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RESPONSE MANUAL FOR COMBATING SPILLS OF FLOATING HAZARDOUS CHRIS CHEMICALS

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16. Abstract

Current response technologies for floating hazardous chemicals were organized into a response manual. Technologies for spill containment, vapor suppression, and spill removal were included. A decision-making process was developed and work sheets included in an appendix. Physical properties and response information are also included in an appendix for each of the floating CHRIS chemicals. This information has been organized into a computerized data base for easy access.

17. Key Words

Hazardous Chemicals
Hazardous Substances
Toxic Substances
Spill Response
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METRIC CONVERSION FACTORS

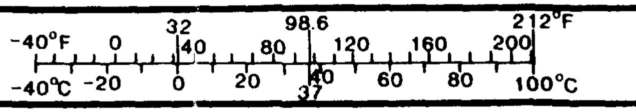
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (WEIGHT)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (EXACT)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures. Price $2.25. SD Catalog No. C13.10.286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (WEIGHT)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (EXACT)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
ACETALDEHYDE	ADD	No
ACETIC ACID	AAC	No
ACETIC ANHYDRIDE	ACA	No
ACETONE	ACT	No
ACETONE CYANOHYDRIN	ACY	No
ACETONITRILE	ATN	No
ACETOPHENONE	ACP	Possibly
ACETYL ACETONE	ATA	Yes
ACETYL BROMIDE	ABM	No
ACETYL CHLORIDE	ACC	No
ACETYLENE	ACE	Yes
ACETYL PEROXIDE SOLUTION	APS	No
ACRIDINE	ACD	No
ACROLEIN	ARL	No
ACRYLAMIDE	AAM	No
ACRYLIC ACID	ACR	No
ACRYLONITRILE	ACN	No
ADIPIC ACID	ADA	No
ADIPONITRILE	ADN	Yes
ALDRIN	ALD	No
ALKYLBENZENESULFONIC ACIDS	ABS	No
ALLYL ALCOHOL	ALA	No
ALLYL BROMIDE	ABR	No
ALLYL CHLORIDE	ALC	Yes
ALLYL CHLOROFORMATE	ACF	No
ALLYL TRICHLOROSILANE	ATC	No
ALUMINUM CHLORIDE	ACL	No
ALUMINUM FLUORIDE	ALF	No
ALUMINUM NITRATE	ALN	No data
ALUMNIUM SULFATE	ALM	No
n-AMINOETHANOLAMINE	AEA	No
2-(2-AMINOETHOXY)ETHANOL	AEX	No data
AMINOETHYL ETHONALAMINE	AEE	No
n-AMINOETHYL PIPERAZINE	AEP	No data
AMMONIA, ANHYDROUS	AMA	No
AMMONIUM ACETATE	AAT	No
AMMONIUM BENZOATE	ABZ	No
AMMONIUM BICARBONATE	ABC	No
AMMONIUM BIFLUORIDE	ABF	No
AMMONIUM BISULFATE	ASU	No
AMMONIUM BROMIDE	ANB	No
AMMONIUM CARBAMATE	ACM	No data
AMMONIUM CARBONATE	ACB	No
AMMONIUM CHLORIDE	AMC	No
AMMONIUM CHROMATE	ACH	No
AMMONIUM CITRATE	ACI	No
AMMONIUM DICHROMATE	AMD	No
AMMONIUM FLUOBORATE	AFB	No
AMMONIUM FLUORIDE	AFR	No

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
AMMONIUM FORMATE	AFM	No
AMMONIUM GLUCONATE	AGC	No data
AMMONIUM HYDROXIDE, 28 PERCENT AQ.	AMH	No
AMMONIUM HYPOPHOSPHITE	AHP	No
AMMONIUM IODIDE	AID	No
AMMONIUM LACTATE	ALT	No
AMMONIUM LAURYL SULFATE	ALS	No
AMMONIUM MOLYBDATE	AMB	No
AMMONIUM NITRATE	AMN	No
AMMONIUM NITRATE - PHOSPHATE MIX	ANP	No
AMMONIUM NITRATE - SULFATE MIX	ANS	No
AMMONIUM NITRATE - UREA SOLUTION	ANU	No
AMMONIUM OLEATE	AOL	No data
AMMONIUM OXALATE	AOX	No
AMMONIUM PENTABORATE	APB	No
AMMONIUM PERCHLORATE	AMP	No
AMMONIUM PERSULFATE	APE	No
AMMONIUM PHOSPHATE	APP	No
AMMONIUM SILICOFLUORIDE	ASL	No
AMMONIUM STEARATE	AMR	No
AMMONIUM SULFAMATE	ASM	No data
AMMONIUM SULFATE	AMS	No
AMMONIUM SULFIDE	ASF	No
AMMONIUM SULFITE	AMF	No
AMMONIUM TARTRATE	ATR	No
AMMONIUM THIOCYANATE	AMT	No
AMMONIUM THIOSULFATE	ATF	No
n-AMYL ACETATE	AML	Yes
sec-AMYL ACETATE	AAS	Yes
tert-AMYL ACETATE	AYA	Yes
n-AMYL ALCOHOL	AAN	Yes
n-AMYL CHLORIDE	AMY	Yes
n-AMYL MERCAPTAN	AMM	Yes
n-AMYL METHYL KETONE	AMK	Yes
n-AMYL NITRATE	ANT	Possibly
iso-AMYL NITRITE	ANI	Yes
AMYL PHTHALATE	ATL	Possibly
n-AMYLTRICHLOROSILANE	ATS	No
ANILINE	ANL	Possibly
ANISOYL CHLORIDE	ASC	No
ANTHRACENE	ATH	No
ANTIMONY PENTACHLORIDE	APC	No
ANTIMONY PENTAFLUORIDE	APF	No
ANTIMONY POTASSIUM TARTRATE	APT	No
ANTIMONY TRIBROMIDE	ATB	No
ANTIMONY TRICHLORIDE	ATM	No
ANTIMONY TRIFLUORIDE	ATT	No
ANTIMONY TRIOXIDE	ATX	No
ARSENIC ACID	ASA	No

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
ARSENIC DISULFIDE	ARD	No
ARSENIC PENTAOXIDE	APO	No
ARSENIC TRICHLORIDE	AST	No
ARSENIC TRIOXIDE	ATO	No
ARSENIC TRISULFIDE	ART	No
ASPHALT	ASP	Possibly
ASPHALT BLENDINGS STOCKS: ROOFERS FLUX	ARF	No
ASPHALT BLENDING STOCKS:STRT.RUN RESIDUE	ASR	No
ATRAZINE	ATZ	No
AZINPHOSMETHYL	AZM	No
BARIUM CARBONATE	BRC	No
BARIUM CHLORATE	BCR	No
BARIUM CYANIDE	BCY	No data
BARIUM NITRATE	BNT	No
BARIUM PERCHLORATE	BPC	No
BARIUM PERMANGANATE	BPM	No
BARIUM PEROXIDE	BPO	No
BENZALDEHYDE	BZD	Possibly
BENZENE	BNZ	Yes
BENZENE HEXACHLORIDE	BHC	No
BENZENE PHOSPORUS DICHLORIDE	BPD	No
BENZENE PHOSPHORUS THIODICHLORIDE	BPT	No
BENZENESULFONYL CHLORIDE	BSC	No
BENZOIC ACID	BZA	No
BENZONITRILE	BZN	Possibly
BENZOPHENONE	BZP	No
BENZOYL CHLORIDE	BZC	No
BENZYL ALCOHOL	BAL	Possibly
BENZYLAMINE	BZM	No
BENZYL BROMIDE	BBR	No
BENZYL-n-BUTYL PHTHALATE	BBP	No
BENZYL CHLORIDE	BCL	No
BENZYL CHLOROFORMATE	BCF	No
BENZYLDIMETHYLOCTA-DECYLAMMONIUM CHLORID	BZO	No
BENZYLTRIMETHYLAMMONIUM CHLORIDE	BMA	No
BERYLLIUM CHLORIDE	BEC	No
BERYLLIUM FLUORIDE	BEF	No
BERYLLIUM, METALLIC	BEM	No
BERYLLIUM NITRATE	BEN	No
BERYLLIUM OXIDE	BEO	No
BERYLLIUM SULFATE	BES	No
BISMUTH OXYCHLORIDE	BOC	No
BISPHENOL A	BPA	No
BISPHENOL A DIGLYCIDYL ETHER	BDE	No
BOILER COMPOUND - LIQUID	BCP	No
BORIC ACID	BAC	No
BORON TRIBROMIDE	BTB	No
BORON TRICHLORIDE	BRT	No
BROMINE	BRX	No

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
BROMINE PENTAFLOURIDE	BPF	No
BROMINE TRIFLUORIDE	BTF	No
BROMOBENZENE	BBZ	No
BRUCINE	BRU	No
BUTADIENE	BDI	Yes
BUTANE	BUT	Yes
1,4-BUTANEDIOL	BDO	No
1,4-BUTENEDIOL	BUD	No
n-BUTYL ACETATE	BCN	Yes
sec-BUTYL ACETATE	BTA	Yes
tert-BUTYL ACETATE	BYA	Yes
iso-BUTYL ACRYLATE	BAI	Yes
n-BUTYL ACRYLATE	BTC	Yes
n-BUTYL ALCOHOL	BAN	No
sec-BUTYL ALCOHOL	BAS	No
tert-BUTYL ALCOHOL	BAT	No
n-BUTYLAMINE	BAM	No
sec-BUTYLAMINE	BTL	No
tert-BUTYLAMINE	BUA	No
BUTYLBENZYL PHTHALATE	BPH	No
BUTYL BUTYRATE	BUB	Yes
BUTYL/DECYL/CETYL-EICOSYL METHACRYLATE	BMM	Yes
BUTYLENE	BTN	Yes
1,2-BUTYLENE OXIDE	BTO	No
n-BUTYL ETHER	BTE	Yes
tert-BUTYL HYDROPEROXIDE	BHP	Yes
n-BUTYL MERCAPTAN	BTM	Yes
iso-BUTYL METHACRYLATE	BMI	Yes
n-BUTYL METHACRYLATE	BMN	Yes
p-tert-BUTYLPHENOL	BTP	Possibly
BUTYLTRICHLOROSILANE	BCS	No
1,4-BUTYNEDIOL	BTD	No
iso-BUTYRALDEHYDE	BAD	Yes
n-BUTYRALDEHYDE	BTR	Yes
n-BUTYRIC ACID	BRA	No
CACODYLIC ACID	CDA	No
CADMIUM ACETATE	CAT	No
CADMIUM BROMIDE	CMB	No
CADMIUM CHLORIDE	CDC	No
CADMIUM FLUOBORATE	CFB	No
CADMIUM NITRATE	CMN	No
CADMIUM OXIDE	COX	No
CADMIUM SULFATE	CMS	No
CALCIUM ARSENATE	CCA	No
CALCIUM ARSENITE	CAS	No data
CALCIUM CARBIDE	CCB	No
CALCIUM CHLORATE	CCC	No
CALCIUM CHLORIDE	CLC	No
CALCIUM CHROMATE	CCR	No

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
CALCIUM CYANIDE	CCN	No
CALCIUM FLUORIDE	CAF	No
CALCIUM HYDROXIDE	CAH	No
CALCIUM HYPOCHLORITE	CHY	No
CALCIUM, METALLIC	CAM	No
CALCIUM NITRATE	CNT	No
CALCIUM OXIDE	CAO	No
CALCIUM PEROXIDE	CCP	No
CALCIUM PHOSPHATE	CAL	No
CALCIUM PHOSPHIDE	CPP	No
CALCIUM RESINATE	CRE	No
CAMPHENE	CPH	Yes
CAMPHOR (OIL)	CPO	Yes
CAPROLACTAM (SOLUTION)	CLS	No
CAPTAN	CPT	No
CARBARYL	CBY	No
CARBOFURAN	CBE	No
CARBOLIC OIL	CBO	No
CARBON DIOXIDE	CDO	No
CARBON DISULFIDE	CBB	No
CARBON MONOXIDE	CMO	Yes
CARBON TETRACHLORIDE	CBT	No
CARENE	CAR	Yes
CATECHOL	CTC	No
CAUSTIC POTASH SOLUTION	CPS	No
CAUSTIC SODA SOLUTION	CSS	No
CETYL EICOSYL METHACRYLATE	CEM	Yes
CHARCOAL	CHC	No
CHLORDANE	CDN	No
CHLORINE	CLX	No
CHLORINE TRIFLUORIDE	CTF	No
CHLOROACETIC ACID	CHL	No
CHLOROACETOPHENONE	CRA	No
CHLOROACETYL CHLORIDE	CAC	No
p-CHLORDANILINE	CAP	No
CHLOROBENZENE	CRB	No
4-CHLOROBUTYRONITRILE	CBN	No
CHLOROFORM	CRF	No
CHLOROHYDRIN (CRUDE)	CHD	No
CHLOROMETHYL METHYL ETHER	CME	No
o-CHLORONITROBENZENE	CNO	No
p-CHLOROPHENOL	CPN	No
CHLOROPICRIN (LIQUID)	CPL	No
CHLOROPRENE	CRP	Yes
2-CHLOROPROPIONIC ACID	CLA	No
3-CHLOROPROPIONIC ACID	CLP	No data
CHLOROSULFONIC ACID	CSA	No
m-CHLOROTOLUENE	CTM	No
o-CHLOROTOLUENE	CTO	No

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
p-CHLOROTOLUENE	CRN	No
4-CHLORO-o-TOLUIDINE	CTD	No
CHROMIC ACETATE	CRT	No data
CHROMIC ANHYDRIDE	CMA	No
CHROMIC SULFATE	CHS	No
CHROMOUS CHLORIDE	CRC	No
CHROMYL CHLORIDE	CMC	No
CITRIC ACID	CIT	No
COBALT ACETATE (OUS) COBALT(II)ACETATE	CBA	No
COBALT BROMIDE(OUS) COBALT(II)BROMIDE	COB	No
COBALT CHLORIDE(OUS) COBALT(II)CHLORIDE	CBC	No
COBALT FLUORIDE(OUS) COBALT(II)FLUORIDE	COF	No
COBALT FORMATE(OUS) COBALT(II)FORMATE	CFM	No
COBALT NITRATE(OUS) COBALT(II)NITRATE	CON	No
COBALT SULFAMATE(OUS) COBALT(II)SULFAMAT	COS	No data
COBALT SULFATE(OUS) COBALT(II)SULFATE	CBS	No
COLLODION	CLD	Yes
COPPER ACETATE(IC) COPPER(II)ACETATE	COP	No
COPPER ACETOARSENITE(IC)	CAA	No
COPPER ARSENITE(IC) COPPER(II)ARSENITE	CPA	No
COPPER BROMIDE(IC) COPPER(II)BROMIDE	CPB	No
COPPER BROMIDE(OUS) COPPER(I)BROMIDE	CBD	No
COPPER CHLORIDE(IC) COPPER(II)CHLORIDE	CPC	No
COPPER CYANIDE(OUS) COPPER(I)CYANIDE	CCY	No
COPPER FLUOBORATE(IC) COPPER(II)FLUOBORA	CPF	No
COPPER FORMATE(IC) COPPER(II)FORMATE	CUF	No
COPPER GLYCINATE	CPG	No
COPPER IODIDE(OUS) COPPER(I)IODIDE	CID	No
COPPER LACTATE(IC) COPPER(II)LACTATE	CLT	No
COPPER NAPTHENATE(IC) COPPER(II)NAPTH	CNN	Possibly
COPPER NITRATE(IC) COPPER(II)NITRATE	CNI	No
COPPER OXALATE(IC) COPPER(II)OXALATE	COL	No
COPPER SUBACETATE(IC) COPPER(II)SUBACETA	CST	No
COPPER SULFATE(IC) COPPER(II)SULFATE	CSF	No
COPPER SULFATE(IC),AMMINIATED	CSN	No
COPPER TARTRATE(IC) COPPER(II)TARTRATE	CTT	No
CORN SYRUP	CSY	No
COUMAPHOS	COU	No
CREOSOTE	CCW	No
CREOSOTE, COAL TAR	CCT	Possibly
m-CRESOL	CRL	No
o-CRESOL	CSL	No
p-CRESOL	CSO	Possibly
CRESOLS	CRS	Possibly
CRESYLATE SPENT CAUSTIC	CSC	No data
CRESYL GLYCIDYL ETHER	CGE	No
CROTONALDEHYDE	CTA	Yes
CUMENE	CUM	Yes
CUMENE HYDROPEROXIDE	CMH	Possibly

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
CUPRIETHYLENEDIAMINE SOLUTION	CES	No
CYANOACETIC ACID	CYA	No
CYANOGEN	CYG	No
CYANOGEN BROMIDE	CBR	No
CYANOGEN CHLORIDE	CCL	No
CYCLOHEXANE	CHX	Yes
CYCLOHEXANOL	CHN	No
CYCLOHEXANONE	CCH	Yes
CYCLOHEXANONE PEROXIDE	CHP	Possibly
CYCLOHEXENE	CYH	Yes
CYCLOHEXENYLTRICLOROSILANE	CHT	No
CYCLOHEXYLAMINE	CHA	No
CYCLOPENTANE	CYP	Yes
CYCLOPROPANE	CPR	Yes
p-CYMENE	CMP	Yes
DALAPON	DLP	No
DDD	DDD	No
DDT	DDT	No
DECABORANE	DBR	Yes
DECAHYDRONAPHTHALENE	DHN	Yes
n-DECALDEHYDE	DAL	Yes
1-DECENE	DCE	Yes
n-DECYL ACRYLATE	DAR	Yes
n-DECYL ALCOHOL	DAN	Yes
n-DECYLBENZENE	DBZ	Yes
DEMETON	DTN	No
2,4-D ESTERS	DES	No
DEXTROSE SOLUTION	DTS	No
DIACETONE ALCOHOL	DAA	No
DIAMMONIUM SALT OF ZINC EDTA(AQ)	DSZ	No data
DI-n-AMYL PHTHALATE	DAP	Yes
DIAZINON	DZN	No
DIBENZOYL PEROXIDE	DPO	No
DIBENZYL ETHER	DBN	Possibly
DI-n-BUTYLAMINE	DBA	Yes
DI-n-BUTYL ETHER	DBE	Yes
DI-n-BUTYL KETONE	DBK	Yes
DIBUTYLPHENOL	DBT	Yes
DIBUTYL PHTHALATE	DPA	Possibly
DICAMBA	DIC	No
DICHLOBENIL	DTB	No
DICHLONE	DCL	No
m-DICHLOROBENZENE	DBM	No
o-DICHLOROBENZENE	DBO	No
p-DICHLOROBENZENE	DBP	No
DI-(p-CHLOROBENZOYL)PEROXIDE	DZP	No
DICHLOROBUTENE	DCB	No
DICHLORODIFLUOROMETHANE	DCF	No
1,1-DICHLOROETHANE	DCH	No

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
1,2-DICHLOROETHYLENE	DEL	No
2,2-DICHLOROETHYL ETHER	DEE	No
DICHLOROISOPROPYL ETHER	DCI	No
DICHLOROMETHANE	DCM	No
DICHLOROMONOFLUOROMEHTANE	DFM	No
2,4-DICHLOROPHENOL	DCP	No
2,4-DICHLOROPHENOXYACETIC ACID	DCA	No
1,1-DICHLOROPROPANE	DPB	No
1,2-DICHLOROPROPANE	DPP	No
1,3-DICHLOROPROPANE	DPC	No
1,3-DICHLOROPROPENE	DPR	No
2,3-DICHLOROPROPENE	DPF	No
DICHLOROPROPENE,DICHLOROPROPANE MIXTURE	DMX	No
2,2-DICHLOROPROPIONIC ACID	DCN	No
DICHLOROTETRAFLUOROETHANE	DTE	No
4,4-DICHLORO-al-TRICHLOROMETHYLBENZYHDRO	DTM	Yes
DICHLOROVOS	DCV	No
DICYCLOPENTADIENE	DPT	Yes
DIELDRIN	DED	No
DIETHANOLAMINE	DEA	No
DIETHYLAMINE	DEN	No
DIETHYLBENZENE	DEB	Yes
DIETHYL CARBONATE	DEC	Yes
DIETHYLENE GLYCOL	DEG	No
DIETHYLENE GLYCOL DIMETHYL ETHER	DGD	No
DIETHYLENE GLYCOL MONOBUTYL ETHER ACETAT	DEM	Yes
DIETHYLENE GLYCOL MONOBUTYL ETHER	DME	No
DIETHYLENE GLYCOL MONOETHYL ETHER	DGE	No
DIETHYLENE GLYCOL MONOMETHYL ETHER	DGM	No
DIETHYLENETRIAMINE	DET	No
DIETHYLETHANOL AMINE	DAE	No
DI-(2-ETHYLHEXYL)PHOSPHORIC ACID	DEP	Yes
DIETHYL KETONE	DEK	Yes
DIETHYL PHTHALATE	DPH	No
DIETHYL SULFATE	DSU	No
DIETHYLZINC	DEZ	No
1,1-DIFLUOROETHANE	DFE	Yes
DIFLUOROPHOSPHORIC ACID, ANHYDROUS	DFA	No
DIHEPTYL PHTHALATE	DHP	Possibly
DIISOBUTYLAMINE	DBU	Yes
DIISOBUTYLCARBINOL	DBC	Yes
DIISOBUTYLENE	DBL	Yes
DIISOBUTYL KETONE	DIK	Yes
DIISOBUTYL PHTHALATE	DIT	Possibly
DIISODECYL PHTHALATE	DID	Yes
DIISONONYL PHTHALATE	DIN	Possibly
DIISOOCTYL PHTHALATE	DIO	Possibly
DIISOPROPANOLAMINE	DIP	No
DIISOPROPYLAMINE	DIA	No

