by extraction with distilled water and isopropyl alcohol, treatment with perchloric acid, and titration with barium perchlorate. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure sulfuric acid may be used. An analytical method for sulfuric acid is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 5, 1979, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00349-1).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with liquid sulfuric acid or solutions containing more than 1% sulfuric acid by weight.
- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with solutions containing 1% or less sulfuric acid by weight.
- Where there is any possibility of exposure of an employee's body to liquid sulfuric acid or solutions containingmore than 1% sulfuric acid by weight, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.
- Non-impervious clothing which becomes contaminated with sulfuric acid should be removed immediately and not reworn until the sulfuric acid is removed from the clothing.
- Clothing contaminated with sulfuric acid should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of sulfuric acid from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the sulfuric acid, the person performing the operation should be informed of sulfuric acid's hazardous properties.
- Employees should be provided with and required to use splash-proof safety goggles where there is any possibility of liquid sulfuric acid or solutions containing sulfuric acid contacting the eyes.
- Where there is any possibility that employees' eyes may be exposed to liquid sulfuric acid or solutions containimore than 1% sulfuric acid by weight, an eye-wash fountain should be provided within the immediate work area for emergency use.

SANITATION

- Skin that becomes contaminated with sulfuric acid should be immediately washed or showered to remove any sulfuric acid.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to sulfuric acid may occur and control methods which may be effective in each case:

Operation	Controls
Use in manufacture of phosphoric acid and fertilizers	Process enclosure; local exhaust ventilation; personal protective equipment
Use in petroleum refining as an alkylation catalyst for production of high-octane gasoline, production of jet fuels, kerosene, lube and white oils, oil additives, and preparation of cracking catalysts	Process enclosure; local exhaust ventilation; personal protective equipment
Use during manufacture of pigments and dyes, and dyestuff intermediates	Process enclosure; local exhaust ventilation; personal protective equipment
Use in manufacture of industrial and military explosives	Process enclosure; local exhaust ventilation; personal protective equipment
Use in production of alcohols, phenols, and inorganic sulfates	Process enclosure; local exhaust ventilation; personal protective equipment
Use in ore leaching and processing; use in metal cleaning and plating; manufacture of *electrogalvanized wire;* anodizing of metal; electroplating	Process enclosure; local exhaust ventilation; personal protective equipment
Use in manufacture of detergents	Process enclosure; local exhaust ventilation; personal protective equipment
Use in coke-oven gas refining; use in plastics industry for manufacture of rayon, cellophane, cellulose, acetate, caprolactam, and others; use in lead storage batteries as electrolyte	Process enclosure; local exhaust ventilation; personal protective equipment
Use in food processing in manufacture of brewing sugars for beer, manufacture of glucose, refining of mineral and vegetable oils	Process enclosure; local exhaust ventilation; personal protective equipment

Operation	Controls
Use for preparation of insecticides; use in manufacture of natural and synthetic rubber	Process enclosure; local exhaust ventilation; personal protective equipment
Use for gas drying to dry acid and corrosive gases; use in treatment of industrial water for pH control	Process enclosure; local exhaust ventilation; personal protective equipment
Use in manufacture of textiles and leather for treatment of wool, pickling leather, as a dye assist, as a solvent for vat dyes, and in fabric finishing	Process enclosure; local exhaust ventilation; personal protective equipment
Use as a laboratory reagent as a solvent and for chemical analysis; use in chemical synthesis in preparation of acids, intermediates for medicinals, gas, esters, and fatty acids	Process enclosure; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

- **Eye Exposure**

If liquid sulfuric acid or solutions containing sulfuric acid get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

- **Skin Exposure**

If liquid sulfuric acid or solutions containing sulfuric acid get on the skin, immediately flush the contaminated skin with water. If liquid sulfuric acid or solutions containing sulfuric acid penetrate through the clothing, remove the clothing immediately and flush the skin with water. Get medical attention immediately.

- **Breathing**

If a person breathes in large amounts of sulfuric acid, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- **Swallowing**

If liquid sulfuric acid or solutions containing sulfuric acid have been swallowed and the person is conscious, give him large quantities of water immediately to dilute the sulfuric acid. Do not attempt to make the exposed person vomit. Get medical attention immediately.

- **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.
- If sulfuric acid is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill or leak.
2. Collect spilled or leaked material in the most convenient and safe manner for reclamation or for disposal in a secured sanitary landfill. Sulfuric acid should be absorbed in vermiculite, dry sand, earth, or a similar material. It may also be diluted and neutralized.

- Waste disposal method:

Sulfuric acid may be placed in sealed containers or absorbed in vermiculite, dry sand, earth, or a similar material and disposed of in a secured sanitary landfill. It may also be diluted and neutralized.

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RESPIRATORY PROTECTION FOR SULFURIC ACID

Condition	Minimum Respiratory Protection* Required Above 1 mg/m³
Particulate Concentration	
50 mg/m³ or less	A gas mask with a chin-style or a front- or back-mounted acid gas canister with a high efficiency particulate filter. A high efficiency particulate filter respirator with a full facepiece. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
100 mg/m³ or less	A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode.
Greater than 100 mg/m³ or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	A gas mask with a chin-style or a front- or back-mounted acid gas canister with a high efficiency particulate filter. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Occupational Health Guideline for Hydrogen Peroxide

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: H_2O_2
- Synonyms: High-strength hydrogen peroxide; peroxide; hydrogen dioxide
- Appearance and odor: Colorless liquid with a slightly sharp odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for hydrogen peroxide is 1 part of hydrogen peroxide per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 1.4 milligrams of hydrogen peroxide per cubic meter of air (mg/m^3).

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Hydrogen peroxide can affect the body if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if it is swallowed.

- **Effects of overexposure**

Exposure to vapor from hydrogen peroxide may cause extreme irritation of the eyes, nose, and throat. Splashes of hydrogen peroxide in the eyes may cause severe damage and possible blindness. Eye damage may appear a week or more after exposure. If the liquid is splashed on the skin, it may cause tingling and temporary whitening. If the skin is washed promptly, the skin will return to normal in 2 or 3 hours. If the hydrogen peroxide is not removed, redness and blister formation may result. If swallowed, hydrogen peroxide may cause injury to the mouth and throat with possible bleeding from the esophagus and stomach. The swallowed hydrogen peroxide may produce large quantities of oxygen gas which may distend the esophagus and stomach and cause severe damage.

- **Reporting signs and symptoms**

A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to hydrogen peroxide.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to hydrogen peroxide at potentially hazardous levels:

1. Initial Medical Screening: Employees should be screened for history of certain medical conditions (listed below) which might place the employee at increased risk from hydrogen peroxide exposure.

—Eye disease: Hydrogen peroxide, 90 percent, is an eye irritant. Persons with pre-existing eye disorders may be more susceptible to the effects of this agent.

—Chronic respiratory disease: Hydrogen peroxide, 90 percent, causes respiratory irritation in animals. In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of hydrogen peroxide, 90 percent, might cause exacerbation of symptoms due to its irritant properties.

—Skin disease: Hydrogen peroxide, 90 percent, is a primary skin irritant. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

2. Periodic Medical Examination: Any employee developing the above-listed conditions should be referred for further medical examination.

- **Summary of toxicology**

Ninety percent hydrogen peroxide vapor, mist, or liquid irritates the eyes, mucous membranes, and skin. Repeated exposure of dogs to 7 ppm for 6 months caused sneezing, lacrimation, and bleaching of hair; at autopsy there was local atelectasis. In humans, inhalation of high concentrations of vapor or mist may cause extreme irritation and inflammation of the nose and

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Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

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throat. Exposure for a short period to mist or diffused spray may cause stinging of the eyes and lacrimation. Splashes of the liquid in the eyes may cause severe damage, including ulceration of the cornea; there may be a delayed appearance of damage to the eyes, and corneal ulceration has, on rare occasions, appeared even a week or more after exposure. Skin contact with the liquid for a short time will cause a temporary whitening or bleaching of the skin; if splashes on the skin are not removed, erythema and formation of vesicles may occur. Ingestion may cause irritation of the upper gastrointestinal tract; decomposition of the hydrogen peroxide will result in the rapid liberation of oxygen, which may distend and damage the esophagus or stomach.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 34
2. Boiling point (760 mm Hg): 141 C (286 F) (calculated)
3. Specific gravity (water = 1): 1.38
4. Vapor density (air = 1 at boiling point of hydrogen peroxide): Not applicable (decomposes)
5. Melting point: −11 C (12 F)
6. Vapor pressure at 30 C (86 F): 5 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Miscible in all proportions
8. Evaporation rate (butyl acetate = 1): Data not available

- **Reactivity**

1. Conditions contributing to instability: Hydrogen peroxide decomposes slowly at ordinary temperatures and builds up pressure if the container is closed. The rate of decomposition doubles for each 10 C rise (1.5 times 10 C rise) in temperature and becomes self-sustaining at 141 C (285 F). Contaminated hydrogen peroxide can decompose at a rate that will exceed the capacity of the vent in the container. Hydrogen peroxide in concentrations up to about 90% does not readily detonate. Higher concentrations or elevated temperatures may facilitate detonation.

2. Incompatibilities: Contact with most organic or readily oxidizable materials and combustibles causes fires and explosions. Contact with iron, copper, brass, bronze, chromium, zinc, lead, manganese, silver, and other catalytic metals (or their salts) causes rapid decomposition with evolution of oxygen gas and heat which may increase container pressure.

3. Hazardous decomposition products: None

4. Special precautions: Liquid hydrogen peroxide will attack some forms of plastics, rubber, and coatings; many will ignite. The adiabatic decomposition temperature is 740 C (1364 F), so that most combustible materials in contact with the decomposition products will readily burst into flames.

- **Flammability**

1. Not combustible, but a powerful oxidizing agent

- **Warning properties**

1. Odor Threshold: No quantitative information is available concerning the odor threshold of hydrogen peroxide.

2. Eye Irritation Level: The AIHA *Hygienic Guide* states that "the eyes do not appear to be damaged from exposure to the vapor." Grant reports, "Injuries of human eyes have been rare. Workers exposed to vapors from 90% hydrogen peroxide have noted primarily respiratory irritation, but a splash of such high concentration is generally feared as a potential cause of severe corneal damage....

'Experimental exposure of dogs to 7 ppm hydrogen peroxide in air 6 hours a day caused no adverse effect during 23 weeks but then began to cause sneezing and lacrimation. Rabbits similarly exposed for 10 weeks suffered no corneal damage."

Deichmann and Gerarde, however, note that "vapors are irritating to the eyes, nose and throat."

According to the *Hygienic Guide,* hydrogen peroxide can be "recognized only by irritant effects, especially in nasal passages." They give an irritation threshold of approximately 100 ppm.

3. Evaluation of Warning Properties: Hydrogen peroxide has poor warning properties.

MONITORING AND MEASUREMENT PROCEDURES

- **General**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Method**

At the time of publication of this guideline, no measurement method for hydrogen peroxide had been published by NIOSH.

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforce-

ment and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with liquid hydrogen peroxide.

• Clothing contaminated with hydrogen peroxide should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of hydrogen peroxide from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the hydrogen peroxide, the person performing the operation should be informed of hydrogen peroxide's hazardous properties.

• Where there is any possibility of exposure of an employee's body to liquid hydrogen peroxide, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

• Non-impervious clothing which becomes contaminated with hydrogen peroxide should be removed immediately and not reworn until the hydrogen peroxide is removed from the clothing.

• Employees should be provided with and required to use splash-proof safety goggles where there is any possibility of liquid hydrogen peroxide contacting the eyes.

• Where there is any possibility that employees' eyes may be exposed to liquid hydrogen peroxide, an eyewash fountain should be provided within the immediate work area for emergency use.

SANITATION

• Skin that becomes contaminated with hydrogen peroxide should be promptly washed or showered to remove any hydrogen peroxide.

• Employees who handle liquid hydrogen peroxide should wash their hands thoroughly before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to hydrogen peroxide may occur and control methods which may be effective in each case:

Operation	Controls
Use in manufacture of propellants for military and space programs; use as a component of explosives	Process enclosure; general dilution ventilation; personal protective equipment; vented containers; ample available water supply
Use in chemical synthesis as an oxidant in organic and inorganic synthesis	Process enclosure; general dilution ventilation; personal protective equipment vented containers; ample available water supply
Use as a polymerization promoter; use as a bleaching agent for oils, waxes, fats, and discolored concentrated acids	Process enclosure; general dilution ventilation; personal protective equipment vented containers; ample available water supply

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If liquid hydrogen peroxide gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

• **Skin Exposure**

If liquid hydrogen peroxide gets on the skin, immediately flush the contaminated skin with water. If liquid hydrogen peroxide soaks through the clothing, remove the clothing immediately and flush the skin with water. Get medical attention promptly.

• **Breathing**

If a person breathes in large amounts of hydrogen peroxide, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When hydrogen peroxide has been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency

rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.
- If hydrogen peroxide is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill or leak.
2. Dilute with copious quantities of water.

- Waste disposal method:

After dilution with copious quantities of water, hydrogen peroxide may be flushed into a sewer.

REFERENCES

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RESPIRATORY PROTECTION FOR HYDROGEN PEROXIDE (90%)

Condition	Minimum Respiratory Protection* Required Above 1 ppm
Vapor Concentration	
10 ppm or less	Any supplied-air respirator. Any self-contained breathing apparatus.
50 ppm or less	Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
75 ppm or less	A Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode.
Greater than 75 ppm** or entry and escape from *unknown concentrations*	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask containing non-oxidizable sorbents and providing protection against hydrogen peroxide. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

**Use of supplied-air suits may be necessary to prevent skin contact while providing respiratory protection from airborne concentrations of hydrogen peroxide; however, this equipment should be selected, used, and maintained under the immediate supervision of trained personnel. Where supplied-air suits are used above a concentration of 75 ppm, an auxiliary self-contained breathing apparatus operated in positive pressure mode should also be worn.

SODIUM HYDROXIDE

SHD

Common Synonyms	Solid flakes or pellets White Odorless
Caustic soda Lye	Sinks and mixes with water.

Avoid contact with solid and dust. Keep people away.
Wear rubber overclothing (including gloves).
Stop discharge if possible.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

Not flammable.
May cause fire on contact with combustibles.
Flammable gas may be produced on contact with metals.
Wear rubber overclothing (including gloves)
Flood discharge area with water.
Cool exposed containers with water

Exposure

CALL FOR MEDICAL AID.

DUST
Irritating to eyes, nose and throat.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.
IF IN EYES, hold eyelids open and flush with plenty of water

SOLID
Will burn skin and eyes.
Harmful if swallowed.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.
DO NOT INDUCE VOMITING

Water Pollution

Dangerous to aquatic life in high concentrations.
May be dangerous if it enters water intakes.

