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DVORSCAK  
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DOE/PC/90177-T19-App.

**EVALUATION, ENGINEERING AND DEVELOPMENT  
OF ADVANCED CYCLONE PROCESSES**

DE-AC 22-90PC 90177

**FINAL SEPARATING MEDIA EVALUATION AND TEST REPORT**

(FSMER)

**APPENDICES**

- Appendix A      Material Safety Data
- Appendix B      Aqueous Medium Regeneration Report
- Appendix C      pH Control Strategy
- Appendix D      MEM Notes and Data

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# Appendix A

CALCIUM NITRATE GRAN

EFFECTIVE DATE: 02-22-90

CC: Ted Durney

SHTP TO:

59289380  
 COAL TECHNOLOGY CORP  
 AIRPORT INDL PARK  
 108 THOMAS RD  
 BRISTOL VA 24201

ORDER NO: 592500156  
 PROD NO: 04094356

VAN WATERS & ROGERS INC., SUBSIDIARY OF UNIVAR  
 1600 NORTON BLDG. SEATTLE, WA 98104-1564 (408) 435-8700

## -----EMERGENCY ASSISTANCE-----

FOR EMERGENCY ASSISTANCE INVOLVING CHEMICALS CALL CHEMTREC (800)424-9300

## -----FOR PRODUCT AND SALES INFORMATION-----

CONTACT YOUR LOCAL VAN WATERS &amp; ROGERS BRANCH OFFICE

## -----PRODUCT IDENTIFICATION-----

PRODUCT NAME: CALCIUM NITRATE  
 COMMON NAMES/SYNONYMS: CALCIUM  
 NITRATE

CAS NO.: 10124-37-5  
 VW&R CODE: T1596

FORMULA: CA N2 O6 . H2 O  
 HAZARD RATING (NFPA 704)  
 HEALTH: 1  
 FIRE: 0  
 REACTIVITY: 0  
 SPECIAL: OXY

DATE ISSUED: 08/89  
 SUPERCEDES: 02/86  
 HAZARD RATING SCALE:  
 0=MINIMAL 3=SERIOUS  
 1=SLIGHT 4=SEVERE  
 2=MODERATE

## -----HAZARDOUS INGREDIENTS-----

COMPONENT	Z	EXPOSURE LIMITS, PPM			HAZARD
		OSHA PEL	ACGIH TLV	OTHER LIMIT	
CALCIUM NITRATE	90-100	NONE	NONE	NONE	OXIDIZER

## -----PHYSICAL PROPERTIES-----

BOILING POINT, DEG F: N/A VAPOR PRESSURE, MM HG/20 DEG C: N/A  
 MELTING POINT, DEG F: 168 VAPOR DENSITY (AIR=1): N/A  
 SPECIFIC GRAVITY (WATER=1): 1.82 WATER SOLUBILITY, %: 100  
 APPEARANCE AND ODOR: WHITE CRYSTALS; ODORLESS  
 EVAPORATION RATE (BUTYL ACETATE=1): N/A

## -----FIRST AID MEASURES-----

IF INHALED: REMOVE TO FRESH AIR. GIVE ARTIFICIAL RESPIRATION IF NOT BREATHING. GET IMMEDIATE MEDICAL ATTENTION.

IN CASE OF EYE CONTACT: IMMEDIATELY FLUSH EYES WITH LOTS OF RUNNING WATER FOR 15 MINUTES, LIFTING THE UPPER AND LOWER EYELIDS OCCASIONALLY. GET IMMEDIATE MEDICAL ATTENTION.

IN CASE OF SKIN CONTACT: IMMEDIATELY WASH SKIN WITH LOTS OF SOAP AND WATER. REMOVE CONTAMINATED CLOTHING AND SHOES; WASH BEFORE REUSE. GET MEDICAL ATTENTION IF IRRITATION PERSISTS AFTER WASHING.

CALCIUM NITRATE GRAN

EFFECTIVE DATE: 02-22-90

IF SWALLOWED: IF CONSCIOUS, IMMEDIATELY INDUCE VOMITING BY GIVING 2 GLASSES OF WATER AND STICKING A FINGER DOWN THE THROAT. GET IMMEDIATE MEDICAL ATTENTION. DO NOT GIVE ANYTHING TO AN UNCONSCIOUS OR CONVULSING PERSON.

## -----HEALTH HAZARD INFORMATION-----

PRIMARY ROUTES OF EXPOSURE: SKIN OR EYE CONTACT

SIGNS AND SYMPTOMS OF EXPOSURE

INHALATION: BREATHING DUST MAY IRRITATE THE NOSE AND THROAT AND CAUSE COUGHING AND CHEST DISCOMFORT.

EYE CONTACT: DUSTS MAY IRRITATE THE EYES.

SKIN CONTACT: PROLONGED OR REPEATED CONTACT WITH THE DUST MAY IRRITATE THE SKIN.

SWALLOWED: SINGLE DOSE ORAL TOXICITY IS LOW TO MODERATE.

CHRONIC EFFECTS OF EXPOSURE: NO SPECIFIC INFORMATION AVAILABLE.

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE: NONE KNOWN.

## -----TOXICITY DATA-----

ORAL: RAT LD50 = 3.7 G/KG

DERMAL: RABBIT 500 MG / 24 H: MODERATE IRRITATION

INHALATION: NO DATA FOUND

CARCINOGENICITY: THIS MATERIAL IS NOT CONSIDERED TO BE A CARCINOGEN BY THE NATIONAL TOXICOLOGY PROGRAM, THE INTERNATIONAL AGENCY FOR RESEARCH ON CANCER, OR THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

OTHER DATA: NONE

## -----PERSONAL PROTECTION-----

VENTILATION: LOCAL MECHANICAL EXHAUST VENTILATION CAPABLE OF MINIMIZING DUST EMISSIONS AT THE POINT OF USE.

RESPIRATORY PROTECTION: NIOSH-APPROVED DUST RESPIRATOR OR MASK IN THE ABSENCE OF ADEQUATE ENVIRONMENTAL CONTROLS AT THE POINT OF USE.

EYE PROTECTION: CHEMICAL GOGGLES.

PROTECTIVE CLOTHING: LONG-SLEEVED SHIRT, TROUSERS, SAFETY SHOES, AND GLOVES.

OTHER PROTECTIVE MEASURES: AN EYEWASH AND SAFETY SHOWER SHOULD BE NEARBY AND READY FOR USE.

## -----FIRE AND EXPLOSION INFORMATION-----

FLASH POINT, DEG F: N/A

FLAMMABLE LIMITS IN AIR, %

METHOD USED: N/A

LOWER: N/A UPPER: N/A

EXTINGUISHING MEDIA: USE WATER SPRAY.

SPECIAL FIRE FIGHTING PROCEDURES: FIRE FIGHTERS SHOULD WEAR SELF-CONTAINED BREATHING APPARATUS. USE WATER SPRAY TO COOL NEARBY CONTAINERS AND STRUCTURES EXPOSED TO FIRE.

UNUSUAL FIRE AND EXPLOSION HAZARDS: STRONG OXIDIZER. CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE.

## -----HAZARDOUS REACTIVITY-----

STABILITY: STABLE

POLYMERIZATION: WILL NOT OCCUR

CONDITIONS TO AVOID: NONE

CALCIUM NITRATE GRAN

EFFECTIVE DATE:02-22-90

MATERIALS TO AVOID: REDUCING AGENTS, COMBUSTIBLE MATERIALS SUCH AS WOOD, CLOTH, OR ORGANIC MATERIALS, METALS SUCH AS IRON AND COPPER AND THEIR ALLOYS, AND ANY OTHER EASILY OXIDIZABLE MATERIALS.

HAZARDOUS DECOMPOSITION PRODUCTS: WILL LIBERATE TOXIC FUMES OF OXIDES OF NITROGEN.

-----SPILL, LEAK, AND DISPOSAL PROCEDURES-----

ACTION TO TAKE FOR SPILLS OR LEAKS: WEAR PROTECTIVE EQUIPMENT INCLUDING RUBBER BOOTS, RUBBER GLOVES, RUBBER APRON, AND CHEMICAL GOGGLES. KEEP COMBUSTIBLES (WOOD, PAPER, OIL, ETC.) AWAY FROM SPILL. FOR SMALL SPILLS, SWEEP UP AND DISPOSE OF IN DOT-APPROVED WASTE CONTAINERS. FOR LARGE SPILLS, SHOVEL INTO DOT-APPROVED WASTE CONTAINERS. COMPLY WITH ALL APPLICABLE GOVERNMENTAL REGULATIONS ON SPILL REPORTING, AND HANDLING AND DISPOSAL OF WASTE.

DISPOSAL METHODS: DISPOSE OF CONTAMINATED PRODUCT AND MATERIALS USED IN CLEANING UP SPILLS OR LEAKS IN A MANNER APPROVED FOR THIS MATERIAL. CONSULT APPROPRIATE FEDERAL, STATE AND LOCAL REGULATORY AGENCIES TO ASCERTAIN PROPER DISPOSAL PROCEDURES.

NOTE: EMPTY CONTAINERS CAN HAVE RESIDUES, GASES AND MISTS AND ARE SUBJECT TO PROPER WASTE DISPOSAL, AS ABOVE.

-----SPECIAL PRECAUTIONS-----

STORAGE AND HANDLING PRECAUTIONS: STORE IN A COOL, DRY PLACE. STORE AWAY FROM ALL OTHER CHEMICALS AND POTENTIAL SOURCES OF CONTAMINATION. KEEP CONTAINER TIGHTLY CLOSED WHEN NOT IN USE. DO NOT USE PRESSURE TO EMPTY CONTAINER. WASH THOROUGHLY AFTER HANDLING. DO NOT GET IN EYES, ON SKIN, OR ON CLOTHING.

REPAIR AND MAINTENANCE PRECAUTIONS: NONE.

OTHER PRECAUTIONS: CONTAINERS, EVEN THOSE THAT HAVE BEEN EMPTIED, WILL RETAIN PRODUCT RESIDUE AND VAPORS. ALWAYS OBEY HAZARD WARNINGS AND HANDLE EMPTY CONTAINERS AS IF THEY WERE FULL.

-----FOR ADDITIONAL INFORMATION-----

CONTACT MSDS COORDINATOR, VAN WATERS & ROGERS INC.  
DURING BUSINESS HOURS, PACIFIC TIME (408)435-8700

-----NOTICE-----

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-----REVISION-----

02/86: REVISED FIRST AID MEASURES.

08/89: CHANGED HEADING AND CONTACT INFORMATION.

\*\*\*\* E N D O F M S D S \*\*\*\*

PROD: 04094356 12:03:35 20 MAR 1991 CUST: 59289380 INVOICE: 592500156

# Vulcan CHEMICALS

## MATERIAL SAFETY DATA SHEET

24 Hour Emergency Phone (316) 524-5751

✕ Division of Vulcan Materials Company / P.O. Box 7689 • Birmingham, AL 35253-0689

### I - IDENTIFICATION

CHEMICAL NAME Dichloromethane	CHEMICAL FORMULA CH <sub>2</sub> Cl <sub>2</sub>	MOLECULAR WEIGHT 84.94
TRADE NAME Methylene Chloride, Technical Grade and Decaffeination Grade		
SYNONYMS Methylene Chloride		DOT IDENTIFICATION NO. UN 1593

### II - PRODUCT AND COMPONENT DATA

COMPONENT(S) CHEMICAL NAME	CAS REGISTRY NO.	% (Approx)	ACGIH TLV-TWA
Dichloromethane	75-09-2	100	100 ppm

### III - PHYSICAL DATA

APPEARANCE AND ODOR Clear, colorless liquid; mildly sweet odor	SPECIFIC GRAVITY 1.32 @ 25/25°C
BOILING POINT 40.1°C. (104°F.)	VAPOR DENSITY IN AIR (Air = 1) 2.9
VAPOR PRESSURE 350 mm Hg @ 20°C	% VOLATILE, BY VOLUME 100
EVAPORATION RATE (ether = 1): 0.7	SOLUBILITY IN WATER 1.32 gm/100 gm @ 25°C

### IV - REACTIVITY DATA

STABILITY Stable	CONDITIONS TO AVOID Avoid contact with open flame, electric arcs, or other hot surfaces which can cause thermal decomposition.
INCOMPATIBILITY (Materials to avoid) Strong alkalis, oxygen, nitrogen peroxide, sodium, potassium, and other oxidizers and reactive metals.	
HAZARDOUS DECOMPOSITION PRODUCTS Hydrogen chloride, phosgene, chlorine.	
HAZARDOUS POLYMERIZATION Will not occur.	