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
DIISOPROPYLBENZENE HYDROPEROXIDE	DIH	Yes
DIMETHYLACETAMIDE	DAC	No
DIMETHYLAMINE	DMA	No
N,N-DIMETHYLCYCLOHEXYLAMINE	DXN	No
DIMETHYLDICHLOROSILANE	DMD	No
DIMETHYLETHANOLAMINE	DMB	No
DIMETHYL ETHER	DIM	No
DIMEHTYLFORMAMIDE	DMF	No
DIMETHYLHEXANE DIHYDROPEROXIDE,WET	DDW	No
1,1-DIMETHYLHYDRAZINE	DMH	No
2,2-DIMETHYL OCTANOIC ACID	DMO	Yes
DIMETHYL PHTHALATE	DTL	No
DIMETHYLPOLYSILOXANE	DMP	Yes
DIMETHYL SULFATE	DSF	No
DIMETHYL SULFIDE	DSL	Yes
DIMETHYL SULFOXIDE	DMS	No
DIMETHYL TEREPHTHALATE	DMT	No
DIMETHYL ZINC	DMZ	No
2,4-DINITROANILINE	DNT	No
DINITROBENZENE	DN	No
m-DINITROBENZENE	DNB	No
o-DINITROBENZENE	DNO	No
DINITROCRESOLS	DNC	No
2,4-DINITROPHENOL	DNP	No
2,5-DINITROPHENOL	DNF	No
2,6-DINITROPHENOL	DNH	No data
2,4-DINITROTOLUENE	DTT	No
2,6-DINITROTOLUENE	DNL	No
3,4-DINITROTOLUENE	DNU	No
DIOCTYL ADIPATE	DOA	Yes
DIOCTYL PHTHALATE	DOP	Yes
DIOCTYL SODIUM SULFOSUCCINATE	DSS	No
1,4-DIOXANE	DOX	No
DIPENTENE	DPN	Yes
DIPHENYLAMINE	DAM	No
DIPHENYLDICHLOROSILANE	DPD	No
DIPHENYL ETHER	DPE	No
DIPHENYLMETHANE DIISOCYANATE	DPM	No
DI-n-PROPYLAMINE	DNA	Yes
DIPROPYLENE GLYCOL	DPG	No
DIQUAT	DIQ	No data
DISTILLATES: FLASHED FEED STOCKS	DFF	Yes
DISTILLATES: STRAIGHT RUN	DSR	Yes
DISULFTON	DIS	No
DIUNDECYL PHTHALATE	DUP	Possibly
DIURON	DIU	No
DODECANOL	DDN	Yes
DODECENE	DOD	Yes
1-DODECENE	DDC	Yes

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
DODECYLBENZENE	DDB	Yes
DODECYL BENZENE SULFONIC ACID	DSA	No
DODECYLBENZENESULFONIC ACID,CALCIUM SALT	DCS	Possibly
DODECYLBENZENESULFONIC ACID,ISOPROPYLAMI	DAI	No
DODECYLBENZENESULFONIC ACID, SODIUM SALT	DAS	No
DODECYLBENZENESULFONIC ACID,TRIETHANOLAM	DBS	No
DODECYLDIPHENYL OXIDE DISULFONATE	DOS	No data
DODECYLMETHACRYALATE	DDM	Yes
DODECYL PENTA DECYL METHACRYLATE	DDP	No data
DODECYL SULFATE, DIETHANOLAMINE SALT	DSD	No
DODECYL SULFATE, MAGNESIUM SALT	DSM	No
DODECYL SULFATE, SODIUM SALT	DDS	No
DODECYL SULFATE, TRIETHANOLAMINE SALT	DST	No
DODECYLTRICHLORISILANE	DTC	No
DOWTHERM	DTH	No
DURSBAN	DUR	No
ENDOSULFAN	ESF	No
ENDRIN	EDR	No
EPICHLOROHYDRIN	EPC	No
EPOXIDIZED VEGATABLE OILS	EVO	Possibly
ETHANE	ETH	Yes
ETHION	ETO	No
ETHOXYDIHYDROPYRAN	EHP	Yes
ETHOXYLATED DODECANOL	EOD	Possibly
ETHOXYLATED NONYLPHENOL	ENP	No
ETHOXYLATED PENTADECANOL	EOP	Possibly
ETHOXYLATED TETRADECANOL	EOT	Possibly
ETHOXYLATED TRIDECANOL	ETD	Possibly
ETHOXY TRIGLYCOL	ETG	No
ETHYL ACETATE	ETA	Yes
ETHYL ACETOACETATE	EAA	Possibly
ETHYL ACRYLATE	EAC	Yes
ETHYL ALCOHOL	EAL	No
ETHYLALUMINUM DICHLORIDE	EAD	No
ETHYLALUMINUM SESQUICHLORIDE	EAS	No
ETHYLAMINE	EAM	No
ETHYLBENZENE	ETB	Yes
ETHYL BUTANOL	EBT	Yes
n-ETHYL-n-BUTYLAMINE	EBU	Yes
ETHYL BUTYRATE	EBR	Yes
ETHYL CHLORIDE	ECL	Yes
ETHYL CHLOROACETATE	ECA	No
ETHYL CHLOROFORMATE	ECF	No
ETHYL CYCLOHEXANE	ECY	Yes
n-ETHYL CYCLOHEXYLAMINE	ECC	Yes
ETHYL DICHLOROSILANE	ECS	No
ETHYLENE	ETL	Yes
ETHYLENE CHLOROHYDRIN	ECH	No
ETHYLENE CYANOHYDRIN	ETC	No

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
ETHYLENEDIAMINE	EDA	No
ETHYLENEDIAMINE TETRACETIC ACID	EDT	Yes
ETHYLENE DIBROMIDE	EDB	No
ETHYLENE DICHLORIDE	EDC	No
ETHYLENE GLYCOL	EGL	No
ETHYLENE GLYCOL DIACETATE	EGY	No
ETHYLENE GLYCOL DIETHYL ETHER	EEE	Yes
ETHYLENE GLYCOL DIMETHYL ETHER	EGD	No
ETHYLENE GLYCOL MONOBUTYL ETHER	EGM	No
ETHYLENE GLYCOL MONOBUTYL ETHER ACETATE	EMA	Yes
ETHYLENE GLYCOL MONOETHYL ETHER	EGE	No
ETHYLENE GLYCOL MONOETHYL ETHER ACETATE	EGA	No
ETHYLENE GLYCOL MONOMETHYL ETHER	EME	No
ETHYLENIMINE	ETI	No
ETHYLENE OXIDE	EOX	No
ETHYL ETHER	EET	Yes
ETHYL FORMATE	EFM	Yes
ETHYLHEXALDEHYDE	EHA	Yes
2-ETHYL HEXANOL	EHX	Yes
2-ETHYLHEXYL ACRYLATE	EAI	Yes
2-ETHYL HEXYLAMINE	EHM	No
ETHYLHEXYL TALLATE	EHT	Yes
ETHYLIDENENORBORNENE	ENB	Yes
ETHYL LACTATE	ELT	No
ETHYL MERCAPTAN	EMC	Yes
ETHYL METHACRYLATE	ETM	Yes
ETHYL NITRITE	ETN	Yes
ETHYLPHENYL DICHLOROSILANE	EPS	No
ETHYL PHOSPHONOTHIOIC DICHLORIDE, ANHYDR	EPD	No
ETHYL PHOSPHORODICHLORIDATE	EPP	No
2-ETHYL-3-PROPYLACROLEIN	EPA	Yes
ETHYL SILICATE	ESC	No
ETHYL TOLUENE	ETE	Yes
ETHYL TRICHLOROSILANE	ETS	No
FERRIC AMMONIUM CITRATE	FAC	No
FERRIC AMMONIUM OXALATE	FAO	No
FERRIC CHLORIDE	FCL	No
FERRIC FLUORIDE	FFX	No
FERRIC GLYCEROPHOSPHATE	FCP	No
FERRIC NITRATE	FNT	No
FERRIC SULFATE	FSF	No
FERROUS AMMONIUM SULFATE	FAS	No
FERROUS CHLORIDE	FEC	No
FERROUS FLUOBORATE	FFB	No
FERROUS OXALATE	FOX	No
FERROUS SULFATE	FRS	No
FLUORINE	FXX	No
FLUOSILICIC ACID	FSL	No
FLUOSULFONIC ACID	FSA	No

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
FORMALDEHYDE SOLUTION	FMS	No
FORMAMIDE	FAM	No
FORMIC ACID	FMA	No
FUMARIC ACID	FUM	No
FURFURAL	FFA	No
FURFURYL ALCOHOL	FAL	No
GALLIC ACID	GLA	No
GAS OIL: CRACKED	GOC	Yes
GASOLINE: AUTOMOTIVE (4.23G Pb/GAL)	GAT	Yes
GASOLINE: AVIATION (4.86G Pb/GAL)	GAV	Yes
GASOLINE BLENDING STOCKS: ALKYLATES	GAK	Yes
GASOLINE BLENDING STOCKS: REFORMATES	GRF	Yes
GASOLINE: CASINGHEAD	GCS	Yes
GASOLINE: POLYMER	GPL	Yes
GASOLINE: STRAIGHT RUN	GSR	Yes
GLUTARALDEHYDE, SOLUTION	GTA	No
GLYCERINE	GCR	No
GLYCIDYL METHACRYLATE	GCM	No
GLYOKAL, 40% SOLUTION	GOS	No
HEPTACHLOR	HTC	No
HEPTANE	HPT	Yes
HEPTANOIC ACID	HEP	Yes
HEPTANOL	HTN	Yes
1-HEPTENE	HTE	Yes
HEXACHLOROCYCLOPENTADIENE	HCC	No
HEXADECYL SULFATE, SODIUM SALT	HSS	No
HEXADECYLTRIMETHYL AMMONIUM CHLORIDE	HAC	No
n-HEXALDEHYDE	HAL	Yes
HEXAMETHYLENEDIAMINE	HMD	No
HEXAMETHYLENEDIAMINE(90% OR LESS)	HMC	No
HEXAMETHYLENEIMINE	HMI	Yes
HEXAMETHYLENEIETRAMINE	HMT	No
HEXANE	HXA	Yes
HEXANOL	HXN	Yes
1-HEXENE	HXE	Yes
HEXYLENE GLYCOL	HXG	No
HYDRAZINE	HDZ	No
HYDROCHLORIC ACID	HCL	No
HYDROFLUORIC ACID	HFA	No
HYDROGEN BROMIDE	HBR	No
HYDROGEN CHLORIDE	HDC	No
HYDROGEN CYANIDE	HCN	No
HYDROGEN FLUORIDE	HFX	No
HYDROGEN, LIQUIFIED	HXX	Yes
HYDROGEN PEROXIDE	HPO	No
HYDROGEN SULFIDE	HDS	Yes
HYDROQUINONE	HDQ	No
2-HYDROXYETHYL ACRYLATE	HAI	No
HYDROXYLAMINE	HDA	No

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
HYDROXYLAMINE SULFATE	HAS	No data
HYDROXYPROPYL ACRYLATE	HPA	No
HYDROXYPROPYL METHACRYLATE	HPM	No
ISOAMYL ACETATE	IAT	Yes
ISOAMYL ALCOHOL	IAA	Yes
ISOBUTANE	IBT	Yes
ISOBUTYL ACETATE	IBA	Yes
ISOBUTYL ALCOHOL	IAL	No
ISOBUTYLAMINE	IAM	No
ISOBUTYLENE	IBL	Yes
ISOBUTYRIC ACID	IBR	No
ISOBUTYRONITRILE	IBN	Yes
ISODECALDEHYDE	IDA	Yes
ISODECYL ACRYLATE	IAI	Yes
ISODECYL ALCOHOL	ISA	Yes
ISOHEXANE	IHA	Yes
ISOOCTALDEHYDE	IOC	Yes
ISOOCTANE	IOO	Yes
ISOOCTYL ALCOHOL	IOA	Yes
ISOPENTANE	IPT	Yes
ISOPHORONE	IPH	Yes
ISOPHORONE DIAMINE	IPI	Yes
ISOPHORONE DIISOCYANATE	IPD	Yes
ISOPHTHALIC ACID	IPL	No
ISOPRENE	IPR	Yes
ISOPROPYL ACETATE	IAC	Yes
ISOPROPYL ALCOHOL	IOA	No
ISOPROPYLAMINE	IPP	No
ISOPROPYL CYLCOHEXANE	IPX	Yes
ISOPROPYL ETHER	IPE	Yes
ISOPROPYL MERCAPTAN	IPM	No
ISOPROPYL PERCARBONATE	IPC	No
ISOVALERALDEHYDE	IVA	Yes
JET FUEL: JP-1 (KEROSENE)	JPO	Yes
JET FUEL: JP-3	JPT	Yes
JET FUEL: JP-4	JPF	Yes
JET FUEL: JP-5 (KEROSENE, HEAVY)	JPV	Yes
KEPONE	KPE	No
KEROSENE	KRS	Yes
LACTIC ACID	LTA	No
LATEX, LIQUID SYNTHETIC	LLS	No
LAUROYL PEROXIDE	LPO	Yes
LAURYL MERCAPTAN	LRM	Yes
LEAD ACETATE	LAC	No
LEAD ARSENATE	LAR	No
LEAD CHLORIDE	LCL	No
LEAD FLUORBORATE	LFB	No
LEAD FLUORIDE	LFR	No
LEAD IODIDE	LID	No

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
LEAD NITRATE	LNT	No
LEAD STEARATE	LSA	No
LEAD SULFATE	LSF	No
LEAD SULFIDE	LSU	No
LEAD TETRAACETATE	LTT	No
LEAD THIOCYANATE	LTC	No
LEAD THIOSULFATE	LTS	No
LEAD TUNGSTATE	LTU	No
LINEAR ALCOHOLS (12-15 CARBONS)	LAL	Yes
LIQUIFIED NATURAL GAS	LNG	No
LIQUIFIED PETROLEUM GAS	LPG	Yes
LITHARGE	LTH	No
LITHIUM ALUMINUM HYDRIDE	LAH	No
LITHIUM BICHROMATE	LBC	No
LITHIUM CHROMATE	LCR	No
LITHIUM HYDRIDE	LHD	No
LITHIUM, METAL	LTM	No
MAGNESIUM	MGX	No
MAGNESIUM PERCHLORATE	MPC	No
MALATHION	MLT	No
MALEIC ACID	MLI	No
MALEIC ANHYDRIDE	MLA	No
MALEIC HYDRAZIDE	MLH	No
MERCAPTODIMETHUR	MCD	No
MERCURIC ACETATE	MAT	No
MERCURIC AMMONIUM CHLORIDE	MCC	No
MERCURIC CHLORIDE	MRC	No
MERCURIC CYANIDE	MCN	No
MERCURIC IODIDE	MID	No
MERCURIC NITRATE	MNT	No
MERCURIC OXIDE	MOX	No
MERCURIC SULFATE	MRS	No
MERCURIC SULFIDE	MSF	No
MERCURIC THIOCYANATE	MRT	No
MERCUROUS CHLORIDE	MRR	No
MERCUROUS NITRATE	MRN	No
MERCURY	MCR	No
MESITYL OXIDE	MSO	Yes
METHACRYLIC ACID	MAD	No
METHALLYL CHLORIDE	MCL	Yes
METHANE	MTH	Yes
METHANEARSONIC ACID, SODIUM SALTS	MSA	No data
METHOXYCHLOR	MOC	No
METHYL ACETATE	MTT	No
METHYL ACETYLENE, PROPADIENE MIXTURE	MAP	Yes
METHYLACRYLATE	MAM	Yes
METHYL ALCOHOL	MAL	No
METHYLAMINE	MTA	No
METHAMINE SOLUTION (< OR = 42%)	MSZ	No data

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
METHYL AMYL ACETATE	MAC	Yes
METHYL AMYL ALCOHOL	MAA	Yes
n-METHYLANILINE	MAN	Yes
METHYL BROMIDE	MTB	No
METHYL-t-BUTYL ETHER	MBE	Yes
METHYL -n-BUTYL KETONE	MBK	Yes
METHYL CHLORIDE	MTC	No
METHYL CHLOROFORMATE	MCH	No
METHYCYCLOPENTADIENYLMANGANESE TRICARBON	MCT	No
METHYLCYCLOPENTANE	MCP	Yes
METHYLDICHLOROSILANE	MCS	No
METHYLENE CHLORIDE	MCE	No
2-METHYL-6-ETHYL ANILINE	MEN	Possibly
METHYL ETHYL KETONE	MEK	No
2-METHYL-5-ETHYLPRYIDINE	MEP	Yes
METHYL FORMAL	MTF	No
METHYL FORMATE	MFM	No
METHYL HYDRAZINE	MHZ	No
2-METHYL-2-HYDROXY-3-BUTYNE	MHB	No
METHYL ISOBUTYL CARBINOL	MIC	Yes
METHYL ISOBUTYL KETONE	MIK	Yes
METHYL ISOPROPENYL KETONE	MPK	No
METHYL MERCAPTAN	MMC	No
METHYL METHACRYLATE	MMM	Yes
METHYL NAPHTHALENE	MNA	Possibly
METHYL PARATHION	MPT	No
2-METHYL PENTENE	MPN	Yes
METHYLPHOSPHONOTHIOIC DICHLORIDE,ANHYDR	MPD	No
2-METHYLPYRIDINE	MPR	No
1-METHYLPYRROLIDONE	MPY	No
METHYL STYRENE, ALPHA	MSR	Yes
METHYLTRICHLOROSILANE	MTS	No
METHYL VINYL KETONE	MVK	No
MINERAL SPIRITS	MNS	Yes
MIREX	MRX	No
MOLYBDIC TRIOXIDE	MTO	No
MONOCHLOROACETIC ACID	MCA	No
MONOCHLORODIFLUOROMETHANE	MCF	No
MONOCHLOROTETRAFLUOROETHANE	MTE	No
MONOCHLOROTRIFLUOROMETHANE	MCM	No
MONOETHANOLAMINE	MEA	No
MONOISOPROPANOLAMINE	MPA	No
MORPHOLINE	MPL	No
MOTOR FUEL ANTINKNOCK CMPDS(PB ALKYLS)	MFA	No
NABAM	NAB	No
NALED	NLD	No
NAPTHA:COAL TAR	NCI	Yes
NAPHTHALENE, MOLTEN	NTM	No
NAPTHA:SOLVENT	NSV	Yes

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
NAPTHA:STODDARD SOLVENT	NSS	Yes
NAPTHA:VM & P (75% NAPTHA)	NVM	Yes
NAPHTHENIC ACID	NTI	Yes
1-NAPHTHYLAMINE	NAO	No
NEOHEXANE	NHX	Yes
NICKEL ACETATE	NKA	No
NICKEL AMMONIUM SULFATE	NAS	No
NICKEL BROMIDE	NBR	No
NICKEL CARBONYL	NKC	No
NICKEL CHLORIDE	NCL	No
NICKEL CYANIDE	NCN	No
NICKEL FLUOBORATE	NFB	No
NICKEL FORMATE	NFM	No
NICKEL HYDROXIDE	NKH	No
NICKEL NITRATE	NNT	No
NICKEL SULFATE	NKS	No
NICOTINE	NIC	No
NICOTINE SULFATE	NCS	No
NITRALIN	NTL	No
NITRIC ACID	NAC	No
NITRIC OXIDE	NTX	No
NITRILOTRIACETIC ACID AND SALTS	NAA	No data
2-NITROANILINE	NTA	No
4-NITROANILINE	NAL	No
NITROBENZENE	NTB	No
NITROETHANE	NTE	No
NITROGEN, LIQUIFIED	NXX	Yes
NITROGEN TETROXIDE	NOX	No
NITROMETHANE	NMT	No
2-NITROPHENOL	NTP	No
3-NITROPHENOL	NIP	No
4-NITROPHENOL	NPH	No
1-NITROPROPANE	NPN	Possibly
2-NITROPROPANE	NPP	Yes
NITROSYL CHLORIDE	NTC	No
m-NITROTOLUENE	NTR	No
o-NITROTOLUENE	NIE	No
p-NITROTOLUENE	NTT	No
NITROUS OXIDE	NTO	No
NONANE	NAN	Yes
NONANOL	NNN	Yes
NONENE	NON	Yes
1-NONENE	NNE	Yes
NONYL PHENOL	NNP	Yes
OCTANE	OAN	Yes
OCTANOL	OTA	Yes
1-OCTENE	OTE	Yes
OCTYL EPOXYTALLATE	OET	Possibly
OIL: CLARIFIED	OCF	Yes

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
OIL: CRUDE	OIL	Yes
OIL: DIESEL	ODS	Yes
OIL, EDIBLE: CASTOR	OCA	Possibly
OIL, EDIBLE: COCONUT	OCC	Yes
OIL, EDIBLE: COTTONSEED	OCS	Yes
OIL, EDIBLE: FISH	OFS	Yes
OIL, EDIBLE: LARD	OLD	Yes
OIL, EDIBLE: OLIVE	OOL	Yes
OIL, EDIBLE: PALM	OPM	Yes
OIL, EDIBLE: PEANUT	OPN	Yes
OIL, EDIBLE: SAFFLOWER	OSF	Yes
OIL, EDIBLE: SOYA BEAN	OSB	Yes
OIL, EDIBLE: TUCUM	OTC	Yes
OIL, EDIBLE: VEGETABLE	OVG	Yes
OIL, FUEL: NO. 1 (KEROSENE)	OON	Yes
OIL, FUEL: NO. 1-D	OOD	Yes
OIL, FUEL: NO. 2	OTW	Yes
OIL, FUEL: NO. 2-D	OTD	Yes
OIL, FUEL: NO. 4	OFR	Yes
OIL, FUEL: NO. 5	OFV	Yes
OIL, FUEL: NO. 6	OSX	Yes
OIL, MISC: ABSORPTION	OAS	Yes
OIL, MISC: CASHEW NUT SHELL (UNTREATED)	OCN	Yes
OIL, MISC: COAL TAR	OCT	Yes
OIL, MISC: CROTON	OCR	Yes
OIL, MISC: LINSEED	OLS	Yes
OIL, MISC: LUBRICATING	OLB	Yes
OIL, MISC: MINERAL	OMN	Yes
OIL, MISC: MINERAL SEAL	OMS	Yes
OIL, MISC: MOTOR	OMT	Yes
OIL, MISC: NEATSFOOT	ONF	Yes
OIL, MISC: PENETRATING	OPT	Yes
OIL, MISC: RANGE	ORG	Yes
OIL, MISC: RESIN	ORS	Yes
OIL, MISC: ROAD	ORD	Possibly
OIL, MISC: ROSIN	ORN	Yes
OIL, MISC: SPERM	OSP	Yes
OIL, MISC: SPINDLE	OSD	Yes
OIL, MISC: SPRAY	OSY	Yes
OIL, MISC: TALL	OTL	Yes
OIL, MISC: TANNER'S	OTN	Yes
OIL, MISC: TRANSFORMER	OTF	Yes
OIL, MISC: TURBINE	OTB	Yes
OLEIC ACID	OLA	Yes
OLEIC ACID, POTASSIUM SALT	OAP	No
OLEIC ACID, SODIUM SALT	OAC	No
OLEUM	OLM	No
OXALIC ACID	OXA	No
OXYGEN, LIQUID	OXY	No