Notify local health and wildlife officials
Notify operators of nearby water intakes

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)

Issue warning-corrosive
Restrict access
Disperse and flush

2. LABEL

2.1 **Category:** Corrosive
2.2 **Class:** 8

3. CHEMICAL DESIGNATIONS

3.1 **CG Compatibility Class:** Not listed
3.2 **Formula:** NaOH
3.3 **IMO/UN Designation:** 8.0/1823
3.4 **DOT ID No.:** 1823
3.5 **CAS Registry No.:** 1310-73-2

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Solid
4.2 **Color:** White
4.3 **Odor:** Odorless

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Chemical safety goggles; face shield; filter or dust-type respirator; rubber boots; rubber gloves.
5.2 **Symptoms Following Exposure:** Strong corrosive action on contacted tissues. INHALATION: dust may cause damage to upper respiratory tract and lung itself, producing from mild nose irritation to pneumonitis. INGESTION: severe damage to mucous membranes; severe scar formation or perforation may occur. EYE CONTACT: produces severe damage.
5.3 **Treatment of Exposure:** INHALATION: remove from exposure; support respiration; call physician. INGESTION: give water or milk followed by dilute vinegar or fruit juice; do NOT induce vomiting. SKIN: wash immediately with large quantities of water under emergency safety shower while removing clothing; continue washing until medical help arrives; call physician. EYES: irrigate immediately with copious amounts of water for at least 15 min.; call physician.
5.4 **Threshold Limit Value:** 2 mg/m³
5.5 **Short Term Inhalation Limits:** Not pertinent
5.6 **Toxicity by Ingestion:** (10% solution) oral rabbit LD_{Lo} = 500 mg/kg
5.7 **Late Toxicity:** None
5.8 **Vapor (Gas) Irritant Characteristics:** Non-volatile
5.9 **Liquid or Solid Irritant Characteristics:** Severe skin irritant. Causes second-and third-degree burns on short contact and is very injurious to the eyes.
5.10 **Odor Threshold:** Not pertinent
5.11 **IDLH Value:** 200 mg/m³

6. FIRE HAZARDS

6.1 **Flash Point:** Not flammable
6.2 **Flammable Limits in Air:** Not flammable
6.3 **Fire Extinguishing Agents:** Not pertinent
6.4 **Fire Extinguishing Agents Not to be Used:** Not pertinent
6.5 **Special Hazards of Combustion Products:** Not pertinent
6.6 **Behavior in Fire:** Not pertinent
6.7 **Ignition Temperature:** Not flammable
6.8 **Electrical Hazard:** Not pertinent
6.9 **Burning Rate:** Not flammable
6.10 **Adiabatic Flame Temperature:** Data not available
6.11 **Stoichiometric Air to Fuel Ratio:** Data not available
6.12 **Flame Temperature:** Data not available

7. CHEMICAL REACTIVITY

7.1 **Reactivity With Water:** Dissolves with liberation of much heat; may steam and splatter
7.2 **Reactivity with Common Materials:** When wet, attacks metals such as aluminum, tin, lead, and zinc to produce flammable hydrogen gas.
7.3 **Stability During Transport:** Stable
7.4 **Neutralizing Agents for Acids and Caustics:** Flush with water, rinse with dilute acetic acid
7.5 **Polymerization:** Not pertinent
7.6 **Inhibitor of Polymerization:** Not pertinent
7.7 **Molar Ratio (Reactant to Product):** Data not available
7.8 **Reactivity Group:** Data not available

8. WATER POLLUTION

8.1 **Aquatic Toxicity:**
125 ppm/96 hr/mosquito fish/TL_m/fresh
180 ppm/23 hr/oysters/lethal/salt water
8.2 **Waterfowl Toxicity:** Data not available
8.3 **Biological Oxygen Demand (BOD):** None
8.4 **Food Chain Concentration Potential:** None

9. SHIPPING INFORMATION

9.1 **Grades of Purity:** Technical flakes; USP pellets
9.2 **Storage Temperature:** Ambient
9.3 **Inert Atmosphere:** No requirement
9.4 **Venting:** Open

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

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11. HAZARD CLASSIFICATIONS

11.1 **Code of Federal Regulations:** Corrosive material
11.2 **NAS Hazard Rating for Bulk Water Transportation:** Not listed
11.3 **NFPA Hazard Classification:**

Category	Classification
Health Hazard (Blue)	3
Flammability (Red)	0
Reactivity (Yellow)	1

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 **Physical State at 15°C and 1 atm:** Solid
12.2 **Molecular Weight:** 40.00
12.3 **Boiling Point at 1 atm:** Very high
12.4 **Freezing Point:** 604°F = 318°C = 591°K
12.5 **Critical Temperature:** Not pertinent
12.6 **Critical Pressure:** Not pertinent
12.7 **Specific Gravity:** 2.13 at 20°C (solid)
12.8 **Liquid Surface Tension:** Not pertinent
12.9 **Liquid Water Interfacial Tension:** Not pertinent
12.10 **Vapor (Gas) Specific Gravity:** Not pertinent
12.11 **Ratio of Specific Heats of Vapor (Gas):** Not pertinent
12.12 **Latent Heat of Vaporization:** Not pertinent
12.13 **Heat of Combustion:** Not pertinent
12.14 **Heat of Decomposition:** Not pertinent
12.15 **Heat of Solution:** Not pertinent
12.16 **Heat of Polymerization:** Not pertinent
12.25 **Heat of Fusion:** 50.0 cal/g
12.26 **Limiting Value:** Data not available
12.27 **Reid Vapor Pressure:** Data not available

NOTES

JUNE 1985

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SHD	SODIUM HYDROXIDE

12.17 SATURATED LIQUID DENSITY		12.18 LIQUID HEAT CAPACITY		12.19 LIQUID THERMAL CONDUCTIVITY		12.20 LIQUID VISCOSITY	
Temperature (degrees F)	Pounds per cubic foot	Temperature (degrees F)	British thermal unit per pound-F	Temperature (degrees F)	British thermal *unit-inch per hour-square foot-F*	Temperature (degrees F)	*Centipoise*
	NOT PERTINENT		NOT PERTINENT		NOT PERTINENT		NOT PERTINENT

12.21 SOLUBILITY IN WATER		12.22 SATURATED VAPOR PRESSURE		12.23 SATURATED VAPOR DENSITY		12.24 IDEAL GAS HEAT CAPACITY	
Temperature (degrees F)	Pounds per 100 pounds of water	Temperature (degrees F)	Pounds per square inch	Temperature (degrees F)	Pounds per cubic foot	Temperature (degrees F)	British thermal unit per pound-F
34	44.810		NOT PERTINENT		NOT PERTINENT		NOT PERTINENT
36	47.660						
38	50.500						
40	53.350						
42	56.190						
44	59.040						
46	61.880						
48	64.719						
50	67.570						
52	70.410						
54	73.259						
56	76.099						
58	78.950						
60	81.790						
62	84.639						
64	87.480						
66	90.320						
68	93.169						
70	96.009						
72	98.860						
74	101.700						
76	104.500						
78	107.400						
80	110.200						
82	113.099						
84	115.900						

Occupational Health Guideline for Coal Tar Pitch Volatiles

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

Anthracene

- *Formula:* $C_{14}H_{10}$
- Synonyms: None
- Appearance and odor: Pale green solid with a faint aromatic odor.

Phenanthrene

- Formula: $C_{14}H_{10}$
- Synonyms: None
- Appearance and odor: Colorless solid with a faint aromatic odor.

Pyrene

- Formula: $C_{14}H_{10}$
- Synonyms: None
- Appearance: Bright yellow solid

Carbazole

- Formula: $C_{12}H_9N$
- Synonyms: None
- Appearance and odor: Colorless solid with a faint aromatic odor.

Benzo(a)pyrene

- Formula: $C_{20}H_{12}$
- Synonyms: BaP, 3,4-benzopyrene
- Appearance and odor: Colorless solid with a faint aromatic odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for coal tar pitch volatiles is 0.2 milligram of coal tar pitch volatiles per cubic meter of air (mg/m^3) averaged over an eight-hour work shift. NIOSH has recommended that the permissible exposure limit for coal tar products be reduced to 0.1 mg/m^3 (cyclohexane-extractable fraction) averaged over a work shift of up to 10 hours per day, 40 hours per week, and that coal tar products be regulated as occupational carcinogens. The NIOSH Criteria Document for Coal Tar Products and NIOSH Criteria Document for Coke Oven Emissions should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- Routes of exposure

Coal tar pitch volatiles can affect the body if they are inhaled or if they come in contact with the eyes or skin.

- Effects of overexposure

Repeated exposure to coal tar pitch volatiles has been associated with an increased risk of developing bronchitis and cancer of the lungs, skin, bladder, and kidneys. Pregnant women may be especially susceptible to exposure effects associated with coal tar pitch volatiles. Repeated exposure to these materials may also cause sunlight to have a more severe effect on a person's skin. In addition, this type of exposure may cause an allergic skin rash.

- Reporting signs and symptoms

A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to coal tar pitch volatiles.

- Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to coal tar pitch volatiles at potentially hazardous levels:

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

1. Initial Medical Examination:

—A complete history and physical examination: The urpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the oral cavity, respiratory tract, bladder, and kidneys should be stressed. The skin should be examined for evidence of chronic disorders, for premalignant nd malignant lesions, and evidence of hyperpigmentaon or photosensitivity.

—Urinalysis: Coal tar pitch volatiles are associated ith an excess of kidney and bladder cancer. A urinalys should be obtained to include at a minimum specific gravity, albumin, glucose, and microscopic on centrifuged sediment, as well as a test for red blood cells.

—Urinary cytology: Coal tar pitch volatiles are associated with an excess of kidney and bladder cancer. Employees having 5 or more years of exposure or who re 45 years of age or older should have a urinary ytology examination.

—Sputum cytology: Coal tar pitch volatiles are assoiated with an excess of lung cancer. Employees having 0 or more years of exposure or who are 45 years of age or older should have a sputum cytology examination.

—14" x 17" chest roentgenogram: Coal tar pitch olatiles are associated with an excess of lung cancer. urveillance of the lungs is indicated.

—FVC and FEV (1 sec): Coal tar pitch volatiles are eported to cause an excess of bronchitis. Periodic urveillance is indicated.

—A complete blood count: Due to the possibility of enzene exposure associated with coal tar pitch volaes, a complete blood count is considered necessary to earch for leukemia and aplastic anemia.

—Skin disease: Coal tar pitch volatiles are defatting gents and can cause dermatitis on prolonged exposure. ersons with pre-existing skin disorders may be more susceptible to the effects of these agents.

2. Periodic Medical Examination: The aforementioned edical examinations should be repeated on an annual basis, and semi-annually for employees 45 years of age or older or with 10 or more years' exposure to coal tar itch volatiles.

Summary of toxicology

Coal tar pitch volatiles (CTPV) are products of the estructive distillation of bituminous coal and contain olynuclear aromatic hydrocarbons (PNA's). These hydrocarbons sublime readily, thereby increasing the mounts of carcinogenic compounds in working areas. pidemiologic evidence suggests that workers intimately exposed to the products of combustion or distillation of bituminous coal are at increased risk of cancer at any sites. These include cancer of the respiratory ract, kidney, bladder, and skin. In a study of coke oven workers, the level of exposure to CTPV and the length f time exposed were related to the development of ancer. Coke oven workers with the highest risk of cancer were those employed exclusively at topside jobs or 5 or more years, for whom the increased risk of dying from lung cancer was 10-fold; all coke oven workers had a 7-½-fold increase in risk of dying from kidney cancer. Although the causative agent or agents of the cancer in coke oven workers is unidentified, it is suspected that several PNA's in the CTPV generated during the coking process are involved. Certain industrial populations exposed to coal tar products have a demonstrated risk of skin cancer. Substances containing PNA's which may produce skin cancer also produce contact dermatitis; examples are coal tar, pitch, and cutting oils. Although allergic dermatitis is readily induced by PNA's in guinea pigs, it is only rarely reported in humans from occupational contact with PNA's; these have resulted largely from the therapeutic use of coal tar preparations. Components of pitch and coal tar produce cutaneous photosensitization; skin eruptions are usually limited to areas exposed to the sun or ultraviolet light. Most of the phototoxic agents will induce hypermelanosis of the skin; if chronic photodermatitis is severe and prolonged, leukoderma may occur. Some oils containing PNA's have been associated with changes of follicular and sebaceous glands which commonly take the form of acne. There is evidence that exposures to emissions at coke ovens and gas retorts may be associated with an increased occurrence of chronic bronchitis. Coal tar pitch volatiles may be associated with benzene, an agent suspected of causing leukemia and known to cause aplastic anemia.

CHEMICAL AND PHYSICAL PROPERTIES

- Physical data—Anthracene
  1. Molecular weight: 178.2
  2. Boiling point (760 mm Hg): 340 C (644 F)
  3. Specific gravity (water = 1): 1.24
  4. Vapor density (air = 1 at boiling point of anthracene): 6.15
  5. Melting point: 217 C (423 F)
  6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
  7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
  8. Evaporation rate (butyl acetate = 1): Not applicable
- Physical data—Phenanthrene
  1. Molecular weight: 178.2
  2. Boiling point (760 mm Hg): 340 C (644 F)
  3. Specific gravity (water = 1): 1.18
  4. Vapor density (air = 1 at boiling point of phenanthrene): 6.15
  5. Melting point: 100.5 C (213 F)
  6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
  7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
  8. Evaporation rate (butyl acetate = 1): Not applicable
- Physical data—Pyrene
  1. Molecular weight: 202.3
  2. Boiling point (760 mm Hg): Greater than 360 C (greater than 680 F)

3. Specific gravity (water = 1): 1.28
4. Vapor density (air = 1 at boiling point of pyrene): 6.9
5. Melting point: 150.4 C (303 F)
6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

• Physical data—Carbazole
1. Molecular weight: 167.2
2. Boiling point (760 mm Hg): 355 C (671 F)
3. Specific gravity (water = 1): Greater than 1
4. Vapor density (air = 1 at boiling point of carbazole): 5.8
5. Melting point: 246 C (475 F)
6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

• Physical data—Benzo(a)pyrene
1. Molecular weight: 252.3
2. Boiling point (760 mm Hg): Greater than 360 C (greater than 680 F)
3. Specific gravity (water = 1): Greater than 1
4. Vapor density (air = 1 at boiling point of benzo(a)pyrene): 8.7
5. Melting point: 179 C (354 F)
6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

• Reactivity
1. Conditions contributing to instability: None hazardous
2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
3. Hazardous decomposition products: None
4. Special precautions: None

• Flammability
1. Flash point: Anthracene: 121 C (250 F) (closed cup); Others: Data not available
2. Autoignition temperature: Anthracene: 540 C (1004 F); Others: Data not available
3. Flammable limits in air, % by volume: Anthracene: Lower: 0.6; Others: Data not available
4. Extinguishant: Foam, dry chemical, and carbon dioxide

• Warning properties

Grant states that "coal tar and its various crude fractions appear principally to cause reddening and squamous eczema of the lid margins, with only small erosions of the corneal epithelium and superficial changes in the stroma, which disappear in a month following exposure. Chronic exposure of workmen to tar fumes and dust has been reported to cause conjunctivitis and discoloration of the cornea in the palpebral fissure, either near the limbus or, in extreme cases, across the whole cornea. Occasionally, epithelioma of the lid margin has been attributed to contact with coal tar."

MONITORING AND MEASUREMENT PROCEDURES

• General

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• Method

Coal tar products may be sampled by collection on a glass fiber filter with subsequent ultrasonic extraction and weighing. An analytical method for coal tar pitch volatiles is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 1, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00267-3).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent skin contact with condensed coal tar pitch volatiles, where skin contact may occur.

• If employees' clothing may have become contaminated with coal tar pitch volatiles, employees should change into uncontaminated clothing before leaving the work premises.

• Clothing contaminated with coal tar pitch volatiles

ıld be placed in closed containers for storage until it an be discarded or until provision is made for the emoval of coal tar pitch volatiles from the clothing. If clothing is to be laundered or otherwise cleaned to emove the coal tar pitch volatiles, the person performng the operation should be informed of coal tar pitch atiles's hazardous properties.

• Employees should be provided with and required to se splash-proof safety goggles where condensed coal pitch volatiles may contact the eyes.

SANITATION

• Workers subject to skin contact with coal tar pitch volatiles should wash with soap or mild detergent and ter any areas of the body which may have contacted l tar pitch volatiles at the end of each work day.

• Employees who handle coal tar pitch volatiles should sh their hands thoroughly with soap or mild detergt and water before eating, smoking, or using toilet facilities.

• Areas in which exposure to coal tar pitch volatiles y occur should be identified by signs or other appropriate means, and access to these areas should be limited to authorized persons.