## V - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used)

None (TOC)

FLAMMABLE LIMITS IN AIR

12 - 19% (Vol.) @ 100°C

EXTINGUISHING AGENTS

Water fog, dry chemical, foam, carbon dioxide

UNUSUAL FIRE AND EXPLOSION HAZARDS

Concentrated vapors can be ignited by high intensity ignition source.

Firefighters should wear self-contained positive pressure breathing apparatus due to thermal decomposition products, and avoid skin contact.

## VI - TOXICITY AND FIRST AID

EXPOSURE LIMITS (When exposure to this product and other chemicals is concurrent, the TLV must be defined in the workplace.)

ACGIH: 100 ppm TWA (8 hr)  
500 ppm STEL

OSHA: 500 ppm TWA (8 hr) 1,000 ppm Ceiling (for peak value  
concentration refer to 29 CFR 1910.1000 Table Z-2)

(Odor threshold approximately 200-300 ppm; causes olfactory fatigue)

Consumption of alcoholic beverages may increase the potential for development of toxic effects resulting from exposure to this product.

Effects described in this section are believed not to occur if exposures are maintained at or below appropriate TLVs.

Because of the wide variation in individual susceptibility, TLVs may not be applicable to all persons and those with medical conditions listed below.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE

Alcoholism, acute and chronic liver and kidney disease, chronic lung disease, anemia, coronary disease or rhythm disorders of the heart.

ACUTE TOXICITY

Primary route(s) of exposure:

Inhalation

Skin Absorption

Ingestion

Inhalation: Major route of potential exposure. Methylene chloride depresses the central nervous system. Concentrations between 900-1,000 ppm may cause dizziness. Nausea, headache, and vomiting can occur at concentrations above 2,000 ppm. At 7,000 ppm, numbness and tingling in arms and legs and rapid heartbeat have occurred. Loss of consciousness and death have occurred at levels above 9,000 ppm, if exposure is prolonged.

Carboxyhemoglobin levels can be elevated in persons exposed to methylene chloride and can cause a substantial stress on the cardiovascular system. This elevation can be additive to the increase caused by smoking and other carbon monoxide sources.

Skin: Liquid methylene chloride is painful and irritating if confined to skin by gloves, clothing, etc. Prolonged or repeated contact may cause irritation, defatting of skin, and dermatitis. Absorption of liquid through intact skin is possible if contact with liquid is prolonged.

Eyes: Liquid may cause temporary irritation with temporary corneal injury. Vapors may irritate eyes.

Ingestion: Single dose toxicity low to moderate. If vomiting occurs, methylene chloride can be aspirated into lungs, which can cause chemical pneumonia and systemic effects.

FIRST AID

Inhalation: Remove to fresh air. If breathing has stopped, administer artificial respiration. Call a physician.

Skin: Remove contaminated clothing and shoes. Wash exposed area thoroughly with large quantities of water, for at least 15 minutes. Wash contaminated clothing before reuse.

Eyes: Flush eyes immediately with water for at least 15 minutes. If irritation persists, call a physician.

Ingestion: Do not induce vomiting. Contact physician or emergency medical facility immediately.

NOTE TO PHYSICIAN: Adrenalin should never be given to person overexposed to methylene chloride.

## CHRONIC TOXICITY

The finding of chronic toxic effects in laboratory animals may indicate toxicity to humans. Overexposure should be avoided, failure to do so could result in injury, illness or even death.

Chronic overexposures to methylene chloride have caused liver and kidney toxic effects in experimental animals.

**Carcinogenicity:** Methylene chloride has been evaluated for possible cancer causing effects in laboratory animals. Inhalation studies at concentrations of 2,000, and 4,000 ppm increased the incidence of malignant liver and lung tumors in mice. Three inhalation studies of rats have shown increased incidence of benign mammary gland tumors in female rats at concentrations of 500 ppm and above and increases in benign mammary gland tumors in males at concentrations of 1,500 ppm and above. Rats exposed to 50 and 200 ppm via inhalation showed no increased incidence of tumors. Mice and rats exposed by ingestion at levels up to 250 mg/kg/day lifetime and hamsters exposed via inhalation to concentrations up to 3,500 ppm lifetime did not show an increased incidence of tumors.

The International Agency for Research on Cancer (IARC) has concluded that there is sufficient evidence for the carcinogenicity of methylene chloride to experimental animals, and inadequate evidence for the carcinogenicity of methylene chloride to humans, resulting in a classification as a 2B animal carcinogen on the IARC list. The NTP has identified methylene chloride as an animal carcinogen, but it is not on the OSHA or NTP Lists as of February 28, 1988.

Epidemiology studies of 751 humans chronically exposed to methylene chloride in the workplace of which 252 were exposed for a minimum of 20 years did not demonstrate any increase in deaths caused by cancer or cardiac problems. A second study of 2,227 workers confirmed these results.

**Reproductive Toxicity:** Reproductive toxicity tests have been conducted to evaluate the adverse effects methylene chloride may have on reproduction and offspring of laboratory animals. The results indicate that methylene chloride does not cause birth defects in laboratory animals.

## VII - PERSONAL PROTECTION AND CONTROLS

### RESPIRATORY PROTECTION

Where vapor concentration exceeds or is likely to exceed 100 ppm, an approved full face respirator with organic vapor canister is acceptable. Approved self-contained breathing apparatus or air line respirator, with full facepiece, is required for vapor concentrations above 1,000 ppm and for spills and/or emergencies. Follow any applicable respirator use standards and regulations.

### VENTILATION

Do not use in closed or confined space. Open doors and/or windows. Use ventilation to maintain exposure levels below 100 ppm (TWA).

### SKIN PROTECTION

Wear solvent-resistant gloves such as Viton, polyvinyl alcohol, or equivalent. Solvent-resistant boots, apron, headgear and/or faceshield should be worn where splashing is possible.

### EYE PROTECTION

Wear safety glasses. Contact lenses should not be worn. Chemical goggles and/or face shields should be worn where splashing is possible.

### HYGIENE

Avoid contact with skin and avoid breathing vapors. Do not eat, drink, or smoke in work area. Wash hands prior to eating, drinking, or using restroom. Any clothing or shoes which become contaminated with methylene chloride should be removed immediately and thoroughly laundered before wearing again.

### OTHER CONTROL MEASURES

To determine exposure level(s), monitoring should be performed regularly. Safety shower and eyewash station should be available.

NOTE: Protective equipment and clothing should be selected, used, and maintained according to applicable standards and regulations. For further information, contact the clothing or equipment manufac-



## VIII - STORAGE AND HANDLING PRECAUTIONS

Follow protective controls set forth in Section VII when handling this product.

Store labeled, sealed containers in a cool, dry, well-ventilated area out of sunlight. Prevent water or moist air from entering storage tanks or containers. Do not cut or weld on empty or full drums.

Aluminum equipment should not be used for storage and/or transfer.

Vapors are heavier than air and will collect in low areas.

Contact with aluminum parts in a pressurizable fluid system may cause violent reactions. Consult equipment supplier for further information.

Do not remove or deface label.

Do not reuse drum without recycling or reconditioning in accordance with any applicable federal, state or local laws.

## IX - SPILL LEAK AND DISPOSAL PRACTICES

### STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

Evacuate the area, ventilate, and avoid breathing vapors. Dike area to contain spill. Clean up area (wear protective equipment - refer to Section VII) by mopping or with absorbent material and place in closed containers for disposal. Avoid contamination of ground and surface waters. Do not flush to sewer.

If spill occurs indoors, turn off air conditioning and/or heating system, to prevent vapors from contaminating entire building.

### WASTE DISPOSAL METHOD

Recovered liquids may be sent to a licensed reclaimer or incineration facility. Contaminated material must be disposed of in a permitted waste management facility. Consult federal, state, or local disposal authorities for approved procedures.

## X - TRANSPORTATION

### DOT HAZARD CLASSIFICATION

None by land or water transportation when containers are less than 1000 lbs each. ORM-A when containers are more than 1000 lbs each or when transported by air in any size container.

### HAZARD CARD REQUIRED

None

### HAZARD LABEL REQUIRED

Label as required by OSHA Hazard Communication Standard, and any applicable state and local regulations. Use Harmful label when transported by air.

### Medical Emergencies

Call collect 24 hours a day  
for emergency toxicological  
information 415/821-5338

### Other Emergency information

Call 316/524-5751 (24 hours)

### For any other information contact:

Vulcan Chemicals  
Technical Service Department  
P. O. Box 7689  
Birmingham, AL 35253-0689  
205/877-3459  
8 AM to 5 PM Central Time  
Monday through Friday

DATE OF PREPARATION: March 1, 1988



PPG INDUSTRIES, INC.

ONE PPG PLACE

PITTSBURGH, PA 15272

\*\*\* PERCHLOROETHYLENE

MSDS NUMBER: 0041  
 DATE: 04/17/89  
 EDITION: '009  
 TRADE NAME: PERCHLOROETHYLENE  
 CHEMICAL NAME/SYNONYMS: TETRACHLOROETHYLENE, PERCHLORETHYLENE, PERCHLOR  
 CHEMICAL FAMILY: HALOGENATED HYDROCARBON  
 FORMULA: CCL2=CCL2 CAS NUMBER: 00127 18 4  
 U. S. DOT SHIPPING NAME: PERCHLOROETHYLENE  
 U. S. DOT HAZARD CLASS: ORM-A  
 SUBSIDIARY RISK: N/A  
 I. D. NUMBER: UN1897  
 REPORTABLE QUANTITY: N/A

SECTION 1 \* PHYSICAL DATA

BOILING POINT @ 760 MM HG: 121 C  
 VAPOR DENSITY (AIR=1): 5.83  
 SPECIFIC GRAVITY (H2O=1): 1.6 @ 20/20 C  
 PH OF SOLUTIONS: 6.8 TO 8.4  
 FREEZING/MELTING POINT: -22.3 C  
 SOLUBILITY (WEIGHT % IN WATER): 0.015% @ 25 C  
 BULK DENSITY: 13.6 LBS/GAL @ 20 C  
 VOLUME % VOLATILE: 100  
 VAPOR PRESSURE: 14.2 MM HG @ 20 C  
 EVAPORATION RATE: (ETHYL ETHER=1): 0.09  
 HEAT OF SOLUTION: N/A  
 APPEARANCE AND ODOR:  
 CLEAR, COLORLESS LIQUID WITH ETHER-LIKE ODOR.

SECTION 2 \* INGREDIENTS

MATERIAL	PERCENT
PERCHLOROETHYLENE (STABILIZED)	> 99

SECTION 3 \* FIRE/EXPLOSION HAZARD DATA

FLASH POINT (METHOD USED):  
 NONE

\*\*\* 24-HOUR EMERGENCY ASSISTANCE: (304) 843-1300 \*\*\*



PPG INDUSTRIES, INC.

ONE PPG PLACE

PITTSBURGH, PA 15272

\* \* PERCHLOROETHYLENE

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**FLAMMABLE LIMITS IN AIR (% BY VOLUME)**

LEL: NONE

UEL: NONE

**EXTINGUISHING MEDIA:**

WATER, DRY CHEMICALS, OR CARBON DIOXIDE

**SPECIAL FIRE FIGHTING PROCEDURES:**

FIRE FIGHTERS SHOULD WEAR NIOSH/MSHA APPROVED PRESSURE DEMAND SELF-CONTAINED BREATHING APPARATUS FOR POSSIBLE EXPOSURE TO HYDROGEN CHLORIDE AND POSSIBLE TRACES OF PHOSGENE.

**UNUSUAL FIRE AND EXPLOSION HAZARDS:**

PERCHLOR INVOLVED IN FIRES CAN DECOMPOSE TO HYDROGEN CHLORIDE AND POSSIBLE TRACES OF PHOSGENE.

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**SECTION 4 \* HEALTH HAZARD DATA**

**TOXICITY DATA:**

LC50 INHALATION: (RAT) 4000 PPM (4 HOURS)  
LD50 DERMAL: NOT DETERMINED  
SKIN/EYE IRRITATION: SEE SECTION 5  
LD50 INGESTION: (RABBIT) 5000 MG/KG  
FISH, LC50 (LETHAL CONCENTRATION): 96 HR TLM: 100-10 PPM

**CLASSIFICATION: (POISON, IRRITANT, ETC.)**

INHALATION: MODERATELY TOXIC  
SKIN: NOT DETERMINED  
SKIN/EYE: MILDLY IRRITATING / IRRITANT  
INGESTION: SLIGHTLY TOXIC  
AQUATIC: TOXIC

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**SECTION 5 \* EFFECTS OF OVEREXPOSURE**

THIS SECTION COVERS EFFECTS OF OVEREXPOSURE FOR INHALATION, EYE/SKIN CONTACT, INGESTION AND OTHER TYPES OF OVEREXPOSURE INFORMATION IN THE ORDER OF THE MOST HAZARDOUS AND THE MOST LIKELY ROUTE OF OVEREXPOSURE.