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
PARAFORMALDEHYDE	PFA	No
PARALDEHYDE	PDH	No
PARATHION	PTO	No
PENTABORANE	PTB	No
PENTACHLOROETHANE	PCE	No
PENTACHLOROPHENOL	PCP	No
PENTADECANOL	PDC	Yes
1,3-PENTADIENE	PDI	Yes
1,4-PENTADIENE	PDN	Yes
PENTAERYTHRITOL	PET	No
n-PENTANE	PTA	Yes
1-PENTENE	PTE	Yes
PERACETIC ACID	PAA	No
PERCHLORIC ACID	PCL	No
PERCHLOROETHYLENE	PER	No
PERCHLOROMETHYL MERCAPTAN	PCM	No
PETROLATUM	PTL	Yes
PETROLEUM NAPHTHA	PTN	Yes
PHENOL	PHN	No
PHENYLDICHLOROARSINE, LIQUID	PDL	No
PHENYLHYDRAZINE HYDROCHLORIDE	PHH	No data
PHOSDRIN	PHD	No
PHOSGENE	PHG	No
PHOSPHORIC ACID	PAC	No
PHOSPHORUS, BLACK	PPB	No
PHOSPHORUS OXYCHLORIDE	PPO	No
PHOSPHORUS PENTASULFIDE	PPP	No
PHOSPHORUS, RED	PPR	No
PHOSPHORUS TRIBROMIDE	PBR	No
PHOSPHORUS TRICHLORIDE	PPT	No
PHOSPHORUS, WHITE	PPW	No
PHTHALIC ANHYDRIDE	PAN	No
PIPERAZINE	PPZ	No
POLYBUTENE	PLB	Yes
POLYCHLORINATED BIPHENYLS	PCB	No
POLYETHYLENE POLYAMINES	PEB	No data
POLYMETHYLENE POLYPHENYL ISOCYANATE	PPI	No
POLYPHOSPHORIC ACID	PPA	No
POLYPROPYLENE	PLP	Yes
POLYPROPYLENE GLYCOL	PGC	No
POLYPROPYLENE GLYCOL METHYL ETHER	PGM	No
POTASSIUM	PTM	No
POTASSIUM ARSENATE	PAS	No
POTASSIUM ARSENITE	POA	No data
POTASSIUM BINOXALATE	PBO	No
POTASSIUM CHLORATE	PCR	No
POTASSIUM CHROMATE	PCH	No
POTASSIUM CYANIDE	PTC	No
POTASSIUM DICHLORO-S-TRIAZINETRIONE	PDT	Yes

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
POTASSIUM DICHROMATE	PTD	No
POTASSIUM HYDROXIDE	PTH	No
POTASSIUM IODIDE	PTI	No
POTASSIUM OXALATE	PTS	No
POTASSIUM PERMANGANATE	PTP	No
POTASSIUM PEROXIDE	POP	No data
PROPANE	PRP	No
beta-PROPANOLAMINE	PLA	No
iso-PROPANOLAMINE	PAJ	No
n-PROPANOLAMINE	PRM	No
PROPARGITE	PRG	No
PROPIOLACTONE, BETA	PLT	No
PROPIONALDEHYDE	PAD	No
PROPIONIC ACID	PNA	No
PROPIONIC ANHYDRIDE	PAH	No
PROPIONITRILE	PCN	No
n-PROPYL ACETATE	PAT	Yes
n-PROPYL ALCOHOL	PAL	No
n-PROPYLAMINE	PRA	No
PROPYLENE	PPL	No
PROPYLENE BUTYLENE POLYMER	PBP	Yes
PROPYLENE GLYCOL	PPG	No
PROPYLENE GYLCOL METHYL ETHER	PME	No
PROPYLENEIMINE	PII	No
PROPYLENE OXIDE	POX	No
PROPYLENE TETRAMER	PTT	Yes
n-PROPYL ETHER	PMN	Yes
PYRETHRINS	PRR	Yes
PYRIDINE	PRD	No
PYROGALLIC ACID	PGA	No
QUINOLINE	QNL	No
RESORCINOL	RSC	No
SALICYLALDEHYDE	SAL	No
SALICYLIC ACID	SLA	No
SELENIUM DIOXIDE	SLD	No
SELENIUM TRIOXIDE	STO	No
SILICON TETRACHLORIDE	STC	No
SILVER ACETATE	SVA	No
SILVER CARBONATE	SVC	No
SILVER FLUORIDE	SVF	No
SILVER IODATE	SVI	No
SILVER NITRATE	SVN	No
SILVER OXIDE	SVO	No
SILVER SULFATE	SVS	No
SODIUM ALKYLBENZENESULFONATES	SAB	No
SODIUM ALKYL SULFATES	SAS	No data
SODIUM AMIDE	SAM	No
SODIUM ARSENATE	SDA	No
SODIUM ARSENITE	SAR	No

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
SODIUM AZIDE	SAZ	No
SODIUM BIFLUORIDE	SBF	No data
SODIUM BISULFITE	SBS	No
SODIUM BORATE	SOB	No
SODIUM BOROHYDRIDE	SBH	No
SODIUM BOROHYDRIDE(15% OR LESS)/NAOH SOL	SBX	No
SODIUM CACODYLATE	SCD	No data
SODIUM CHLORATE	SDC	No
SODIUM CHLORATE (50% OR LESS)	SDD	No data
SODIUM CHROMATE	SCH	No
SODIUM CYANIDE	SCN	No
SODIUM DICHLORO-S-TRIAZINETRIONE	SDT	No
SODIUM DICHROMATE	SCR	No
SODIUM FERROCYANIDE	SFC	No
SODIUM FLUORIDE	SDF	No
SODIUM HYDRIDE	SDH	No
SODIUM HYDROSULFIDE SOLUTION	SHS	No
SODIUM HYDROXIDE	SHD	No
SODIUM HYPOCHLORITE	SHC	No
SODIUM HYPOCHLORITE SOLN(15% OR LESS)	SHP	No
SODIUM 2-MERCAPTOBENZOTHIAZOL SOLUTION	SMB	No
SODIUM, METALLIC	SDU	No
SODIUM METHYLATE	SML	No data
SODIUM NITRATE	SDN	No
SODIUM NITRITE	SNT	No
SODIUM OXALATE	SOX	No
SODIUM PHOSPHATE	SPP	No
SODIUM PHOSPHATE (TRIBASIC)	SPH	No
SODIUM SELENITE	SSE	No data
SODIUM SILICATE	SSC	No
SODIUM SILICOFLUORIDE	SFR	No
SODIUM SULFIDE	SDS	No
SODIUM SULFITE	SSF	No
SODIUM THIOCYANATE	SCY	No data
SORBITOL	SBT	No
STANNOUS FLUORIDE	STF	No
STEARIC ACID	SRA	Yes
STRONTIUM CHROMATE	SCM	No
STRYCHNINE	STR	No
STYRENE	STY	Yes
SUCROSE	SRS	No
SULFOLANE	SFL	No
SULFUR	SXX	No
SULFUR DIOXIDE	SFD	No
SULFURIC ACID	SFA	No
SULFURIC ACID, SPENT	SAC	No
SULFUR MONOCHLORIDE	SFM	No
SULFURYL CHLORIDE	SCL	No
TALLOW	TLO	Yes

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
TALLOW FATTY ALCOHOL	TFA	Yes
TANNIC ACID	TNA	No data
2,4,5-T ESTERS	TES	No
TETRABUTYL TITANATE	TBT	No
TETRACHLOROETHANE	TEC	No
1,1,2,2-TETRACHLOROETHANE	TEO	No
TETRACHLOROETHYLENE	TTE	No
TETRADECANOL	TTN	Yes
1-TETRADECENE	TTD	Yes
TETRADECYLBENZENE	TDB	Yes
TETRAETHYL DITHIOPYROPHOSPHATE	TED	No
TETRAETHYLENE GLYCOL	TTG	No
TETRAETHYLENE-PENTAMINE	TTP	No
TETRAETHYL LEAD	TEL	No
TETRAETHYL PYROPHOSPHATE	TEP	No
TETRAFLUORORETHYLENE	TFE	No
TETRAHYDROFURAN	THF	No
TETRAHYDRONAPHTHALENE	THN	Yes
TETRAMETHYL LEAD	TML	No
THALLIUM SULFATE	TSU	No
THIOPHOSGENE	TPG	No
THIRAM	THR	No
THORIUM NITRATE	TRN	No data
TITANIUM TETRACHLORIDE	TTT	No
TOLUENE	TOL	Yes
TOLUENEDIAMINE	TDA	No data
TOLUENE 2,4-DIISOCYANATE	TDI	No
p-TOLUENESULFONIC ACID	TAP	No
o-TOLUIDINE	TLI	Possibly
TOXAPHENE	TXP	No
TRIBUTYL PHOSPHATE	TRP	No
TRICHLORFON	TRC	No
TRICHLOROBENZENE	TBZ	No
1,2,4-TRICHLOROBENZENE	TCB	No
1,1,1-TRICHLOROETHANE	TCE	No
1,1,2-TRICHLOROETHANE	TCM	No
TRICHLOROETHYLENE	TCL	No
TRICHLOROFLUOROMETHANE	TCF	No
TRICHLOROPHENOL	TPH	No
2,4,5-TRICHLOROPHENOXYACETIC ACID	TCA	No
2,4,5-TRICHLOROPHENOXYACETIC ACID, NA SA	TAS	No data
2-(2,4,5-TRICHLOROPHENOXY)PROPANOIC ACID	TPA	No
2-(2,4,5-TRICHLOROPHENOXY)PROPANOIC, ISO	TPE	No
1,2,3-TRICHLOROPROPANE	TCN	No
TRICHLOROSILANE	TCS	No
TRICHLORO-s-TRIAZINETRIONE	TCT	No data
TRICRESYL PHOSPHATE(<1% O- ISOMER)	TCP	No
TRICRESYL PHOSPHATE(> 1% ORTHO)	TCO	No
TRIDECANOL	TDN	Yes

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
1-TRIDECENE	TDC	Yes
TRIETHANOLAMINE	TEA	No
TRIETHYLALUMINUM	TAL	No
TRIETHYLAMINE	TEN	Yes
TRIETHYLBENZENE	TEB	Yes
TRIETHYLENE GLYCOL	TEG	No
TRIETHYLENETETRAMINE	TET	No
TRIFLUOROCHLOROETHYLENE	TEC	No
TRIFLURALIN	TFR	No
TRIISOBUTYLALUMINUM	TIA	No
TRIISOPROPANOLAMINE	TIP	No
TRIMETHYLACETIC ACID	TAA	Yes
TRIMETHYLAMINE	TMA	No
TRIMETHYLCHLOROSILANE	TMC	No
TRIMETHYL HEXAMETHYLENE DIAMINE	THA	No data
TRIMETHYL HEXAMETHYLENE DIISOCYANATE	THI	No data
TRIMETHYL PHOSPHITE	TPP	No
TRIPROPYLENE GLYCOL	TGC	No
TRIS(AZIRIDINYL)PHOSPHINE OXIDE	TPO	No data
TURPENTINE	TPT	Yes
UNDECANOL	UND	Yes
1-UNDECENE	UDC	Yes
n-UNDECYLBENZENE	UDB	Yes
URANIUM PEROXIDE	URP	No
URANYL ACETATE	URA	No
URANYL NITRATE	UAN	No
URANYL SULFATE	URS	No
UREA	URE	No
UREA, AMMONIUM NITRATE SOLN(W AQAU NH3)	UAS	No data
UREA PEROXIDE	UPO	No
n-VALERALDEHYDE	VAL	Yes
VANADIUM OXYTRICHLORIDE	VOT	No
VANADIUM PENTOXIDE	VOX	No
VANADYL SULFATE	VSF	No
VINYL ACETATE	VAM	Yes
VINYL CHLORIDE	VCM	Yes
VINYL ETHYL ETHER	VEE	Yes
VINYL FLUORIDE	VFI	Yes
VINYLIDENE CHLORIDE	VCI	No
VINYL METHYL ETHER	VME	Yes
VINYL NEODECANATE	VND	Yes
VINYL TOLUENE	VNT	Yes
VINYL TRICHLOROSILANE	VTS	No
WAX: CARNAUBA	WCA	Yes
WAX: PARAFFIN	WPF	Yes
m-XYLENE	XLM	Yes
o-XYLENE	XLO	Yes
p-XYLENE	XLP	Yes
XYLENOL	XYL	Possibly

Classification of CHRIS Chemicals

Chemical Name	CHRIS Code	Floatability
ZECTRAN	ZEC	No
ZINC ACETATE	ZNA	No
ZINC AMMONIUM CHLORIDE	ZAC	No
ZINC ARSENATE	ZAR	No
ZINC BICHROMATE	ZBC	No data
ZINC BORATE	ZBO	No
ZINC BROMIDE	ZBR	No
ZINC CARBONATE	ZCB	No
ZINC CHLORIDE	ZCL	No
ZINC CHROMATE	ZCR	No
ZINC CYANIDE	ZCN	No
ZINC DIALKYLDITHIOPHOSPHATE	ZDP	No
ZINC FLUOBORATE	ZFB	No
ZINC FLOURIDE	ZFX	No
ZINC FORMATE	ZFM	No
ZINC HYDROSULFITE	ZHS	No data
ZINC NITRATE	ZNT	No
ZINC PHENOLSULFONATE	ZPS	No data
ZINC PHOSPHIDE	ZPP	No
ZINC POTASSIUM CHROMATE	ZPC	No
ZINC SILICOFLUORIDE	ZSL	No
ZINC SULFATE	ZSF	No
ZIRCONIUM ACETATE	ZCA	No
ZIRCONIUM NITRATE	ZIR	No data
ZIRCONIUM OXYCHLORIDE	ZCO	No data
ZIRCONIUM POTASSIUM FLUORIDE	ZPF	No data
ZIRCONIUM SULFATE	ZCS	No

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1.0 INTRODUCTION

The United States Coast Guard, by virtue of the Federal Water Pollution Control Act, as amended; the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA); and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), provides the predesignated Federal On-Scene Coordinator (OSC) for response to hazardous chemical releases occurring in the coastal zones, Great Lakes waters, and intercoastal waterways. The responsibility of the OSC within a predesignated area is to respond to the release or threat of release of hazardous substances, pollutants, or contaminants into all environmental media - air, land, groundwater, and surface water. A variety of chemicals have the potential for release into the environment and will exhibit a variety of behaviors once released. The OSC will have to rely on their experience and resources to predict the behavior of the chemical and select the proper response action.

This handbook has been developed to augment existing Coast Guard hazardous material guides and Local Contingency Plans with information on handling floating chemical spills. The sequence of activities which follows the release of a spill is outlined. This sequence includes a summary of the decision-making processes which lead to the selection and implementation of the appropriate response methods. Response methods cover a wide range of state-of-the-art technologies which isolate and mitigate the potential hazards of the released chemical. Attention is given to special problems which might arise from responses to spills of floating chemicals. Appendices provide information on the hazards and response methods for each of the floating chemicals, the evaluation of containment and cleanup equipment, NCP equipment requirements and existing inventories, and results from mathematical modeling of foam efficiency and vapor dispersion.

The selection of the most effective response method will depend on the spill situation and environmental conditions. The OSC will have to combine his experience and knowledge of the water body, effect of environmental conditions, and spill responses with the information presented in the handbook to formulate a plan to minimize injury, loss of life, and impact to the environment.

2.0 PURPOSE

Releases of floating hazardous chemicals pose a serious threat to the population and the environment. By the emission of flammable and/or toxic vapors, the spill can produce vapor clouds or plumes which can impact areas much larger than the area of the spill itself. The area of impact can be further increased by the mobility of the floating spill. The action of currents and winds can displace spills great distances from the original source point. Fouling of shorelines is also possible, creating a situation requiring an expensive and time-consuming cleanup operation.

The purpose of this handbook is to provide the OSC with the most up-to-date methods to supplement USCG Policy Guidance for Response to Hazardous Chemical Release (COMDTINST. M16465.30) and alert response personnel of the associated hazards of response to floating hazardous chemicals. Evaluations and limitations of response methods are provided to aid in the decision-making process. Response methods are developed to reduce the magnitude of the impact of the hazards to cleanup personnel, affected populated areas, the environment, and personal property, in that order.

The procedures outlined in this handbook are consistent with the National Contingency Plan as promulgated under Section 311 of the Federal Water Pollution Control Act and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Disposal procedures are in agreement with federal requirements outlined under the Resource Conservation and Recovery Act (RCRA).

This handbook is intended for use by personnel with knowledge of response procedures, federal regulations, and navigable waterways. The handbook is designed to offer alternatives for responses and is not meant to replace the knowledge and experience of the cleanup personnel.

2.1 Scope

This handbook is concerned with response methods which isolate and mitigate hazards related to releases of floating CHRIS chemicals. Crude oil spill technology is discussed only briefly where it applies to spills of floating CHRIS chemicals which behave similarly to crude oil. The main thrust of the work is concerned with spills capable of emitting flammable and/or toxic vapors. Spills of this type pose a serious health hazard to the cleanup personnel and populated areas, and have the potential to cause extensive damage to personal property. Decision-making processes are outlined, and methods of organizing experienced personnel, equipment, and pertinent data are discussed.

Response equipment and products are evaluated on their limitations and chemical compatibility. For each floating chemical, selected physical properties of floating chemicals and hazards resulting from their release are organized in appendices. Results from mathematical models developed to provide optimal foam thickness and available response times for a given spill volume are also given in appendices.

This handbook is not concerned with the effects of the hazardous chemical on the environment once an area has been contaminated. Nor are the long-term effects of a spill or the cleanup of contaminated shorelines discussed. The response procedures are intended only to reduce the impact of the potential hazards, and addressing environmental contamination is beyond the scope of this manual.

2.2 An Overview of Spill Responses

The formulation of a safe and effective response to floating hazardous chemicals should begin long before th actual incident. Personnel should be aware of the associated hazards of response to floating chemicals and technologies used to abate the hazards. Presently, most technologies used to combat floating chemical spills are not well developed. The development of contacts from response equipment manufacturers is essential to keep abreast of new developments and results from testing. Conferences and journals related to hazardous material management are other sources for keeping current with new developments. By being aware of the needs for response of floating chemicals the OSC can contribute to the development of a contingency plan suitable for floating hazardous chemicals.

The U. S. Coast Guard OSC is authorized to respond to releases or threats of releases of chemicals within a predefined area which adversely affect the environment (air, land, groundwater, and surface water). The type of response required will depend on spill situations but primarily centers on insuring that the proper action is taken. Figure 2.1 outlines the selection of the proper response action.

The U. S. Coast Guard's OSC will be required to respond to a variety of situations involving floating hazardous materials. The potential list of materials is not limited to the floating CHRIS chemicals. In some siutations, the hazardous material involved may have only a limited amount of physical data or the identity of the chemical may not be unknown. The release may take place in a location where the environmental conditions severely limit the efficiency of the available mitigation techniques. In all of these situations for releases requiring responses, the OSC will be responsible for selecting an appropriate mitigation technique which reduces the hazardous impacts of the spill to response personnel, adjacent populated area, and the environment.

The selection of an appropriate mitigation technique is not a trivial task. Chapter 4, The Decision-Making Process, outlines a fast, simple method for gathering the proper information and, with the proper knowledge, selecting suitable response alternatives and implementing it. The difficulty arises because suitable technologies for the mitigation of releases of floating hazardous chemicals are either limited to a narrow range of environmental conditions or lack in field applications and testing, thus little guidance is available for effective response methods for a wide range of environmental conditions and for all materials which may be encountered.

In any response, regardless of its simplicity, the first priority for the OSC is to insure the safety of response personnel. Proper protective clothing should be worn using the guidelines described in Report Nos. CG-D-7-87 and CG-D-8-87, Guidelines for the Selection of Chemical Protection Clothing, Volumes 1 and 2, respectively (Schwope, et al., 1987). If the identity of the material is unknown, the material should be treated as though it were highly hazardous, and the highest level of safety precautions taken.

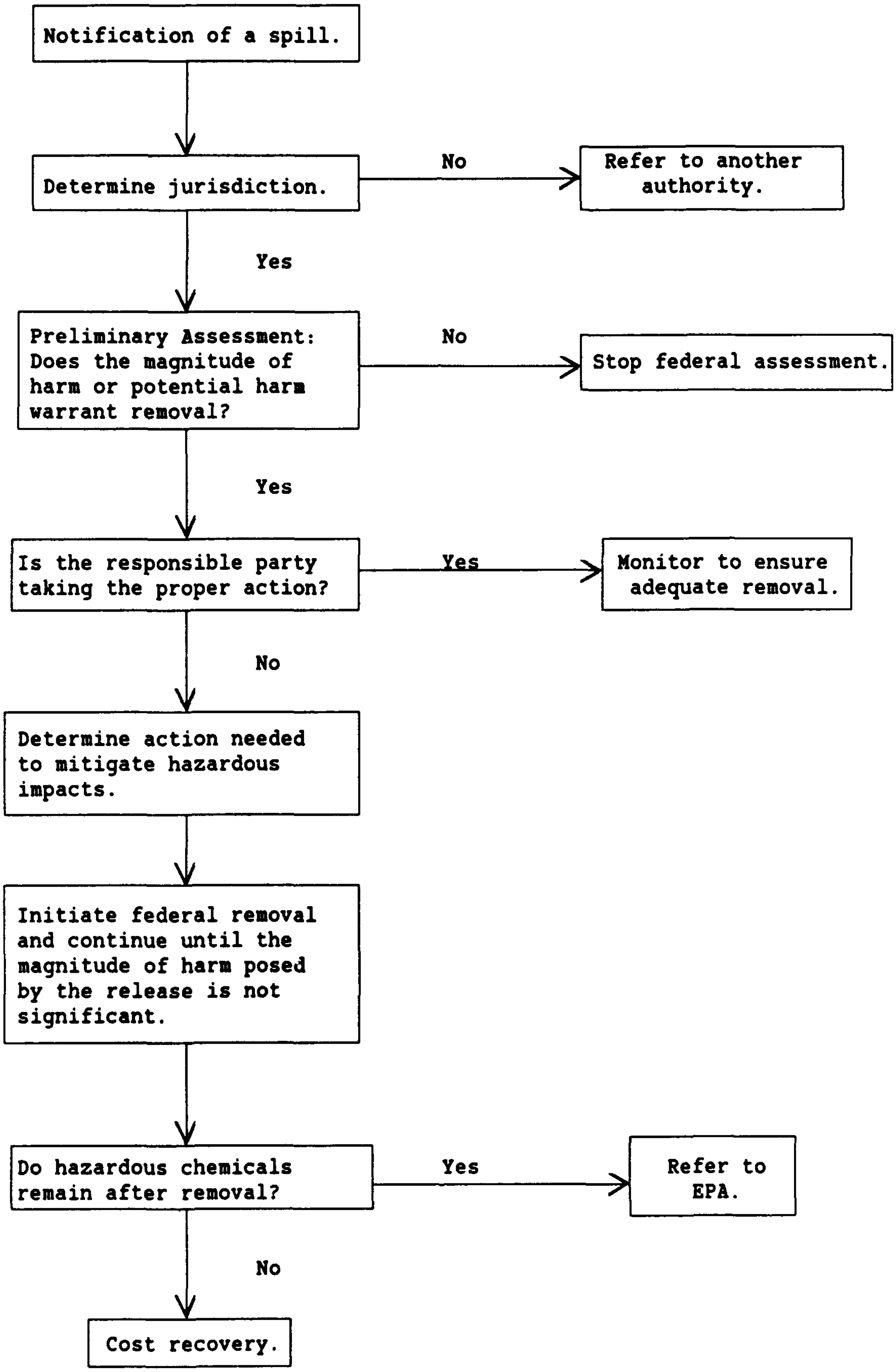


FIGURE 2.1. SUMMARY OF OSC RESPONSE ACTIVITIES

3.0 THE DECISION-MAKING PROCESS

In the midst of an emergency, a time efficient and effective method is needed to bring order to an otherwise chaotic situation. For releases or threats of releases of hazardous chemicals within the U. S. Coast Guard's predefined jurisdiction which pose an adverse impact to the environment (air, land, ground- or surface water), federal regulations have designated the U.S. Coast Guard's OSC with the responsibility of being in charge of the emergency situation. The role of the OSC is to ensure that the proper response action is taken by the responsible party or local agencies to mitigate the hazardous impacts. If the needed response exceeds the capacity of the responsible party or local agencies, the OSC can implement a federal response action. Response to releases of hazardous chemicals on water requires special consideration because of the mobility of the spill. Wind and current action, as well as the spreading of the chemical on the water surface can quickly disperse the spill over a large area.