COMMON OPERATIONS AND CONTROLS

e following list includes some common operations in uich exposure to coal tar pitch volatiles may occur and control methods which may be effective in each se:

Operation	Controls
peration from traction and packaging from coal tar fraction of coking	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
se as a binding agent manufacture of coal briquettes used for fuel; se as a dielectric in the anufacture of battery electrodes, electric-arc furnace electrodes, and ectrodes for alumina duction	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in manufacture of oofing felts and papers and roofing	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use for protective coatings for pipes for underground conduits and drainage; use as a coating on concrete as waterproofing and corrosion-resistant material; use in road paving and sealing	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in manufacture and repair of refractory brick; use in production of foundry cores; use in manufacture of carbon ceramic items	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Eye Exposure

If condensed coal tar pitch volatiles get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with these chemicals.

• Skin Exposure

If condensed coal tar pitch volatiles get on the skin, wash the contaminated skin using soap or mild detergent and water. Be sure to wash the hands before eating or smoking and to wash thoroughly at the close of work.

• Breathing

If a person breathes in large amounts of coal tar pitch volatiles, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of releases until cleanup has been completed.

• If coal tar pitch volatiles are released in hazardous concentrations, the following steps should be taken:

1. Ventilate area of spill.

2. Collect released material in the most convenient and safe manner for reclamation or for disposal in sealed containers in a secured sanitary landfill.

• Waste disposal method:

Coal tar pitch volatiles may be disposed of in sealed containers in a secured sanitary landfill.

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RESPIRATORY PROTECTION FOR COAL TAR PITCH VOLATILES

Condition	Minimum Respiratory Protection* Required Above 0.2 mg/m³
Particulate and Vapor Concentration	
2 mg/m³ or less	A chemical cartridge respirator with an organic vapor cartridge(s) and with a fume or high-efficiency filter. Any supplied-air respirator. Any self-contained breathing apparatus.
10 mg/m³ or less	A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s) and with a fume or high-efficiency filter. A gas mask with a chin-style or a front- or back-mounted organic vapor canister and with a full facepiece and a fume or high-efficiency filter. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
200 mg/m³ or less	A Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode. A powered air-purifying respirator with an organic vapor cartridge and a high-efficiency particulate filter.
400 mg/m³ or less	A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode.
Greater than 400 mg/m³ or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors and particulates, including pesticide respirators which meet the requirements of this class. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

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RENZENE**
NZENE**
NZENE**

MATERIAL SAFETY DATA SHEET

: SCIENTIFIC
AL DIVISION
AGENT LANE
LAWN NJ 07410
) 796-7100

EMERGENCY CONTACTS:
GASTON L. PILLORI: (201) 796-7100
AFTER BUSINESS HOURS; HOLIDAYS:
(201) 796-7523
CHEMTREC ASSISTANCE: (800) 424-9300

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MATION FOR THEIR PARTICULAR PURPOSES.

SUBSTANCE IDENTIFICATION

CAS-NUMBER 71-43-2

ANCE: **BENZENE**

DE NAMES/SYNONYMS:
ENZOL; CYCLOHEXATRIENE; BENZOLE; PHENE; PYROBENZOL; PYROBENZOLE;
BON OIL; COAL TAR NAPHTHA; PHENYL HYDRIDE; BENZOLENE;
ARBURET OF HYDROGEN; COAL NAPHTHA; MOTOR BENZOL; ANNULENE; (6)ANNULENE;
A U019; STCC 4908110; UN 1114;
r26; 1306S; B-243; B-245-S; B-245; B-411; C6H6; ACC02610

MICAL FAMILY:
CARBON, AROMATIC

ULAR FORMULA: C6-H6

ECULAR WEIGHT: 78.11

A RATINGS (SCALE 0-3): HEALTH=3 FIRE=3 REACTIVITY=0 PERSISTENCE=1
RATINGS (SCALE 0-4): HEALTH=2 FIRE=3 REACTIVITY=0

COMPONENTS AND CONTAMINANTS

ONENT: BENZENE PERCENT: >99
CAS= 71-43-2

ER CONTAMINANTS: 0.15% NON-AROMATICS; 1 PPM THIOPHENE

OSURE LIMITS:
ENE:
PPM OSHA TWA; 5 PPM OSHA 15 MINUTE STEL;
.5 PPM OSHA ACTION LEVEL
10 PPM (30 MG/M3) ACGIH TWA;
ACGIH A2-SUSPECTED HUMAN CARCINOGEN
.1 PPM (0.32 MG/M3) NIOSH RECOMMENDED 8 HOUR TWA;
1 PPM (3.2 MG/M3) NIOSH RECOMMENDED 15 MINUTE CEILING

10 POUNDS CERCLA SECTION 103 REPORTABLE QUANTITY
SUBJECT TO SARA SECTION 313 ANNUAL TOXIC CHEMICAL RELEASE REPORTING
SUBJECT TO CALIFORNIA PROPOSITION 65 CANCER AND/OR REPRODUCTIVE TOXICITY
WARNING AND RELEASE REQUIREMENTS- (FEBRUARY 27, 1987)

PHYSICAL DATA

RIPTION: COLORLESS TO LIGHT YELLOW LIQUID WITH AN AROMATIC ODOR.

ING POINT: 176 F (80 C) MELTING POINT: 42 F (6 C)

ECIFIC GRAVITY: 0.8765 @ 20 C VISCOSITY: 0.6468 CP @ 20 C

TILITY: 100% VAPOR PRESSURE: 75 MMHG @ 20 C

ORATION RATE: (BUTYL ACETATE = 1) 5.1 SOLUBILITY IN WATER: 0.18% @ 25 C

OR THRESHOLD: 4.68 PPM VAPOR DENSITY: 2.8

VENT SOLUBILITY: ACETONE, ALCOHOL, CARBON DISULFIDE, ACETIC ACID,
BON TETRACHLORIDE, CHLOROFORM, ETHER, OILS

FIRE AND EXPLOSION DATA

E AND EXPLOSION HAZARD:
GEROUS FIRE HAZARD WHEN EXPOSED TO HEAT OR FLAME.

DERATE EXPLOSION HAZARD WHEN EXPOSED TO HEAT OR FLAME.

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B-AIR MIXTURES ARE EXPLOSIVE ABOVE FLASH POINT.

; ARE HEAVIER THAN AIR AND MAY TRAVEL A CONSIDERABLE DISTANCE TO A SOURCE
ITION AND FLASH BACK.

TO LOW ELECTROCONDUCTIVITY OF THE SUBSTANCE, FLOW OR AGITATION MAY
TE ELECTROSTATIC CHARGES RESULTING IN SPARKS WITH POSSIBLE IGNITION.

POINT: 12 F (-11 C) (CC) UPPER EXPLOSIVE LIMIT: 7.8%

R EXPLOSIVE LIMIT: 1.2% AUTOIGNITION TEMP.: 928 F (498 C)

BILITY CLASS(OSHA): IB

IGHTING MEDIA:
CHEMICAL, CARBON DIOXIDE, HALON, WATER SPRAY OR STANDARD FOAM
7 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4).

ARGER FIRES, USE WATER SPRAY, FOG OR STANDARD FOAM
EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4).

EFIGHTING:
E CONTAINER FROM FIRE AREA IF POSSIBLE. COOL FIRE-EXPOSED CONTAINERS WITH
FROM SIDE UNTIL WELL AFTER FIRE IS OUT. STAY AWAY FROM STORAGE TANK
FOR MASSIVE FIRE IN STORAGE AREA, USE UNMANNED HOSE HOLDER OR MONITOR
ES. ELSE WITHDRAW FROM AREA AND LET FIRE BURN. WITHDRAW IMMEDIATELY IN
E OF RISING SOUND FROM VENTING SAFETY DEVICE OR ANY DISCOLORATION OF
RAGE TANK DUE TO FIRE (1987 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4,
PAGE 27).

GUISH ONLY IF FLOW CAN BE STOPPED. USE WATER IN FLOODING QUANTITIES
A FOG; SOLID STREAMS MAY SPREAD FIRE. COOL CONTAINERS WITH FLOODING
UNTS OF WATER; APPLY FROM AS FAR A DISTANCE AS POSSIBLE. AVOID BREATHING
ARDOUS MATERIALS; KEEP UPWIND. EVACUATE TO A RADIUS OF 1500 FEET FOR
TROLABLE FIRES. CONSIDER EVACUATION OF DOWNWIND AREA IF MATERIAL IS
NG.

ER MAY BE INEFFECTIVE (NFPA 325M, FIRE HAZARD PROPERTIES OF FLAMMABLE
UIDS, GASES, AND VOLATILE SOLIDS, 1984)

FIGHTING PHASES: DRY CHEMICAL, ALCOHOL FOAM OR CARBON DIOXIDE. WATER MAY
EFFECTIVE. USE WATER TO KEEP FIRE-EXPOSED CONTAINERS COOL. IF A LEAK OR
HAS NOT IGNITED, USE WATER SPRAY TO DISPERSE THE VAPORS AND TO PROVIDE
TECTION FOR THE MEN ATTEMPTING TO STOP THE LEAK. WATER SPRAY MAY BE USED
FLUSH SPILLS AWAY FROM EXPOSURES (NFPA 49, HAZARDOUS CHEMICALS DATA, 1975).

TRANSPORTATION DATA

ARTMENT OF TRANSPORTATION HAZARD CLASSIFICATION 49 CFR 172.101:
AMMABLE LIQUID

RTMENT OF TRANSPORTATION LABELING REQUIREMENTS 49 CFR 172.101 AND
ART E:
LAMMABLE LIQUID

RTMENT OF TRANSPORTATION PACKAGING REQUIREMENTS: 49 CFR 173.119
PTIONS: 49 CFR 173.118

TOXICITY

ENE:
TATION DATA: 20 MG/24 HOURS SKIN-RABBIT MODERATE; 15 MG/24 HOURS OPEN
IN-RABBIT MILD; 88 MG EYE-RABBIT MODERATE; 2 MG/24 HOURS EYE-RABBIT
SEVERE.
XICITY DATA: 2000 PPM/5 MINUTES INHALATION-HUMAN LCLO; 2 PPM/5 MINUTES
HALATION-HUMAN LCLO; 65 MG/M3/5 YEARS INHALATION-HUMAN LCLO; 100
M INHALATION-HUMAN TCLO; 150 PPM/1 YEAR INTERMITTENT INHALATION-MAN
LO; 20,000 PPM/5 MINUTES INHALATION-MAMMAL LCLO; 10,000 PPM/7 HOURS
INHALATION-RAT LC50; 9980 PPM INHALATION-MOUSE LC50; 146,000 MG/M3
INHALATION-DOG LCLO; 170,000 MG/M3 INHALATION-CAT LCLO;
45000 PPM/30 MINUTES INHALATION-RABBIT LCLO; 50 MG/KG ORAL-MAN LDLO;
06 MG/KG ORAL-RAT LD50; 4700 MG/KG ORAL-MOUSE LD50;
00 MG/KG ORAL-DOG LDLO; 88 MG/KG INTRAVENOUS-RABBIT LDLO; 2890 UG/KG
TRAPERITONEAL-RAT LD50; 340 MG/KG INTRAPERITONEAL-MOUSE LD50; 527 MG/KG
INTRAPERITONEAL-GUINEA PIG LDLO; 194 MG/KG UNREPORTED-MAN LDLO; MUTAGENIC
DATA (RTECS); REPRODUCTIVE EFFECTS DATA (RTECS); TUMORIGENIC DATA (RTECS).
INOGEN STATUS: OSHA CARCINOGEN; KNOWN HUMAN CARCINOGEN (NTP); HUMAN
FFICIENT EVIDENCE, ANIMAL SUFFICIENT EVIDENCE (IARC GROUP-1). THE
LATIONSHIP BETWEEN EXPOSURE TO BENZENE AND THE DEVELOPMENT OF ACUTE
MYELOGENOUS LEUKEMIA HAS BEEN ESTABLISHED IN EPIDEMIOLOGICAL STUDIES.
CAL EFFECTS: IRRITANT- SKIN, EYE.
UTE TOXICITY LEVEL: MODERATELY TOXIC BY INHALATION AND INGESTION.
ET EFFECTS: CENTRAL NERVOUS SYSTEM DEPRESSANT; BONE MARROW DEPRESSANT.
OISONING MAY ALSO AFFECT THE IMMUNE, HEMATOPOIETIC AND NERVOUS SYSTEMS.
INCREASED RISK FROM EXPOSURE: PERSONS WITH CERTAIN IMMUNOLOGICAL
TENDENCIES.
DDITIONAL DATA: USE OF ALCOHOLIC BEVERAGES MAY ENHANCE THE TOXIC EFFECTS.
SE OF STIMULANTS SUCH AS EPINEPHRINE MAY CAUSE CARDIAC ARRYTHMIAS.

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HEALTH EFFECTS AND FIRST AID