IS CHEMICAL LISTED AS A CARCINOGEN OR POTENTIAL CARCINOGEN?

\*\*\* 24-HOUR EMERGENCY ASSISTANCE: (304) 843-1300 \*\*\*



NTP - NO IARC - YES OSHA - NO

**MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE:**

PROLONGED EXPOSURE ABOVE THE OSHA PERMISSIBLE EXPOSURE LIMIT MAY COMPLICATE EXISTING LIVER AND KIDNEY DISEASES.

**PERMISSIBLE EXPOSURE LIMITS:**

OSHA: 25 PPM, 8-HOUR TWA (TIME WEIGHTED AVERAGE); 29 CFR 1910.1000, TABLE Z-2, REV. 3/1/89.

ACGIH: 50 PPM, 8-HOUR TWA; 200 PPM, 15-MINUTE STEL (SHORT-TERM EXPOSURE LIMIT).

PPG INTERNAL PERMISSIBLE EXPOSURE LIMIT: 25 PPM, 8-HOUR TWA; 100 PPM, STEL.

**ACUTE:**

INHALATION: PERCHLOROETHYLENE IS PRIMARILY A CENTRAL NERVOUS SYSTEM DEPRESSANT AND CAN CAUSE POSSIBLE CENTRAL NERVOUS SYSTEM DAMAGE WITH OVEREXPOSURE. INHALATION CAN CAUSE IRRITATION OF THE RESPIRATORY TRACT, DIZZINESS, NAUSEA, HEADACHE, LOSS OF COORDINATION AND EQUILIBRIUM, UNCONSCIOUSNESS AND EVEN DEATH IN CONFINED OR POORLY VENTILATED AREA. FATALITIES FOLLOWING SEVERE ACUTE EXPOSURE TO VARIOUS CHLORINATED SOLVENTS HAVE BEEN ATTRIBUTED TO VENTRICULAR FIBRILLATION.

EYE/SKIN: LIQUID SPLASHED IN THE EYE CAN RESULT IN DISCOMFORT, PAIN AND IRRITATION. PROLONGED OR REPEATED CONTACT WITH LIQUID ON THE SKIN CAN CAUSE IRRITATION AND DERMATITIS. THE PROBLEM MAY BE ACCENTUATED BY LIQUID BECOMING TRAPPED AGAINST THE SKIN BY CONTAMINATED CLOTHING AND SHOES, AND SKIN ABSORPTION CAN OCCUR.

INGESTION: SWALLOWING OF THIS MATERIAL MAY RESULT IN IRRITATION OF THE MOUTH AND GI TRACT ALONG WITH OTHER EFFECTS AS LISTED ABOVE FOR INHALATION. VOMITING AND SUBSEQUENT ASPIRATION INTO THE LUNGS MAY LEAD TO CHEMICAL PNEUMONIA AND PULMONARY EDEMA WHICH IS A POTENTIALLY FATAL CONDITION.

**CHRONIC:**

PROLONGED EXPOSURE ABOVE THE OSHA PERMISSIBLE EXPOSURE LIMITS MAY RESULT IN LIVER AND KIDNEY DAMAGE. PERCHLOROETHYLENE HAS BEEN EXTENSIVELY STUDIED FOR ITS CANCER POTENTIAL. A RECENT NTP STUDY HAS DETERMINED THAT THERE IS CLEAR EVIDENCE OF CARCINOGENICITY (LIVER) IN BOTH MALE AND FEMALE MICE, CLEAR EVIDENCE OF LEUKEMIA IN MALE AND FEMALE RATS AND SOME EVIDENCE OF ANIMAL CARCINOGENICITY (KIDNEY TUMORS) IN MALE RATS. THE NTP STUDY EXPOSED RATS TO 200 AND 400 PPM AND MICE TO 100 AND 200 PPM IN A LIFETIME STUDY. PRUDENT HANDLING PRACTICES SHOULD BE FOLLOWED TO MINIMIZE HUMAN EXPOSURE.

\*\*\* 24-HOUR EMERGENCY ASSISTANCE: (304) 843-1300 \*\*\*



PERCHLOROETHYLENE IS LISTED UNDER IARC AS A 2B.

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**\* EMERGENCY AND FIRST AID PROCEDURES**

**INHALATION:**

REMOVE TO FRESH AIR. IF NOT BREATHING, GIVE ARTIFICIAL RESPIRATION, PREFERABLY MOUTH-TO-MOUTH. IF BREATHING IS DIFFICULT, GIVE OXYGEN. CALL A PHYSICIAN.

**EYE OR SKIN CONTACT:**

FLUSH EYES AND SKIN WITH PLENTY OF WATER (SOAP AND WATER FOR SKIN) FOR AT LEAST 15 MINUTES, WHILE REMOVING CONTAMINATED CLOTHING AND SHOES. IF IRRITATION OCCURS, CONSULT A PHYSICIAN. THOROUGHLY CLEAN CONTAMINATED CLOTHING AND SHOES BEFORE REUSE OR DISCARD.

**INGESTION:**

IF CONSCIOUS, DRINK LARGE QUANTITIES OF WATER. DO NOT INDUCE VOMITING. TAKE IMMEDIATELY TO A HOSPITAL OR PHYSICIAN. IF UNCONSCIOUS, OR IN CONVULSIONS, TAKE IMMEDIATELY TO A HOSPITAL. DO NOT ATTEMPT TO GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON.

**NOTES TO PHYSICIAN (INCLUDING ANTIDOTES):**

NEVER ADMINISTER ADRENALINE FOLLOWING PERCHLOROETHYLENE OVEREXPOSURE. INCREASED SENSITIVITY OF THE HEART TO ADRENALINE MAY BE CAUSED BY OVEREXPOSURE TO PERCHLOROETHYLENE.

-----  
**SECTION 6 \* REACTIVITY DATA**

**STABILITY: STABLE**

CONDITIONS TO AVOID: OPEN FLAMES, HOT GLOWING SURFACES OR ELECTRIC ARCS

**HAZARDOUS POLYMERIZATION: WILL NOT OCCUR**

CONDITIONS TO AVOID: NONE

**INCOMPATIBILITY (MATERIALS TO AVOID):**

NONE

**HAZARDOUS DECOMPOSITION PRODUCTS:**

HYDROGEN CHLORIDE AND POSSIBLE TRACES OF PHOSGENE

-----  
**SECTION 7 \* SPILL OR LEAK PROCEDURES**

**STEPS TO BE TAKEN IF MATERIAL IS SPILLED OR RELEASED:**

IMMEDIATELY EVACUATE THE AREA AND PROVIDE MAXIMUM VENTILATION. UNPROTECTED

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PERSONNEL SHOULD MOVE UPWIND OF SPILL. ONLY PERSONNEL EQUIPPED WITH PROPER RESPIRATORY AND SKIN/EYE PROTECTION (SEE SECTION 8) SHOULD BE PERMITTED IN AREA. DIKE AREA TO CONTAIN SPILL. TAKE PRECAUTIONS AS NECESSARY TO PREVENT CONTAMINATION OF GROUND AND SURFACE WATERS. RECOVER SPILLED MATERIAL ON ADSORBENTS, SUCH AS SAWDUST OR VERMICULITE, AND SWEEP INTO CLOSED CONTAINERS FOR DISPOSAL. AFTER ALL VISIBLE TRACES, INCLUDING IGNITABLE VAPORS, HAVE BEEN REMOVED, THOROUGHLY WET VACUUM THE AREA. DO NOT FLUSH TO SEWER. IF AREA OF SPILL IS POROUS, REMOVE AS MUCH EARTH AND GRAVEL, ETC. AS NECESSARY AND PLACE IN CLOSED CONTAINERS FOR DISPOSAL.

**WASTE DISPOSAL METHOD:**

CONTAMINATED SAWDUST, VERMICULITE, SOIL OR POROUS SURFACE MUST BE DISPOSED OF IN A PERMITTED HAZARDOUS WASTE MANAGEMENT FACILITY. RECOVERED LIQUIDS MAY BE REPROCESSED OR INCINERATED OR MUST BE TREATED IN A PERMITTED HAZARDOUS WASTE MANAGEMENT FACILITY. CARE MUST BE TAKEN WHEN USING OR DISPOSING OF CHEMICAL MATERIALS AND/OR THEIR CONTAINERS TO PREVENT ENVIRONMENTAL CONTAMINATION. IT IS YOUR DUTY TO DISPOSE OF THE CHEMICAL MATERIALS AND/OR THEIR CONTAINERS IN ACCORDANCE WITH THE CLEAN AIR ACT, THE CLEAN WATER ACT, THE RESOURCE CONSERVATION AND RECOVERY ACT, AS WELL AS ANY OTHER RELEVANT FEDERAL, STATE, OR LOCAL LAWS/REGULATIONS REGARDING DISPOSAL.

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**SECTION 8 \* SPECIAL PROTECTION INFORMATION****RESPIRATORY PROTECTION:**

USE A HALF OR FULL FACEPIECE ORGANIC VAPOR CHEMICAL CARTRIDGE OR CANISTER RESPIRATOR WHEN CONCENTRATIONS EXCEED PERMISSIBLE LIMITS. USE SELF-CONTAINED BREATHING APPARATUS (SCBA) OR FULL FACEPIECE AIRLINE RESPIRATOR WITH AUXILIARY SCBA OPERATED IN THE PRESSURE DEMAND MODE FOR EMERGENCIES AND FOR ALL WORK PERFORMED IN STORAGE VESSELS, POORLY VENTILATED ROOMS, AND OTHER CONFINED AREAS. RESPIRATORS MUST BE APPROVED BY NIOSH OR MSHA. THE RESPIRATOR USE LIMITATIONS MADE BY NIOSH/MSHA AND BY THE MANUFACTURER MUST BE OBSERVED. RESPIRATORY PROTECTION PROGRAMS MUST BE IN ACCORDANCE WITH 29 CFR 1910.134.

**VENTILATION(TYPE):**

USE LOCAL EXHAUST OR DILUTION VENTILATION AS APPROPRIATE TO CONTROL EXPOSURES TO BELOW PERMISSIBLE LIMITS.

**EYE PROTECTION:**

SPLASHPROOF GOGGLES

**GLOVES:**

VITON(R), SILVER SHIELD(R),  
FOR LIMITED SERVICE ONLY: NITRILE AND  
POLYVINYL ALCOHOL (DEGRADES IN WATER).

**OTHER PROTECTIVE EQUIPMENT:**

BOOTS, APRONS, OR CHEMICAL SUITS SHOULD BE USED WHEN NECESSARY TO PREVENT

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SKIN CONTACT. PERSONAL PROTECTIVE CLOTHING AND USE OF EQUIPMENT MUST BE IN ACCORDANCE WITH 29 CFR 1910.132 AND 29 CFR 1910.133.

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### SECTION 9 \* SPECIAL PRECAUTIONS

#### PRECAUTIONS TO BE TAKEN DURING HANDLING AND STORING:

- \* CANCER INFORMATION: HAS CAUSED CANCER IN CERTAIN LABORATORY ANIMALS, OF QUESTIONABLE RELEVANCE TO HUMANS.
- \* DO NOT USE IN POORLY VENTILATED OR CONFINED SPACES WITHOUT PROPER RESPIRATORY PROTECTION (SEE SECTION 8).
- \* PERCHLOROETHYLENE VAPORS ARE HEAVIER THAN AIR AND WILL COLLECT IN LOW AREAS.
- \* KEEP CONTAINER CLOSED WHEN NOT IN USE.
- \* STORE ONLY IN CLOSED, PROPERLY LABELED CONTAINERS.
- \* THIS MATERIAL OR ITS VAPORS WHEN IN CONTACT WITH FLAMES, HOT GLOWING SURFACES OR ELECTRIC ARCS CAN DECOMPOSE TO FORM HYDROGEN CHLORIDE GAS AND TRACES OF PHOSGENE.
- \* AVOID CONTAMINATION OF WATER SUPPLIES. HANDLING, STORAGE AND USE PROCEDURES MUST BE CAREFULLY MONITORED TO AVOID SPILLS OR LEAKS. ANY SPILL OR LEAK HAS THE POTENTIAL TO CAUSE UNDERGROUND WATER CONTAMINATION WHICH MAY, IF SUFFICIENTLY SEVERE, RENDER A DRINKING WATER SOURCE UNFIT FOR HUMAN CONSUMPTION. CONTAMINATION THAT DOES OCCUR CANNOT BE EASILY CORRECTED.
- \* A CHLORINATED SOLVENT USED AS A FLASHPOINT SUPPRESSANT MUST BE ADDED IN SUFFICIENT QUANTITY OR THE RESULTANT MIXTURE MAY HAVE A FLASHPOINT LOWER THAN THE FLAMMABLE COMPONENT.
- \* DO NOT USE CUTTING OR WELDING TORCHES ON DRUMS THAT CONTAINED PERCHLOROETHYLENE UNLESS PROPERLY PURGED AND CLEANED.