The OSC will be required to make many decisions in a short time to reduce the impact of the associated hazards, to bring order and organization to the situation, and to clean up and dispose of the hazardous chemical if proper actions are not being taken. The methodology for decision making will primarily be concerned with the preservation of human life, followed by the protection of the environment and personal property. By virtue of the situation, the decision-making process is required to be fast and simple, and the determination of a process begins long before the actual emergency situation.

Such a decision-making process was developed by Esso Chemical Canada (Mackey and Goodman, 1986) and is referred to as the "disciplined approach" for emergency responses. This process is a simple four-step process for decision making. The four steps of the process are: (1) Spill Characterization, (2) Decision Analysis, (3) Implementation, and (4) Feedback. Figure 3.1 shows a flow diagram of the process. Each step outlines procedures to accomplish the desired goal. Since the Coast Guard response team may be joined by a response team from the chemical manufacturer and representatives of numerous local, state, and federal agencies, emphasis must be placed on clear, accurate communication. Work sheets are provided in Appendix C for each step of the decision-making process. These worksheets can be used to document the decision-making process and to insure that the essential information is gathered at the scene of the spill.

3.1 Spill Characterization

Spill characterization is an ongoing process which provides pertinent information needed to formulate a response action and determine its effectiveness. The goal of characterizing the spill situation is to centrally organize all information needed to determine the potential impact to response personnel, populated areas, and the environment. Information can be collected from a variety of sources. Some information may not be available and may have to be acquired by more of a detective method.

The development of the decision making process stresses the importance of gathering information in a timely fashion. Although lack of time is an important consideration, it should be emphasized that the characterization must be as complete and accurate as possible. Exclusion of useful information for the sake of saving time could increase the potential hazards to response personnel, populated areas, and the environment.

Information needed to formulate a response action includes identification, classification, and location of the spill situation. Classification of the spill situation entails compiling chemical and physical characteristics of the chemical, reporting environmental conditions, and determining the state of the spill. For situations which expose response personnel to the associated hazards of the spilled material, proper protective clothing must be worn. The following section provides the methods for characterization of the spill situation.

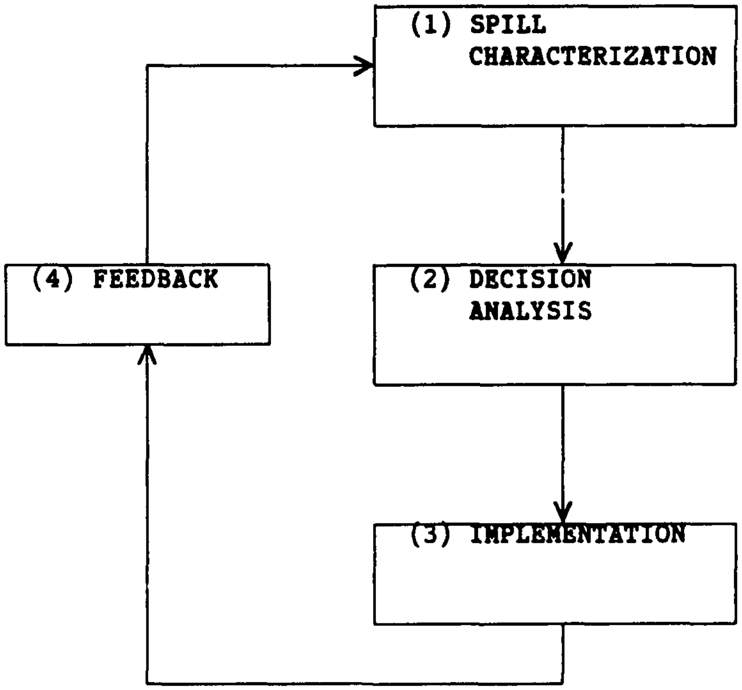


FIGURE 3.1. FLOW DIAGRAM OF THE DECISION-MAKING PROCESS

3.1.1 Identification of the Spill

Identification of the spilled chemical is probably the most important piece of information. The personnel in charge of the shipping or the source of the spill, whether it be a ship, train, truck, or a facility, will be a good source of information. Federal regulations require that each shipment carry specific documents which describe the type and nature of the material being transported. In some instances, specific information about the chemical may not be available. The response team will have to rely on observations and detecting equipment to gain information on the spilled chemical. If the identity of the chemical is not known and some of the physical characteristics can be determined, the Chemical Information System (CIS) can be queried to aid in identifying the unknown chemical.

Many of the responses by the Coast Guard will involve ships or barges. These vessels are required to carry shipping papers and manifests which describe the contents of the vessel and the hazards which may be associated with them. These documents include information on the quantity of chemicals and the types of storage containers used.

Another good source of information, particularly for barges, is the certificate of inspection which is stored in a sealed tube on the deck of the vessel. This certificate contains a list of hazardous chemicals which the barge may carry, the maximum cargo weight, and the owner's name and address. Reference to the certificate will help to narrow the list of possible hazardous chemicals.

For substances not transported in bulk quantities, additional information can be obtained directly from the containers. If the vessel's crew is not available, the Captain of the Port, which is the OSC in coastal areas, can be notified for further information. The U. S. Coast Guard presently requires a 24-hour advanced notification of scheduled arrivals of any of 40 specified hazardous chemicals. Contacting the nearest Captain of the Port may provide information on the contents of a vessel that is planning to enter or which has recently left a specific port.

If information concerning the contents of the vessel is not accessible by any of the previously mentioned methods, the owner and home port of the vessel can be identified by checking records which are maintained by the Army Corps of Engineers (Corps) and the Department of Transportation (DOT). These compilations of vessel information are kept in each Coast Guard district.

The booklet maintained by the Corps contains two tables for each of three regions: the Atlantic, Gulf, and Pacific Coasts constitute Series 3; the Mississippi River System and the Gulf Inter-Coastal Waterway as Series 4; and the Great Lakes System, labeled Series 5. The first table is a list of vessel operators sorted alphabetically by name and includes an address. The second table contains more detailed information and is sorted by operator's name. For each operator it identifies vessels owned and specifics such as net register tonnage, register and overall length, register and overall breadth, draft, horsepower, capacity, and other items.

Although the Corps booklet is useful, it has limited application if the only known information is the name of the vessel.

The other compilation offered by the Department of Transportation -- U. S. Coast Guard's "Merchant Vessels of the U. S." -- contains three useful tables. The List of Vessels itemizes all registered vessels in the U. S. alphabetically. Additional information is detailed, such as type of rig, gross and net tonnage, length and breadth, width, hull type, when and where built, type of service used for, horsepower, name of owner, and home port.

The second table, Signal Letters, gives an alphabetical listing of the signal and radio call letters. This would be useful in the rare event that only the signal letters are known but no other information. The third table, Index of Managing Owners, is an alphabetized listing of vessel owners. Also included in this table are owners' addresses and names of all the vessels they own.

These compilations are useful references when the known information consists of the vessel's name or signal call letters. This will help to locate the owner. However, only vessels which are registered are included in the list. Unfortunately, not all barges are registered; certain types, like the open-hoppers, are neither registered nor certified.

Trucks are also required to carry documents describing the contents of the carrier. The shipper is required to complete a bill of lading which gives a description of the shipment and a United Nations Number (UN#), which refers to a specific chemical. The document also contains an area which designates whether the shipment is hazardous. If a hazardous material is shipped in quantities equal to or greater than the Department of Transportation's reportable quantity, the vehicle must be placarded with the proper warning (flammable, corrosive, oxidizer, etc.). The lack of a placard on a vehicle means one of two possibilities: (1) no hazardous material is present or (2) the amount of hazardous material is below the reportable quantity. The Department of Transportation has a placard for shipments containing various hazardous materials. A "Dangerous" placard is required for shipments which meet the reportable quantity of mixed hazardous materials.

The bill of lading is kept in the cab of the truck. If for some reason this document cannot be obtained, the trucking line can be notified. Only large trucking lines may have specific information about the chemical. Smaller trucking lines only maintain a general description of the chemical shipped. For specific information, the trucking line would have to contact the shipper.

In some instances, analytical detection instruments can aid in identifying chemicals. Most analytical detection instruments, such as combustible gas indicators, photoionization devices, and flame ionization devices, require the identity of the chemical and proper calibration before reliable information can be obtained. One type of analytical detection device combines a portable gas chromatograph with a flame ionization detector to assist in the determination of unknown chemicals. After a sample has been analyzed, the instrument compares the sample results with results of known chemicals to identify the chemical.

It would be desirable to have response personnel with training in the use of a gas chromatography flame ionization detector or knowledgeable in the area of analytical chemistry. Results from novice users may not be accurate. The identity of the chemical will have to be determined in a relatively short time. Under these time constraints, the results, even when obtained by an experienced user, may not be accurate because of the presence of other compounds. The identification of a chemical by using an analytical detection device alone should be avoided. If analytical data are available, the characteristics of the chemical can be compared with the observed characteristics of the spilled chemical to increase the probability that the chemical has been correctly identified.

If after using the preceding information sources the identity of the chemical remains unknown response personnel will have to use more of a detective approach. Initially, response personnel will need to gather as much information as possible from observation. Reference can then be made to the Oil and Hazardous Material Technical Assistance Data System (OHM/TADS), which has a procedure available to assist in identification of spilled materials from observed characteristics such as physical state, smell, and color. OHM/TADS is managed by CIS and requires prearranged authority before using. The OSC can access OHM/TADS through either the U. S. Coast Guard's National Response Center (NRC), the National Strike Force, or through the Chemical Information System (800-CIS-USER).

A great deal of information can be obtained from observation. Placards and warning signs can give the associated hazards of the cargo. For instance, "No Smoking" or "No Open Lights" indicate a flammable cargo. "No Visitors" indicates the possibility of toxic substances. Toxicity can also be determined by looking for dead fish near the spill site.

Physical characteristics can also be determined from observation or from persons reporting the release by viewing from a distance, the state of the chemical, and color may be observable. Ice formations around the spilled chemical indicate cryogenics or liquids with boiling points well below ambient temperatures. Important information can be obtained from people present at the time of the release. Such information can include chemical behavior and odor. A large number of questions can be asked to gain much needed information about the spilled chemical. Is the liquid vaporizing? Is the chemical viscous? Is it water reactive? Does it spread on water? Are the vapors heavier or lighter than air? More information will aid in the identification of the chemical.

Once the available information has been gathered, the OSC can access OHM/TADS. As of December 1985, the system contained information for 1,402 substances. OHM/TADS searches are based on 126 subjects which have been organized. These subjects are generally referred to as "fields." Searches can be made on different fields and, through the process of elimination, identification of the chemical may be possible.

3.1.2 Chemical and Physical Characteristics

After the spilled chemical has been identified, the response team must compile a list of physical properties to determine the chemical/water behavior and the associated hazards from the spill. This information can be used to determine the extent and magnitude of the emergency situation and to aid in the formulation of a response scenario and in the selection of proper protective clothing. Data can be accessed from a wide variety of handbooks and data bases.

Appendix A can be consulted for flammability and toxicity data and some selected physical properties for the floating CHRIS chemicals. A computerized version of data, as shown in Appendix A, is available for OSC with personal computers.

A source of physical property data for the OSC is the Chemical Hazards Response Information System (CHRIS) Volume 2, Hazardous Chemical Data. This collection of data contains detailed information on the chemical, physical, and toxicological properties of hazardous chemicals. In addition, information is given for expected behavior of the chemical on water, the risks of exposure, symptoms following exposure, selected chemical manufacturers, and shipping information. Hazardous assessment codes are given to be used later in determining the impact of the spill to populated areas through the Hazardous Assessment Computer System (HACS).

If for some reason the OSC requires information not available through the Hazardous Chemical Data Handbook, several alternative sources are available. For example, the OSC has access to data bases offered by CIS (1-800-CIS-USER). CIS has approximately thirty data bases with information on physical and chemical properties, federal regulations, and more. The OSC can make use of this information through either the U.S. Coast Guard's National Response Center (NRC) or the National Strike Force, although some OSC offices have a direct link to the CIS data bases. Probably the most useful data base offered by CIS is the Oil and Hazardous Material Technical Assistance Database System (OHM/TADS). OHM/TADS contains data for any material designated an oil or hazardous material by the EPA.

The Chemical Manufacturers Association operates the Chemical Transportation Emergency Center (CHEMTREC). CHEMTREC can be accessed through its emergency telephone number 1-800-424-9300. CHEMTREC's function is to serve as a liaison between response personnel and the chemical manufacturer and/or shipper. The theory behind this service is that the manufacturer will know more about its product than anyone else. Upon notification, CHEMTREC contacts the shipper of the chemical for assistance and follow-up procedures. Warnings and limited guidance to emergency personnel at the scene of the emergency situation are available. The system covers 3,600 items which have been submitted by manufacturers as their primary items of shipment.

Chlorine manufacturers in the United States and Canada established the Chlorine Emergency Plan through the Chlorine Institute. This service is accessed through CHEMTREC and is a mutual-aid program where the manufacturer closest to the emergency provides technical assistance.

The NACA Pesticides Safety Team Network is operated by members of the National Agricultural Chemicals Association (NACA). It is also accessed through CHEMTREC and provides technical information assistance or, if needed, response teams in the event of accidental spills of pesticides.

3.1.2.1 Water/Chemical Behavior

The OSC will organize the data to determine the behavior of the chemical on water. The behavior can be classified by its floatability and mobility. With the spill situation classified, predictions can be made about the impact of the hazard. The classification will also aid in the formulation of a response scenario.

At present, no clear-cut method exists to determine the floatability of every chemical on water under all environmental conditions. The criteria used to determine whether a chemical will float are specific gravity less than 1.05 and/or solubility no greater than 25 g/100ml. For chemicals with specific gravities much less or much greater than 1.0, the method works quite well. However, for chemicals with specific gravities only slightly less than 1.05 and solubilities close to the upper solubility limit, the criteria predict floating when borderline behavior exists. Since solubility and specific gravity are temperature dependent, the chemical may or may not float in a given spill situation. A list characterizing the floatability of CHRIS chemicals is provided at the beginning of this manual. This list designates for each chemical: "yes" if the chemical floats on water, "possible" if the chemical will float on water under certain environmental conditions, "no" if the chemical will not float on water, and "no data" for chemicals with limited information. Appendix A also designates chemicals that may not float under all environmental conditions. For chemicals designated "possible" and "no data," the OSC may have to rely on observed information from the actual spill site to determine floatability of the chemical. This handbook covers responses to all chemicals which are known or suspected floaters (313 chemicals).

This floating criterion is broadly interpreted to include chemicals which may float on saline water but not on fresh water. The small amount of salt present in salt water will increase its density slightly and, therefore, will support heavier chemicals than fresh water. The floating criterion was raised to 1.05 to include heavier chemicals which may float in some spill situations.

The mobility of the chemical on the water surface will need to be characterized to complete the characterization of the chemical/water behavior. Environmental effects of current and wind will increase the mobility of the spill, and guidelines for the characterization of these efforts are discussed in sections 3.1.4.3 and 3.1.4.4, respectively. In addition to environmental-aided mobility of the spill, the chemical interaction of the chemical and water will determine the spreadability of the chemical on the water surface. Because of their chemical properties, some chemicals spread quickly over the water surface to form monolayers (a layer of chemical on the water surface one molecule thick). This behavior is discussed further in Section 6.4. Appendix A alerts response personnel to chemicals which exhibit this behavior.

3.1.2.2 Hazards to Response Personnel

Along with the water/chemical behavior, the hazards to response personnel must be determined to accurately characterize the spill situation. Information on the flammability and/or toxicity of the identified spilled chemical must be gathered. Special consideration needs to be given to the effects of solubility, skin permeability, and downwind concentrations.

In addition to information provided in Appendix A, information on the hazards associated with chemicals can be found in documents provided by the National Academy of Science (NAS) and the National Fire Protection Association (NFPA) which classify hazardous chemicals as to their flammability, toxicity, and reactivity (with water). These lists are not complete, and some of the hazardous CHRIS chemicals may not be classified. However, the CHRIS Hazardous Chemical Data Manual includes flammability and toxicity criteria on the majority of hazardous CHRIS chemicals. Appendix A provides toxicity and flammability information for the floating CHRIS chemicals.

To accurately assess the dangers posed to cleanup personnel, information is needed on the degree to which the vapors are flammable. This is usually given as a class or rank by one of the aforementioned groups. For chemicals which emit flammable vapors, a lower explosive limit (LEL) and an upper explosive limit (UEL) are given. This information can be used to determine the extent to which possible ignition sources will have to be eliminated.

The flash point is another critical piece of information necessary to characterize the flammability hazard. The flash point is the lowest temperature which will produce flammable vapors. It is important to consider that this temperature is based on pure chemicals. If the chemical is water soluble, the actual flash point of the mixture could be higher.

The National Fire Protection Association rates flammability on a scale of 0 to 4 with 0 designating no flammability hazard and 4 designating the highest flammability hazard. Flammability ratings in Appendix A used the criteria shown in Table 3.1.

TABLE 3.1. FLAMMABILITY RATINGS

	NFPA Rating	Flashpoint
Noncombustible	0 or 1	$\geq 200^{o}F$
Combustible	2	$\overline{100} - 200^{o}F$
Flammable	3	$< 100^{o}F$
Highly Flammable	4	--

Chemicals which meet either NFPA or flashpoint criteria, or both, are assigned the corresponding flammability rating.

Toxicity information is much the same as flammability but is presented in a more qualitative way. The threshold limit value (TLV) is the concentration of chemical to which a worker can be exposed for eight hours a day, five days a week, with no ill effects. A short term exposure limit (STEL) is the concentration of chemical to which a worker can be exposed for 15 minutes with no adverse effects. Lethal dose fifty (LD_{50}) is a calculated dose of a substance which is expected to cause death in 50% of a defined experimental animal population when taken into the system by any means excluding inhalation. Lethal concentration fifty (LC_{50}), the same type of measure of toxicity as LD_{50}, is for exposure to the substance through inhalation. Lethal dose low (LD_{Lo}) is the lowest dose of substance introduced by any route other than inhalation which has been reported to produce fatal effects in humans. Lethal concentration low (LC_{Lo}) is similar to LD_{Lo} except it pertains to exposure to the substance through inhalation.

Guidelines for toxicity ratings were developed for the U. S. Coast Guard using a least squares regression technique (Szluha, et al., 1986). TLVs, STELs, rat LD_{50}s, and Immediately Dangerous to Life and Health were considered in the linear regression study. Based on the results, the following guidelines were developed to establish a lower toxicity limit:

1. STEL less than 130 ppm
2. IDLH less than 11,200 ppm
3. TLV less than 50 ppm
4. LD_{50} less than 5,000 ppm
5. NFPA health rating of 2 or more

TLVs and STELs were given priority for ranking toxicity based on the regression analysis. Table 3.2 shows guidelines for ranking toxicity using TLVs and STELs.

TABLE 3.2. CHEMICAL RANKING GUIDELINES

Group	TLV (ppm)	STEL (ppm)
Practically nontoxic	1,000	5,500
Slightly toxic	100	130
Moderately toxic	5	3
Highly toxic	0.1	0.1

These guidelines were used to classify the 313 floating chemicals. The ratings are included in Appendix A. For some of the chemicals, the necessary information needed to rank them was not available. Statistical and extrapolation methods were employed to estimate the needed data. (Szluha, et al., 1986)

Once the toxic or flammable information has been collected for the spilled chemical, response personnel will need to characterize the possible pathway to which personnel can be exposed to the hazards. For the floating CHRIS chemicals, a large number of the chemicals are organic solvents with high vapor pressures (boiling point near or below ambient temperatures). Once released, these chemicals produce vapors which are carried downwind spreading the toxic and/or flammable hazards to areas downwind from the original release. Two pieces of information would be useful to characterize the degree to which a vapor plume will develop and how it will impact response personnel. First, the boiling point can be used to give some insight on the amount of vapor produced by the chemical. Chemicals with boiling near or below ambient temperatures will produce more vapors than chemicals with boiling points higher than ambient temperatures. Knowing the boiling point of the released chemical will give the response personnel some qualitative basis on the amount of vapors produced.

Boiling points for the floating CHRIS chemicals are included in Appendix A of this manual.

Second, consideration should be given to the behavior of the vapors. This can be classified by the vapor specific gravity. The vapor specific gravity is the ratio of the vapor density of the chemical to that of dry air. This value can be estimated by the following ratio:

$$\text{Vapor Specific Gravity} = {}^{M}/29$$

where M is the molecular weight of the chemical. Knowing the specific gravity of the vapors, response personnel can determine their behavior. Vapors with specific gravities less than one are lighter than air and will rise. Vapors with specific gravities greater than or equal to one will hover close to the ground. These vapors are more hazardous (if they are toxic and/or flammable) because they can pose a toxic or explosive threat to a large area downwind from the spill site. Appendix A alerts response personnel to chemicals which produce buoyant vapors. Response activities should include techniques to reduce these hazardous impacts to response personnel and affected populated areas.

It would be useful to have information on the effect of exposure to the skin. Effects could range from burns of contacted area to skin permeation. Information on skin permeation may be difficult to ascertain from compliled sources of data. Since the chemical manufacturers should be well informed about related hazards, they can be contacted for specific information.

Water reactivity of the substance needs to be determined due to the possibility of the production of a chemical of equal or even greater danger. All possible sources of hazards must be considered before sending response personnel into the contaminated area.

When combined, this information can be used to characterize the hazards to cleanup personnel associated with the release of a hazardous chemical. The information will also assist in the formulation of a response scenario. Types of personnel protection equipment and downwind or downstream hazards can be determined from the characterization of hazards to cleanup personnel. A comprehensive guide entitled Guidelines for the Selection of Chemical Protective Clothing (Schwope, et al., 1987) is useful for determining the proper protective clothing required for exposure to various chemicals.

3.1.3 Characterization of the Spill Location

The next step in classifying the spill situation is the determination of the location of the spill. This piece of information will be known from the notification of the spill. The type of water body will be useful in formulating a spill response scenario and ambient water quality criteria (AWQC). Impacts to populated areas, drinking water intakes, and industrial water intakes can also be judged by considering the location of the spill.

Types of bodies of water include lakes, harbors, rivers, and the coastal and intercoastal waterways. A description of the body of water uses is also important. For example, primary uses can include swimming and recreation, public water and industrial water supply, and a sanctuary for fish and wildlife. By characterizing the uses, criteria for acceptable levels of water pollution can be determined.