LATION:
ENE:
.NT/NARCOTIC/BONE MARROW DEPRESSANT/CARCINOGEN.
E EXPOSURE- CONCENTRATIONS OF 3000 PPM MAY CAUSE RESPIRATORY TRACT
.RITATION; MORE SEVERE EXPOSURES MAY RESULT IN PULMONARY EDEMA. SYSTEMIC
EFFECTS ARE MAINLY ON THE CENTRAL NERVOUS SYSTEM AND DEPEND ON EXPOSURE
TIME AND CONCENTRATION. NO EFFECTS WERE NOTED AT 25 PPM FOR 8 HOURS;
SIGNS OF INTOXICATION BEGAN AT 50-150 PPM WITHIN 5 HOURS; AT 500-1500 PPM,
.ITHIN 1 HOUR; WERE SEVERE AT 7500 PPM, WITHIN 30-60 MINUTES; AND
),000 PPM WAS FATAL WITHIN 5-10 MINUTES. EFFECTS MAY INCLUDE NAUSEA,
.OMITING, HEADACHE, DIZZINESS, DROWSINESS, WEAKNESS, SOMETIMES PRECEDED
BY A BRIEF PERIOD OF EXHILARATION OR EUPHORIA, IRRITABILITY, MALAISE,
CONFUSION, ATAXIA, STAGGERING, WEAK, RAPID PULSE, CHEST PAIN AND
IGHTNESS WITH BREATHLESSNESS, PALLOR, CYANOSIS OF THE LIPS AND
INGERTIPS, AND TINNITUS. IN SEVERE EXPOSURES THERE MAY BE BLURRED
ISION, SHALLOW, RAPID BREATHING, DELIRIUM, CARDIAC ARRHYTHMIAS,
UNCONSCIOUSNESS, DEEP ANESTHESIA, PARALYSIS, AND COMA CHARACTERIZED
BY MOTOR RESTLESSNESS, TREMORS AND HYPERREFLEXIA. SOMETIMES PRECEDED
BY CONVULSIONS. RECOVERY DEPENDS ON THE SEVERITY OF EXPOSURE.
OLYNEURITIS MAY OCCUR AND THERE MAY BE PERSISTENT NAUSEA, ANOREXIA,
USCULAR WEAKNESS, HEADACHE, DROWSINESS, INSOMNIA, AND AGITATION. NERVOUS
RRITABILITY, BREATHLESSNESS, AND UNSTEADY GAIT MAY PERSIST FOR 2-3 WEEKS;
A PECULIAR SKIN COLOR AND CARDIAC DISTRESS MAY PERSIST FOR 4 WEEKS. LIVER
AND KIDNEY EFFECTS MAY OCCUR, BUT ARE USUALLY MILD, TEMPORARY IMPAIRMENTS.
HROMOSOMAL DAMAGE HAS BEEN FOUND AFTER EXPOSURE TO TOXIC LEVELS. ALTHOUGH
ENERALLY HEMATOTOXICITY IS NOT A SIGNIFICANT CONCERN IN ACUTE EXPOSURE.
ELAYED HEMATOLOGICAL EFFECTS, INCLUDING ANEMIA AND THROMBOCYTOPENIA,
HAVE BEEN REPORTED, AS HAVE HEMORRHAGES, SPONTANEOUS BLEEDING
AND SECONDARY INFECTIONS. IN FATAL EXPOSURES, DEATH MAY BE DUE TO
ASPHYXIA, CENTRAL NERVOUS SYSTEM DEPRESSION, CARDIAC OR RESPIRATORY
AILURE AND CIRCULATORY COLLAPSE, OR OCCASIONALLY, SUDDEN VENTRICULAR
IBRILLATION. IT MAY OCCUR WITHIN A FEW MINUTES TO SEVERAL HOURS. OR
ARDIAC ARRYTHMIA MAY OCCUR AT ANYTIME WITHIN 24 HOURS. ALSO, DEATH FROM
CENTRAL NERVOUS SYSTEM, RESPIRATORY OR HEMORRHAGIC COMPLICATIONS MAY OCCUR
UP TO 5 DAYS AFTER EXPOSURE. PATHOLOGIC FINDINGS HAVE INCLUDED
RESPIRATORY INFLAMMATION WITH EDEMA AND HEMORRHAGE OF THE LUNGS, RENAL
CONGESTION, CEREBRAL EDEMA, AND EXTENSIVE PETECHIAL HEMORRHAGES IN THE
IRAIN, PLEURAE, PERICARDIUM, URINARY TRACT, MUCOUS MEMBRANES, AND SKIN.
HRONIC EXPOSURE- LONGTERM EXPOSURE MAY CAUSE SYMPTOMS REFERABLE TO THE
CENTRAL NERVOUS, HEMATOPOIETIC AND IMMUNE SYSTEMS. EARLY EFFECTS ARE VAGUE
AND VARIED AND MAY INCLUDE HEADACHE, LIGHT-HEADEDNESS, DIZZINESS, NAUSEA,
INOREXIA, ABDOMINAL DISCOMFORT, AND FATIGUE. SORE, DRY THROAT, WEAKNESS,
.ETHARGY, MALAISE, DROWSINESS, NERVOUSNESS, AND IRRITABILITY HAVE
)LSO BEEN REPORTED. LATER THERE MAY BE DYSPNEA, PALLOR, SLIGHTLY INCREASED
TEMPERATURE, DECREASED BLOOD PRESSURE, RAPID PULSE, PALPITATIONS, AND
VISUAL DISTURBANCES. DIZZINESS WHEN COLD WATER IS PLACED IN THE EAR AND
HEARING IMPAIRMENT HAVE BEEN REPORTED, AS HAVE DIFFUSE CEREBRAL ATROPHY
ASSOCIATED WITH ATAXIA, TREMORS AND EMOTIONAL LABILITY. WORKERS EXPOSED TO
BENZENE IN COMBINATION WITH OTHER SOLVENTS HAVE EXHIBITED POLYNEURITIS.
SEVERAL CASE REPORTS, ONE OF THEM AN ACUTE EXPOSURE, SUGGEST THE
POSSIBILITY THAT SYSTEMIC EXPOSURE MAY BE ASSOCIATED WITH RETROBULBAR
OR OPTIC NEURITIS. OCCASIONALLY HEMORRHAGES IN RETINA AND CONJUNCTIVA
OCCUR AND RARELY NEURORETINAL EDEMA AND PAPILLEDEMA HAVE ACCOMPANIED
THE RETINAL HEMORRHAGES. HEMATOLOGICAL EFFECTS VARY WIDELY AND MAY
APPEAR AFTER A FEW WEEKS OR MANY YEARS OF EXPOSURE OR EVEN MANY YEARS
AFTER EXPOSURE HAS CEASED. THE DEGREE OF EXPOSURE BELOW WHICH NO
BLOOD EFFECTS WILL OCCUR CANNOT BE ESTABLISHED WITH CERTAINTY. IN THE
EARLY STAGES, THERE MAY BE BLOOD CLOTTING DEFECTS DUE TO FUNCTIONAL,
MORPHOLOGICAL AND QUANTITATIVE PLATELET ALTERATION WITH RESULTANT
BLEEDING FROM THE NOSE AND GUMS, EASY BRUISING AND PETECHIAE; LEUKOPENIA
WITH PREDOMINANT LYMPHOCYTOPENIA OR NEUTROPENIA; AND ANEMIA WHICH MAY BE
NORMOCHROMIC OR MACROCYTIC AND HYPOCHROMIC. LEUKOCYTOSIS AND
CIRCULATING IMMATURE MARROW CELLS HAVE ALSO BEEN REPORTED. BONE MARROW
MAY BE HYPER-, HYPO- OR .ORMOPLASTIC AND DOES NOT ALWAYS CORRELATE
WITH THE PERIPHERAL BLOOD PICTURE. ALSO, THE SYMPTOMS DO NOT ALWAYS
:ARALLEL THE LABORATORY FINDINGS. IF TREATED AT THIS STAGE, THE EFFECTS
APPEAR REVERSIBLE, ALTHOUGH RECOVERY MAY BE PROTRACTED AND THERE MAY BE
RELAPSES. DECREASED ERYTHROCYTE SURVIVAL, HEMOLYSIS, CAPILLARY
FRAGILITY, INTERNAL HEMORRHAGES, IRON METABOLISM DISTURBANCES, AND
HYPERBILIRUBINEMIA HAVE ALSO BEEN REPORTED. EXPOSURE TO HIGH LEVELS FOR
LONGER PERIODS MAY RESULT IN APLASIA AND FATTY DEGENERATION OF THE
BONE MARROW WITH PANCYTOPENIA. THE MOST SERIOUS CASES OF APLASTIC ANEMIA
MAY BE FATAL DUE TO HEMORRHAGE AND INFECTION; DEATH MAY OCCUR WITHIN 3
MONTH OF DIAGNOSIS. ENORMOUS VARIABILITY IN INDIVIDUAL RESPONSE, INCLUDING
NON-DOSE DEPENDENT APLASIA, AND THE FINDING OF EOSINOPHILIA SUGGESTS
THAT, IN SOME CASES, THE BLOOD DYSCRASIA MAY PARTIALLY BE AN ALLERGIC
REACTION. NUMEROUS CASE REPORTS AND SERIES HAVE SUGGESTED A
RELATIONSHIP BETWEEN EXPOSURE TO BENZENE AND THE OCCURRENCE OF
VARIOUS TYPES OF LEUKEMIA. SEVERAL CASE-CONTROL STUDIES HAVE ALSO
SHOWN INCREASED ODDS RATIOS FOR EXPOSURE TO BENZENE, BUT MIXED EXPOSURE
PATTERNS AND POORLY DEFINED EXPOSURES RENDER THEIR INTERPRETATION
DIFFICULT. THREE INDEPENDENT COHORT STUDIES HAVE DEMONSTRATED AN INCREASED
INCIDENCE OF ACUTE NONLYMPHOCYTIC LEUKEMIA IN WORKERS EXPOSED TO BENZENE.
ALTHOUGH APLASTIC ANEMIA IS PROBABLY THE MORE LIKELY CONSEQUENCE OF
LONGTERM EXPOSURE, IT IS NOT UNCOMMON FOR AN INDIVIDUAL SURVIVING THIS,
TO GO THROUGH A PRELEUKEMIC PHASE INTO FRANK LEUKEMIA. CONVERSELY,

UKEMIA WITHOUT PRECEDENT APLASTIC ANEMIA CAN OCCUR. IN ONE STUDY THE GE OF TIME FROM THE START OF THE EXPOSURE TO THE DIAGNOSIS OF UKEMIA WAS 3-24 YEARS. IT HAS BEEN SUGGESTED THAT THE CHROMOSOMAL BERATIONS WHICH CAN ARISE IN PERIPHERAL BLOOD AND BONE MARROW CELLS ND PERSIST FOR A LONG TIME AFTER EXPOSURE CEASES, MAY BE ASSOCIATED WITH HE INCREASED INCIDENCE OF LEUKEMIA. THE IMMUNOSUPPRESSIVE EFFECT HAS SO BEEN SUGGESTED AS BEING ASSOCIATED WITH THE LEUKEMOGENESIS. ADVERSE FECTS ON THE IMMUNOLOGICAL SYSTEM HAVE BEEN SHOWN TO MAKE RABBITS RE SUSCEPTIBLE TO TUBERCULOSIS AND PNEUMONIA AND MAY EXPLAIN WHY THE TERMINAL EVENT IN SOME CASES OF BENZENE INTOXICATION MAY BE OVERWHELMING INFECTION. EXPOSED MICE EXHIBITED A TENDENCY TOWARD INDUCTION OF LYMPHOID NEOPLASMS. RATS EXHIBITED AN INCREASED INCIDENCE OF NEOPLASMS, MAINLY CARCINOMAS, AT VARIOUS SITES. MENSTRUAL DISTURBANCES HAVE BEEN REPORTED MORE FREQUENTLY IN EXPOSED WOMEN. TESTICULAR DAMAGE HAS BEEN REPORTED IN RATS, RABBITS AND GUINEA PIGS. SOME ANIMAL STUDIES HAVE DEMONSTRATED EMBRYO/FETOTOXICITY, SOMETIMES AT LEVELS AS LOW AS 10 PPM AND THE POTENTIAL FOR TERATOGENIC EFFECTS SUCH AS DECREASED BODY WEIGHT AND SKELETAL VARIANTS, HAVE ALSO BEEN SHOWN. OTHER STUDIES HAVE NOT PRODUCED ANY ABNORMALITIES OR EMBRYOLETHALITY.

T AID- REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING S STOPPED, GIVE ARTIFICIAL RESPIRATION. MAINTAIN AIRWAY AND BLOOD ESSURE AND ADMINISTER OXYGEN IF AVAILABLE. KEEP AFFECTED PERSON WARM AND EST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. ADMINISTRATION OF OXYGEN LD BE PERFORMED BY QUALIFIED PERSONNEL. GET MEDICAL ATTENTION DIATELY.

ONTACT:
JE:
INT.
UTE EXPOSURE- DIRECT CONTACT MAY CAUSE IRRITATION. EFFECTS MAY INCLUDE ERYTHEMA, A BURNING SENSATION, AND WITH PROLONGED CONTACT, BLISTERING AND EDEMA. UNDER NORMAL CONDITIONS, SIGNIFICANT SIGNS OF SYSTEMIC TOXICITY RE UNLIKELY FROM SKIN CONTACT ALONE DUE TO THE SLOW RATE OF ABSORPTION; T MAY HOWEVER, CONTRIBUTE TO THE TOXICITY FROM INHALATION. APPLICATION D GUINEA PIGS RESULTED IN INCREASED DERMAL PERMEABILITY.
RONIC EXPOSURE- REPEATED OR PROLONGED CONTACT DEFATS THE SKIN AND MAY RESULT IN DERMATITIS WITH ERYTHEMA, SCALING, DRYNESS, VESICULATION, AND FISSURING, POSSIBLY ACCOMPANIED BY PARESTHESIAS OF THE FINGERS WHICH MAY ERSIST SEVERAL WEEKS AFTER THE DERMATITIS SUBSIDES. PERIPHERAL NEURITIS AS ALSO BEEN REPORTED. SECONDARY INFECTIONS MAY OCCUR. TESTS ON GUINEA PIGS INDICATE SENSITIZATION IS POSSIBLE. ALTHOUGH ANIMAL STUDIES HAVE FAILED TO ESTABLISH A RELATIONSHIP BETWEEN SKIN CONTACT AND A CARCINOGENIC EFFECT, MOST OF THE STUDIES WERE INADEQUATE; SOME PAPILLOMAS ND HEMATOPOIETIC EFFECTS HAVE BEEN REPORTED.

AID- REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED REA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO VIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL TENTION IMMEDIATELY.

ONTACT:
ENE:
ITANT.
CUTE EXPOSURE- VAPOR CONCENTRATIONS OF 3000 PPM ARE VERY IRRITATING, EVEN ON BRIEF EXPOSURE. DROPLETS CAUSE MODERATE BURNING SENSATION, BUT ONLY SLIGHT, TRANSIENT CORNEAL EPITHELIAL INJURY WITH RAPID RECOVERY.
RONIC EXPOSURE- REPEATED OR PROLONGED EXPOSURE MAY CAUSE CONJUNCTIVITIS. 50% OF RATS EXPOSED TO 50 PPM FOR MORE THAN 600 HOURS DEVELOPED CATARACTS.

T AID- WASH EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, ASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL AINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

ESTION:
ZENE:
OTIC/CARCINOGEN.
UTE EXPOSURE- MAY CAUSE LOCAL IRRITATION AND BURNING SENSATION IN THE MOUTH, THROAT, AND STOMACH. SIGNS AND SYMPTOMS OF SYSTEMIC INTOXICATION MAY INCLUDE NAUSEA, VOMITING, HEADACHE, DIZZINESS, WEAKNESS, STAGGERING, CHEST PAIN AND TIGHTNESS, SHALLOW, RAPID PULSE, BREATHLESSNESS, PALLOR FOLLOWED BY FLUSHING, AND A FEAR OF IMPENDING DEATH. THERE MAY BE VISUAL DISTURBANCES AND CONVULSIONS. VIOLENT EXCITEMENT, EUPHORIA OR DELIRIUM MAY PRECEDE WEARINESS, FATIGUE AND SLEEPINESS FOLLOWED BY UNCONSCIOUSNESS, COMA AND DEATH. THOSE WHO SURVIVE THE CENTRAL NERVOUS SYSTEM EFFECTS MAY DEVELOP BRONCHITIS, PNEUMONIA, PULMONARY EDEMA, AND INTRAPULMONARY HEMORRHAGE. ASPIRATION MAY CAUSE IMMEDIATE PULMONARY EDEMA AND HEMORRHAGE. THE USUAL LETHAL DOSE IN HUMANS IS 10-15 MILLILITERS. BUT SMALLER AMOUNTS HAVE BEEN REPORTED TO CAUSE DEATH. A SINGLE EXPOSURE MAY PRODUCE LONGTERM EFFECTS WITH PANCYTOPENIA PERSISTING UP TO A YEAR.
CHRONIC EXPOSURE- DAILY ADMINISTRATION TO HUMANS OF 2-5 GRAMS IN OLIVE OIL HAS CAUSED HEADACHE, VERTIGO, BLADDER IRRITABILITY, IMPOTENCE, GASTRIC DISTURBANCES, AND RENAL DYSFUNCTION. IN FEMALE RATS TREATED WITH 132 SINGLE DAILY DOSES OVER 187 DAYS, NO EFFECTS WERE OBSERVED AT 1 MG/KG; SLIGHT LEUKOPENIA AT 10 MG/KG; AND BOTH LEUKOPENIA AND ANEMIA AT 50 AND 200 MG/KG. IN A 2 YEAR GAVAGE STUDY WITH RATS AND MICE, THERE WAS AN INCREASED INCIDENCE OF LYMPHOMAS AND TUMORS OF THE ORAL CAVITY, SKIN, LUNGS, OVARIES, AND MAMMARY, HARDERIAN, AND PREPUTIAL GLANDS. IN A ONE YEAR GAVAGE STUDY, RATS GIVEN 50 OR 250 MG/KG, 4-5 DAYS/WEEK FOR 52 WEEKS

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DID NOT EXHIBIT ACUTE OR SUBACUTE TOXIC EFFECTS. BUT A DOSE CORRELATED CREASE OF LEUKEMIAS AND MAMMARY CARCINOMAS WAS OBSERVED. REPRODUCTIVE FECTS HAVE BEEN REPORTED IN ANIMALS.

T AID- EXTREME CARE MUST BE USED TO PREVENT ASPIRATION. GASTRIC LAVAGE TH A CUFFED ENDOTRACHEAL TUBE IN PLACE TO PREVENT FURTHER ASPIRATION LD BE DONE WITHIN 15 MINUTES. IN THE ABSENCE OF DEPRESSION OR ULSIONS OR IMPAIRED GAG REFLEX, EMESIS CAN ALSO BE INDUCED USING SYRUP IPECAC WITHOUT INCREASING THE HAZARD OF ASPIRATION (DREISBACH, HANDBOOK OISONING, 12TH ED.). TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GASTRIC VAGE SHOULD BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. GET MEDICAL TTENTION IMMEDIATELY.

)TE:
S ICIFIC ANTIDOTE. TREAT SYMPTOMATICALLY AND SUPPORTIVELY.