#### OTHER PRECAUTIONS:

- \* DO NOT BREATHE VAPORS. HIGH VAPOR CONCENTRATIONS CAN CAUSE DIZZINESS, UNCONSCIOUSNESS, POSSIBLE CENTRAL NERVOUS SYSTEM DAMAGE OR DEATH. LONG-TERM OVEREXPOSURE MAY CAUSE LIVER/KIDNEY INJURY.
- \* USE ONLY WITH ADEQUATE VENTILATION. VENTILATION MUST BE SUFFICIENT TO LIMIT EMPLOYEE EXPOSURE TO PERCHLOROETHYLENE BELOW PERMISSIBLE EXPOSURE LIMITS. OBSERVANCE OF LOWER LIMITS (OUTLINED IN SECTION 5) IS ADVISABLE.
- \* AVOID CONTACT WITH EYES. WILL CAUSE IRRITATION AND PAIN.
- \* AVOID PROLONGED OR REPEATED CONTACT WITH SKIN. MAY CAUSE IRRITATION OR DERMATITIS.
- \* DO NOT SWALLOW. SWALLOWING MAY CAUSE INJURY OR DEATH.
- \* DO NOT EAT, DRINK, OR SMOKE IN WORK AREA.

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\* \* \* 24-HOUR EMERGENCY ASSISTANCE: (304) 843-1300 \* \* \*



PPG INDUSTRIES, INC.

ONE PPG PLACE

PITTSBURGH, PA 15272

\* \* PERCHLOROETHYLENE

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**COMMENTS:**

TSCA - PERCHLOROETHYLENE IS LISTED ON THE TSCA INVENTORY UNDER CAS NO. 127-18-4.

SARA TITLE III - A) 311/312 CATEGORIES - ACUTE, CHRONIC, B) LISTED IN SECTION 313 UNDER TETRACHLOROETHYLENE, C) LISTED IN SECTION 302 AS A HAZARDOUS SUBSTANCE WITH REPORTABLE QUANTITY OF 1# (PROPOSED RQ REVISION TO 100#'S).

RCRA - WASTE PERCHLOROETHYLENE AND CONTAMINATED SOILS/MATERIALS FROM SPILL CLEAN-UP ARE U210 HAZARDOUS WASTE AS PER 40 CFR 261.33 AND MUST BE DISPOSED OF ACCORDINGLY UNDER RCRA. SEE 40 CFR 261.33(C) AND 261.7(B)(3) FOR TRIPLE RINSING REQUIREMENTS FOR EMPTY DRUMS.

CALIFORNIA PROP. 65 - THIS PRODUCT IS A CHEMICAL KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER.

R. KENNETH LEE  
MANAGER, PRODUCT SAFETY

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# Perchlorethylene



Perchlorethylene or Perchlor is a chlorinated solvent produced by PPG Industries, and used primarily by dry cleaning plants. Other applications include vapor degreasing, and use as a chemical intermediate and as a processing solvent.

Perchlor is nonflammable, has low toxicity, and has an inherent stability further enhanced by PPG's stabilizer system.

## Properties and Characteristics

Perchlor has no flash point and no fire point, which gives it an important advantage over petroleum distillates such as Stoddard solvent for dry cleaning operations. As a result, along with its low toxicity and other desirable physical properties, Perchlor has become the largest-volume dry cleaning solvent.

Perchlor is relatively inert, and is inherently more stable than other chlorinated solvents. PPG Perchlor is further stabilized to prevent solvent degradation or decomposition, and corrosion of metal parts and equipment in vapor degreasing. The PPG stabilizers are designed to be recoverable along with the perchlorethylene after repeated cleaning cycles, including recovery from carbon adsorbers.

## General Application

In addition to its wide use as a drycleaning solvent, PPG Perchlor is used extensively for vapor degreasing because of its high solvency, non-flammability and high vapor density.

**Drycleaning**—Perchlor is the preferred solvent because, in addition to its nonflammability and low toxicity, it provides a fast, powerful yet gentle cleaning action with a minimum of mechanical agitation. The result is less fabric wear. PPG Perchlor cleans all natural and synthetic fibers.

Cleaning cycle and drying times are fast with Perchlor, and because of its high solvency fewer stains are left for the spotter. Because the solvent is recoverable, it has a long service life.

PPG Perchlor works with any drycleaning detergent, so that the drycleaner can add detergent or soap and make his own charged system as needed.

**Vapor Degreasing**—Many industries, including aerospace, appliance and automotive, use Perchlor for vapor degreasing of metal parts. Although Trichlor has a more general usage for vapor degreasing, Perchlor is preferred in some situations because of its higher boiling point (above that of water). Many soils such as waxes and resins must be melted in order for them to be solubilized.

The high boiling point (250°F or 121°C) of perchlorethylene enables it to condense more vapor on the metal to be cleaned than other

## Typical Properties

Perchlorethylene is a clear, water-white liquid at ordinary temperatures. It is completely miscible with most organic liquids. The stabilized product, Perchlor, can be used with any of the common construction metals.

<b>Chemical Names</b>	Tetrachloroethylene; perchloroethylene
<b>Chemical Formula</b>	$\text{CCl}_2\text{CCl}_2$
<b>Molecular Weight</b>	165.85
<b>Boiling Point, °F</b>	250.0
<b>°C</b>	121.1
<b>Freezing Point, °F</b>	-8.2
<b>°C</b>	-22.3
<b>Pounds per Gallon at 68°F (20°C)</b>	13.57
<b>Kilograms per Liter at 20°C</b>	1.63
<b>Refractive Index, <math>n_D^{20}</math></b>	1.5053
<b>Dielectric Constant at 1000 cps and 25°C</b>	2.365
<b>Specific Heat at 20°C cal/(g)(°C) or Btu/(lb)(°F)</b>	0.205
<b>Flash Point (Tag open cup)</b>	None
<b>Fire Point (Tag open cup)</b>	None
<b>Heat of Vaporization at 760 mm Hg, cal/g</b>	50.1
<b>Btu/lb</b>	90.2
<b>Vapor Density at 121.1°C and 760 mm Hg, g/l</b>	5.22
<b>lb/ft<sup>3</sup></b>	0.326
<b>Specific Gravity of Vapor (air = 1)</b>	5.83
<b>Vapor Pressure at 20°C, mm Hg</b>	14.2
<b>Evaporation Rate at 77°F (25°C) (ether = 100)</b>	9
<b>gal/(ft<sup>2</sup>)(day)</b>	0.15
<b>Flammability</b>	Nonflammable
<b>Viscosity at 20°C, cps</b>	0.88
<b>Solubility at 25°C, g Perchlor/100 g water</b>	0.015
<b>g water/100 g Perchlor</b>	0.0105
<b>Azeotrope with Water, Boiling Point, °F</b>	189.2
<b>°C</b>	87.7
<b>Azeotropic Water Content, wt %</b>	15.8
<b>Permissible Exposure Limit (8-hour TWA) ppm</b>	100

## Specification and Typical Analysis, PPG Perchlor, All Grades

	Specification	Typical Analysis
<b>Appearance</b>	Clear, free of suspended matter	Clear, free of suspended matter
<b>Color, APHA</b>	15 maximum	8
<b>Odor</b>	Characteristic; no residual	Characteristic; no residual
<b>Spot Test</b>	No spot or stain	No spot or stain
<b>Specific Gravity, 20°C/20°C</b>	1.623 to 1.628	1.624
<b>Nonvolatile Residue, wt %</b>	0.0025 maximum	0.0003
<b>Free Chlorine</b>	None	None
<b>Moisture, ppm maximum</b>	30	25
<b>cloud point</b>	No cloud at 0°C	No cloud at -5°C
<b>Distillation Range (100%), °C</b>	120.0 to 122.0	120.8 to 121.6
<b>°F</b>	248.0 to 251.6	249.4 to 250.9
<b>pH</b>	—	Drycleaning, 6.8 Degreasing, 8.4

chlorinated solvents, thus washing the parts with a greater volume of solvent. Perchloroethylene cleans longer and removes higher-melting-point pitches and waxes more easily. It is effective with lightweight and light-gauge parts that warm up to the temperature of a lower boiling-point solvent and therefore stop condensing liquid on the parts before cleaning is complete. Perchloroethylene is particularly effective in fine orifices and spot-welded seams.

Perchloroethylene forms an azeotrope with water that has a boiling point below that of water, while perchlorethylene itself has a higher boiling point than water. As a result, perchlorethylene allows a vapor degreaser to function as a drying device for metal parts and to remove water films from metals without degradation of the solvent.

**Chemical Processing**—Perchlor serves as a carrier solvent for fabric finishes, rubber and silicones; and as an extractive solvent. It is used in paint remover formulations and in printing inks. It serves as a chemical intermediate for chlorofluorocarbons. Perchlor also is often used as a component of "safety" solvent blends. When used for this purpose it is important to determine the flash point of the mixture as it is to be used before using or selling, since an insufficient quantity of Perchlor may actually lower the flash point of the mixture below that of the flammable component.

### Grades and Forms

PPG Perchlor is available in three grades for drycleaning, vapor degreasing and general-purpose use.

**Drycleaning Grade**—Formulated especially for drycleaning operations, this grade incorporates a stabilizer that is completely removed from garments and leaves no residual odor. The stabilizers are recoverable with the solvent after distilling. Solvent removed from carbon adsorbers also is suitable for reuse in dry cleaning. Drycleaning Grade is not suitable for vapor degreasing.

**Degreasing and General-Purpose Grade**—This general-purpose grade is suited for many vapor degreasing, cold cleaning and drycleaning applications. It incorporates stabilizers to protect the solvent against degradation or decomposition caused by such contaminants as metal chips and fines, acids, alkalis and oxidants.

**Heavy-Duty Degreasing Grade**—Perchlor HD is a much more heavily stabilized solvent intended for more rigorous production vapor degreasing. It is not recommended for drycleaning or general solvent use.

### Government Specifications

The various PPG grades meet the chemical and physical requirements of the current version of Federal Specification O-T-236, Technical Grade.

### Health Hazards

Perchloroethylene is a central nervous system depressant. Acute inhalation overexposure can cause irritation of the respiratory tract, dizziness, nausea, headache, loss of coordination and equilibrium, unconsciousness and even death in confined or poorly ventilated areas, such as tanks or pits. Adrenalin should not be administered to a person overcome by perchlorethylene.

Chronic inhalation overexposure may damage the liver and kidneys. Perchloroethylene has been studied extensively for cancer both in the United States and Europe by government, industry and academia in multiple species and biological test systems. A recent National Toxicology Program (NTP) study has determined that there is clear evidence of carcinogenicity (liver) in both male and female mice, clear evidence of leukemia in male and female rats and some evidence of carcinogenicity (kidney tumor) in male rats. The NTP study exposed rats to 200 and 400 ppm and mice to 100 and 200 ppm in a lifetime study. At the present time the International Agency for Research on Cancer (IARC) lists perchlorethylene in Group 3. There is no documented evidence that perchlorethylene causes an increased cancer incidence in humans. In an exhaustive epidemiology study sponsored by NIOSH no increased risk of cancer in dry cleaning workers was noted. However, it is strongly suggested that perchlorethylene users review their health programs, "tighten up" their operations and institute good operating and housekeeping practices designed to limit employee exposure as much below OSHA permissible exposure limits as practical.

The current OSHA permissible exposure limits for perchlorethylene as published in 29CFR § 1910.1000, Table Z-3, are 100 ppm (eight-hour time-weighted average) with an acceptable ceiling concentration of 200 ppm and maximum allowable concentration (MAC) of 300 ppm (excursions between 200 and 300 ppm are allowed only for a maximum of five minutes in any three-hour period). The MAC must not be exceeded.

The current PPG Internal Permissible Limit (IPEL) is 50 ppm (skin), 8-hour TWA (time-weighted average) with a STEL (short-term exposure limit) of 200 ppm. The "skin" nota-

tion is provided to alert the user that absorption through the skin upon contact, including mucous membranes and eyes, can be significant. Measures to prevent such contact must be taken so that the above exposure limits are not invalidated. The MAC must not be exceeded.

Swallowing perchlorethylene could cause illness. Ingestion of substantial quantities could be fatal.

Small amounts of perchlorethylene splashed into the eyes may result in pain and irritation. While irritation usually disappears within a few hours, there is considerable discomfort. Carefully fitted chemical safety goggles should be worn where there is danger that perchlorethylene may be splashed into the eyes.