EPA promulgated AWQC for different water usage criteria. The four usage criteria are (1) swimming and recreation, (2) fish and wildlife, (3) public water supply, and (4) industrial water supply. The AWQC gives acceptable guidelines for water quality. The acceptable criteria are based on minimum limits for biological oxygen demand (BOD), total organic carbon (TOC), total suspended solids (TSS), and pH.

Impact to drinking and industrial water intakes also must be considered. Contaminated drinking water supplies can pose a serious health threat, and the proper authorities must be notified. Affected industrial water intakes must be notified of possible contaminants to be aware of associated corrosion problems or extra disposal considerations.

Releases may occur within the Coast Guard jurisdiction that are not located on bodies of water. Response personnel may be required to characterize spills located on land. Important considerations include soil type, land use, and proximity to populated areas and water bodies.

Consideration must be given to the proximity of populated areas to the spill. Hazards to recreational areas also need consideration. Populated or recreational areas can be impacted by either contaminated water or by a toxic and/or flammable plume. Emphasis is placed on the mobility of the spill and the vapor plume. Consideration of an impact area must include much more than the area immediately adjacent to the spill site.

Other information would require assistance from someone knowledgeable of the area. To answer these types of questions, it may be useful to incorporate some local authorities. The following is a summary of important information to be gathered to characterize the spill location. A portion of the information can be gathered by the man-on-the-scene from observations.

TABLE 3.3. SUMMARY OF SPILL LOCATION CHARACTERIZATION

Land	Water
Location of the spill	Location of the spill
Response access routes*	Response access routes*
Land use*	Type of water body
Proximity to populated areas and water bodies*	Use of water body*
Description of land topography	Proximity to populated areas and water intakes*

*Determining this information may require assistance from local authorities.

3.1.4 Impacts of Environmental Conditions on Spill Response

The chemical and toxicological properties of materials spilled on water greatly influence applicable response measures and hazards to response personnel and population centers. Environmental conditions also impact response techniques by limiting the availability of response methods and affecting the transport mechanisms of dissolution and vaporization. Ambient air temperature will directly affect the rate of evaporation of chemical spills. Water temperature will affect the tendency of chemical spills to dissolve, float, and evaporate. Adverse weather conditions will destabilize spills and potentially limit certain response methodologies.

In the characterization of the environmental conditions at the spill site, it is important to collect information on the impact of the environmental conditions as well as temperature, wind speed, current velocity, etc. Collecting environmental data can be accomplished by using various measuring devices, but characterizing the effects of the environmental conditions will come from observations from the man on the scene. The following sections designate the environmental data necessary and discusses some possible impacts of environmental conditions.

3.1.4.1 Temperature Related Impacts

The temperature of the surrounding air and water affect the physical properties of the chemical. The affected properties include vaporization rate, water solubility, density, and the rate of the transfer of heat between the chemical and the surroundings. Response personnel must be aware of the effects of temperature to ensure a proper response.

Both ambient air and water temperature affect the driving force for vaporization of the spill. Increasing temperature results in increased evaporation rate. For example, ethyl ether has a vapor pressure of 760mmHg at 100^{o}F. If the temperature is lowered to 68^{o}F, the vapor pressure is lowered to 200mmHg. The amount of vapor present is proportional to the vapor pressure and, with an increase of vapor pressure, the amount of vapor is increased.

Water temperature will also affect chemical density. For substances considerably less or more dense than water, this temperature-dependent effect will be negligible. However, as the specific gravity of the chemical approaches 1.0, the temperature-density relationship becomes more important. Density of liquids tends to decrease with increasing temperature. Thus, a chemical with a specific gravity (density of chemical/density of water) of 1.01 @ 68^{o}F may exhibit a density of .98 @ 80^{o}F. This indicates that chemicals with densities very near water may undergo transition from floater to sinker or vice versa, dependent upon water temperature. More importantly, this tendency, and temperature stratifications that normally occur in bodies of water, may cause chemical suspension below the surface. The potential for transition in buoyant behavior for chemicals with densities similar to water should be noted by response personnel.

3.1.4.2 Radiant Energy Effects

Radiant energy is energy transferred from the sun. It affects the stability of the spill by increasing the amount of vaporization of the floating chemical.

Energy is absorbed by the pool of chemical, increasing the rate of evaporization. Increased evaporation can worsen the hazardous impacts to surrounding areas.

The extent of adverse effects from radiant energy is dependent on the amount of cloud cover and the time of the year (angle of the sun). Full cloud cover will block a large portion of the radiant energy, increasing spill stability. The amount of radiant energy is greater in the warmer months than in cooler months because of the angle of the sun to the horizon. Response personnel can characterize the intensity of radiant energy to determine its effects on the spill situation.

3.1.4.3 Water Current Velocity

Dispersion of chemical spills will be directly related to agitation from water current and wave conditions. Wave conditions and wind effects will be discussed in future sections, and this discussion is limited to impacts from current velocity. Lower current velocities aid response efforts by reducing transport to downstream populations and increasing the effectiveness of response efforts by lowering mixing and dissolution of the chemical. High water velocities adversely affect spill response by increasing transport to population zones and increasing dispersion of the chemical into the water body. Current velocities greater than 1.0 knot can adversely effect deployment and efficiency of booms.

In many cases it may not be possible to contain the entire spill. In this situation, dilution of that portion of the spill escaping containment becomes very important. A plug flow situation may occur in waters with low current velocities. This can have an adverse impact for downstream uses due to the high concentration of the spilled substance within the plug flow. On the other hand, high water velocities can break up the plug flow increasing the dilution of the spilled substance. Depending upon the circumstances, there may be enough dilution to render the spill harmless to the downstream user. Dilution estimates can be provided by the HACS computer model.

3.1.4.4 Wind Related Effects

Wind speed and direction will affect response methods due to four impacts related to wind conditions. These are (1) increased evaporation of chemical due to convective transport of chemical vapors, (2) dispersion/dissolution of chemical from wave action caused by wind, (3) adverse impacts upon response materials at higher wind speeds, and (4) population effects due to wind direction.

Wind direction may be categorized as favorable/unfavorable with respect to population centers. Favorable wind conditions are those in which wind carried vapors would migrate away from population centers. An example of such a situation would occur when windswept chemical vapors are carried to sea without crossing a populated zone. An unfavorable wind direction is one which carries vapors to the proximity of a population zone, adversely effects response options, or a combination of both. Adverse windborne population effects are readily recognizable. Their determination relies upon the angle of the plume centerline to the population centerline, distance to population zone, spill quantity, rate of evaporation, and chemical toxicity. The OSC should note the capability of the HACS model for providing estimates of downwind effects.

Wind speed will adversely impact response due to its effects of increasing the evaporation and transport of the chemical, thereby reducing possible response options. Higher wind speeds will result in adverse conditions for response personnel due to increased transport of chemical vapors. Downwind populations are likewise effected.

3.1.4.5 Weather Forecast

In addition to the present environmental conditions, it is also important to know what type of weather is expected. Response personnel can obtain the latest forecast from the nearest NOAA Weather Forecast. After the weather forecase is known, response personnel can determine how the changes, if any, will impact the spill situation.

3.1.5 State of the Spill

Characterization of the state of the spill is also important in obtaining enough information to complete the decision-making process. Information obtained in this phase of the characterization concerns the spill itself and the ongoing response activities. Topics covered in subsequent sections include: general description, burning spills, spill dispersion, and spill site activity. For more information, refer to USCG Policy Guidance for Response to Hazardous Chemical Releases - COMDTINST. M16465.30.

3.1.5.1 General Description

A general description is needed to characterize the state of the spill. The description should include information on the movement of the spill chemical on land or water, vapor behavior, volume, and physical state of the material (solid, liquid, or gas). Estimates should be made on the rate and duration of discharge.

The source of the spill also needs characterizing. For example, the size and position of the hole of a damaged container would be important information; it would be useful in determining the type of patching technology and the amount of material being discharged.

The extent of contamination should also be characterized. This would include contamination of shorelines and downstream distance the spill has traveled. For land-based spills, the extent of contamination should consider the paths of runoff from the source location to low-lying areas.

3.1.5.2 Burning Spills

The response methods applicable to burning spills differ greatly from methodologies for spills which are not burning. In fact, a major consideration in addressing chemical spills should be the prevention of ignition. Every consideration should be taken to determine the ignition potential of a chemical spill, such as the LEL and flashpoint, and to segregate the material from sources of spark, fire, and heat. Use of intrinsically safe equipment must be ensured. These considerations are further developed in subsequent chapters.

3.1.5.3 Spill Dispersion

Waterway obstructions such as bridge pillars, skimmers, dikes, and land peninsulas may cause the spill to break up. Response personnel must take note of the presence of such diversions in formulating the response method. Failure to consider downstream obstructions can result in limited space for response operations, impaction of response equipment upon obstructions (for instance, booms against bridge pillars), resulting in increased shedding or containment failure.

3.1.5.4 Spill Site Activity

Another important piece of information which is necessary for characterizing the state of the spill is the spill site activity. This information is useful for the OSC in constructing an appropriate response. The specific type of activity of interest is the response activity. The personnel involved could be local firefighting or police departments or an emergency spill response team from the responsible party.

To completely describe the spill site activity, on-scene personnel will need to report the action being taken. For example, the type of action could include plugging the damaged container, extinguishing the ignited materials, controlling crowds, or containing and cleaning up the spilled material. The report should also include the successes and failures of the actions.

3.1.6 Summary of Spill Characterization

It is important that all aspects of spill characterization be complete before proceeding to the decision analysis step. For the decision-making process to work efficiently, reevaluation of the preceeding steps should be audited. Figure 3.2 is a summary of information needed for the spill site to be fully characterized. An additional source of information for the characterization of a spill can be found in COMDTINST. M16465.30.

FIGURE 3.2. SUMMARY OF SPILL CHARACTERIZATION ACTIVITIES

Has the identity of the spill been determined?

No → Identification sources:

(1) Consult shipping information
(2) Contact shipper or manufacturer
(3) Contact COTP
(4) Observe physical characteristics
(5) Search OHM/TADS data base

Yes ↓

Characterize the physical properties of the spilled chemical:

(1) Behavior on water
(2) Associated hazards

↓

Characterize the spill site:

(1) Type and location
(2) Proximity to populated or environmentally sensitive areas
(3) Proximity to water intakes

↓

Characterize the environmental conditions:

(1) Weather conditions
(2) Time of day
(3) Water temperature
(4) Current velocity
(5) Weather forecast

↓

Characterization of spill site activities:

(1) Present response activities
(2) State of the spill

↓

Continue to the Decision Analysis Step.

3.2 Decision Analysis

The next step in the decision-making process is referred to as the decision analysis. This step defines the critical issues and formulates preventive and corrective strategies. Appropriate tactics are selected to implement the chosen strategies. The decision analysis uses information gathered in the spill characterization to assess the potential hazards to populations, the environment, and personal property and to formulate an appropriate response action.

The critical issues include the possible hazards of the spill which may impact population, environment, and personal property. Defining the critical issues involves identifying the type of hazard and the extent to which it exists. A clear definition of the critical issues will answer the following questions: (1) What is the hazard? (2) Who, what, and to what degree are they effected?

Preventive strategies are strategies which involve the protection of populated areas, the environment, and personal property from the associated and potential hazards of the spill. They include containment of the spill, extinguishing ignited materials, or suppression of hazardous vapors. Corrective strategies are those strategies which involve the cleanup and disposal of contaminated materials and debris.

Once the critical issues have been defined and the preventive and corrective strategies selected, the OSC will need a plan of implementation. This does not include the actual implementation of the strategies but is the organization of personnel and equipment to accomplish the desired goals.

3.2.1 Type of Response

The OSC can determine and define the critical issues by considering the information obtained in characterizing the spill situation and by using all the resources which are available. The formulation of preventive and corrective strategies is dependent on the critical issues. Corrective and preventive strategies are accomplished by response actions.

The OSC will have to determine the type of response needed for a given spill situation. The responsibility of the OSC is to ensure that the proper response action is taken to mitigate the hazards associated with a spill. The situation may merit a very involved response including local and state agencies, as well as the response capabilities of the OSC. On the other hand, the OSC may respond only to monitor the spill site activities to insure that the proper action is being taken. Some instances may occur where no response is merited.

To determine the type of response needed, the OSC will have to evaluate the impact of the hazards. A tool available to the OSC for the evaluation of hazards is the Hazardous Assessment Computer System (HACS). It is available through the U. S. Coast Guard's National Response Center. With the correct information, HACS can be used to estimate the following: liquid and vapor rates issuing from a damaged vessel, maximum downwind distances for the lower explosive limit and toxicity limit, pool size, duration of the impact, movement characteristics due to current and wind action, and more. The time required to obtain estimates will depend on the nature of the spill and the accuracy of the given information. If the information is accurate, an assessment may take as little as 15 minutes; with inaccurate information, the assessment may take hours.

The information needed to obtain an estimation from HACS is summarized in Table 3.4. Depending on the nature of the spill, HACS may require more information; therefore, a call back number should be left.

Another tool available to estimate hazardous impacts is the CAMEO system. This system can be accessed by the OSC through the NOAA Scientific Coordinator.

Once the hazards have been assessed, the OSC can determine the critical issues and ultimately the type of response needed. The action taken can be an active response involving containment and mitigation techniques or a response involving only the monitoring of response action taken by other personnel.

TABLE 3.4. DATA FOR HACS ASSESSMENT

Material discharged
Quantity spilled
Quantity originally in tank
Location of spill
Tank dimensions
Type of spill (instantaneous or continuous)
Temperature (air)
Cloud cover (percent)
Hole diameter
Location of the hole
River depth
River width
Stream velocity
Air Velocity
Temperature (water)

3.2.2 Response Planning

The next step for the OSC is to formulate preventive and corrective strategies as a response action. Depending on the type of response planned, the OSC will have to coordinate the capabilities of local, state, and federal agencies and other response personnel to accomplish the desired goals. The OSC will have to make use of contingency planning to determine the type of response capabilities which are available in the area. Other federal agencies with specialized talents are available to the OSC if needed.

Federal legislation has established the development of a National Contingency Plan (NCP). Through the structure of federal, state, and local agencies, contingency plans have been constructed on a national, regional, and local level. These contingency plans include the procedures and resources available in the event of the release of hazardous materials. The local contingency plan is designed as an "immediate response" to assist the OSC in preparation for response to spills. The plan includes a response equipment guide and operational contacts throughout the local response network. The plan also identifies environmentally sensitive areas and resources at risk from spills of hazardous materials. From this information, the OSC can construct a list of response resources available locally. The list can be compared to a list of resources needed for the chosen response to determine if additional assistance is needed from regional and national response plans.

Additional resources available to the OSC provide unique services to support the response effort, e.g., the Environmental Response Team (ERT). The ERT is funded by the EPA and based in Edison, NJ. Capabilities of the ERT include site assessment and contamination monitoring for response episodes which exceed the resources available to the OSC.

A very important part of the response effort is the flow of factual information from the OSC to the public through the media. Since the OSC is probably not trained in this area, the Public Information Assist Team (PIAT) is available through the USCG in Washington, DC. The PIAT is a highly skilled group of public affairs specialists.

The Scientific Support Coordinator (SSC) is a member of a group of highly skilled technical advisors/communicators and is funded by the National Oceanic and Atmospheric Administration (NOAA). One SSC is assigned per USCG district to assist the OSC in the evaluation of technical data. The capabilities of the SSC include contingency planning, risk analysis, technical hazard data, and general communications.

The National Strike Force (NSF) is funded by the USCG and consists of the Pacific and Gulf teams. Each team includes 25 to 40 members who are highly trained in large scale responses. To assist in a response, each NSF maintains an intensive inventory of pollution response equipment.

The OSC will need to set up a command post and an order of command if the situation merits it. The command post will be used to relay information from the spill site to OSC offices and coordinate on-scene activities. The order of command will designate personnel with specific responsibilities. The person in charge of on-scene activities will need to establish work zones. These work zones include a clean zone, contamination reduction zone, and a contamination or hot zone.

Figure 3.3 shows an idealized on-scene control and work zones. The response team will use these boundaries to control access of non-response personnel into contamination reduction and contamination zones.

3.2.3 Implementation Tactics

The implementation tactics involve the formulation of a plan to transport equipment and personnel to the spill site. The equipment to be transported may include various monitoring, containment, and cleanup devices. Personnel may include state and local agencies or federal agencies. The personnel and equipment will most likely come from a variety of sources, and a timely and organized relocation is beneficial in a successful response.

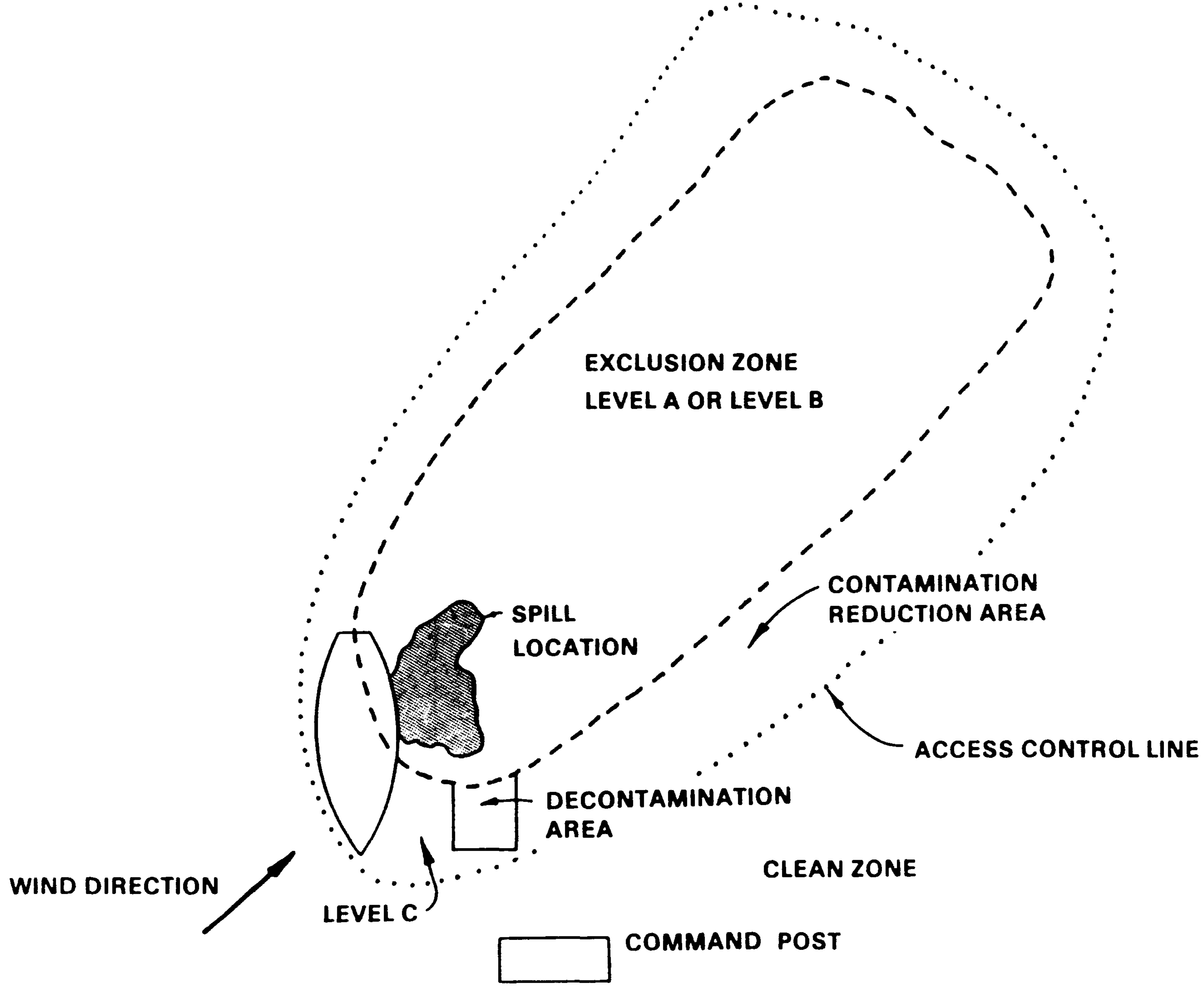


FIGURE 3.3. IDEALIZED ON-SCENE CONTROL AND WORK ZONES

In addition to relocation of equipment and personnel, the OSC will be needed to coordinate personnel in charge of different aspects of the response. Responsibility for various phases of the response activity will have to be designated to other personnel. Before the actual implementation takes place, all the details of the response need to be specified. These phases will include communication, mitigation of hazards, and cleanup.

The actual implementation of the response actions can be quite intensive. It could involve the transport and organization of several resources in the area. For responses to floating chemicals, available time for a response may be limited due to the mobility of the spill. It is most imperative that the OSC plan every phase of the response to insure a timely implementation of the selected responses.

3.2.4 Summary of the Decision Analysis Step

The decision analysis step uses information to determine the response required by the spill situation. A list of alternatives is compiled, evaluated, and the best alternative selected. Figure 3.4 is a summary of the decision analysis step.