REACTIVITY

TIVITY:
SLE UNDER NORMAL TEMPERATURES AND PRESSURES.

OMPATIBILITIES:
NE:
DS (STRONG): INCOMPATIBLE.
YL CHLORIDE WITH DICHLOROETHYL ALUMINUM OR ETHYLALUMINUM SESQUICHLORIDE: POSSIBLE EXPLOSION.
RSENIC PENTAFLUORIDE + POTASSIUM METHOXIDE: EXPLOSIVE INTERACTION.
ASES (STRONG): INCOMPATIBLE.
MINE + IRON: INCOMPATIBLE.
MINE PENTAFLUORIDE: FIRE AND EXPLOSION HAZARD.
MINE TRIFLUORIDE: POSSIBLE EXPLOSION OR IGNITION.
HLORINE: EXPLOSION IN THE PRESENCE OF LIGHT.
HLORINE TRIFLUORIDE: VIOLENT REACTION WITH POSSIBLE EXPLOSION.
OMIC ANHYDRIDE (POWDERED): IGNITION.
ORANE: SPONTANEOUSLY EXPLOSIVE REACTION IN AIR.
XYGEN DIFLUORIDE: IGNITION, EVEN AT REDUCED TEMPERATURES.
IOXYGENYL TETRAFLUOROBORATE: IGNITION REACTION.
NTERHALOGEN COMPOUNDS: IGNITION OR EXPLOSION.
ORINE HEPTAFLUORIDE: IGNITION ON CONTACT.
INE PENTAFLUORIDE: VIOLENT INTERACTION ABOVE 50 C.
RIC ACID: VIOLENT OR EXPLOSIVE UNLESS PROPERLY AGITATED AND COOLED.
.RYL PERCHLORATE: EXPLOSIVE INTERACTION.
XIDIZERS (STRONG): FIRE AND EXPLOSION HAZARD.
XYGEN (LIQUID): EXPLOSIVE MIXTURE.
ONE: FORMATION OF EXPLOSIVE GELATINOUS OZONIDE.
CHLORATES (METAL): FORMATION OF EXPLOSIVE COMPLEX.
CHLORYL FLUORIDE + ALUMINUM CHLORIDE: FORMATION OF SHOCK SENSITIVE COMPOUND.
ERMANGANATES + SULFURIC ACID: POSSIBLE EXPLOSION.
ERMANGANIC ACID: EXPLOSION HAZARD.
ROXODISULFURIC ACID: EXPLOSION HAZARD.
ROXOMONOSULFURIC ACID: EXPLOSIVE INTERACTION.
ASSIUM PEROXIDE: IGNITION.
SILVER PERCHLORATE: FORMATION OF EXPLOSIVE COMPLEX.
SODIUM PEROXIDE + WATER: IGNITION.
ANIUM HEXAFLUORIDE: VIOLENT REACTION.

MPOSITION:
ERMAL DECOMPOSITION PRODUCTS MAY INCLUDE TOXIC OXIDES OF CARBON.

YMERIZATION:
RDOUS POLYMERIZATION HAS NOT BEEN REPORTED TO OCCUR UNDER NORMAL ERATURES AND PRESSURES.

STORAGE AND DISPOSAL

RVE ALL FEDERAL, STATE AND LOCAL REGULATIONS WHEN STORING OR DISPOSING HIS SUBSTANCE. FOR ASSISTANCE, CONTACT THE DISTRICT DIRECTOR OF THE VIRONMENTAL PROTECTION AGENCY.

STORAGE

E IN ACCORDANCE WITH 29 CFR 1910.106.

NOING AND GROUNDING: SUBSTANCES WITH LOW ELECTROCONDUCTIVITY, WHICH EE IGNITED BY ELECTROSTATIC SPARKS, SHOULD BE STORED IN CONTAINERS H MEET THE BONDING AND GROUNDING GUIDELINES SPECIFIED IN NFPA 77-1983, OMMENDED PRACTICE ON STATIC ELECTRICITY.

OTECT AGAINST PHYSICAL DAMAGE. OUTSIDE OR DETACHED STORAGE IS PREFERABLE. SIDE STORAGE SHOULD BE IN A STANDARD FLAMMABLE LIQUIDS STORAGE ROOM OR INET. SEPARATE FROM OXIDIZING MATERIALS (NFPA 49, HAZARDOUS CHEMICALS . 1975).

RE AWAY FROM INCOMPATIBLE SUBSTANCES.

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xxDISPOSALxx

)SAL MUST BE IN ACCORDANCE WITH STANDARDS APPLICABLE TO GENERATORS OF
.DOUS WASTE, 40CFR 262. EPA HAZARDOUS WASTE NUMBER D018.

)ZENE - REGULATORY LEVEL: 0.5 MG/L
TERIALS WHICH CONTAIN THE ABOVE SUBSTANCE AT OR ABOVE THE REGULATORY
VEL MEET THE EPA CHARACTERISTIC OF TOXICITY, AND MUST BE DISPOSED OF IN
CORDANCE WITH 40 CFR PART 262. EPA HAZARDOUS WASTE NUMBER D018.

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
CONDITIONS TO AVOID

D CONTACT WITH HEAT, SPARKS, FLAMES, OR OTHER SOURCES OF IGNITION. VAPORS
BE EXPLOSIVE. AVOID OVERHEATING OF CONTAINERS; CONTAINERS MAY VIOLENTLY
PTURE IN HEAT OF FIRE. AVOID CONTAMINATION OF WATER SOURCES.

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
SPILL AND LEAK PROCEDURES

IL SPILL:
HOLDING AREA SUCH AS LAGOON, POND OR PIT FOR CONTAINMENT.
. FLOW OF SPILLED MATERIAL USING SOIL OR SANDBAGS OR FOAMED BARRIERS SUCH
OLYURETHANE OR CONCRETE.
CEMENT POWDER, FLY ASH, SAWDUST OR COMMERCIAL SORBENT TO ABSORB BULK
QUID.
DUCE VAPOR AND FIRE HAZARD WITH FLUOROCARBON WATER FOAM.

SPILL:
)CK DOWN VAPORS WITH WATER SPRAY. KEEP UPWIND.

TER SPILL:
IMIT SPILL MOTION AND DISPERSION WITH NATURAL BARRIERS OR OIL SPILL CONTROL
) AS.
.Y DETERGENTS, SOAPS, ALCOHOLS OR ANOTHER SURFACE ACTIVE AGENT TO THICKEN
.LED MATERIAL.
PLY UNIVERSAL GELLING AGENT TO IMMOBILIZE TRAPPED SPILL AND INCREASE
FFICIENCY OF REMOVAL.
DISSOLVED, APPLY ACTIVATED CARBON AT TEN TIMES THE SPILLED AMOUNT IN THE
ION OF 10 PPM OR GREATER CONCENTRATION.
SUCTION HOSES TO REMOVE TRAPPED SPILL MATERIAL.
DREDGES OR LIFTS TO EXTRACT IMMOBILIZED MASSES OF POLLUTION AND
RECIPITATES.

UPATIONAL SPILL:
T OFF IGNITION SOURCES. STOP LEAK IF YOU CAN DO IT WITHOUT RISK. USE WATER
AY TO REDUCE VAPORS. FOR SMALL SPILLS, TAKE UP WITH SAND OR OTHER ABSORBENT
ATERIAL AND PLACE INTO CONTAINERS FOR LATER DISPOSAL. FOR LARGER SPILLS, DIKE
AR AHEAD OF SPILL FOR LATER DISPOSAL. NO SMOKING. FLAMES OR FLARES IN HAZARD
REA. KEEP UNNECESSARY PEOPLE AWAY; ISOLATE HAZARD AREA AND RESTRICT ENTRY.

E ORTABLE QUANTITY (RQ): 1000 POUNDS
SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA) SECTION 304 REQUIRES
HAT A RELEASE EQUAL TO OR GREATER THAN THE REPORTABLE QUANTITY FOR THIS
UBSTANCE BE IMMEDIATELY REPORTED TO THE LOCAL EMERGENCY PLANNING COMMITTEE
THE STATE EMERGENCY RESPONSE COMMISSION (40 CFR 355.40). IF THE RELEASE OF
S SUBSTANCE IS REPORTABLE UNDER CERCLA SECTION 103, THE NATIONAL RESPONSE
ITER MUST BE NOTIFIED IMMEDIATELY AT (800) 424-8802 OR (202) 426-2675 IN THE
ETROPOLITAN WASHINGTON, D.C. AREA (40 CFR 302.6).

PROTECTIVE EQUIPMENT

NTILATION:
ROVIDE LOCAL EXHAUST OR PROCESS ENCLOSURE VENTILATION TO MEET THE PUBLISHED
XPOSURE LIMITS. VENTILATION EQUIPMENT MUST BE EXPLOSION-PROOF.

NZENE:
NTILATION SHOULD MEET THE REQUIREMENTS IN 29 CFR 1910.1028(F).

ESPIRATOR:
HE FOLLOWING RESPIRATORS ARE THE MINIMUM LEGAL REQUIREMENTS AS SET FORTH
BY THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION FOUND IN 29 CFR 1910,
SUBPART Z.

ENZENE:

NCENTRATION: REQUIRED RESPIRATOR:

SS THAN OR
QUAL TO 10 PPM- HALF-MASK AIR-PURIFYING RESPIRATOR WITH ORGANIC VAPOR CARTRIDGE.

SS THAN OR
UAL TO 50 PPM- FULL FACEPIECE RESPIRATOR WITH ORGANIC VAPOR CARTRIDGES.
FULL FACEPIECE GAS MASK WITH CHIN STYLE CANISTER.

ESS THAN OR
QUAL TO 100 PPM- FULL FACEPIECE POWERED AIR-PURIFYING RESPIRATOR WITH

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ORGANIC VAPOR CANISTER.

HAN OR
L TO 1000 PPM- SUPPLIED AIR RESPIRATOR WITH FULL FACEPIECE IN POSITIVE-PRESSURE MODE.

TER THAN
PM OR
N
ENTRATION- SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE IN POSITIVE-PRESSURE MODE.
FULL FACEPIECE POSITIVE-PRESSURE SUPPLIED-AIR RESPIRATOR WITH AUXILIARY SELF-CONTAINED AIR SUPPLY.

:- ANY ORGANIC VAPOR GAS MASK.
ANY SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE.

: :GHTING- FULL FACEPIECE SELF-CONTAINED BREATHING APPARATUS IN POSITIVE-PRESSURE MODE.

FOLLOWING RESPIRATORS AND MAXIMUM USE CONCENTRATIONS ARE RECOMMENDATIONS THE U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES. NIOSH POCKET GUIDE TO AL HAZARDS OR NIOSH CRITERIA DOCUMENTS.
PECIFIC RESPIRATOR SELECTED MUST BE BASED ON CONTAMINATION LEVELS FOUND E WORK PLACE AND BE JOINTLY APPROVED BY THE NATIONAL INSTITUTE OF PATIONAL SAFETY AND HEALTH AND THE MINE SAFETY AND HEALTH ADMINSTRATION.

Y DETECTABLE CONCENTRATION:

SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.
SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE IN COMBINATION WITH AN AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

APE- AIR-PURIFYING FULL FACEPIECE RESPIRATOR (GAS MASK) WITH A CHIN-STYLE OR FRONT- OR BACK-MOUNTED ORGANIC VAPOR CANISTER.
ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS.

IREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS:

ELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

PLIED-AIR RESPIRATOR WITH FULL FACEPIECE AND OPERATED IN PRESSURE-DEMAND R OTHER POSITIVE PRESSURE MODE IN COMBINATION WITH AN AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

ING:
YEE MUST WEAR APPROPRIATE PROTECTIVE (IMPERVIOUS) CLOTHING AND EQUIPMENT EVENT REPEATED OR PROLONGED SKIN CONTACT WITH THIS SUBSTANCE.

ZENE:
TECTIVE CLOTHING SHOULD MEET THE REQUIREMENTS FOR PERSONAL PROTECTIVE MENT IN 29 CFR 1910.1028(H).

VES:
LOYEE MUST WEAR APPROPRIATE PROTECTIVE GLOVES TO PREVENT CONTACT WITH THIS STANCE.

. INE:
TECTIVE GLOVES SHOULD MEET THE REQUIREMENTS FOR PERSONAL PROTECTIVE IPMENT IN 29 CFR 1910.1028(H).

PROTECTION:
YEE MUST WEAR SPLASH-PROOF OR DUST-RESISTANT SAFETY GOGGLES TO PREVENT CONTACT WITH THIS SUBSTANCE.

GENCY EYE WASH: WHERE THERE IS ANY POSSIBILITY THAT AN EMPLOYEE'S EYES MAY XPOSED TO THIS SUBSTANCE, THE EMPLOYER SHOULD PROVIDE AN EYE WASH TAIN WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

NZENE:
TECTIVE EYE EQUIPMENT SHOULD MEET THE REQUIREMENTS FOR PROTECTIVE CLOTHING EQUIPMENT IN 29 CFR 1910.1028(H).

AUTHORIZED - FISHER SCIENTIFIC GROUP, INC.
CREATION DATE: 10/11/84 REVISION DATE: 07/13/90

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ORMATION FOR THEIR PARTICULAR PURPOSES.

ETHYLBENZENE

ETB

Common Synonyms	Liquid	Colorless	Sweet, gasolinelike odor
Phenylethane EB	Floats on water. Flammable, irritating vapor is produced.		

Avoid contact with liquid and vapor. Keep people away.
Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves).
Shut off ignition sources and call fire department.
Stop discharge if possible.
Stay upwind and use water spray to "knock down" vapor.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

FLAMMABLE.
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.
Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves).
Extinguish with dry chemical, foam, or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to eyes, nose and throat.
If inhaled, will cause dizziness or difficult breathing.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
May burn skin and eyes.
Harmful if swallowed.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim give water or milk.
DO NOT INDUCE VOMITING.

Water Pollution

HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS.
Floating to shoreline.
May be dangerous if it enters water intakes.

Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)

Mechanical containment.
Should be removed.
Chemical and physical treatment.

2. LABEL

2.1 Category: Flammable liquid
2.2 Class: 3

3. CHEMICAL DESIGNATIONS

3.1 CG Compatibility Class: Aromatic hydrocarbon
3.2 Formula: $C_6H_5CH_2CH_3$
3.3 IMO/UN Designation: 3.3/1175
3.4 DOT ID No.: 1175
3.5 CAS Registry No.: 100-41-4

4. OBSERVABLE CHARACTERISTICS

4.1 Physical State (as shipped): Liquid
4.2 Color: Colorless
4.3 Odor: Aromatic

5. HEALTH HAZARDS

5.1 Personal Protective Equipment: Self-contained breathing apparatus, safety goggles.
5.2 Symptoms Following Exposure: Inhalation may cause irritation of nose, dizziness, depression. Severe irritation of eye with corneal injury possible. Irritates skin and may cause blisters.
5.3 Treatment of Exposure: INHALATION: if ill effects occur, remove victim to fresh air, keep him warm and quiet, and get medical help promptly. If breathing stops, give artificial respiration. INGESTION: induce vomiting only upon physician's approval; material in lung may cause chemical pneumonitis. SKIN AND EYES: promptly flush with plenty of water (15 min. for eyes) and get medical attention; remove and wash contaminated clothing before reuse.
5.4 Threshold Limit Value: 100 ppm
5.5 Short Term Inhalation Limits: 200 ppm for 30 min.
5.6 Toxicity by Ingestion: Grade 2; LD_{50} = 0.5 to 5 g/kg (rat)
5.7 Late Toxicity: Data not available
5.8 Vapor (Gas) Irritant Characteristics: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary.
5.9 Liquid or Solid Irritant Characteristics: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure.
5.10 Odor Threshold: 140 ppm
5.11 IDLH Value: 2,000 ppm

6. FIRE HAZARDS

6.1 Flash Point: 80°F O.C.; 59°F C.C.
6.2 Flammable Limits in Air: 1.0%-6.7%
6.3 Fire Extinguishing Agents: Foam (most effective), water fog, carbon dioxide or dry chemical.
6.4 Fire Extinguishing Agents Not to be Used: Not pertinent.
6.5 Special Hazards of Combustion Products: Irritating vapors are generated when heated.
6.6 Behavior in Fire: Vapor is heavier than air and may travel considerable distance to the source of ignition and flash back.
6.7 Ignition Temperature: 860°F
6.8 Electrical Hazard: Not pertinent.
6.9 Burning Rate: 5.8 mm/min.
6.10 Adiabatic Flame Temperature: Data Not Available.