Prolonged or repeated contact with perchlorethylene may cause skin irritation. Since perchlorethylene is a good oil or grease solvent, it removes oils and greases from the skin, and, in some cases may cause dermatitis. Protective clothing, such as gloves or aprons, should be made from neoprene, polyvinyl alcohol or Viton® A fluoroelastomer. Clothing which becomes soaked with perchlorethylene should not be worn until it is thoroughly dried.

Additional information is contained in the Material Safety Data Sheet, available on request.

### Handling and Storage

Perchlor has no flash point, fire point or autoignition temperature. However, when exposed to open flames, hot glowing surfaces or electrical arcs, Perchlor liquid or vapor can decompose to form toxic and corrosive acid fumes.

More information on bulk and drum handling and storage appears in the manual *Bulk Handling and Properties of PPG Chlorinated Solvents*, and in the Cleaner-Cleaner bulletin *Unloading PPG Perchlor Drums*.

### Packaging and Shipping

Perchlor is shipped in 55-gallon drums, tank trucks and tank cars. Single-compartment cars are available with nominal capacities of 10,000 and 20,000 gallons. Perchlor is shipped from the Lake Charles, Louisiana plant and from terminals at Bayonne, New Jersey; Chicago, Illinois and San Pedro, California.

### Samples and Service

Samples of Perchlor are available on request through the nearest PPG sales office. The technical service staff of PPG Industries' Chemicals Group is available for consulting on handling, storage, properties and use.



PPG Industries, Inc.  
One PPG Place  
Pittsburgh, PA 15272

Statements and methods presented are based upon the best available information and practices known to PPG Industries at present, but are not representations or warranties of performance, result or comprehensiveness, nor do they imply any recommendations to infringe any patent or an offer of license under any patent.

The products mentioned herein can be hazardous if not used properly. Any health hazard and safety information contained herein should be passed on to your customers or employees, as the case may be. PPG Industries also recommends that, before use, anyone using or handling this product thoroughly read and understand the information and precautions on the label, as well as in other product safety publications such as the Material Safety Data Sheet.

Like all potentially hazardous materials, this product must be kept out of the reach of children.

**CALCIUM(II) NITRATE TETRAHYDRATE (1:2:4)**

CAS RN: 13477344                      NIOSH #: EW 3000000

mf:  $N_2O_6 \cdot Ca \cdot 4H_2O$ ;    mw: 236.18

Cubic, colorless, hygroscopic crystals. mp: 561.0°, d: 2.36.

SYN: DUSIGNAN VAPENATY (CZECH)

TOXICITY DATA:	2	CODEN:
skn-rbt 500 mg/24H MOD		28ZPAK -9,72
eye-rbt 500 mg/24H SEV		28ZPAK -9,72
ori-rat LD50:3900 mg/kg		28ZPAK -9,72

*THR*: MOD orl. A skn, eye irr. See also calcium compounds, nitrates.

*Disaster Hazard*: When heated to decomp it emits tox fumes of  $NO_x$ .

For further information see Vol. 2, No. 1 of *DPIM Report*.

## METHANE DICHLORIDE

CAS RN: 75092

mf: CH<sub>2</sub>Cl<sub>2</sub>; mw: 84.93

NIOSH #: PA 8050000

Colorless volatile liquid. bp: 39.8°, lel = 15.5% in O<sub>2</sub>, uel = 66.4% in O<sub>2</sub>, fp: -96.7°, d: 1.326 @ 20°/4°, autoign. temp.: 1139°F, vap. press: 380 mm @ 22°, vap. d: 2.93.

### SYNS:

CHLORURE DE METHYLENE  
(FRENCH)  
DICHLOROMETHANE (DOT)  
FREON 30  
METHYLENE BICHLORIDE

METHYLENE CHLORIDE (DOT)  
METHYLENE DICHLORIDE  
METYLENU CHLOREK (POLISH)  
NCI-C50102

### TOXICITY DATA: 3

skn-rbt 810 mg/24H SEV  
eye-rbt 162 mg MOD  
eye-rbt 10 mg MLD  
eye-rbt 17500 mg/m<sup>3</sup>/10M  
mmo-sat 5700 ppm  
mma-sat 5700 ppm  
dni-hmn:fbr 5000 ppm/1H-C  
dni-ham:lng 5000 ppm/1H-C  
sce-ham:lng 5000 ppm/1H-C  
ihl-rat TCLo:4500 ppm/24H (1-17D  
preg)  
ihl-rat TCLo:1250 ppm/7H (6-15D  
preg)  
ihl-mus TCLo:1250 ppm/7H (6-15D  
preg)  
ihl-rat TCLo:500 ppm/6H/2Y:ETA  
ihl-hmn TCLo:500 ppm/1Y-I:CNS  
ihl-hmn TCLo:500 ppm/8H:BLD  
orl-rat LD50:167 mg/kg  
ihl-rat LC50:88000 mg/m<sup>3</sup>/30M  
ihl-mus LC50:14400 ppm/7H  
ipr-mus LD50:1500 mg/kg  
scu-mus LD50:6460 mg/kg  
orl-dog LDLo:3000 mg/kg  
ihl-dog LCLo:14108 ppm/7H  
ipr-dog LDLo:950 mg/kg  
scu-dog LDLo:2700 mg/kg  
ivn-dog LDLo:200 mg/kg  
ihl-cat LCLo:43400 mg/m<sup>3</sup>/4.5H  
orl-rab LDLo:1900 mg/kg  
scu-rbt LDLo:2700 mg/kg  
ihl-gpg LCLo:5000 ppm/2H

### CODEN:

JETOAS 9,171,76  
JETOAS 9,171,76  
TXCYAC 6,173,76  
TXCYAC 6,173,76  
MUREAV 56,245,78  
MUREAV 56,245,78  
MUREAV 81,203,81  
MUREAV 81,203,81  
MUREAV 81,203,81  
TXAPA9 52,29,80  
TXAPA9 32,84,75  
TXAPA9 32,84,75  
TXAPA9 48,A185,79  
ABHYAE 43,1123,68  
SCIEAS 176,295,72  
DOWSD\* 1/26/76  
FAVUAI 7,35,75  
NIHBAZ 191,1,49  
TXAPA9 9,139,66  
TXAPA9 4,354,62  
QJPPAL 7,205,34  
NIHBAZ 191,1,49  
TXAPA9 10,119,67  
QJPPAL 7,205,34  
QJPPAL 7,205,34  
AHBAAM 116,131,36  
HBTXAC 1,94,56  
QJPPAL 7,205,34  
FLCRAP 1,197,67

Aquatic Toxicity Rating: TLm96:1000-100 ppm  
WQCHM\* 3,-,74. Carcinogenic Determination: Indefi-  
nite IARC\*\* 20,449,79.

TLV: Air: 100 ppm DTLVS\* 4,275,80. *Toxicology Re-  
view*: FAZMAE 18,365,74; 27ZTAP 3,94,69. OSHA  
Standard: Air: TWA 500 ppm; CL 1000; Pk 2000/5M/  
2H (SCP-J) FEREAC 39,23540,74. DOT-ORM-A,  
Label: None FEREAC 41,57018,76. Occupational Ex-  
posure to Methylene Chloride recm std: Air: TWA 75  
ppm; Pk 500 ppm/15M NTIS\*\*. Currently tested by  
NTP for Carcinogenesis by Standard Bioassay Protocol  
as of December 1980. "NIOSH Manual of Analytical  
Methods" Vol 1 127, Vol 3 S329. Reported in EPA  
TSCA Inventory, 1980. EPA TSCA 8(a) Preliminary  
Assessment Information Proposed Rule FERREAC  
45,13646,80.

THR: MUT data. A skn, eye irr. An exper ETA, ±  
CARC. A hmn CNS, BLD. HIGH orl, ivn; MOD  
ipr, orl, scu, ihl; LOW ihl, scu. See also chlorinated  
aliphatic hydrocarbons. Very dangerous to the eyes.  
Except for its property of inducing narcosis, it has very  
few other acute toxicity effects. Its narcotic powers  
are quite strong, and in view of its great volatility,  
care should be taken in its use. It will not form explosive  
mixtures with air at ordinary temp. However, it can  
be decomp by contact with hot surfaces and open flame,  
and it can then yield toxic fumes, which are irr and  
will thus give warning of their presence. It has been  
used as an anesthetic in Europe and is still used there  
for local anesthesia. Exper have shown that 25,000 ppm  
conc for 2 hr exposures were not lethal. Conc of 7,200  
ppm after 8 min caused paresthesia of the extremities;  
after 16 min, acceleration of the pulse to 100; during  
the first 20 min, congestion in the head, a sense of  
heat and slight irr of the eyes. At a level of 2,300  
ppm, there was no feeling of dizziness during 1-hr  
exposures, but nausea did occur after 30 min of ex-  
posure. The limit of perception by smell is set at 25-  
50 ppm conc. Can cause a dermatitis upon prolonged  
skin contact. A respirator for organic vapors and  
fumes should be worn to avoid excessive inhal. Used  
as a food additive permitted in food for human con-  
sumption.

**Fire Hazard:** Reacts violently with Li, NaK, potassium-  
tert-butoxide, (KOH + *n*-methyl-*n*-nitrosourea).

**Explosion Hazard:** None under ordinary conditions, but  
will form explosive mixtures in atmosphere having high  
oxygen content, in liquid O<sub>2</sub>, N<sub>2</sub>O<sub>4</sub>, K, Na, NaK.

**Disaster Hazard:** Dangerous; when heated to decomp,  
emits highly tox fumes of phosgene.

# 1,1,2,2-TETRACHLOROETHYLENE

CAS RN: 127184

NIOSH #: KX 3850000

mf: C<sub>2</sub>Cl<sub>4</sub>; mw: 165.82

Colorless liquid, chloroform-like odor. mp: -23.35°, bp: 121.20°, flash p: none, d: 1.6311 @ 15°/4°, vap. press: 15.8 mm @ 22°, vap. d: 5.83.

## SYNS:

CARBON BICHLORIDE	PERCHLOROETHYLENE, PER (FRENCH)
CARBON DICHLORIDE	PERCHLOROETHYLENE
CZTEROCHLOROETYLEN (POLISH)	PERCLENE
DOW-PER	PERCLOROETILENE (ITALIAN)
ETHYLENE TETRACHLORIDE	TETRACHLOORETHEEN (DUTCH)
NCI-C04580	TETRACHLORAETHEN (GERMAN)
PERCHLOORETHYLEEN, PER (DUTCH)	TETRACHLOROETHYLENE (DOT)
PERCHLORAETHYLEN, PER (GERMAN)	TETRACLOROETENE (ITALIAN)

## TOXICITY DATA: 3

ihl-rat TCLo: 1000 ppm/24H (14D pre/1-22D preg)	CODEN: APTOD9 19,A21,80
ihl-rat TCLo: 1000 ppm/24H (1-22D preg)	APTOD9 19,A21,80
ihl-rat TCLo: 900 ppm/7H (7-13D preg)	TJADAB 19,41A,79
ihl-rat TCLo: 300 ppm/7H (6-15D preg)	TXAPA9 32,84,75
ihl-mus TCLo: 300 ppm/7H (6-15D preg)	TXAPA9 32,84,75
skn-rbt 810 mg/24H SEV	JETOAS 9,171,76
eye-rbt 162 mg MLD	JETOAS 9,171,76
mmo-sat 50 uL/plate	NIOSH* 5AUG77
mma-sat 200 uL/plate	NIOSH* 5AUG77
ori-mus TDLo: 195 gm/kg/50W-I:CAR	NCITR* NCI-CG-TR-13,77
ori-mus TD: 240 gm/kg/62W-I:CAR	NCITR* NCI-CG-TR-13,77
ihl-hmn TCLo: 96 ppm/7H:SYS	NTIS** PB257-185
ihl-man TCLo: 280 ppm/2H:EYE	AMIHBC 5,566,52
ihl-mo-sat TCLo: 600 ppm/10M:CNS	AMIHBC 5,566,52
ori-rat LD50: 8850 mg/kg	NPRI* 1,96,74
ihl-rat LCLo: 4000 ppm/4H	JOCMA7 4,262,62
ori-mus LD50: 8100 mg/kg	NTIS** PB257-185
ihl-mus LCLo: 23000 mg/m <sup>3</sup> /2H	AHBAAM 116,131,36
ipr-mus LD50: 4700 mg/kg	NTIS** PB257-185
ori-dog LDLo: 4000 mg/kg	AJHYA2 9,430,29
ipr-dog LD50: 2100 mg/kg	TXAPA9 10,119,67
ivn-dog LDLo: 85 mg/kg	QJPPAL 7,205,34
ori-cat LDLo: 4000 mg/kg	AJHYA2 9,430,29
ori-rbt LDLo: 5000 mg/kg	AJHYA2 9,430,29
scu-rbt LDLo: 2200 mg/kg	QJPPAL 7,205,34

Aquatic Toxicity Rating: TLm96: 100-10 ppm WQCHM\* 3,-,74. Carcinogenic Determination: Animal Positive IARC\*\* 20,491,79.