3.3 Implementation

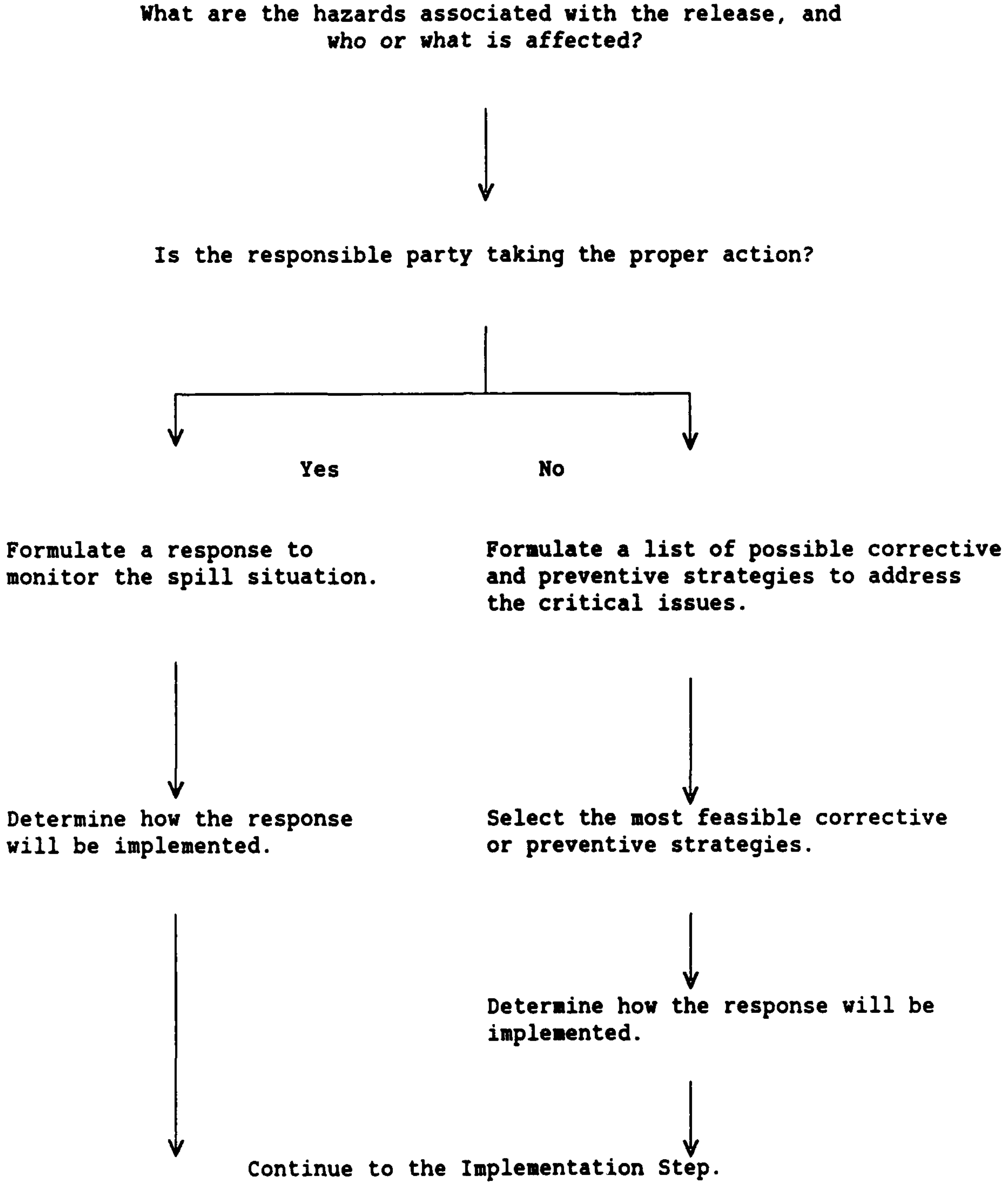
This step involves actually putting the chosen preventive and corrective strategies to address the critical issues into action. It is desirable that this action proceed in an organized and timely fashion. The previously selected implementation tactics should be employed to insure an organized and timely operation. The first priority is the protection of life, followed by the protection of the environment and personal property.

According to the level of response required, the implementation phase will require the mobilization and coordination of equipment and personnel. The different phases of the operation such as crowd control, mitigation of associated hazards, and cleanup and disposal of the hazardous chemical will have to be implemented and coordinated.

Several aspects of communication are important for the successful completion of the implementation phase. Aspects of communication include the efficient flow of details of the response among response personnel and the availability of factual information to the media.

Communication between response personnel is necessary for proper coordination and assessment of response actions. In an involved response, the action taken could include several operations, implemented separately or in conjunction with one another. Details of the response action can be used to determine the appropriate time to implement the next phase of the operation.

FIGURE 3.4. SUMMARY OF THE DECISION ANALYSIS STEP



3.4 Feedback

The feedback step involves reassessing the spill situation to determine if the corrective and preventive strategies are accomplishing the desired goals. Feedback is actually repeating the decision-making process. The spill characterization step will provide information on the hazards to response personnel, populated areas, and the environment after the implementation of corrective or preventive strategies. The decison analysis step will determine if the strategies are accomplishing the desired goals and if changes are needed.

Again, communication between personnel involved in various activities is important. Information should flow efficiently from the personnel involved in the response to the command post for evaluation and reassessment of the activities.

4.0 SPILL ISOLATION

Spill isolation involves limiting lateral movement of the spill which aids in cleanup operations and protecting areas against impact. Causes of lateral movement on water surfaces are wind, current action, or the spreading of the spilled chemical over the water body.

The OSC will also be required to respond to land based spills. Containment of land based spills would involve controlling run-off from the spill, preventing run-off from reaching bodies of water, and reducing the size of the contaminated area. Reducing the area and limiting the mobility of the spill will aid in minimizing the hazardous impacts from the spill.

The selection of the proper spill isolation technique will be dependent on the spill situation. Isolation techniques differ between water and land based spills. Consideration must be given to the identity and volume of the spilled chemical and the environmental conditions to ensure the selection of the most effective isolation technique.

Another important consideration involved in isolating the spill is reducing the flow of chemical, either liquid or vapor, from the damaged container. A variety of patching kits and patching materials are on the market. The effectiveness of these methods is dependent on the size of the hole and the chemical involved.

To select the most appropriate response for containment, the OSC will rely on prior experience and background in responses to hazardous spills and current knowledge of spill isolation equipment. The OSC will also have to be aware of the limitations of the chosen containment equipment or method(s) and make efforts to reduce the associated hazardous impacts.

4.1 Spill Isolation on Water

Isolation techniques for spills of hazardous materials on water are, in general, more difficult than for spills on land. The reasons for the difficulty stem from the mobility of the spill. Wind and current action can quickly disperse the spilled material, increasing the area of contamination and the extent of potential hazardous impacts. By virtue of their physical properties, some chemicals have the ability to spread rapidly on water surfaces. To limit the area of contamination, isolation techniques should be implemented as soon as possible.

The type of body of water is a primary concern when selecting an appropriate containment technique. Containment techniques vary with the type. For example, the isolation techniques for lakes, large rivers, and harbors are limited to booms and gels, whereas small streams, creeks, and drainage systems, may have more options available.

Technology for the containment of oil spills is well developed and widely available. The technology involves the use of booms to encircle the spill limiting its movement and facilitating in cleanup operations. Since the objective of containment for spills of hazardous materials is the same as for oil spills and methods for isolating hazardous chemicals on water are neither well developed nor widely available, it is logical to apply oil spill containment technology to spills of hazardous chemicals. However, the differences between oil and hazardous floating chemicals require modifications to the methodology for deployment of booms.

Response to oil spills present low flammability and toxicity hazards to response personnel and, due to physical properties, a wide range of polymer materials are not adversely affected from contact with oils. A large portion of floating CHRIS chemicals are organic solvents and fuels which present toxicity and flammability hazards to response personnel and high solvency to polymer materials. Response personnel must protect themselves from toxicity hazards by wearing proper protective clothing and limit ignition sources. The most difficult task for boom deployment is the selection of boom constructed with a material which is compatible with the spilled chemical. These aspects are discussed in Section 4.1.2.5.

With the differences between oil spills and hazardous chemical spills understood and the limitations known, containment technology for oil spills is the best isolation technique available to spills of hazardous chemicals.

Other isolation techniques include excavation, dams, weirs, and underflow devices. Each technique has its area of application and limitations. The following sections provide a description of each type of equipment, its use, the variables which effect its use, logistical requirements, and limitations.

4.1.1 Boom Deployment

The deployment of booms for floating hazardous chemicals, after the selection of a compatible construction material, is the same for oil spills with one exception. The exception involves avoiding ignition sources for chemicals which present flammability hazards. Sources of ignition can come from deployments or, if more than one boom is required, boom connecting operations. If sources of ignition can be avoided, the deployment of booms will offer a beneficial means of isolating the spill.

Booms that require inflation should be inflated on land. Inflation on water can be difficult because of the lack of mobility of personnel. The selection of boats for deployment will depend on the spill situation. Factors influencing the choice of ideal boats are weather conditions and water current. Another important consideration are the flammability hazards associated with the spilled chemical. Outboard motors may present an ignition source if they travel through the vapor plume with explosion limits. Under these circumstances, one possible alternative would be to fix a strong rope along the proposed run of the boom, and personnel on board (wearing the proper protective equipment and clothing) can pull the boat along by hand. Another possible ignition source is from connecting operations. Connectors for booms are usually made of metal couplings which could offer a spark while adjoining two booms. This hazard can be avoided if the couplings are emersed in water before joining.

Booms are held in place by anchors and mooring lines. The arrangement of anchors and mooring lines will be dictated by the area of deployment. Anchors should be marked with floats to ensure that they are maintaining their deployed position.

In general, mooring lines between the boom and waterbed should be about 5 times the water depth. For tidal waters, the depth of water at high tide should be taken into account. Selection of the proper mooring length is important to maintain the proper position of the boom. Clearly, if the mooring lines are too short, the boom may become submerged increasing the force of current and possibly displacing the boom from the desired position. Mooring lines which are too long increase the movement of the boom due to current flow, causing the boom to inadequately divert or contain the spilled material.

Anchors of the Danforth or Bruce type, used in association with heavy clumps of iron (sinkers), form the best means of mooring in flowing waters. Figure 4.1 shows the general arrangement and dimensions of mooring of this type. The placement of a bouy on the mooring line will prevent a downward pull on the boom. The location of the buoy should be approximately one quarter of the water depth from the end of the boom.

Bank mooring may take several forms. For light loads, a post or anchor on the bank may be sufficient to hold the boom in place. For heavier loads, a buried piece of stone, wood, or iron, wrapped in a steel chain forms an economical and workable mooring anchor. Figure 4.2 shows a possible arrangement of such a mooring. As the water current increases beyond 1.0 knot, vortexes and eddies form beneath the contained spill (see Figure 4.3). These vortexes and eddies shear material away from the chemical/water interface pulling it under the skirt of the boom. As the current increases, the amount of material lost also increases. This phenomenon is referred to as shedding or entrainment.

This can be overcome by reducing the angle between the current direction and the boom. Placement of a boom perpendicular to a current greater than 1 knot offers a situation most suitable for shedding. Reduction of the angle between the boom and the current direction will decrease the amount of shedding and divert the spilled material to a removal area. Shedding is possible from the area where spilled material collects when the current perpendicular to the boom exceeds 1 knot. Therefore, spilled material should be removed at the rate at which it accumulates.

Figure 4.4 shows the relationship between current speed and boom angle. The optimum angle of the boom is dependent on the current speed and the length and type of the boom used. To avoid shedding in strong currents, the angle must be smaller than in weak currents.

In some situations, booms may be exposed to burning materials. Most booms are not designed for deployment in such environments. However, at least one manufacturer markets a fireproof boom. The boom is manufactured in 50-foot lengths and constructed of a blend of metallic materials woven into a fabric with a high temperature polymer coating. The boom is stabilized with bouyant stainless steel spheres and lead weights. Tests have demonstrated that the boom can withstand temperatures up to 2,400^{0} F for extended periods of time.

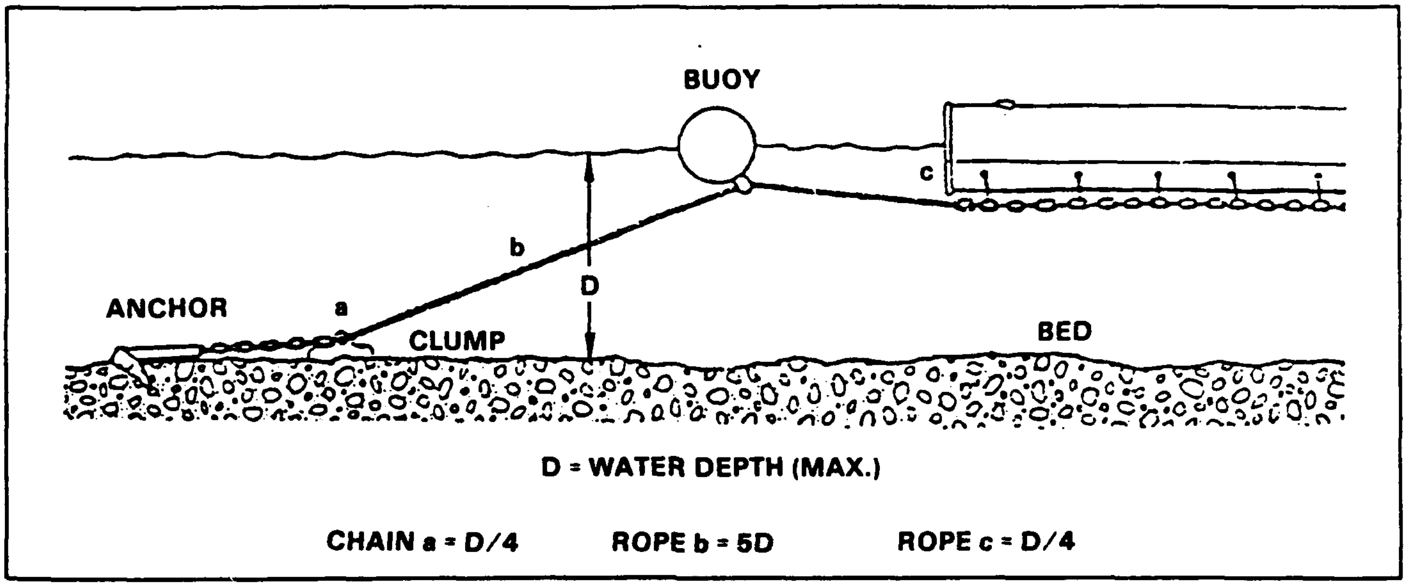


FIGURE 4.1. ARRANGEMENT OF MOORING ELEMENTS RELATIVE TO WATER DEPTHS

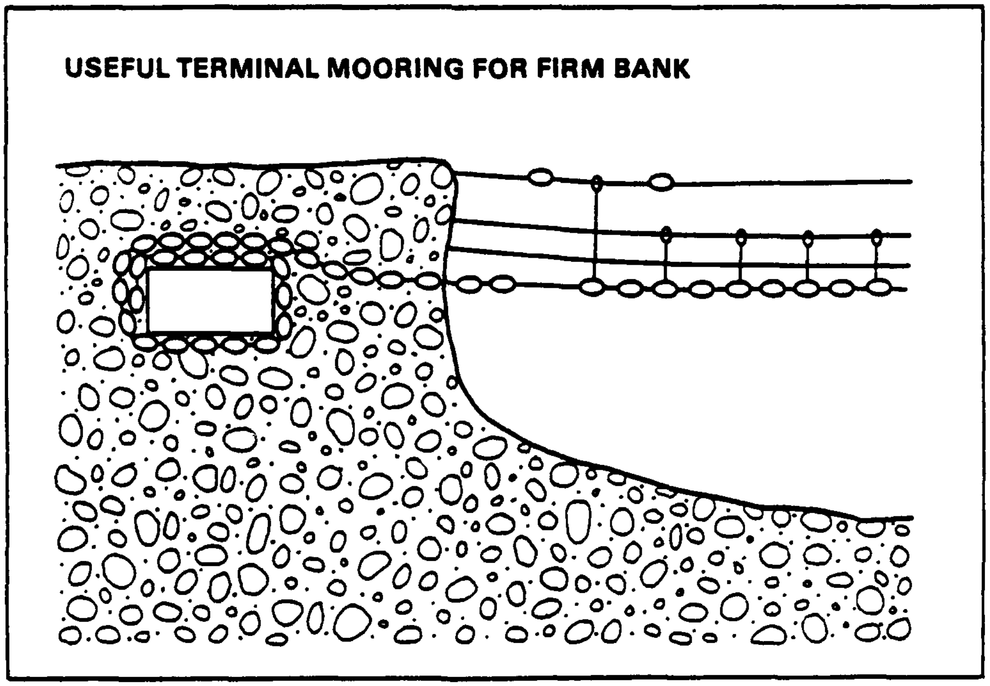


FIGURE 4.2. ARRANGEMENT OF MOORING ELEMENTS RELATIVE TO A BANK

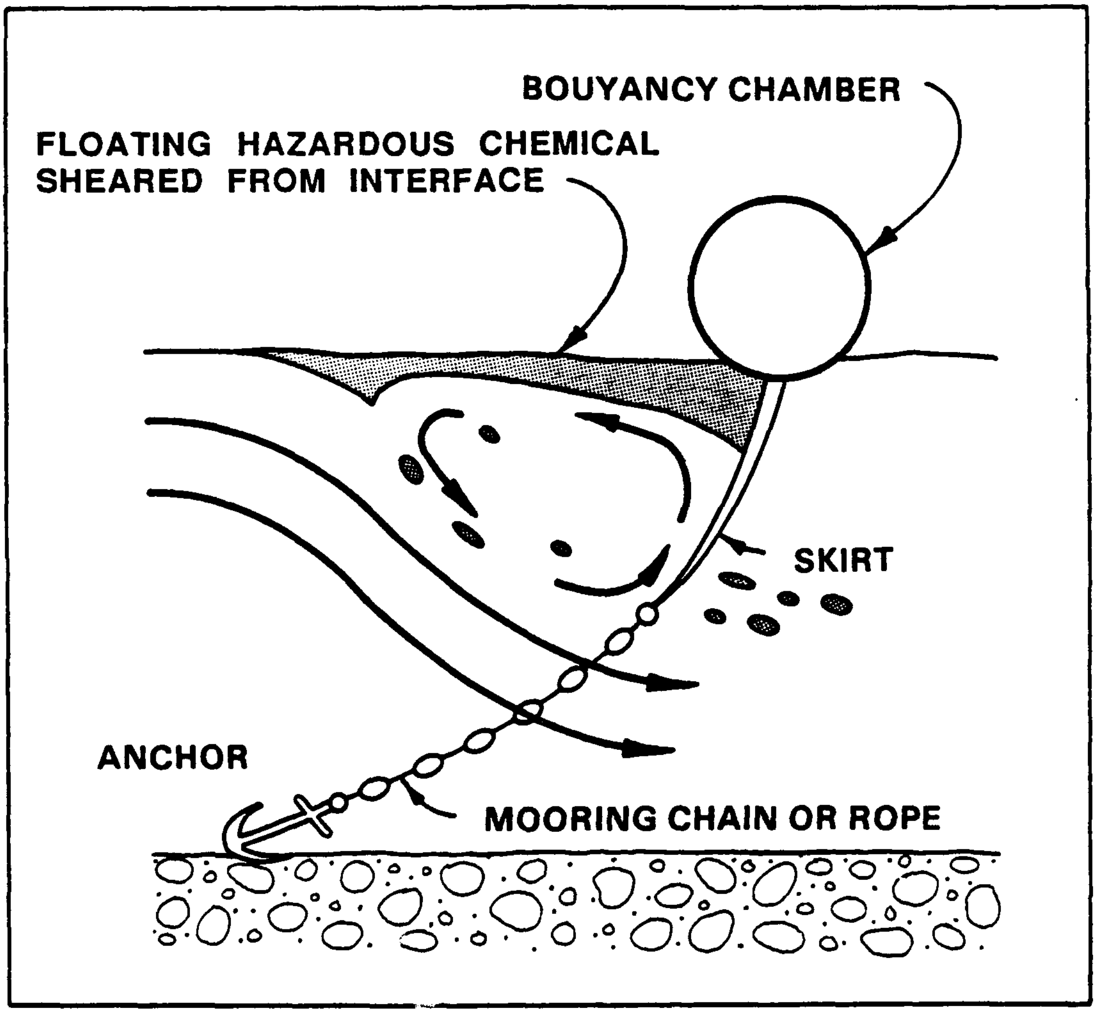


FIGURE 4.3. DIAGRAM OF THE MECHANISM OF SHEDDING WITH BOOMS

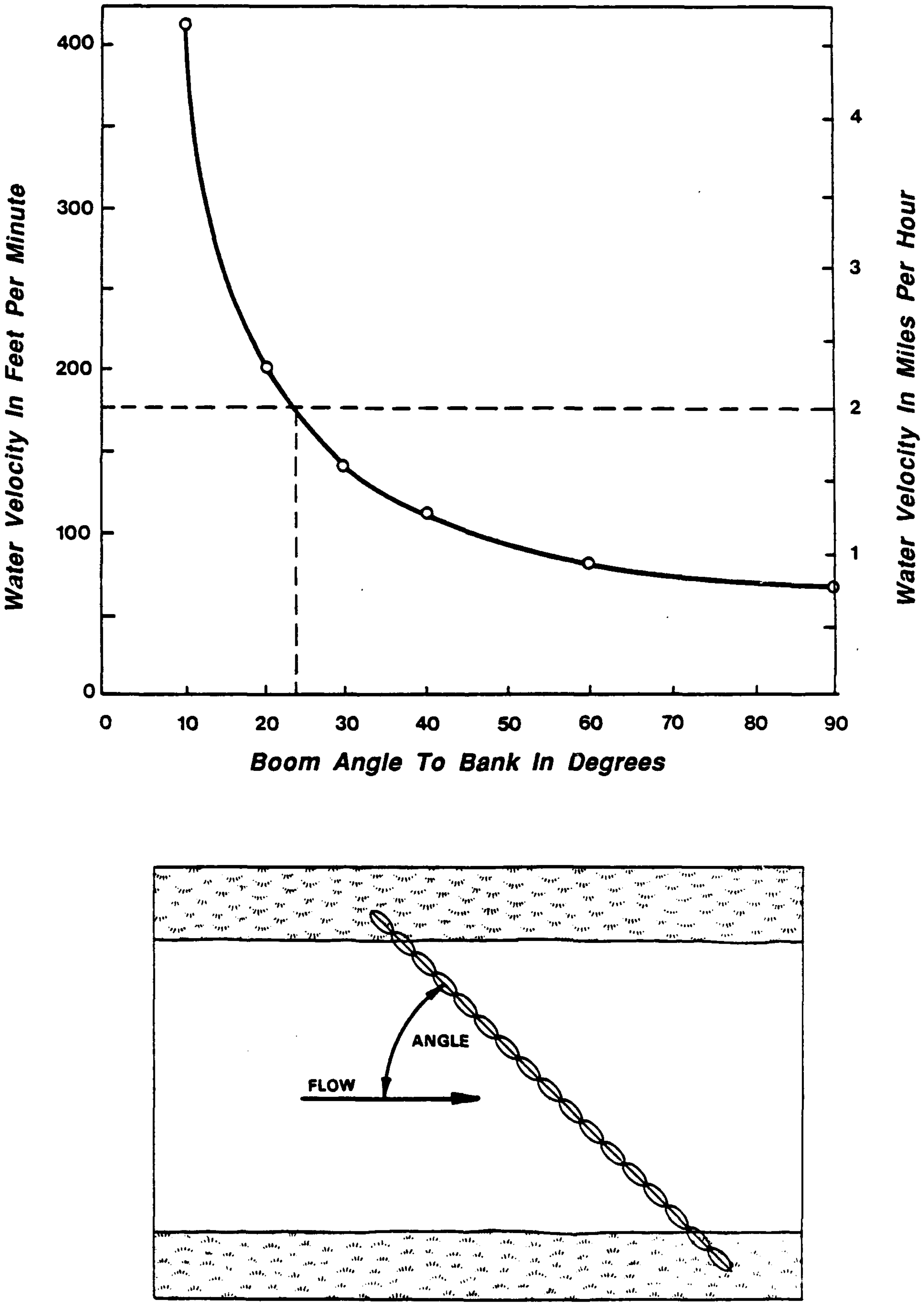


FIGURE 4.4. RELATIONSHIP BETWEEN BOOM ANGLES AND CURRENT SPEED

4.1.2 Types of Boom Applications

There are a variety of booms on the market. Booms vary in construction material and design, but they all have one thing in common: they are engineered to isolated spilled materials on water surfaces. Instead of offering a detailed description of the different types of booms, this section will describe the application of boom deployment in three categories: (1) exclusion booms; (2) diverting booms; and (3) containment booms.