(Continued)

7. CHEMICAL REACTIVITY

7.1 Reactivity With Water: No reaction
7.2 Reactivity with Common Materials: No reaction
7.3 Stability During Transport: Stable
7.4 Neutralizing Agents for Acids and Caustics: Not pertinent
7.5 Polymerization: Not pertinent
7.6 Inhibitor of Polymerization: Not pertinent
7.7 Molar Ratio (Reactant to Product): Data Not Available
7.8 Reactivity Group: 32

8. WATER POLLUTION

8.1 Aquatic Toxicity: 25 ppm/96 hr/bluegill/TL_m/fresh water
8.2 Waterfowl Toxicity: Data not available
8.3 Biological Oxygen Demand (BOD): 2.6% theor. 5 days
8.4 Food Chain Concentration Potential: None

9. SHIPPING INFORMATION

9.1 Grades of Purity: Research grade 99.96%, pure grade 99.5%, technical grade 99.0%
9.2 Storage Temperature: Ambient
9.3 Inert Atmosphere: No requirement
9.4 Venting: Open (flame arrester) or pressure-vacuum

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

A-T-U

11. HAZARD CLASSIFICATIONS

11.1 Code of Federal Regulations: Flammable liquid
11.2 NAS Hazard Rating for Bulk Water Transportation:

Category	Rating
Fire	3
Health	
Vapor Irritant	2
Liquid or Solid Irritant	2
Poisons	2
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	3
Aesthetic Effect	2
Reactivity	
Other Chemicals	1
Water	0
Self Reaction	0

11.3 NFPA Hazard Classification:

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	3
Reactivity (Yellow)	0

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 Physical State at 15°C and 1 atm: Liquid
12.2 Molecular Weight: 106.17
12.3 Boiling Point at 1 atm: 277.2°F = 136.2°C = 409.4°K
12.4 Freezing Point: −139°F = −95°C = 178°K
12.5 Critical Temperature: 651.0°F = 343.9°C = 617.1°K
12.6 Critical Pressure: 523 psia = 35.6 atm = 3.61 MN/m²
12.7 Specific Gravity: 0.867 at 20°C (liquid)
12.8 Liquid Surface Tension: 29.2 dynes/cm = 0.0292 N/m at 20°C
12.9 Liquid-Water Interfacial Tension: 35.48 dynes/cm = 0.03548 N/m at 20°C
12.10 Vapor (Gas) Specific Gravity: Not pertinent
12.11 Ratio of Specific Heats of Vapor (Gas): 1.071
12.12 Latent Heat of Vaporization: 144 Btu/lb = 80.1 cal/g = 3.35 × 10⁵ J/kg
12.13 Heat of Combustion: −17,780 Btu/lb = −9927 cal/g = −413.5 × 10⁵ J/kg
12.14 Heat of Decomposition: Not pertinent
12.15 Heat of Solution: Not pertinent
12.16 Heat of Polymerization: Not pertinent
12.25 Heat of Fusion: Data Not Available
12.26 Limiting Value: Data Not Available
12.27 Reid Vapor Pressure: 0.4 psia

6. FIRE HAZARDS (Continued)

6.11 Stoichiometric Air to Fuel Ratio: Data Not Available
6.12 Flame Temperature: Data Not Available

ETHYLBENZENE

12.17 SATURATED LIQUID DENSITY

Temperature (degrees F)	Pounds per cubic foot
40	54.990
50	54.680
60	54.370
70	54.060
80	53.750
90	53.430
100	53.120
110	52.810
120	52.500
130	52.190
140	51.870
150	51.560
160	51.250
170	50.940
180	50.620
190	50.310
200	50.000
210	49.690

12.18 LIQUID HEAT CAPACITY

Temperature (degrees F)	British thermal unit per pound-F
40	.402
50	.404
60	.407
70	.409
80	.412
90	.414
100	.417
110	.419
120	.421
130	.424
140	.426
150	.429
160	.431
170	.434
180	.436
190	.439
200	.441
210	.443

12.19 LIQUID THERMAL CONDUCTIVITY

Temperature (degrees F)	British thermal unit-inch per hour-square foot-F
—90	1.065
—80	1.056
—70	1.047
—60	1.037
—50	1.028
—40	1.018
—30	1.009
—20	1.000
—10	.990
0	.981
10	.971
20	.962
30	.953
40	.943
50	.934
60	.924
70	.915
80	.906
90	.896
100	.887
110	.877
120	.868
130	.859
140	.849
150	.840
160	.830

12.20 LIQUID VISCOSITY

Temperature (degrees F)	Centipoise
40	.835
50	.774
60	.719
70	.670
80	.626
90	.586
100	.550
110	.518
120	.488
130	.461
140	.436
150	.414
160	.393
170	.374
180	.356
190	.340
200	.325
210	.311

12.21 SOLUBILITY IN WATER

Temperature (degrees F)	Pounds per 100 pounds of water
68.02	.020

12.22 SATURATED VAPOR PRESSURE

Temperature (degrees F)	Pounds per square inch
80	.202
100	.370
120	.644
140	1.071
160	1.713
180	2.643
200	3.953
220	5.747
240	8.147
260	11.290
280	15.320
300	20.410
320	26.730
340	34.460
360	43.800
380	54.950

12.23 SATURATED VAPOR DENSITY

Temperature (degrees F)	Pounds per cubic foot
80	.00370
100	.00654
120	.01099
140	.01767
160	.02734
180	.04087
200	.05926
220	.08363
240	.11520
260	.15510
280	.20490
300	.26570
320	.33910
340	.42620
360	.52850
380	.64720

12.24 IDEAL GAS HEAT CAPACITY

Temperature (degrees F)	British thermal unit per pound-F
—400	—.007
—350	.026
—300	.060
—250	.093
—200	.125
—150	.157
—100	.187
—50	.217
0	.246
50	.274
100	.301
150	.327
200	.353
250	.377
300	.401
350	.424
400	.446
450	.467
500	.487
550	.507
600	.525

TOLUENE

TOL

Common Synonyms	Watery liquid	Colorless	Pleasant odor
Toluol Methylbenzene Methylbenzol	Floats on water. Flammable, irritating vapor is produced		

Stop discharge if possible. Keep people away.
Shut off ignition sources and call fire department.
Stay upwind and use water spray to "knock down" vapor.
Avoid contact with liquid and vapor.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

FLAMMABLE.
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.
Wear goggles and self-contained breathing apparatus.
Extinguish with dry chemical, foam, or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to eyes, nose and throat.
If inhaled, will cause nausea, vomiting, headache, dizziness, difficult breathing, or loss of consciousness.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing difficult, give oxygen.

LIQUID
Irritating to skin and eyes.
If swallowed, will cause nausea, vomiting or loss of consciousness.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.
DO NOT INDUCE VOMITING.

Water Pollution

Dangerous to aquatic life in high concentrations.
Floating to shoreline.
May be dangerous if it enters water intakes.

Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)

Issue warning-high flammability.
Evacuate area.

2. LABEL

2.1 Category: Flammable liquid
2.2 Class: 3

3. CHEMICAL DESIGNATIONS

3.1 CG Compatibility Class: Aromatic Hydrocarbon
3.2 Formula: $C_6H_5CH_3$
3.3 IMO/UN Designations: 3.2/1294
3.4 DOT ID No.: 1294
3.5 CAS Registry No.: 108-88-3

4. OBSERVABLE CHARACTERISTICS

4.1 Physical State (at ambient): Liquid
4.2 Color: Colorless
4.3 Odor: Pungent, aromatic, benzene-like, distinct, pleasant

5. HEALTH HAZARDS

5.1 Personal Protective Equipment: Air-supplied mask, goggles or face shield, plastic gloves.
5.2 Symptoms Following Exposure: Vapors irritate eyes and upper respiratory tract, cause dizziness, headache, drowsiness, respiratory arrest. Liquid irritates eyes and causes drying of skin. If aspirated, causes coughing, gagging, distress, and rapidly developing pulmonary edema. If ingested causes vomiting, griping, diarrhea, depressed respiration.
5.3 Treatment of Exposure: INHALATION: remove to fresh air, give artificial respiration and oxygen if needed; call a doctor. INGESTION: do NOT induce vomiting; call a doctor. EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water.
5.4 Threshold Limit Value: 100 ppm
5.5 Short Term Inhalation Limits: 600 ppm for 30 min.
5.6 Toxicity by Ingestion: Grade 2; LD_{50} = 0.5 to 5 g/kg
5.7 Late Toxicity: Kidney and liver damage may follow ingestion.
5.8 Vapor (Gas) Irritant Characteristics: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary.
5.9 Liquid or Solid Irritant Characteristics: Minimum hazard, if spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.
5.10 Odor Threshold: 0.17 ppm
5.11 IDLH Value: 2,000 ppm

6. FIRE HAZARDS

6.1 Flash Point: 40°F C.C.; 55°F O.C.
6.2 Flammable Limits in Air: 1.27%-7%
6.3 Fire Extinguishing Agents: Carbon dioxide or dry chemical for small fires, ordinary foam for large fires.
6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective.
6.5 Special Hazards of Combustion Products: Not pertinent
6.6 Behavior in Fire: Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back.
6.7 Ignition Temperature: 997°F
6.8 Electrical Hazard: Class I, Group D
6.9 Burning Rate: 5.7 mm/min.
6.10 Adiabatic Flame Temperature: Data not available

(Continued)

7. CHEMICAL REACTIVITY

7.1 Reactivity With Water: No reaction
7.2 Reactivity with Common Materials: No reaction
7.3 Stability During Transport: Stable
7.4 Neutralizing Agents for Acids and Caustics: Not pertinent
7.5 Polymerization: Not pertinent
7.6 Inhibitor of Polymerization: Not pertinent
7.7 Molar Ratio (Reactant to Product): Data not available
7.8 Reactivity Group: 32

8. WATER POLLUTION

8.1 Aquatic Toxicity: 1180 mg/l/96 hr/surface/TL_/fresh water
8.2 Waterfowl Toxicity: Data not available
8.3 Biological Oxygen Demand (BOD): 0%, 5 days, 38% (Theor), 8 days
8.4 Food Chain Concentration Potential: None

9. SHIPPING INFORMATION

9.1 Grades of Purity: Research, reagent, nitration-all 99.8 + %, industrial dry: ≥ 94 + %, with 5% xylene and small amounts of benzene and nonaromatic hydrocarbons; 90/120 less pure than industrial
9.2 Storage Temperature: Ambient
9.3 Inert Atmosphere: No requirement
9.4 Venting: Open (flame arrester) or pressure-vacuum

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

A-T-U

11. HAZARD CLASSIFICATIONS

11.1 Code of Federal Regulations: Flammable liquid
11.2 NAS Hazard Rating for Bulk Water Transportation:

Category	Rating
Fire	3
Health	
Vapor Irritant	1
Liquid or Solid Irritant	1
Poisons	2
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	3
Aesthetic Effect	2
Reactivity	
Other Chemicals	1
Water	0
Self Reaction	0

11.3 NFPA Hazard Classification:

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	3
Reactivity (Yellow)	0

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 Physical State at 15°C and 1 atm: Liquid
12.2 Molecular Weight: 92.14
12.3 Boiling Point at 1 atm: 231.1°F = 110.6°C = 383.8°K
12.4 Freezing Point: −139°F = −95.0°C = 178.2°K
12.5 Critical Temperature: 605.4°F = 318.6°C = 591.8°K
12.6 Critical Pressure: 595.1 psia = 40.55 atm = 4.108 MN/m²
12.7 Specific Gravity: 0.867 at 20°C (liquid)
12.8 Liquid Surface Tension: 29.0 dynes/cm = 0.0290 N/m at 20°C
12.9 Liquid Water Interfacial Tension: 36.1 dynes/cm = 0.0361 N/m at 25°C
12.10 Vapor (Gas) Specific Gravity: Not pertinent
12.11 Ratio of Specific Heats of Vapor (Gas): 1.099
12.12 Latent Heat of Vaporization: 155 Btu/lb = 86.1 cal/g = 3.61 × 10⁵ J/kg
12.13 Heat of Combustion: −17,430 Btu/lb = −9686 cal/g = −405.5 × 10⁵ J/kg
12.14 Heat of Decomposition: Not pertinent
12.15 Heat of Solution: Not pertinent
12.16 Heat of Polymerization: Not pertinent
12.25 Heat of Fusion: 17.17 cal/g
12.26 Limiting Value: Data not available
12.27 Reid Vapor Pressure: 1.1 psia

6. FIRE HAZARDS (Continued)

6.11 Stoichiometric Air to Fuel Ratio: Data not available
6.12 Flame Temperature: Data not available

TOL

TOLUENE

12.17 SATURATED LIQUID DENSITY

Temperature (degrees F)	Pounds per cubic foot
−30	57.180
−20	56.870
−10	56.550
0	56.240
10	55.930
20	55.620
30	55.310
40	54.990
50	54.680
60	54.370
70	54.060
80	53.750
90	53.430
100	53.120
110	52.810
120	52.500

12.18 LIQUID HEAT CAPACITY

Temperature (degrees F)	British thermal unit per pound-F
0	.396
5	.397
10	.399
15	.400
20	.402
25	.403
30	.404
35	.406
40	.407
45	.409
50	.410
55	.411
60	.413
65	.414
70	.415
75	.417
80	.418
85	.420
90	.421
95	.422
100	.424
105	.425
110	.427
115	.428
120	.429
125	.431

12.19 LIQUID THERMAL CONDUCTIVITY

Temperature (degrees F)	British thermal unit-inch per hour-square foot-F
0	1.026
10	1.015
20	1.005
30	.994
40	.983
50	.972
60	.962
70	.951
80	.940
90	.929
100	.919
110	.908
120	.897
130	.886
140	.876
150	.865
160	.854
170	.843
180	.833
190	.822
200	.811
210	.800

12.20 LIQUID VISCOSITY

Temperature (degrees F)	Centipoise
0	1.024
5	.978
10	.935
15	.894
20	.857
25	.821
30	.788
35	.757
40	.727
45	.700
50	.673
55	.649
60	.625
65	.603
70	.582
75	.562
80	.544
85	.526
90	.509
95	.493
100	.477

12.21 SOLUBILITY IN WATER

Temperature (degrees F)	Pounds per 100 pounds of water
68.02	.050

12.22 SATURATED VAPOR PRESSURE

Temperature (degrees F)	Pounds per square inch
0	.038
10	.057
20	.084
30	.121
40	.172
50	.241
60	.331
70	.449
80	.600
90	.792
100	1.033
110	1.332
120	1.700
130	2.148
140	2.690
150	3.338
160	4.109
170	5.018
180	6.083
190	7.323
200	8.758
210	10.410

12.23 SATURATED VAPOR DENSITY

Temperature (degrees F)	Pounds per cubic foot
0	.00070
10	.00103
20	.00150
30	.00212
40	.00295
50	.00405
60	.00547
70	.00727
80	.00954
90	.01237
100	.01584
110	.02007
120	.02518
130	.03127
140	.03850
150	.04700
160	.05691
170	.06840
180	.08162
190	.09675
200	.11400
210	.13340

12.24 IDEAL GAS HEAT CAPACITY

Temperature (degrees F)	British thermal unit per pound-F
0	.228
25	.241
50	.255
75	.268
100	.281
125	.294
150	.306
175	.319
200	.331
225	.343
250	.355
275	.367
300	.378
325	.389
350	.400
375	.411
400	.422
425	.432
450	.443
475	.453
500	.462
525	.472
550	.482
575	.491
600	.500

m-XYLENE

XLM

Common Synonyms	Watery liquid	Colorless	Sweet odor
1, 3-Dimethylbenzene Xylol	Floats on water. Flammable, irritating vapor is produced.		