TLV: Air: 50 ppm (skin) DTLVS\* 4,325,80. Toxicology Review: AJMEAZ 38,409,65; 27ZTAP 3,139,69. OSHA Standard: Air: TWA 100 ppm; CL 200; Pk 300/5M/3H (SCP-J) FEREAC 39,23540,74. DOT: ORM-A, Label: None FEREAC 41,57018,76. Occupational Exposure to Tetrachloroethylene recm std: Air: TWA 50 ppm; CL 100 ppm/15M NTIS\*\*. NCI Carcinogenesis Bioassay Completed; Results Positive: Mouse

(NCITR\* NCI-CG-TR-13,77). NCI Carcinogenesis Bioassay Completed; Results Negative: Rat (NCITR\* NCI-CG-TR-13,77). Currently Tested by NTP for Carcinogenesis by Standard Bioassay Protocol as of December 1980. "NIOSH Manual of Analytical Methods" VOL 1 127, VOL 3 S335. NIOSH Current Intelligence Bulletin 20, 1978. Reported in EPA TSCA Inventory, 1980. EPA TSCA 8E No: 05780146-Followup Sent as of April, 1979.

THR: MOD via inhal, oral, scu, ipr and dermal routes. HIGH via ivn route. Not corrosive or dangerously acutely reactive, but toxic by inhal, by prolonged or repeated contact with the skin or mu mem, or when ingested by mouth. The liquid can cause injuries to the eyes; however, with proper precautions it can be handled safely. The symptoms of acute intoxication from this material are the result of its effects upon the nervous system.

Exposures to higher conc than 200 ppm cause irr, lachrymation and burning of the eyes and irr of the nose and throat. There may be vomiting, nausea, drowsiness, an attitude of irresponsibility, and even an appearance resembling alcoholic intoxication. This material also acts as an anesthetic, through the inhalation of excessive amounts within a short time. The symptoms of fatal intoxication are irritation of the eyes, nose and throat, then fullness in the head, mental confusion; there may be headache stupefaction, nausea and vomiting, personnel suffering from subacute poisoning may suffer from such symptoms as headache, fatigue, nausea, vomiting, mental confusion and temporary blurring of the vision. This can occur when inadequate ventilation results in concentrations higher than 200 ppm, or where the vapor conc are intermittently high due to faulty handling of the material, or when an individual fails to take adequate precautionary measures.

This material can cause dermatitis, particularly after repeated or prolonged contact with the skin. The dermatitis is preceded by a reddening and burning and more rarely, a blistering of the skin. In any event, the skin becomes rough and dry, due largely to the removal of skin oils by material. The skin then cracks easily and is readily susceptible to infection. Upon ingestion it causes irr of the gastrointestinal tract, which, in turn, causes nausea, vomiting, diarrhea and bloody stools. However, such effects are usually less severe than the effects of swallowing similar amounts of other chlorinated hydrocarbons. An exper CARC. MUT data.

It may be handled in the presence or absence of air, water, and light with any of the common construction materials at temp. up to 140°C. This material is extremely stable and resists hydrolysis. A common air contaminant. Reacts violently with Ba, Be, Li; N<sub>2</sub>O<sub>4</sub>; metals; NaOH.

Disaster Hazard: Dangerous; when heated to decomp it emits high tox fumes of chlorides.

For further information see Perchloroethylene Vol. 1, No. 2 of DPIM Report.

Sax, N. Irving, Dangerous Properties of Industrial Materials, Sixth Edition, 1984, pp. 2517-2518.

# Appendix B



# SWENSON

Harvey, Illinois 60426

SWENSON RESEARCH & DEVELOPMENT  
DEPARTMENT

4-LITER JAR  
TEST REPORT  
ON  
CALCIUM NITRATE

FOR

COAL TECHNOLOGY CORPORATION

FILE: S-6295  
BY: JIM SENDRA  
DATE: SEPTEMBER 12, 1992



# SWENSON

15700 Lathrop Avenue • Harvey, Illinois 60426  
Telephone 708 • 331-5500 Telex 25-3274  
Fax 708 • 331-5559

September 22, 1992  
S-6295

VIA COURIER

Coal Technology Corporation  
103 Thomas Road  
Bristol, VA 24201

Attention: Mr. Ted Durney, Project Manager  
(703) 669-6515

Subject: Calcium Nitrate Test Report

Dear Mr. Durney:

We are enclosing three (3) copies of our test report for the evaporation of calcium nitrate solutions done in our laboratory on September 4th and 5th of this year.

The solutions were mixed according to instructions in your August 18, 1992 letter and processed first in our rising film pilot plant evaporator and then moved to our 4-liter evaporator in order to complete the evaporation with the remaining limited volume of material. The necessary data for design of a pilot plant and commercial scale equipment was obtained and is reported in the accompanying report.

Our design group is now in the process of preparing a firm quotation for the pilot plant unit and a budget price for the commercial scale unit. We will advise you of the submittal date in the very near future. We wish to thank you for the opportunity of conducting this testwork and look forward to working with you on this project. Should you have any questions regarding our test report, please do not hesitate to contact the writer.

Very truly yours,

SWENSON

Louis F. LaPosa, P.E.  
Sales Manager  
Swenson East

LFL/bh  
Enclosures

5/sls/CoalTech.LFL

Direct Dial No. 708-210-5069





# SWENSON

## SWENSON 4 LITER JAR TEST

PAGE: ONE

MATERIAL: CALCIUM NITRATE  
 COMPANY: COAL TECHNOLOGY CORPORATION  
 DATE: SEPTEMBER 4, 1992  
 TEST NUMBER: ONE  
 FILE NUMBER: S-6295

### FEED MATERIAL INFORMATION:

SPECIFIC GRAVITY: 1.036 @ 68.0 F.  
 TOTAL DISSOLVED SOLIDS: -----  
 VISCOSITY: 2.98 cps. @ 68.0 F.  
 START UP B.P.E.: 0.0 F.  
 START UP pH: 6.0

REMARKS: Feed make up:                   14,754.0 grams - Distilled Water  
   896.4 grams - Calcium Nitrate

-----  
 15,650.4                   - Total Feed

First stage of evaporation will be done in the wall mounted rising film evaporator.

### RISING FILM EVAPORATOR

TIME	LIQUOR DISCH. TEMP. F.	HEATER PRESS. psig	BAR. PRESS. in/Hg.	EVAP. RATE Liters	B.P.E.	SP. GR. DISCH.
0930	212.0	12.50	29.75	---	0.0	1.008
0950	212.0	8.50	29.75	3.0	0.0	1.032
1015	213.0	8.75	29.75	7.5	1.0	1.050
1030	215.0	9.25	29.75	10.5	3.0	1.108
1040	220.0	9.50	29.75	12.6	8.0	1.240

REMARKS: 0930: Start evaporating. unit will be run at atmospheric pressure.  
 0950: Twenty minutes into operation, three liters of condensate removed.  
 1040: With just a little over 1.5 liters left, moved operation to the glass jar evaporator.



# SWENSON

## SWENSON FOUR LITER JAR TEST REPORT

Material: CALCIUM NITRATE

Company: COAL TECHNOLOGY

Page: TWO  
Date: 9/4/92

TIME	LIQUOR TEMP. ° F.	V.H.P. in/Hg.	BAR. PRESS. in/Hg.	CUM. COND. REMOVED	B.F.E. ° F.	pH COND.
1300	229.6	1.5	29.80	---	20.6	----
1340	230.1	1.2	29.80	60	20.6	----
1500	231.2	1.1	29.80	150	21.2	----
1530	231.4	1.0	29.80	175	21.4	8.69

REMARKS: 1300: Started boiling, agitator speed set at 450 rpm..  
 1500: Approximately 150 cc's. of condensate off. 1.288 sp. gr.  
 1530: Removed 175 cc's. of condensate, 1.306 sp. gr..  
 shut down to go total reflux. No crystals present.

### TOTAL REFLUX VACUUM COOLING / BOILING POINT CHECK 9/5/92

TIME	LIQUOR TEMP. ° F.	V.H.P. in/Hg.	BAR. PRESS. in/Hg.	B.P.E. ° F.
0845	179.9	19.4	30.02	11.9
0855	149.9	24.5	30.02	11.9
0915	113.3	27.7	30.02	7.0

REMARKS: After boiling points were checked, unit was shut down, and the following physical data was taken on the liquor.

1375 cc's. of liquor left °  
 1.310 Specific Gravity at 70.0 F.  
 5.88 Centipoise at 70.0 F.  
 4.77 pH

Samples were sent to customers marked as follows.  
 2 - bottles Final Mother Liquor  
 1 - bottle Condensate (composite)  
 1 - bottle Original Feed.

# Appendix C

**Acid Problem Associated  
With Calcium Nitrate Solution  
Evaporation and the  
Preventing Method**

Submitted to:

**Coal Technology Corporation  
103 Thomas Road  
Bristol, VA 24201**

Submitted by:

**J. Y. Hwang and X. Wang  
Institute of Materials Processing  
Michigan Technological University  
1400 Townsend Drive  
Houghton, MI 49931-1295**

November 3, 1992

## 1. Problem Characterization

Industrial grade calcium nitrate was evaluated to characterize the pH change problem associated with evaporation of calcium nitrate solution from specific gravity of 1.05 to 1.35.

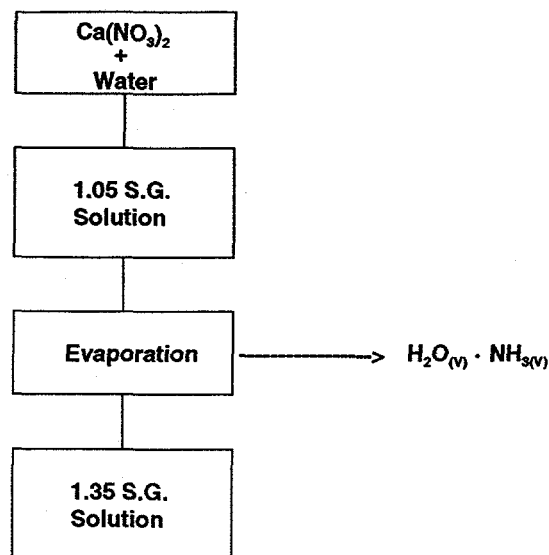
The composition of the industrial grade calcium nitrate, obtained from Mr. Peter Suardini of Process Technology, Inc., has 70-80%  $\text{Ca}(\text{NO}_3)_2$ , 5-6%  $\text{NH}_4\text{NO}_3$ , and 15-16%  $\text{H}_2\text{O}$ . A solution of this material may release ammonia vapor when heated and leave nitric acid in solution according to the following reaction:



Nitric acid is a strong acid and a strong oxidant. It should be avoided to have this acid in the media recovering process.

Experiments to verify this problem were conducted following the flowchart shown in Figure 1. Industrial grade calcium nitrate was dissolved in water to make up a solution with 1.05 specific gravity. The pH of the solution is 5.58 and the concentration of ammonia is 1180 ppm in the solution. After boiling the solution to increase the specific gravity to 1.35 by evaporating the excess water (about 89% in volume) the pH of the 1.35 S.G. solution becomes 2.41 and the ammonia concentration increases to 10,200 ppm in the 1.35 S.G. solution.

FIGURE 1. Flowchart of Evaporation Test



This experiment shows that most ammonia (about 96%) stayed in the heavy liquid solution. However, the small amount of ammonia evaporated is sufficient to result in a strong acid condition.

2. Remove Ammonia from Calcium Nitrate

To eliminate strong acid problem, one possibility is to release ammonia from the dry solids of the industrial grade calcium nitrate. This approach would also provide the advantage of getting more consistent calcium nitrate feed during the process. Heating the solids directly involves the treatment of a small amount of material and can yield an ammonia compound in good purity as a by-product.

A series of experiments was carried out to determine the feasibility of driving off ammonia from the solids. In each experiment, 30 grams of industrial grade calcium nitrate were heated in an oven at a temperature for an hour. After heating, the residual solids were added to 200 ml water. The ammonia concentration in the solution was then measured. The results are shown in Table 1.

TABLE 1 Removal of Ammonia from Industrial Grade Calcium Nitrate by Heating			
Test	Heating		Ammonia Conc. (ppm)
	Temp. C	Time, min	
1	25	--	1100
2	250	60	1110
3	300	60	130
4	350	60	120
5	446	60	20

To drive off ammonia from calcium nitrate, it is necessary to heat the compound at temperatures above 250°C. The results shown in Table 1 suggest that it would be preferable to heat at a temperature of about 450°C.