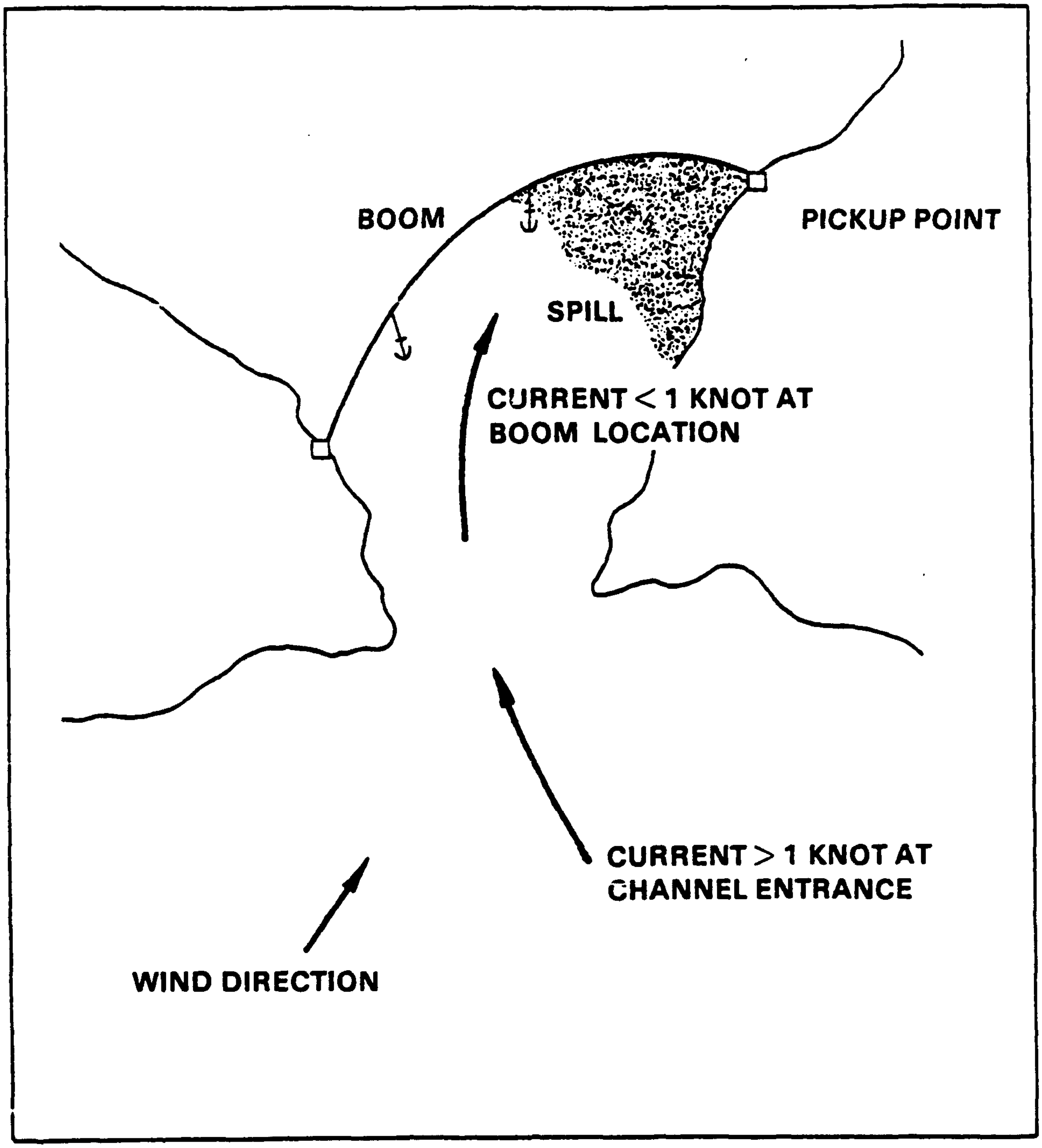
4.1.2.1 Exclusion Booms

Exclusion booms are used across small bays, harbor entrances, inlets, rivers, and creeks. This boom configuration involves the blocking of a water body to prevent the entrance or exit of hazardous materials and to aid in recovery of the spilled material. Exclusion booming is applicable in calm water bodies with low water currents.

Deployment of an exclusion boom involves anchoring the boom between stationary points. Figures 4.5 - 4.6 are examples of some possible exclusion boom configurations. Exclusion booms should be placed at an angle to the shoreline (whenever possible), preferably in the direction of the wind, to guide the spilled material to an area for recovery. In some cases, it may be necessary to anchor the upstream end of the exclusion boom to a small boat to allow traffic to enter or leave the enclosed area.

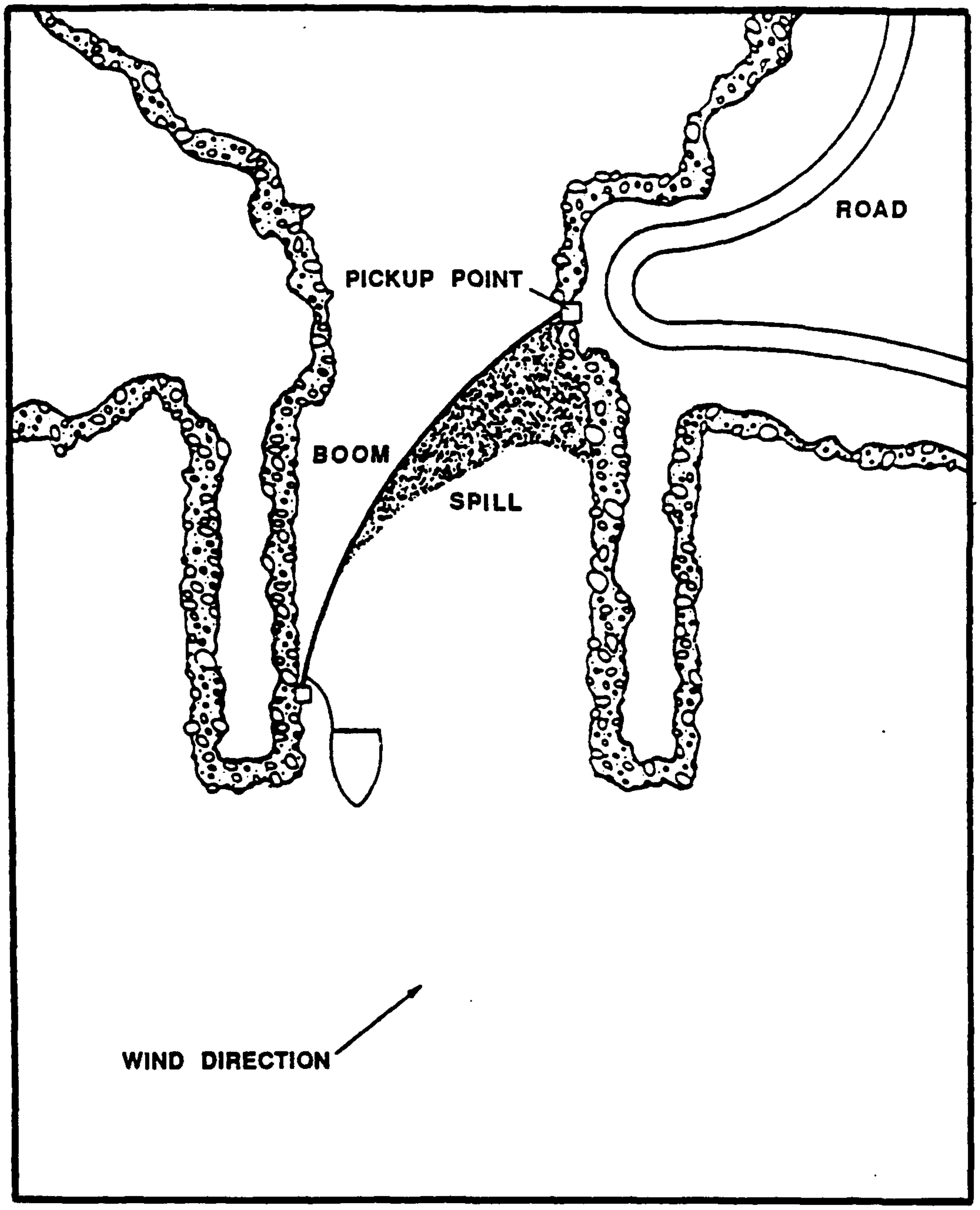
Deployment of exclusion booms in estuaries and rivers can pose problems in boom placement because of the possibility of high water currents. In this situation, deployment should be attempted in an area where the water velocity drops off, usually near the shoreline. Areas characterized by ripples or boils should be avoided if possible.

Manpower and equipment requirements for deployment of exclusion booms will vary with boom type, the nature of the area of deployment, and the environmental conditions. Table 4.1 gives a range of personnel and equipment requirements for deployment of exclusion booms. Actual requirements can be greater if the booms used are large and environmental conditions are undesirable.



Redrawn from Oil Spill Cleanup and Protection Techniques for Shoreline and Marshlands, A. Breuel

FIGURE 4.5. EXCLUSION BOOM ARRANGEMENT FOR AN INLET



Redrawn from Oil Spill Cleanup and Protection Techniques for Shoreline and Marshlands, A. Breuel

FIGURE 4.6. EXCLUSION BOOM ARRANGEMENT FOR A HARBOR ENTRANCE

TABLE 4.1. LOGISTICAL REQUIREMENTS PER 305 METERS (1000 FT) OF BOOM*

	Calm Weather or Light Boom	Rough Weather or Heavy Boom
Personnel	3	5
Support	1 workboat - 6 to 9 m (20 to 30 ft) plus crew	1 workboat - 12 to 15 m (40 to 50 ft) plus crew
Material	6 anchors plus anchor line and buoys	12 anchors plus anchor line and buoys

*Data from <u>Oil Spill Cleanup and Protection Techniques for Shorelines and Marshlands</u>, A. Breuel

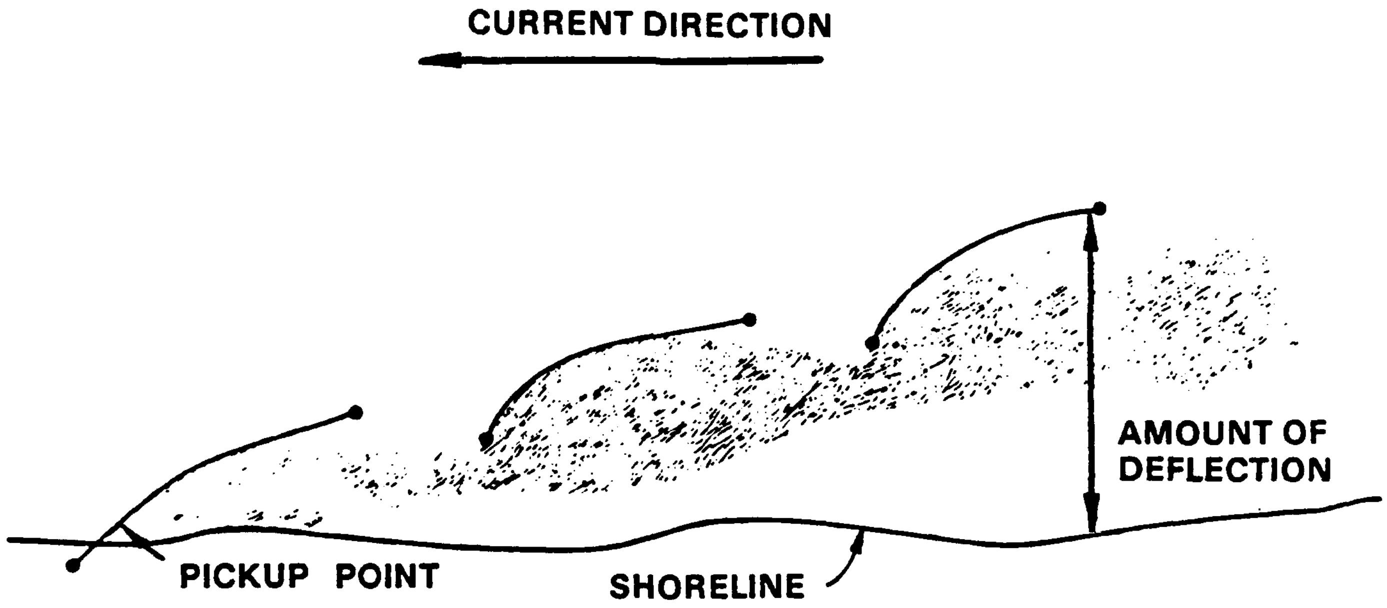
Exclusion booms can be effective if water currents are less than 1 knot, waves are less than 25 cm, and the water depth is at least twice the boom depth. For deployment in areas that experience tidal fluctuation, a flexible curtain-type boom should be used since it will perform better with tidal level fluctuations than a rigid fence-type boom.

4.1.2.2 Diversion Booms

Diversion booming should be used in areas of high water current (greater than 1 knot) or where the area to be contained is so large that available booms are not sufficient. Diversion booming is also useful for preventing spills from impacting sensitive areas or diverting spills to areas suitable for cleanup.

Diversion booming techniques can be summarized by two methods. The first method consists of arranging several booms in a cascading formation. This booming configuration consists of two or more booms placed step wise down stream. The lead boom intercepts the spill and diverts it towards the shore or an established removal area. Subsequent booms are placed downstream with the upstream end slightly overlapping the preceding boom. With this configuration, the spill is continually being diverted toward the shoreline or to an area of quiet water for removal. An example of a cascading diversion booming configuration is shown in Figure 4.7.

Selection of the proper boom angle is very important in this type of boom configuration. As the current increases, the angle of the boom needs to be decreased to lower the current speed perpendicular to the boom. This will decrease the likelihood of shedding. By estimating or measuring the water current, the proper boom angle can be determined from Figure 4.4.



Redrawn from Oil Spill Cleanup and Protection Techniques for Shoreline and Marshlands, A. Breuel

FIGURE 4.7. PLACEMENT CONFIGURATION FOR CASCADING DIVERSION BOOMS

The following steps summarize the procedures for deployment of the cascading diversion booms.

1. The lead boom is towed to a predetermined position to intercept the oncoming spill. The upstream anchor is put into place.

2. The deployment vessel maneuvers the downstream end of the boom to achieve the proper angle to divert the spill towards the desired position.

3. The first two steps are repeated until the end of the last boom reaches the recovery area. The booms are positioned so that the beginning of the boom overlaps the end of the upstream boom. The number of booms required will depend on the diverting distance, current speed, and size of the spill. Current speed affects the amount of booming required because the boom angle will have to be reduced to accommodate higher water currents. This reduces the area covered by the boom, increasing the number of booms required.

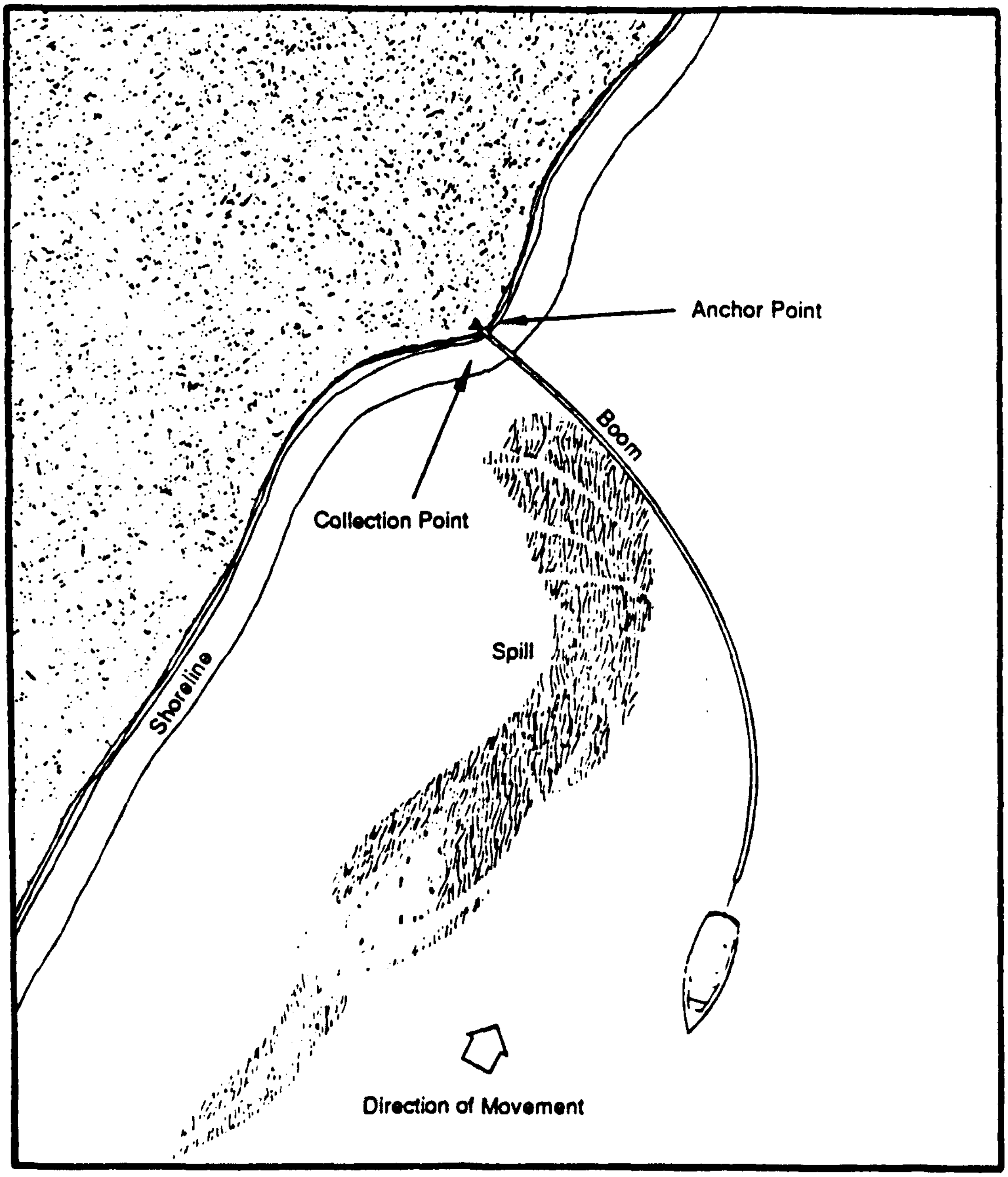
The second type of diverting boom is similar to the first, except only one or several booms connected together, are used to divert the spill to a collection area. This type of booming configuration is usually anchored at the downstream end to the shoreline while the other end is attached to a towing vessel. Figure 4.8 shows an example of the deployment of single diversion boom. Attaching the upstream end of the boom to a towing vessel allows easy variance of the boom angle if necessary. Again, selection of the proper boom angle is important to insure efficient diversion of the spill.

The specific logistical requirements for manpower and equipment will be dependent upon the size of the spill, environmental conditions, and the current speed. The type of booming equipment will also affect the logistical requirements. Table 4.2 gives an average logistical requirements for deployment of cascading or single diversion booms.

TABLE 4.2. LOGISTICAL REQUIREMENTS FOR DIVERSION BOOMING FOR DEFLECTION IN A 1.5-KNOT CURRENT*

Item	Single Boom	Cascading Booms
Equipment		
o Total boom length	61 m (200 ft)	183 m (600 ft)
o Anchors	1	6-9
Personnel	3-4	4-6
Support		
o Workboat (6 to 9 m)	1	1
o Recovery units	1	1-2

*Data from <u>Oil Spill Cleanup and Protection Techniques for Shorelines and Marshlands</u>, A. Breuel



Redrawn from Oil Spill Cleanup and Protection Techniques for Shoreline and Marshlands, A. Breuel

FIGURE 4.8. DIAGRAM FOR PLACEMENT OF A SINGLE DIVERSION BOOM

Limitations for deployment of diversion booms occur for high water currents and undesirable environmental conditions. At high water currents, where the limit for boom angle reduction has been reached, shedding will be experienced and the efficiency of booming will be less than optimum. High wind speed is an undesirable environmental condition which can cause increased wave height. This will disperse the spill and cause a loss of material over the boom.

4.1.2.3 Containment Booms

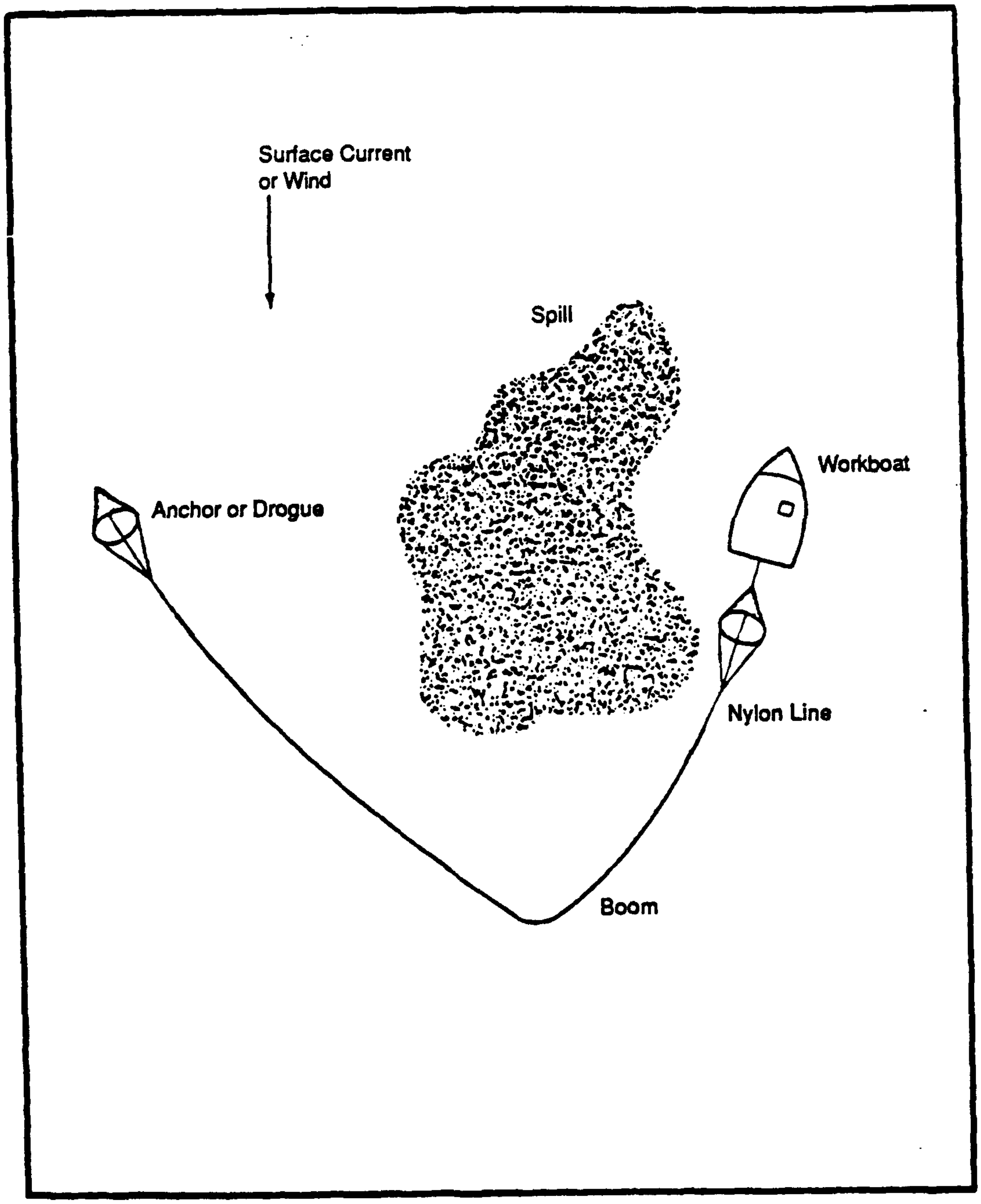
Containment booming is used in open water as a means of limiting the dispersion of the spill and aiding cleanup operations. Usually it is not necessary to encapsulate the entire spill for containment and cleanup. By considering wind and current directions, it is possible to deploy booms in a U-shape configuration to isolate the oncoming spill.