Stop discharge if possible. Keep people away.
Call fire department.
Avoid contact with liquid and vapor.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

FLAMMABLE
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.
Wear self-contained breathing apparatus.
Extinguish with foam, dry chemical, or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to eyes, nose, and throat.
If inhaled, will cause headache, difficult breathing, or loss of consciousness.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Irritating to skin and eyes.
If swallowed, will cause nausea, vomiting, or loss of consciousness.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.
DO NOT INDUCE VOMITING.

Water Pollution

HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS.
Fouling to shoreline.
May be dangerous if it enters water intakes.

Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)

Have warning/high flammability
Evacuate area
Should be removed
Chemical and physical treatment

2. LABEL

2.1 Category: Flammable liquid
2.2 Class: 3

3. CHEMICAL DESIGNATIONS

3.1 CG Compatibility Class: Aromatic Hydrocarbon
3.2 Formula: $m\text{-}C_6H_4(CH_3)_2$
3.3 IMO/UN Designation: 3.2/1307
3.4 DOT ID No.: 1307
3.5 CAS Registry No.: 108-38-3

4. OBSERVABLE CHARACTERISTICS

4.1 Physical State (at ambient): Liquid
4.2 Color: Colorless
4.3 Odor: Like benzene, characteristic aromatic

5. HEALTH HAZARDS

5.1 Personal Protective Equipment: Approved canister or air-supplied mask, goggles or face shield, plastic gloves and boots.
5.2 Symptoms Following Exposure: Vapors cause headache and dizziness. Liquid irritates eyes and skin. If taken into lungs, causes severe coughing, distress, and rapidly developing pulmonary edema. If ingested, causes nausea, vomiting, cramps, headache, and coma; can be fatal. Kidney and liver damage can occur.
5.3 Treatment of Exposure: INHALATION: remove to fresh air, administer artificial respiration and oxygen if required; call a doctor. INGESTION: do NOT induce vomiting; call a doctor. EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water.
5.4 Threshold Limit Value: 100 ppm
5.5 Short Term Inhalation Limits: 300 ppm for 30 min.
5.6 Toxicity by Ingestion: Grade 3; LD_{50} = 50 to 500 g/kg
5.7 Late Toxicity: Kidney and liver damage.
5.8 Vapor (Gas) Irritant Characteristics: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary.
5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If soaked on clothing and allowed to remain, may cause smarting and reddening of the skin.
5.10 Odor Threshold: 0.05 ppm
5.11 IDLH Value: 10,000 ppm

6. FIRE HAZARDS

6.1 Flash Point: 84°F C.C.
6.2 Flammable Limits in Air: 1.1%-6.4%
6.3 Fire Extinguishing Agents: Foam, dry chemical, or carbon dioxide
6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective.
6.5 Special Hazards of Combustion Products: Not pertinent
6.6 Behavior in Fire: Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back.
6.7 Ignition Temperature: 986°F
6.8 Electrical Hazard: Class I, Group D
6.9 Burning Rate: 5.8 mm/min.
6.10 Adiabatic Flame Temperature: Data not available
6.11 Stoichiometric Air to Fuel Ratio: Data not available
6.12 Flame Temperature: Data not available

7. CHEMICAL REACTIVITY

7.1 Reactivity With Water: No reaction
7.2 Reactivity with Common Materials: No reaction
7.3 Stability During Transport: Stable
7.4 Neutralizing Agents for Acids and Caustics: Not pertinent
7.5 Polymerization: Not pertinent
7.6 Inhibitor of Polymerization: Not pertinent
7.7 Molar Ratio (Reactant to Product): Data not available
7.8 Reactivity Group: 32

8. WATER POLLUTION

8.1 Aquatic Toxicity: 22 ppm/96 hr/bluegill/TL$_m$/fresh water
8.2 Waterfowl Toxicity: Data not available
8.3 Biological Oxygen Demand (BOD): 0 lb/lb, 5 days, 0% (theor.), 0 Gals
8.4 Food Chain Concentration Potential: Data not available

9. SHIPPING INFORMATION

9.1 Grades of Purity: Research 99.99%, Pure 99.9%; Technical 99.2%
9.2 Storage Temperature: Ambient
9.3 Inert Atmosphere: No requirement
9.4 Venting: Open (flame arrester), or pressure-vacuum

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

F A-T-U

11. HAZARD CLASSIFICATIONS

11.1 Code of Federal Regulations: Flammable liquid
11.2 NAS Hazard Rating for Bulk Water Transportation:

Category	Rating
Fire	3
Health	
Vapor Irritant	1
Liquid or Solid Irritant	1
Poisons	2
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	3
Aesthetic Effect	2
Reactivity	
Other Chemicals	1
Water	0
Self Reaction	0

11.3 NFPA Hazard Classification:

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	3
Reactivity (Yellow)	0

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 Physical State at 15°C and 1 atm: Liquid
12.2 Molecular Weight: 106.16
12.3 Boiling Point at 1 atm: 282.4°F = 139.1°C = 412.1°K
12.4 Freezing Point: -54.2°F = -47.9°C = 225.2°K
12.5 Critical Temperature: 650.2°F = 343.8°C = 617.0°K
12.6 Critical Pressure: 513.8 atm = 34.96 gma = 3,540 kN/m^2
12.7 Specific Gravity: 0.864 at 20°C (liquid)
12.8 Liquid Surface Tension: 28.6 dynes/cm = 0.0286 N/m at 20°C
12.9 Liquid-Water Interfacial Tension: 36.0 dynes/cm = 0.036 N/m at 30°C
12.10 Vapor (Gas) Specific Gravity: Not pertinent
12.11 Ratio of Specific Heats of Vapor (Gas): 1.071
12.12 Latent Heat of Vaporization: 147 Btu/lb = 81.9 cal/g = 3.43 x 10^5 J/kg
12.13 Heat of Combustion: -17,554 Btu/lb = -9752.4 cal/g = -408.31 x 10^5 J/kg
12.14 Heat of Decomposition: Not pertinent
12.15 Heat of Solution: Not pertinent
12.16 Heat of Polymerization: Not pertinent
12.25 Heat of Fusion: 26.01 cal/g
12.26 Limiting Value: Data not available
12.27 Reid Vapor Pressure: 0.34 psia

NOTES

LM

m-XYLENE

12.17 SATURATED LIQUID DENSITY

Temperature (degrees F)	Pounds per cubic foot
15	55.400
20	55.260
25	55.130
30	54.990
35	54.850
40	54.710
45	54.570
50	54.430
55	54.290
60	54.160
65	54.020
70	53.880
75	53.740
80	53.600
85	53.460
90	53.320
95	53.180
100	53.050

12.18 LIQUID HEAT CAPACITY

Temperature (degrees F)	British thermal unit per pound-F
40	.387
50	.393
60	.398
70	.404
80	.410
90	.415
100	.421
110	.426
120	.432
130	.437
140	.443
150	.448
160	.454
170	.460
180	.465
190	.471
200	.476
210	.482

12.19 LIQUID THERMAL CONDUCTIVITY

Temperature (degrees F)	British thermal unit-inch per hour-square foot-F
35	.962
40	.953
45	.944
50	.935
55	.926
60	.917
65	.908
70	.899
75	.890
80	.881
85	.873
90	.864
95	.855
100	.846

12.20 LIQUID VISCOSITY

Temperature (degrees F)	Centipoise
15	.938
20	.898
25	.862
30	.827
35	.794
40	.764
45	.735
50	.708
55	.682
60	.658
65	.635
70	.613
75	.592
80	.572
85	.554

12.21 SOLUBILITY IN WATER

Temperature (degrees F)	Pounds per 100 pounds of water
	I
	N
	S
	O
	L
	U
	B
	L
	E

12.22 SATURATED VAPOR PRESSURE

Temperature (degrees F)	Pounds per square inch
60	.090
70	.127
80	.177
90	.242
100	.326
110	.434
120	.571
130	.743
140	.956
150	1.219
160	1.538
170	1.924
180	2.388
190	2.939
200	3.590
210	4.355
220	5.247
230	6.282
240	7.476
250	8.846
260	10.410

12.23 SATURATED VAPOR DENSITY

Temperature (degrees F)	Pounds per cubic foot
60	.00172
70	.00238
80	.00324
90	.00435
100	.00577
110	.00754
120	.00975
130	.01247
140	.01577
150	.01977
160	.02455
170	.03023
180	.03691
190	.04473
200	.05382
210	.06431
220	.07635
230	.09009
240	.10570
250	.12330
260	.14310

12.24 IDEAL GAS HEAT CAPACITY

Temperature (degrees F)	British thermal unit per pound-F
0	.247
25	.260
50	.273
75	.286
100	.299
125	.311
150	.324
175	.336
200	.348
225	.360
250	.371
275	.383
300	.394
325	.406
350	.417
375	.427
400	.438
425	.449
450	.459
475	.469
500	.479
525	.489
550	.499
575	.508
600	.517

****NAPHTHALENE****
****NAPHTHALENE****
****NAPHTHALENE****

MATERIAL SAFETY DATA SHEET

FISHER SCIENTIFIC
CHEMICAL DIVISION
1 REAGENT LANE
FAIR LAWN NJ 07410
(201) 796-7100

EMERGENCY CONTACTS
GASTON L. PILLORI
(201) 796-7100

DATE 09/04/87
PO NBR: 87-029956
ACCT: 695038-01
INDEX: 44872440131
CAT NO: N134500

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SUBSTANCE IDENTIFICATION

CAS-NUMBER 91-20-3

SUBSTANCE: **NAPHTHALENE**

TRADE NAMES/SYNONYMS:
NAPHTHALIN; TAR CAMPHOR; WHITE TAR; NAPHTHENE; MOTH BALLS; MOTH FLAKES; NAPHTHALINE; NAPHTHALEN; ALBOCARBON; CAMPHOR TAR; UN 1334; N-7; N-134; N-136; ACC16120

CHEMICAL FAMILY:
HYDROCARBON, POLYNUCLEAR

MOLECULAR FORMULA: C10-H8 MOL WT: 128

CERCLA RATINGS (SCALE 0-3): HEALTH=2 FIRE=2 REACTIVITY=0 PERSISTENCE=3
NFPA RATINGS (SCALE 0-4): HEALTH=2 FIRE=2 REACTIVITY=0

COMPONENTS AND CONTAMINANTS

COMPONENT: NAPHTHALENE PERCENT: 100

OTHER CONTAMINANTS: NONE

EXPOSURE LIMITS:
10 PPM (50 MG/M3) OSHA TWA
10 PPM ACGIH TWA; 15 PPM ACGIH STEL

PHYSICAL DATA

DESCRIPTION: WHITE CRYSTALLINE, VOLATILE FLAKES; ODOR OF MOTH BALLS. ODOR TAKEN WITH THE IRRITANT PROPERTIES IS A SATISFACTORY WARNING PROPERTY. BOILING POINT: 424 F (218 C)

MELTING POINT: 176 F (80 C) SPECIFIC GRAVITY: 1.1

VAPOR PRESSURE: 0.05 MMHG @ 20 C EVAPORATION RATE: (DU ACETATE=1) >1.0

SOLUBILITY IN WATER: .033 VAPOR DENSITY: 4.4

SOLVENT SOLUBILITY: ALCOHOL, BENZENE, CCL4, FIXED & VOLATILE OILS.

FIRE AND EXPLOSION DATA

FIRE AND EXPLOSION HAZARD:
MODERATE FIRE HAZARD WHEN EXPOSED TO HEAT OR FLAME, AND A MODERATE EXPLOSION HAZARD IN THE FORM OF DUST AT 176 F. REACTIONS WITH INCOMPATIBLE SUBSTANCES MAY CAUSE FIRES AND EXPLOSIONS. VAPOR FORMS EXPLOSIVE MIXTURES WITH AIR.

FLASH POINT: 174 F (79 C) UPPER EXPLOSIVE LIMIT: 5.9%

LOWER EXPLOSIVE LIMIT: 0.9% AUTOIGNITION TEMP.: 979 F (526 C)

FIREFIGHTING MEDIA:
DRY CHEMICAL, CARBON DIOXIDE, WATER SPRAY

FOR LARGER FIRES, USE WATER SPRAY, FOG OR ALCOHOL FOAM
(1984 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.3).

FIREFIGHTING:
WEAR PERSONAL PROTECTIVE EQUIPMENT (RESPIRATORY AND EYE). MOVE CONTAINER FROM FIRE AREA IF POSSIBLE. COOL CONTAINERS EXPOSED TO FLAME WITH WATER FROM SIDE UNTIL WELL AFTER FIRE IS OUT.

TOXICITY

100 MG/KG ORAL-CHILD LDLO; 1250 MG/KG ORAL-RAT LD50; 400 MG/KG ORAL-DOG LDLO; 533 MG/KG ORAL-MOUSE LD50; 150 MG/KG INTRAPERITONEAL-MOUSE LD50; 100 MG/KG INTRAVENOUS-MOUSE LD50; MUTATION DATA (RTECS); REPRODUCITVE EFFECTS DATA (RTECS); CARCINOGEN STATUS: NONE.

NAPHTHALENE IS A SKIN SENSITIZER AND A DEFICIENCY OF GLUCOSE-6-PHOSPHATE DEHYDROGENASE ARE MORE SUSCEPTIBLE TO THE HEMOLYTIC EFFECTS.

HEALTH EFFECTS AND FIRST AID

INHALATION:
HEMOLYTIC AGENT.
500 PPM IMMEDIATELY DANGEROUS TO LIFE OR HEALTH.

ACUTE EXPOSURE- CAUSES CENTRAL NERVOUS SYSTEM DEPRESSION, WITH HEADACHE, CONFUSION, EXCITEMENT, NAUSEA, VOMITING, SWEATING, DYSURIA, HEMATURIA, HEMOLYSIS AND CONVULSIONS. OPTIC NEURITIS IS RARE. PAROTID GLAND ENLARGEMENT IS POSSIBLE. HEPATIC NECROSIS MAY OCCUR. SEE ALSO INGESTION.

CHRONIC EXPOSURE- HEMOLYTIC EFFECTS IN SUSCEPTIBLE POPULATIONS (GLUCOSE-6-PHOSPHATE DEHYDROGENASE DEFICIENCY). SEE MUTAGENIC DATA, ANIMAL REPRODUCTIVE DATA AND ANIMAL TUMORIGENIC DATA REFERENCES IN TOXICITY SECTION.

FIRST AID- REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST.

NAPHTHALENE
GET MEDICAL ATTENTION IMMEDIATELY.

SKIN CONTACT:
IRRITANT/SENSITIZER.
ACUTE EXPOSURE- MAY CAUSE IRRITATION AND, IN SENSITIZED INDIVIDUALS, SEVERE DERMATITIS. POISONING MAY OCCUR BY SKIN ABSORPTION.

CHRONIC EXPOSURE- ITCHING, REDNESS, SCALING, WEEPING, AND CRUSTING OF THE SKIN. MAY PRODUCE SENSITIZATION DERMATITIS FOLLOWING REPEATED CONTACT. SEE MUTAGENIC DATA, ANIMAL REPRODUCTIVE EFFECTS DATA AND ANIMAL TUMORIGENIC DATA REFERENCES IN TOXICITY SECTION.

FIRST AID- REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

EYE CONTACT:
IRRITANT.
ACUTE EXPOSURE- 15 PPM OF VAPOR IS IRRITATING. VAPOR OR MIST MAY CAUSE SUPERFICIAL INJURY, CONJUNCTIVITIS, AND VISUAL DISTURBANCES.

CHRONIC EXPOSURE- WORKERS EXPOSED TO HIGH CONCENTRATIONS HAVE DEVELOPED CATARACTS.