3. Recycling of Treated Calcium Nitrate

To confirm the effectiveness of the treatment on avoiding the acid problem, an experiment following the procedures shown in Figure 1 was conducted again using the treated calcium nitrate. A large amount of calcium nitrate was heated to 450°C for an hour to prepare the feed.

The pH of the 1.05 specific gravity solution using the treated calcium nitrate is 7.02. This neutral pH indicates that ammonia nitrate, instead of ammonia, has been evaporated. Thus, nitric acid is not left in the calcium nitrate and would not bring pH of

the 1.05 solution to a strong acid condition. After boiling the solution to 1.35 specific gravity and cool down, the pH of the 1.35 S.G. solution becomes 5.38. This pH is in the mild acid range and is about the same as the original untreated calcium nitrate solution at 1.05 S.G. A very small amount of lime or sodium hydroxide will be able to neutralize. The ammonia concentration in the 1.05 S.G. solution is 23 ppm. After evaporation, it increases to 40 ppm in the 1.35 S.G. solution. This ammonia level is believed to be too low to cause any problem in operation.

# Appendix D



Kamesh/ALDevernoe

## Ferrofluid Cyclone -- some quick observations

•The radial velocity of particles is significantly affected by the applied magnetic field strength, and by the number of pole pairs. The magnetic force in the region near the central axis decreases with increase of number of pole pairs, while in the zone near the magnetic poles it increases sharply. Therefore, a more uniform distribution of magnetic field strength can be achieved by reducing the number of pole pairs. In the IGC's design, with six pole pairs, it is possible that there is a high magnetic field strength near the cyclone wall, and little or no magnetic field strength a few mm from the wall.

•The maximum size of a feed particle should be finer than the d50 of the cyclone, if the effect of the magnetic field is to control the separation. In the IGC's cyclone, the feed size (<150 mesh) is much coarser than d50, under the operating conditions used.

•There is a limiting value of the mean inlet velocity (approximately 2 m/s), above which the effect of magnetic field strength may become insignificant, again for feed sizes finer than the d50.

•The rheology of the ferrofluid under the influence of the magnetic field is also very important. Further, the extreme fines in the coal will form part of the ferrofluid medium, and will influence its rheology. It is known that for magnetite concentrations above about 18% by volume, the ferrofluid behaves as pseudoplastic under the influence of applied magnetic field. In the absence of a magnetic field, the fluid behaves as Newtonian. The concentration of the magnetic particles in IGC's ferrofluid is far below this limit, (assumed <4-6% by volume) and therefore the fluid is considered to behave as Newtonian both with and without the application of magnetic field.

•The arrangement of the magnet zone in the IGC's cyclone is such that there is no magnetic field at the entry and discharge ends of the cyclone cylinder. It is likely that particles already separated under the influence of the magnetic force field again get mixed up at the discharge end of the cyclone.

•For  $v_{rp} > v_{rf}$ , the particle moves towards the wall; for  $v_{rp} < v_{rf}$ , the particle moves towards the center; for  $v_{rp} = v_{rf}$ , the particle simply rotates at equilibrium, and will follow the local stream. The fluidflow patterns -- specifically the locus of zero axial velocity and the zone of zero radial velocity -- are to be known, if the fate of a particle has to be predicted with precision. For an unconventional cyclone design as used, and for a ferrofluid under the influence of applied magnetic field -- such information is non-existing.

•The separation density is strongly dependent on the volume split, which in turn depends on the ratio of the apex and vortex (inlet) diameters. Therefore, the underflow opening should be made a variable. The diameter of the air-core depends on the inlet velocity. At low velocities, the aircore will be of a smaller diameter, and as the inlet velocity is increased, the aircore increases in diameter upto a limit. If the size of the apex is smaller than the aircore diameter, there will be no underflow. Thus, the volume split is affected. Attempts to cause a variation in the aircore diameter by blowing air through the apex or by inducing back pressure are known to disturb the velocity profile in the cyclone. In a cylindrical cyclone, laser velocimetric studies have shown multiple recirculations in the axial direction. Unless the magnetic field near the core of the cyclone is strong enough, there is a great likelihood for a major radial inflow near the cyclone bottom -- resulting in misplaced particles.

....page 1 of 2....

•The flow pattern in the magstream is a forced vortex. Its success indicates the desirability of having a similar forced vortex condition in a ferrofluidic cyclone for a good selectivity. A totally cylindrical cyclone, a long vortex finder, and a fluid which is dilatant -- all these conditions which are traditionally considered undesirable for a cyclone for density separations and classifications, seem to offer favorable performance in the case of a ferrofluid cyclone. However, by properly balancing the magnetic force field and the centrifugal force field one should be able obtain a desired separation.

•The subject of ferrofluid cyclone is more complicated than that of the usual dense liquid cycloning. The scientific issues are quite involved and require a thorough study through intensive basic research, before any developmental work can be taken up.

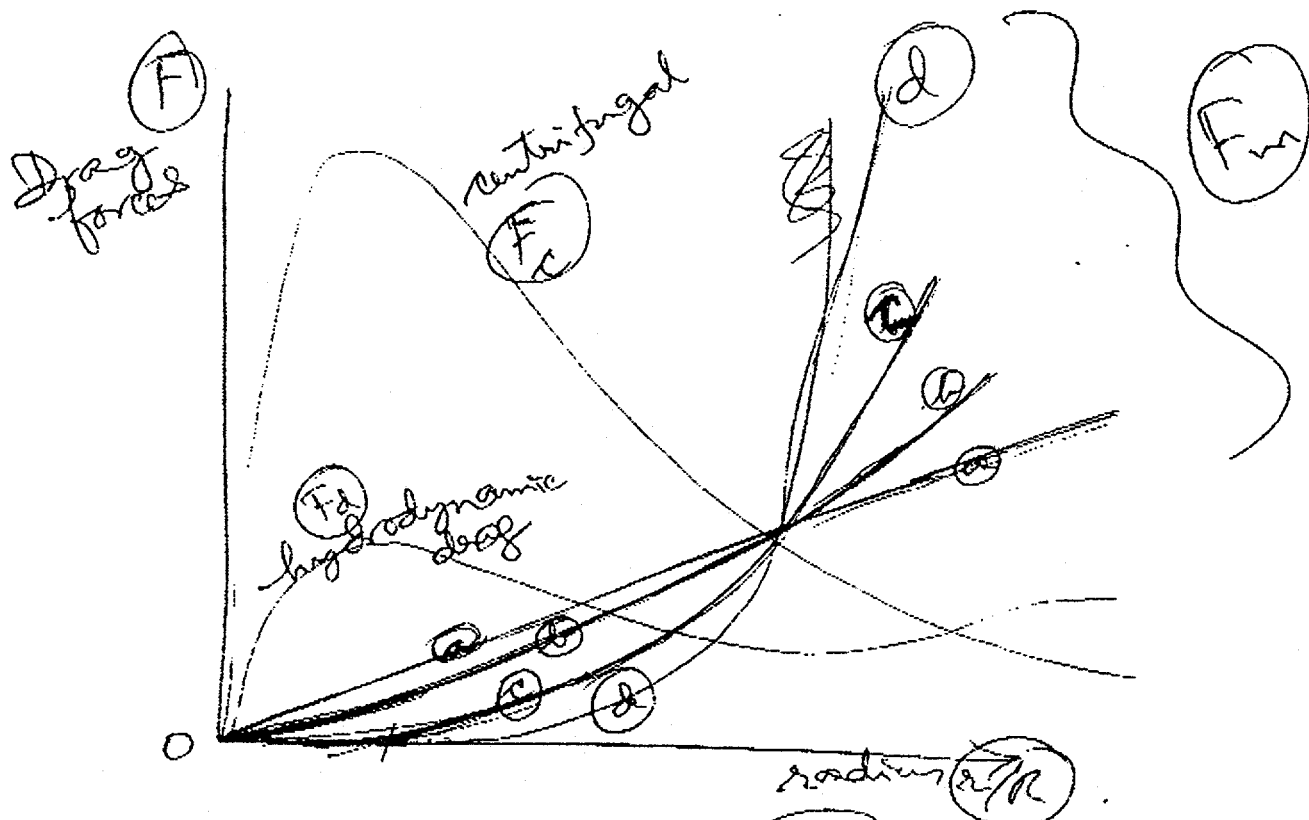
•Though the economics may not be favorable for a low density application as coal, the technology has a great future for separation densities greater than about 2.0.

Kamesh Upadrashta / 10.12.91

28

$$H = H_0 \cdot \left( \frac{r}{R} \right)^{\beta-1}$$

$\beta = \text{no. of pole-pairs}$



- example
- $a-a \rightarrow$  linear variation, 2 pole-pairs
  - $b-b \rightarrow$  3 pole-pairs
  - $c-c \rightarrow$  6 pole-pairs, 4
  - $d-d \rightarrow$  8 pole-pairs



**INTERMAGNETICS GENERAL**  
CORPORATION

PANAFAX TRANSMITTAL

No. 1773

FROM: A.L.Devernoe

DATE: 10/01/91

TO: Kamesh Uphradashta

TELECOPY No. (612) 379-3919

FIRM: PRAD

TELECOPY RESPONSE No. (518) 456-0590

SUBJECT: Magstream Cyclone Test Data Summary

PAGES BEING SENT INCLUDING THIS PAGE: 7

---

IF THERE ARE ANY PROBLEMS RECEIVING THIS TRANSMISSION, PLEASE CALL  
PAT SZCZESNIAK IMMEDIATELY. THANK YOU.

---

Attached is an up to date summary of our test data. Regarding the configurations, you already have sketches of alternates "a" and "b" and the table identifies the length and diameter of the vortex finder used for each data point. In all cases except configurations "c" and "d", the underflow outlet was 0.402" id. I will fill you in on the c and d configurations when you come here next week. Please note that the "b" configuration will cleanly separate an artificial mixture of waste coal when used with Certigrav. media but that no separation is observed (both overflow and underflow products of same SG grade) when similar flow conditions used with magnetic media.

I will be traveling for the next 2 days but expect to be back in my office on Friday if you wish to talk before leaving Minneapolis. Otherwise, I will pick you up in Albany at your arrival gate (Ted Durney will give me your flight number) Sunday evening. If something comes up to change your travel schedule, please call. My office number is (518) 456-5456 ext 3042 and my home number is (518) 374-5910.

Good luck and have a safe trip.

Copies: Ted Durney CTC.

Cyclone Feed Test Mat'l Config. tstd	Test No.	Fluid M <sub>f</sub> (emu)	Inlet Flow (l/m)	Inlet Press (psi)	Inlet Vel. (c/s)	Flo-Rate % distr. OF / UF	Prod Wt. % distr. OF / UF	Notes
A47	S+1.35	529-1	0.6	40	n/r	342	80/20	14/85
A47	S-1.35	529-5	"	"	"	"	"	22/78
A47	S+1.35	529-2	"	"	"	"	90/10	12/88
A47	S-1.35	529-6	"	"	"	"	"	23/77
A47	S+1.35	529-3	"	24	"	205	67/33	24/76
A47	S-1.35	529-7	"	"	"	"	"	33/67
A47	S+1.35	529-4	"	"	"	"	83/17	26/74
A47	S-1.35	529-8	"	"	"	"	"	36/64
A47	S+1.35	530-1	1.2	40	"	342	80/20	43/57
A47	S-1.35	530-5	"	"	"	"	"	56/44
A47	S+1.35	530-2	"	"	"	"	90/10	54/46
A47	S-1.35	530-6	"	"	"	"	"	63/37
A47	S+1.35	530-3	"	24	"	205	67/33	64/36
A47	S-1.35	530-7	"	"	"	"	"	84/16
A47	S+1.35	530-4	"	"	"	"	83/17	79/21
A47	S-1.35	530-8	"	"	"	"	"	92/08
A55i	S+1.35	619-1	0.8	32	"	429	75/25	28/72
A55i	S-1.35	618-1	"	"	"	"	"	42/58
A55i	S+1.35	619-6	0.8	30	"	403	67/33	24/76
A55i	S-1.35	618-6	"	"	"	"	"	41/59
A55i	S+1.35	619-2	"	"	"	"	75/25	28/72
A55i	S-1.35	618-2	"	"	"	"	"	47/53
A55i	S+1.35	619-7	"	"	"	"	80/20	26/74
A55i	S-1.35	618-7	"	"	"	"	"	43/57
A55i	S+1.35	619-8	"	"	"	"	83/17	25/75
A55i	S-1.35	618-8	"	"	"	"	"	43/57
A55i	S+1.35	619-3	0.8	28	"	376	75/25	29/71
A55i	S-1.35	618-3	"	"	"	"	"	45/55
A55i	S+1.35	619-4	"	26	"	349	"	29/71
A55i	S-1.35	618-4	"	"	"	"	"	46/54
A55i	S+1.35	619-5	"	24	"	322	"	29/71
A55i	S-1.35	618-5	"	"	"	"	"	50/50
A55i	S+1.35	620-4	1.6	30	"	403	67/33	50/50
A55i	S-1.35	620-1	"	"	"	"	"	83/17
A55i	S+1.35	620-5	"	"	"	"	80/20	73/27
A55i	S-1.35	620-2	"	"	"	"	"	93/07
A55i	S+1.35	620-6	"	"	"	"	86/14	79/21
A55i	S-1.35	620-3	"	"	"	"	"	96/04

10/01/91

Cyclone Feed Test Mat'l Config. tstd	Test No.	Fluid Inlet M <sub>f</sub> (emu)	Inlet Flow (l/m)	Inlet Press (psi)	Inlet Vel. (c/s)	Flo Rate % distr. OF / UF	Prod Wt. % distr. OF / UF	Notes
B55	S+1.35	514-1	0.6	40	n/r	342	80/20	35/65
B55	S+1.35	514-2	"	"	"	"	90/10	43/57
B55	S+1.35	514-3	"	24	"	205	67/33	39/61
B55	S+1.35	611-1	0.8	36	"	308	75/25	47/53
B55	S-1.35	610-1	"	"	"	"	"	64/36
B55	S+1.35	611-2	"	34	"	290	"	67/33
B55	S-1.35	610-2	"	"	"	"	"	72/28
B55	S+1.35	611-3	"	32	"	273	"	46/54
B55	S-1.35	610-3	"	"	"	"	"	73/27
B55	S+1.35	611-5	"	30	"	256	67/33	51/49
B55	S-1.35	610-5	"	"	"	"	"	67/33
B55	S+1.35	611-4	"	"	"	"	75/25	53/47
B55	S-1.35	610-4	"	"	"	"	"	80/20
B55	S+1.35	611-6	"	"	"	"	80/20	53/47
B55	S-1.35	610-6	"	"	"	"	"	82/18
B55	S+1.35	611-7	"	"	"	"	83/17	55/45
B55	S-1.35	610-7	"	"	"	"	"	86/14
B55i	S+1.35	617-1	"	32	"	429	75/25	45/55
B55i	S-1.35	614-1	"	"	"	"	"	67/33
B55i	S+1.35	617-6	"	30	"	403	67/33	41/59
B55i	S-1.35	614-6	"	"	"	"	"	61/39
B55i	S+1.35	617-2	"	"	"	"	75/25	48/52
B55i	S-1.35	714-2	"	"	"	"	"	72/28
B55i	S+1.35	617-7	"	"	"	"	80/20	49/51
B55i	S-1.35	614-7	"	"	"	"	"	74/26
B55i	S+1.35	617-8	"	"	"	"	83/17	49/51
B55i	S-1.35	614-8	"	"	"	"	"	75/25
B55i	S+1.35	617-3	"	28	"	376	75/25	52/48
B55i	S-1.35	614-3	"	"	"	"	"	73/27
B55i	S+1.35	617-4	"	26	"	349	75/25	54/46
B55i	S-1.35	614-4	"	"	"	"	"	73/27
B55i	S+1.35	617-5	"	24	"	322	75/25	57/43
B55i	S-1.35	614-5	"	"	"	"	"	75/25
B45	S+1.35	514-4	"	40	"	342	80/20	25/75
B45	"	514-3	"	"	"	"	"	27/73
B45	S-1.35	516-1	"	"	"	"	"	40/60
B45	S+1.35	514-5	"	"	"	"	90/10	34/66
B45	S-1.35	516-2	"	"	"	"	"	59/41
B45	S+1.35	604-1	"	24	"	205	83/17	66/34
B45	"	604-5	"	"	"	"	"	58/42
B45	S-1.35	516-3	"	"	"	"	"	71/29
B45	S+1.35	604-2	"	"	"	"	92/08	80/20
B45	"	604-6	"	"	"	"	"	70/30
B45	S-1.35	516-4	"	"	"	"	"	72/28
B45	S+1.35	514-6	"	"	"	"	67/33	34/66
B45	S+1.35	514-8	"	48	"	410	62/38	23/77
B45	S+1.35	515-1	"	"	"	"	"	27/73

Cyclone Feed		Fluid Inlet		Inlet	Inlet	Flo Rate	Prod Wt.		Notes
Test Config.	Mat'l tstd	Test No.	M <sub>f</sub> (emu)	Flow (l/m)	Press (psi)	Vel. (c/s)	% distr. OF / UF	% distr. OF / UF	
B45	S+1.35	607-1	0.8	36	n/r	308	75/25	40/60	
B45	S-1.35	605-1	"	"	"	"	"	56/44	c
B45	"	606-1	"	"	"	"	"	55/45	
B45	S+1.35	604-3	0.6	32	"	273	89/11	54/46	
B45	"	604-7	"	"	"	"	"	48/52	c
B45	"	604-4	"	"	"	"	94/06	76/24	
B45	"	604-8	"	"	"	"	"	69/31	c
B45	S-1.35	605-5	0.8	"	"	"	83/17	71/29	c
B45	S+1.35	607-2	"	"	"	"	75/25	40/60	
B45	S-1.35	605-2	"	"	"	"	"	70/30	c
B45	"	606-2	"	"	"	"	"	60/40	
B45	"	605-4	"	"	"	"	67/33	48/52	
B45	S+1.35	607-5	"	28	"	239	83/17	49/51	
B45	S-1.35	606-5	"	"	"	"	"	77/23	
B45	S-1.35	605-3	"	"	"	"	75/25	64/36	c
B45	"	606-3	"	"	"	"	"	70/30	
B45	S+1.35	607-4	"	"	"	"	67/33	46/54	
B45	S-1.35	606-4	"	"	"	"	"	66/34	
B35	S+1.35		H <sub>2</sub> O		8.0		50/50	07/93	
B35	"		"				83/17	11/89	
B35	"		"				87/13	12/88	
B35	S+1.35		1.45	41	8.0		68/32	02/98	
B35	S-1.35		"	"	"		"	100/00	
B35	60/40 Mix		"	"	"		"	46/54	
B35	S+1.35		"	"	9.0		66/34	00/100	
B35	S-1.35		"	"	"		"	100/00	
B35	S+1.35		"	"	10.0		59/41	00/100	
B35	S-1.35		"	"	"		"	100/00	
B35	60/40 Mix		"	"	"		"	62/38	
B35	"		"	"	"		"	59/41	

Cyclone Feed		Fluid Inlet		Inlet	Inlet	Flo Rate	Prod Wt.	Notes
Test Config.	Mat'l tstd	Test No.	M <sub>f</sub> (emu)	Flow (l/m)	Press (psi)	Vel. (c/s)	% distr. OF / UF	
B35i	S+1.35	n24-1	0.8	45	5.0		72/28	
B35i	"	n24-2	"	43	"		60/40	
B35i	"	n24-3	"	41	4.0		64/36	
B35i	"	n24-4	"	40	"		63/37	
B35i	"	n24-5	"	30	2.0		69/31	
B35i	"	n24-6	"	31	"		54/66	
B35i	"	n24-7	"	uf- 9	2.0		33/67	bp
B35i	"	n24-8	"	uf-14	"		19/81	bp
B35i	"	n24-9	"	uf- 9	5.0		30/70	bp
B35i	"	n2410	"	uf-11	"		20/80	bp
B35i	"	n2411	"	uf-13	"		25/75	bp
B35i	"	n2412	"	uf-14	"		17/83	bp
B35i	"	n2413	"	uf- 9	9.0		27/73	bp
B35i	"	n2414	"	uf-11	"		30/70	bp
B35i	"	n2415	"	uf-13	"		25/75	bp
B35i	"	n2416	"	uf-14	"		18/82	bp
B35i	"	n2417	"	uf- 9	10		31/69	bp
B35i	"	n2418	"	uf-11	"		25/75	bp
B35i	"	n2419	"	uf-13	"		21/79	bp
B35i	"	n2420	"	uf-14	"		17/83	bp
B35i	S-1.35	814-1	0.8	44	4.8		64/36	
B35i	"	814-2	"	"	"		68/32	
B35i	"	814-3	"	45	5.2		73/27	
B35i	"	814-4	"	41	4.0		72/28	
B35i	"	814-5	"	37	3.0		68/32	
B35i	S-1.35	819-1	0.56	48	4.5		81/19	
B35i	"	819-2	"	42	4.0		79/21	
B35i	"	819-3	"	40	3.5		"	
B35i	"	820-1	"	41	4.3		76/24	
B35i	"	820-2	"	37	3.3		"	
B35i	"	820-3	"	32	2.3		75/25	



Cyclone Feed		Fluid Inlet		Inlet	Inlet	Flo Rate	Prod Wt.		Notes
Test	Mat'l	Test	M <sub>f</sub>	Flow	Press	Vel. % distr.	% distr.		
Config.	tstd	No.	(emu)	(l/m)	(psi)	(c/s) OF / UF	OF / UF	OF / UF	
B35i	#6+100M	904-1	1.0	36	2.8		75/25	52/48	
B35i	"	904-2	"	30	1.8		"	57/43	
B35i	"	904-3	"		0.8		"	67/33	
C35i	"	906-1	"		3.3		"	88/12	d
C35i	"	906-2	"		2.3		"	92/08	d
C35i	"	906-3	"		1.3		"	94/06	d
D35	"	912-1	"	36	6.0		"	08/92	e
D35	"	912-2	"		5.0		"	10/90	e
D35	"	912-3	"		4.0		"	09/91	e
D35	"	912-4	"		3.0		"	11/89	e
B35i	#6+100M	910-A	4+	40	10		56/44	65/35	bp
B35i	"	910-B	"	"	"		64/36	68/32	bp
B35i	"	910-C	"	"	"		69/31	69/31	bp
B35i	"	910-D	"	"	"		75/25	79/21	bp
B35i	"	911D1	"	"	"		"	80/20	bp
B35i	"	911D2	"	"	"		"	79/21	bp
B35i	"	911D3	"	"	"		"	79/21	bp
B35i	"	911D4	"	"	"		"	78/22	bp
B35i	"	911D5	"	"	"		"	78/22	bp
B35i	"	910-O	"	"	"		90/10	90/10	bp
B35i	"	910-R	"	"	"		95/05	95/05	bp
B35i	"	910-E	"	"	7		63/37	66/34	bp
B35i	"	910-F	"	"	"		68/32	70/30	bp
B35i	"	910-G	"	"	"		72/28	74/26	bp
B35i	"	910-H	"	"	"		76/24	80/20	bp
B35i	"	910-N	"	"	"		90/10	90/10	bp
B35i	"	910-Q	"	"	"		95/05	96/04	bp
B35i	"	910-I	"	30	3		61/39	75/25	bp
B35i	"	910-J	"	"	"		63/37	75/25	bp
B35i	"	910-K	"	"	"		68/32	78/22	bp
B35i	"	910-L	"	29	"		72/28	84/16	bp
B35i	"	910-M	"	uf-4	"			93/07	bp
B35i	"	910-N	"	uf-2	"			97/03	bp
A35i	#6+100M	916-1	1.0		3.7		77/23	12/88	
A35i	#6+100M	916-2	"		2.7		"	14/86	
A35i	#6+100M	916-3	"		1.7		"	16/84	

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Notes: 1) Test Mixtures      a) S+1.35 Waste Coal Heavies plus 1.35 SG  
                                  b) S-1.35 Waste Coal Lights minus 1.35 SG  
                                  c) 60/40 Mix - mix of waste coal lights and  
                                  heavies (+- 1.35 SG) in 60/40 ratio.  
                                  d) #6+100M Illinois N0. 6 plus 100 Mesh

2) Configuration Code: XYZ\_

X = Configuration A,B,C or D  
 Y = Dia. of Vortex finder in 1/4" incr., ie; 3 = 3/4"od  
 Z = Length of Vortex Finder in inches.  
 = If "i", indicates inlet nozzle dia. of 0.50"  
 otherwise, inlet dia. equals 0.62"

3) Notes:            c = inclined 30° from horizontal  
                          d = special internal config.  
                          e = solid feed separate from fluid recycle  
                          bp= backpressure control at overflow discharge

4) Coal Product Grades for mixtures determined first by optical      c  
 omparison to true Heavy Liquid products, then by Heavy Liquids      if  
 warranted. Overflow and Underflow products from D1 thru D5      seq  
 uence assayed by H.L. to show no upgrading from separation.      Tes  
 ts on SG graded feeds graded by weight distr. and optical      eva  
 luation.