FIRST AID- WASH EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES) GET MEDICAL ATTENTION IMMEDIATELY.

INGESTION:
HEMOLYTIC AGENT.
ACUTE EXPOSURE- INGESTION MAY CAUSE INTRAVASCULAR HEMOLYSIS. INITIAL SYMPTOMS MAY INCLUDE HEADACHE, CONFUSION, EXCITEMENT, MALAISE, PROFUSE SWEATING, NAUSEA, VOMITING, ABDOMINAL PAIN, AND IRRITATION OF THE BLADDER. THERE MAY BE PROGRESSIVE JAUNDICE, HEMATURIA, HEMOGLOBINURIA, RENAL TUBULAR BLOCKAGE, AND ACUTE RENAL SHUTDOWN.

FIRST AID- IF VICTIM IS CONSCIOUS AND NOT CONVULSIVE, IMMEDIATELY GIVE 2 TO 4 GLASSES OF WATER. INDUCE VOMITING BY TOUCHING FINGER TO BACK OF THROAT. GET MEDICAL ATTENTION IMMEDIATELY.

REACTIVITY

REACTIVITY:
STABLE AT ORDINARY PRESSURES UP TO THE BOILING POINT, 218 C.

INCOMPATIBILITIES:
OXIDIZERS AND OTHER MATERIALS, EXAMPLES FOLLOW:

NAPHTHALENE:
CHROMIC ANHYDRIDE: VIOLENT REACTION.
ALUMINUM TRICHLORIDE + BENZOYL CHLORIDE MIXTURE: VIOLENT REACTION.
STRONG OXIDIZERS: VIOLENT REACTION.
DINITROGEN PENTAOXIDE: POSSIBLE EXPLOSION.
PLASTICS: MELTED FORM WILL ATTACK.
RUBBER: MELTED FORM WILL ATTACK.

COATINGS: MELTED FORM WILL ATTACK.

DECOMPOSITION:
COMBUSTION PREDICTED TO CAUSE EMISSION OF CARBON MONOXIDE AND CARBON DIOXIDE AND POSSIBLY OTHER HAZARDOUS ORGANICS AS WELL AS SMOKE.

POLYMERIZATION:
WILL NOT OCCUR.

****
CONDITIONS TO AVOID

AVOID HEATING TO THE FLASH POINT, 79 C, UNLESS UNDER CAREFULLY ENGINEERED CONDITIONS. AVOID CONTACT WITH OR STORAGE WITH INCOMPATIBLE MATERIALS, INCLUDING THOSE LISTED IN THE REACTIVITY SECTION.

****
SPILL AND LEAK PROCEDURES

OCCUPATIONAL SPILL:
SHUT OFF IGNITION SOURCES. FOR SMALL SPILLS, WITH CLEAN SHOVEL, PLACE MATERIAL INTO CLEAN, DRY CONTAINER AND COVER; MOVE CONTAINERS FROM SPILL AREA. NO SMOKING, FLAMES OR FLARES IN HAZARD AREA. KEEP UNNECESSARY PEOPLE AWAY. ISOLATE HAZARD AREA AND DENY ENTRY. KEEP OUT OF SEWERS, WATERWAYS AND OTHER WATER SOURCES.

WHEN MATERIAL NOT INVOLVED IN FIRE:
KEEP OPEN FLAMES, SPARKS AND OTHER IGNITION SOURCES AWAY.
DO NOT ALLOW MATERIAL TO CONTAMINATE SEWERS AND WATER SOURCES.
BUILD DIKES FOR CONTAINMENT OF SPILL FLOW.

PROTECTIVE EQUIPMENT

VENTILATION:
PROVIDE LOCAL EXHAUST VENTILATION SYSTEM TO MEET PUBLISHED EXPOSURE LIMITS.

RESPIRATOR:
EXPOSURE LIMIT TO 100 PPM-
CHEMICAL CARTRIDGE RESPIRATOR WITH AN ORGANIC VAPOR CARTRIDGE WITH A FULL FACEPIECE AND A DUST FILTER.
TYPE C SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN A PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE OR WITH A FULL FACEPIECE, HELMET OR HOOD OPERATED IN CONTINUOUS FLOW MODE.
SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACEPIECE, OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

250 PPM-
GAS MASK WITH AN ORGANIC VAPOR CANISTER (CHIN-STYLE, FRONT- OR BACK-MOUNTED CANISTER) WITH A FULL FACEPIECE.
SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACEPIECE.

>250 PPM, INCLUDING THE IDLH LEVEL, 500 PPM
SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE, OR USE EQUIVALENT RESPIRATOR.

CLOTHING:
PROTECTIVE CLOTHING NOT REQUIRED. AVOID REPEATED OR PROLONGED CONTACT WITH THIS SUBSTANCE.

GLOVES:
EMPLOYEE MUST WEAR APPROPRIATE PROTECTIVE GLOVES TO PREVENT REPEATED OR PROLONGED CONTACT WITH THIS SUBSTANCE. PREFERRED MATERIALS: PVA AND VITON PLASTICS.

EYE PROTECTION:
EMPLOYEE MUST WEAR SPLASH-PROOF SAFETY GOGGLES WHENEVER THERE IS REASONABLE PROBABILITY OF EYE CONTACT WITH THIS SOLUTION. DO NOT WEAR CONTACT LENSES WHEN WORKING WITH CHEMICALS.

WHEN THERE IS ANY POSSIBILITY THAT AN EMPLOYEE'S EYES MAY BE EXPOSED TO THIS SUBSTANCE, THE EMPLOYER SHALL PROVIDE AN EYE-WASH FOUNTAIN WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

AUTHORIZED - FISHER SCIENTIFIC GROUP, INC.
CREATION DATE: 01/11/85 REVISION DATE: 10/15/86

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MILPORT CHEMICAL COMPANY
2829 South 5th Court
Milwaukee, Wisconsin 53207

MATERIAL SAFETY DATA SHEET

Phone 414-769-1556
Emergency Phone: CHEMTREC 1-800-424-9300

SECTION 1 - IDENTITY

COMMON NAME: BIO TREATMENT NUTRIENTS #36 DATE: 3/26/92
CHEMICAL NAME: Mixture CAS NO: None assigned
CHEMICAL FAMILY: Mixture FORMULA: Proprietary

SECTION 2 - HAZARDOUS COMPONENTS

1. Urea CAS#: 57-13-6
PEL: NE TLV: NE WGT%: 67.7%
2. Diammonium Phosphate CAS#: 7783-28-0
PEL: NE TLV: NE WGT%: 33.3%

NE = NONE ESTABLISHED

These items may require reporting under Title III, Section 313(40CFR 372):

SECTION 3 PHYSICAL DATA

BOILING POINT: Not applicable SPECIFIC GRAVITY: Not established VAPOR PRESSURE: Not applicable
EVAPORATION RATE: Not applicable
SOLUBILITY IN WATER: Complete.
APPEARANCE AND ODOR: White or off white solids with slight odor

SECTION 4 - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT: Not applicable FLAMMABLE LIMITS: Not applicable EXTINGUISHING MEDIA: Water spray. CO2, dry chemical or foam
SPECIAL FIRE FIGHTING PROCEDURES: Wear self contained

breathing apparatus and full personal protective clothing to prevent any skin or eye contact with this material.
UNUSUAL FIRE AND EXPLOSION HAZARDS: Under fire conditions this material may give off oxides of carbon and nitrogen. If any aqeous solution exposed to extreme heat could potentially give off extremely toxic hydrogen cyanide gas.

SECTION 5 - REACTIVITY DATA

STABILITY: Stable CONDITIONS TO AVOID: Extreme heat
INCOMPATABILITY(Materials to Avoid): Acids, nitrates, chlorine, hypochlorites, oxidizers and heat.
HAZARDOUS DECOMPOSITION PRODUCTS: Ammonia
HAZARDOUS POLYMERIZATION: Will not occur
CONDITIONS TO AVOID: Extreme heat

SECTION 6 - HEALTH HAZARDS

EFFECTS OF OVEREXPOSURE
(1) ACUTE: Irritant, slightly toxic may cause nausea, vomiting or diahrea if ingested.
(2) CHRONIC: None known
CARCINOGENICY: None known
OSHA PEL: None established ACGIH TLV: None established

SECTION 7 - EMERGENCY AND FIRST AID PROCEDURES

EXPOSURE
INHALATION: Remove victim to fresh air, if unconscious give artificial respiration. Consult a physician.
INJESTION: If conscious, give victim water. Immediately consult a physician.
EYES: Flush eyes with water for at least fifteen minutes. Consult a physician
SKIN: Flush effected area with water, remove contaminated clothing. If redness persists consult a physician.
SPILLS: If necessary, contain spill with diking agent. Transfer contained and spilled material to a chemically compatible container for reuse or disposal.
WASTE DISPOSAL METHODS: Dispose of according to all local state and federal regulations.

SECTION 8 - SAFE USAGE DATA

RESPIRATORY PROTECTION: NIOSH or MSHA approved respirator when dust, mists or vapors present.
VENTILATION: General
PROTECTIVE GLOVES: Impervious EYE PROTECTION: Goggles or face shield
OTHER PROTECTIVE EQUIPMENT: Rubber apron and boots. Eyewash available in area
STORAGE AND HANDLING: Store in a cool dry place away from incompatible materials.
OTHER PRECAUTIONS: None known

The information contained herein is offered only as a guide to the handling of this specific material and has been prepared in good faith by technically knowledgeable personnel. It is not intended to be all-inclusive and the manner and conditions of use and handling may involve other and additional considerations. No warranty of any kind is given or implied and Milport Chemical will not be liable for any damages, losses, injuries or consequential damages which may result from the use or reliance on any information contained herein.

MATERIAL SAFETY DATA SHEET

DATE January, 1992

PRODUCT NAME MRX-P ACTIVATED CARBON

CALGON CARBON CORPORATION

SECTION I

MANUFACTURER'S NAME	Calgon Carbon Corporation	EMERGENCY TELEPHONE NO.	412-787-6700
ADDRESS	P.O. Box 717 Pittsburgh, PA 15230-0717		
CHEMICAL NAME AND SYNONYMS	Carbon	FORMULA	C

SECTION II HAZARDOUS INGREDIENTS

PRINCIPAL HAZARDOUS COMPONENT (S)	CAS #	% BY WEIGHT	ORAL LD_{50}	DERMAL LD_{50}	TLV (Units) ACGIH	OSHA	OTHE
Chemical Name: Carbon Common Name: Activated Carbon	7440-44-0	100%	>10g/Kg* (rat)	--	N/A	N/A	N/A
Chemical Name: Common Name:							
Chemical Name: Common Name:							
Chemical Name: Common Name:							
Chemical Name: Common Name:							

*No animal mortalities during course of 14-day study.

CAUTION!! Wet activated carbon removes oxygen from air causing a severe hazard to worker inside carbon vessels and enclosed or confined spaces. Before entering such an area, sampling and work procedures for low oxygen levels should be taken to ensure ample oxygen availability, observing all local, state, and federal regulations.

This product is non-hazardous according to the definitions for "health hazard" and "physical hazard" provided in the OSHA Hazard Communication Law (29 CFR part 1910).

SECTION III PHYSICAL DATA

BOILING POINT (° F)	N/A	SPECIFIC GRAVITY (H_2O=1)	2.3g/cc real densi
VAPOR PRESSURE (mmHg.)	N/A	PERCENT VOLATILE BY VOLUME (%)	N/A
VAPOR DENSITY (AIR=1)	N/A	pH	N/A
SOLUBILITY IN WATER	insoluble	OTHER packing density	0.4 to 0.7g/cc

APPEARANCE AND ODOR black particulate solid

While this information and recommendations set forth herein are believed to be accurate as of the date hereof, CALGON CARBON CORPORATION MAKES NO WARRANTY

SECTION IV FIRE AND EXPLOSION HAZARD DATA

H POINT (Method Used)	N/A
NGUISHING MEDIA	If involved in fire, flood with plenty of water.
ECIAL FIRE FIGHTING ROCEDURES	None
UNUSUAL FIRE AND LOSION HAZARDS	Contact with strong oxidizers such as ozone, liquid oxygen, chlorine, permanganate, etc. may result in fire.

SECTION V HEALTH HAZARD DATA

EFFECT OF OVEREXPOSURE

A. ACUTE

1. INGESTION

The product is non-toxic through ingestion. The acute oral LD_{50} (rat) is >10g/Kg.

2. INHALATION

The acute inhalation LC_{50} (rat) is >64.4 mg/ℓ (nominal concentration) for activated carbon.

3. DERMAL EXPOSURE

a. TOXIC

Non-toxic

b. IRRITATION

The product is not a primary skin irritant. The primary skin irritation index (rabbit) is 0.

c. SENSITIZATION

None

4. EYE IRRITATION

The physical nature of the product may produce eye irritation.

B. SUBCHRONIC, CHRONIC, OTHER

The effects of long-term, low-level exposures to this product have not been determined. Safe handling of this material on a long-term basis should emphasize the avoidance of all effects from repetitive acute exposures.

FIRST AID

A. EYE

Flush with plenty of water for at least 15 minutes.

B. SKIN

Wash with soap and water.

C. INGESTION

D. INHALATION

SECTION VI REACTIVITY DATA

LITY	STABLE	X	CONDITIONS TO AVOID: None
	UNSTABLE		

ATABILITY
. to Avoid)

Strong oxidizers such as ozone, liquid oxygen, chlorine, permanganate, etc.

OUS DECOMPOSITION
TS

Carbon monoxide may be generated in the event of fire.

SECTION VII SPILL OR LEAK PROCEDURES

RTABLE QUANTITIES (RQ)
BS OF EPA HAZARDOUS
ANCES IN PRODUCT

1. N/A
2.
3.

NOTIFY EPA OF PRODUCT SPILLS EQUAL TO OR EXCEEDING N/A LBS.

TO BE TAKEN IN CASE
RIAL IS RELEASED
ILLED

Sweep up unused carbon and discard in refuse container or repackage.

E DISPOSAL METHOD

Dispose of unused carbon in refuse container. Dispose of in accordance with local, state, and federal regulations.

SECTION VIII HANDLING & STORAGE

TECTIVE GLOVES	EYE PROTECTION
Rubber gloves recommended	Safety glasses or goggles recommended

ER PROTECTIVE
THING: Not required

ESPIRATORY PROTECTION: A NIOSH approved particulate filter respirator is recommended if excessive dust is generated.

ENTILATION	LOCAL EXHAUST	OTHER
	Recommended	
	MECHANICAL (General) Recommended	

ORAGE & HANDLING

CAUTION!! Wet activated carbon removes oxygen from air causing a severe hazard to workers inside carbon vessels and enclosed or confined spaces. Before entering such an area, sampling and work procedures for low oxygen levels should be taken to ensure ample oxygen availability, observing all local, state, and federal regulations.

ER PRECAUTIONS

Wash thoroughly after handling. Exercise caution in the storage and handling of all chemical substances.

CALGON CARBON CORPORATION
P.O. BOX 717 • PITTSBURGH, PA 15230-0717

TYPE MRX-P 10 X 30 GRANULAR ACTIVATED CARBON

SPECIFICATIONS

Butane Capacity, minimum	210 mg/g
Ash, maximum	15%
Abrasion No., minimum	75
Screen Analysis -	
+10 mesh, maximum	1%
-30 mesh, maximum	2%

Physical properties of Calgon Carbon Type MRX-P are as follows:

Total Surface Area - (N_2 BET Method), m^2/g	900
Apparent Density, g/cc	0.50
Real Density, g/cc	2.1
Particle Density, g/cc	0.76
Total Pore Volume, cc/g	0.84
pH	7.2

COMMERCIAL INFORMATION

Shipping Point:	Catlettsburg, Kentucky
Packaging:	Type MRX-P is packaged in four-ply kraft bags, 55 lbs. net weight, 56 lbs. gross weight. Also available in bulk and 74 cubic foot tote bins.