Timely response and deployment of containment booms are important when working spills on open waters before they are dispersed over a large area. The shape of the pool will be dictated by surface currents, obstructions in the water, and wind speed and direction. As the time between the actual spill and deployment of booms increases, the difficulty in containing the spill increases, requiring more time and manpower for deployment.

Consideration of spill movement is very important in determining the position of the containment booms. Figure 4.9 shows the deployment position of a containment boom considering the movement of the spill. Notice that the boom is deployed downwind or downstream of the spill, around the leading edge, and back into the wind or current. This technique will minimize the area of the boom which is positioned perpendicular to the current or wind direction reducing the amount of shedding.

Figure 4.9 shows one end of the boom anchored or drogued while the other end is held in place by a towing vessel. This is only one possible configuration for containment booming. Response personnel can alter the deployment method to tailor the boom configuration to fit the needs of the spill situation. For example, a spill situation where the wind direction is fluctuating or the water depth is too great for anchoring may require that both ends of the boom be attached to towing vessels for easy repositioning as the situation merits, and for anchoring. Or the spill situation may dictate that the booming configuration drift with the current.

Requirements for equipment and manpower will primarily be dependent on the size of the spill to be contained. Other variables such as boom type and environmental conditions will affect the logistic requirements. Table 4.3 gives some estimations of manpower and equipment requirements for a 150 m and 250 m spill diameter.



Redrawn from Oil Spill Cleanup and Protection Techniques for Shoreline and Marshlands, A. Breuel

FIGURE 4.9. PLACEMENT CONFIGURATION FOR CONTAINMENT BOOM

TABLE 4.3. LOGISTICAL REQUIREMENTS FOR CONTAINMENT BOOMING*

	For a 150 m (656 ft) Spill Diameter	For a 250 m (820 ft) Spill Diameter
Equipment		
o Boom	282 m (927 ft)	471 m (1545 ft)
o Work boat	1	1-2
Personnel	Boat crew and 2 boom deployers	Boat crew(s) and 2-4 boom deployers

*Data from Oil Spill Cleanup and Protection Techniques for Shorelines and Marshlands, A. Breuel

The values in Table 4.3 were determined by considering that the boom configuration will assume the shape of a semicircle, and each end will require a 10 percent boom lead for towing, anchoring, and drogue deployment. Boom requirements may exceed those given for actual situations.

The limitations of containment booms are related to the size of the spill and environmental conditions. If deployment is delayed so that the spill is dispersed over a large area, boom requirements may exceed available booms. Environmental conditions may be such that booming is impractical or inefficient.

4.1.2.4 Secondary Booms

In most applications of booms, the conditions of the body of water will exceed the limitations for shedding (perpendicular water current > 1 knot). Under these conditions, spilled material will be lost from beneath the boom and dispersed by wind and current action. Isolated material can also be lost over the boom by oversplash from wave action. Secondary booms can be placed downstream or downwind of the primary boom configuration. Secondary booms may either be similar to the primary booms or of a sorbent type.

Sorbent booms are constructed of a sorbent held together by a mesh material to allow the passage of water and spilled chemical. The sorbent will have an affinity for the spilled material. Sorbent booms are deployed and anchored in much the same way as regular booms. Once sorbent booms are deployed, it is necessary to rotate them because the portion of the boom exposed to the spilled material will become saturated. It is also important to replace sorbent booms which are completely saturated with spilled materials. Sorbent booms work best in quiet waters.

Secondary booms will be used primarily as backups to exclusion and containment booming configurations. Deployment and positioning will be similar to the primary boom. Logistical requirements for manpower and equipment for secondary booms are similar to those for the primary except for sorbent booms, where logistical requirements may increase due to replacement of saturated booms.

4.1.2.5 Problems Associated With Booming

Booming techniques under most situations encountered by response personnel will offer only limited isolation and containment. Surface currents and wave height usually exceed the limits for highly efficient containment. Response personnel need to consider the environmental conditions and determine the extent of shedding. Techniques, such as secondary booming, need to be employed to treat the hazardous material escaping containment. Compatibility between the spilled chemical and boom construction material is also an important consideration. The chemical properties of the spill may adversely effect the construction material of the boom. Adverse effects include swelling, curling, and softening of the polymeric material from contact with the spilled chemical. These effects can weaken the strength of the boom causing collapse and loss of contained spilled material. Some effects may not be noticed until after the boom has been removed from deployment. Curling and buckling are the common effects leaving the boom useless for future use.

No conclusive studies have been performed comparing a large number of the floating CHRIS chemicals to various boom materials. Table 4.4 provides some information based on qualitative considerations. The information was gleaned from a variety of sources on compatibility of various polymeric materials with chemical functional groups. Care must be taken in using the table because specific chemicals within a functional group can exhibit a wide range of solubility behavior. The polymeric material can also exhibit a wide range of behavior due to the method of processing. For example, the solubility properties of low density polypropylene are quite different from the solubility properties of high density polypropylene. Table 4.4 is offered as a guideline for response personnel. Manufacturers of booms should be consulted for quantitative data on chemical compatibility.

TABLE 4.4. CHEMICAL RESISTANCE OF SOME COMMON BOOM CONSTRUCTION MATERIALS*

	Aliphatic Solvents	Aromatic Solvents	Halogenated Solvents	Organic Acids	Oils	Fuels
Polyethylene	Fair	Fair	Fair	Good	Good	Poor
Polypropylene	Good	Fair	Fair	Good	Good	Poor
PVC	Poor	Poor	Poor	Fair	Good	Poor
Polyurethane	Good	Good	Fair	Fair	Good	Fair
Neoprene	Good	Poor	Poor	Fair	Good	Good
Nitrile Rubber	Fair	Fair	Fair	Good	Good	Good

*Sources: Encyclopedia of Polymer Science and Engineering, 2nd Edition, John Wiley and Sons, New York, New York, 1985; Branrup, J. and E. H. Immergut, Polymer Handbook, John Wiley and Sons, New York, New York, 1985; and Percy, Rober H. and Cecil H. Chilton, Chemical Engineers' Handbook, Fifth Edition, McGraw-Hill Book Company, New York, New York, 1973.

A study was performed by Bauer, et al. (1975) which compared eight representative CHRIS floating chemicals to various polymeric materials used in the construction of containment (and removal of equipment). Table 4.5 is a summary of the results from the compatibility tests. The tests consisted of placing a piece of the polymer material in a beaker of each of the eight representatives, and for two weeks comparing the polymer material before and after contact with the chemical. A rating of good stability was assigned to materials which would be suitable for response efforts involving the tested chemical. A poor stability rating was assigned to materials not suitable for response efforts to the tested chemical. A poor stability rating was assigned to materials not suitable for response efforts to the tested chemical. Comments on the effects from contact are also included. From Table 4.5, poly vinyl chloride products performed poorly when contacted with all eight representative chemicals and should be avoided in responses involving hazardous chemicals.

In recent years the need for a material with a high resistance to permeability and chemical attack from hazardous materials has provided new membranes which can maintain their integrity in harsh environments. One such material is XR-5, a woven fabric of polyester fibers saturated with primers, then coated with a compound containing Elvaloy resin modifiers. These membranes are widely used as liners for hazardous waste storage ponds and with a recent demand for response equipment for mitigation of hazardous chemical spills, their use has been expanded as a construction material for containment booms. Table 4.6 shows XR-5 compatibility with a variety of chemicals, and Table 4.7 shows a comparison of XR-5 with other polymer materials.

Response personnel have little resources to access the compatibility of boom material with spilled hazardous chemicals during the response activity. It would be advantageous for response personnel to determine the suitable environments for available booms in preparation for response activities.

In areas of high probability of hazardous chemical spills, it may be possible to obtain boom made from non-polymer materials as equipment inventory, avoiding the problem of determining chemical compatibility. However, response personnel will probably be faced with the task of predicting chemical compatibility with boom materials. From the limited available information, poly vinyl chloride materials should be avoided in response to organic chemicals, except organic acids. For other polymer materials, Tables 4.4-4.7 can be consulted for guidelines for behavior in various chemical environments.

The new blends of polymer materials (XR-5) will offer a wide range of compatibility since they are engineered to perform in harsh chemical environments. For very short response activities, all polymer materials used for booms would be resistant to hazardous chemicals, since it requires contact time for solvent action on solids to take place (Bauer, et al., 1975).

Once the boom has been deployed and recovered, it should be treated as cautiously as the spilled material, wearing protective clothing, and avoiding exposure to ignition sources if a flammability hazard is associated with the spilled chemical. Hazardous chemicals may still be present in the boom material even after decontamination. Spilled chemicals can be absorbed if the chemical

TABLE 4.5. RESULTS FROM CHEMICAL COMPATIBILITY TESTS

	Ethyl Ether	Kerosene	n-Amyl Alcohol	Naphtha: Solvent	Ethyl Acetate	Hexane	n-Butyrldehyde	Benzene
Poly Vinyl Chloride PVC	Poor stability. Extreme curling in solvent and stiffening when dry.	Poor stability. Extreme curling in solvent and stiffening when dry.	Poor stability. Extreme curling in solvent and stiffening when dry.	Poor stability. Extreme curling in solvent and stiffening when dry.	Poor stability. Extreme curling in solvent and stiffening when dry.	Poor stability. Extreme curling in solvent and stiffening when dry.	Poor stability. Extreme curling in solvent and stiffening when dry.	Poor stability. Extreme curling in solvent and stiffening when dry.
Chemigram Coated Nylon Fabric	Good stability. Softening in solvent; stiffening when dry.	Good stability. Slight weight loss by polymer.	Good stability. Slight weight loss by polymer.	Good stability. Slight weight loss by polymer. Stiffening when dry.	Poor stability. Curling, swelling and softening in solvent.	Good stability. Slight weight loss by polymer.	Good stability. Curling, swelling and stiffening in solvent.	Good stability. Curling, swelling and stiffening in solvent.
Polyurethane	Good stability. No deterioration.	Good stability. No deterioration.	Good stability. No deterioration.	Good stability. No deterioration.	Good stability. Some swelling and curling in solvent.	Good stability. No deterioration.	Good stability. Some swelling and curling in solvent.	Good stability. Some swelling and curling in solvent.
Polypropylene	Good stability. No deterioration.	Good stability. No deterioration.	Good stability. No deterioration.	Good stability. No deterioration.	Good stability. No deterioration.	Good stability. No deterioration.	Good stability. No deterioration.	Good stability. No deterioration.
Nitrile Elastomer	Good stability. Stiffening when dry.	Good stability. Stiffening when dry.	Good stability. Stiffening when dry.	Good stability. Stiffening when dry.	Good stability. Stiffening when dry.	Good stability. Stiffening when dry.	Poor stability. Swelling in solvent and stiffening when dry.	Good stability. Some stiffening in solvent.

TABLE 4.5 RESULTS FROM CHEMICAL COMPATIBILITY TESTS (con'd.)

	Ethyl Ether	Kerosene	n-Amyl Alcohol	Naphtha: Solvent	Ethyl Acetate	Hexane	n-Butyrldehyde	Benzene
Buna Rubber	Good stability. Swelling in solvent; slight stiffening when dry.	Good stability. Slight weight loss by polymer.	Good stability. Slight stiffening when dry.	Good stability. Slight stiffening when dry.	Good stability. Slight stiffening when dry.	Good stability. Slight stiffening when dry.	Good stability. Slight stiffening when dry.	Good stability. Slight stiffening when dry.
Royalex	Good stability. No deterioration.	Good stability. No deterioration.	Good stability. No deterioration.	Good stability. No deterioration.	Poor stability. Extreme softening and dissolu- in solvent.	Good stability. No deterioration.	Poor stability. Swelling and softening in solvent, and stiffening when dry.	Poor stability. Swelling and softening in solvent, and stiffening when dry.
Butachlor Coated Nylon Fabric	Good stability. No deterioration.	Good stability. No deterioration.	Good stability. No deterioration.	Good stability. No deterioration.	Good stability. No deterioration.	Good stability. No deterioration.	Good stability. Some curling in solvent.	Good stability. Some curling in solvent.
Paracril-020 Coated Fabric	Good stability. Slight weight loss by polymer.	Good stability. Slight weight loss by polymer.	Good stability. No deterioration.	Good stability. Slight weight loss by polymer.	Good stability. No deterioration.	Good stability. No deterioration.	Good stability. Some softening and swelling in solvent.	Good stability. Some softening and swelling in solvent.

Data from Agents, Methods, and Devices for Amelioration of Discharges of Hazardous Chemicals on Waters, Bauer, et al., 1975.

TABLE 4.6. XR-5 FLUID RESISTANCE

EXPOSURE	RATING	EXPOSURE	RATING
Acetic Acid (5%)	B	Kerosene	A
Acetic Acid (50%)	C	Magnesium Chloride	T
Ammonium Phosphate	T	Magnesium Hydroxide	T
Ammonium Sulfate	T	Methyl Alcohol	A
Antifreeze (ethylene glycol)	A	Methyl Ethyl Ketone	X
Animal Oil	A	Mineral Spirits	A
Aqua Regia	X	Naptha	A
ASTM Fuel A	A	Nitric Acid (5%)	B
ASTM Oil #2	A	Nitric Acid (50%)	C
Benzene	X	Perchloroethylene	C
Calcium Chloride Solutions	T	Phenol	X
Calcium Hydroxide	T	Phenol Formaldehyde	B
20% Chlorine Solution	A	Phosphoric Acid (50%)	A
Clorox	A	Phosphoric Acid (100%)	C
Conc. Ammonium Hydroxide	A	Phthalate Plasticizer	C
Corn Oil	A	Potassium Chloride	T
Crude Oil	A	Potassium Sulphate	T
Diesel Fuel	A	Raw Linseed Oil	A
Ethyl Acetate	C	SAE-30 Oil	A
Ethyl Alcohol	A	Salt Water (25%)	B
Fertilizer Solution	A	Sea Water	A
#2 Fuel Oil	A	Sodium Acetate Solutions	T
#6 Fuel Oil	A	Sodium Bisulfite Solution	T
Furfural	X	Sodium Hydroxide (60%)	A
Gasoline	B	Sodium Phosphate	T
Glycerin	A	Sulphuric Acid (50%)	A
Hydraulic Fluid	A	50% Tanic Acid	A
Hydrocarbon Type II	C	Toluene	C
Hydrochloric Acid (50%)	A	Transformer Oil	A
Hydrochloric Acid (5%)	A	Turpentine	A
Hydrofluoric Acid (50%)	A	Urea Formaldehyde	A
Hydrofluosilicic Acid (30%)	A	Vegetable Oil	A
Isopropyl Alcohol	T	Water (200°F.)	A
Ivory Soap	A	Xylene	X
JP-4 Jet Fuel	A	Zinc Chloride	T

Ratings are based on visual and physical examination of samples after removal from the test chemical after the samples of Black XR-5 were immersed for 28 days at room temperature. Results represent ability of material to retain its performance properties when in contact with the indicated chemical.

RATING KEY:
A = Fluid has little or no effect
B = Fluid has minor to moderate effect
C = Fluid has severe effect
T = No data - likely to be acceptable
X = No data - not likely to be acceptable

Reference: Seaman Corporation marketing booklet.

TABLE 4.7. COMPARATIVE CHEMICAL RESISTANCE

Chemical	XR-5®	Hypalon	Urethane	CPE	Poly Vinyl Chloride
Kerosene	A	C	A	C	C
Diesel Fuel	A	C	A	C	C
Ohio Crude Oil	A	B	A	B	C
Hydraulic Fluid	A	C	A	B	C
Naptha	A	B	A	B	C
Conc. Ammonia Hydroxide	A	A	C	A	A
50% Acetic Acid	C	B	C	B	C
50% Phosphoric Acid	A	B	C	A	A
50% Hydrochloric Acid	A	A	C	A	A
50% Nitric Acid	C	B	C	A	C
50% Sulfuric Acid	A	C	C	C	A
60% Sodium Hydroxide	A	A	C	B	C
Methyl Alcohol	A	A	A	A	C
JP-4 Jet Fuel	A	B	A	B	C
Salt Water 180°F	A	B	B	B	C
Phthalate Plasticizers	B	C	A	C	C
SAE-30 Oil	A	A	A	A	C
Raw Linseed Oil	A	A	A	A	C

Coated fabric samples were totally immersed in each of the chemicals for a period of 28 days at room temperature. The rating system is indicated as:

A = Fluid has little or no effect at R.T.
B = Fluid has minor to moderate effect at R.T.
C = Fluid has severe effect at R.T.

Reference: Seaman Corporation marketing booklet.

is soluble in the polymer material. After cleaning the surface, hazardous chemicals can diffuse to the surface creating a hazard to unprotected response personnel. Booms which experience swelling during deployment are likely to have absorbed hazardous chemicals and should be treated with caution and may require disposal. Booms which exhibit curling, discoloration, and stiffening have likely been damaged by contact with the spilled chemical and may not be suitable for reuse.

Boom stability is very important in maintaining efficient containment. Boom stability refers to the boom maintaining a vertical position in the water. The force of the water can angle the curtain or skirt, increasing the possibility of material escaping from beneath the boom. In general, highly stable booms have a high ratio of buoyancy to weight, have tension members located at the top and bottom edges, and have horizontal floatation collars. Booms with these characteristics resist pivoting and are stable under most conditions. Figure 4.10 shows cross sections of three of the most stable boom types determined by the Canadian Environmental Protection (Bareuel, 1981).

Floating debris can decrease the efficiency of the boom or cause damage. Contained floating debris can increase the forces against the boom which could lead to pivoting and subsequently loss of contained material. Damage to the boom in the form of tears and rips can also be sustained from floating debris. Response personnel will need to inspect the boom periodically and remove floating debris.

In responses to large spills, numerous sections of booming may be required. Booms may be supplied from several different sources and consist of different boom types. Problems may be encountered in connecting these different boom types. The connection may not be satisfactory for containing spilled material resulting in leakage. Gels and patching materials can be used to seal these areas.

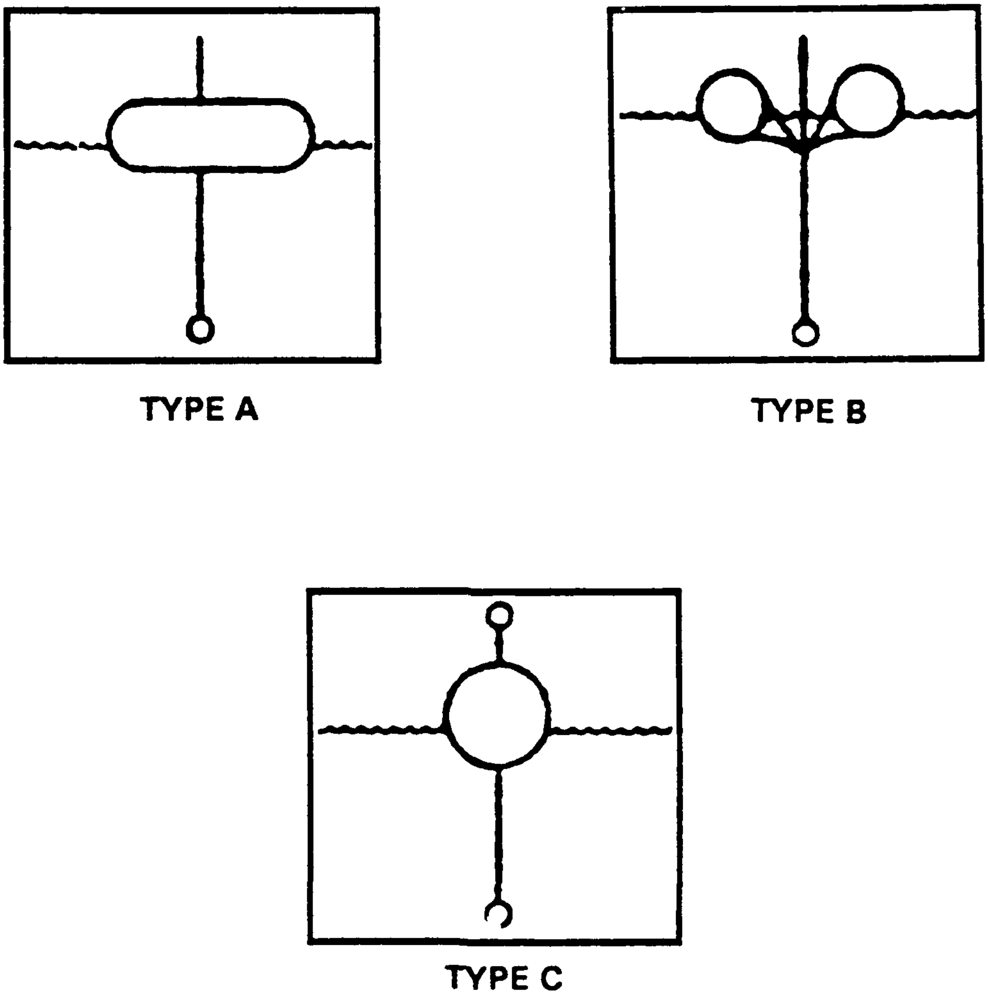
Response personnel must be aware of possible ignition sources from the boom if a flammability hazard exists. The possible ignition sources from booms are metal connectors for joining boom together, chain ballasts, and tension cables. These present an ignition source, but it will be eliminated once the boom is wet.

4.1.3 Other Types of Isolation Techniques Applicable to Bodies of Water

A variety of other techniques exist to isolate spilled floating material. Most are rather limited in their application by spill volume and the nature of the body of water under consideration. The following sections outline the methods and equipment needs for the various isolation methods.

4.1.3.1 Pneumatic Barriers

Pneumatic barriers make use of air bubbles to create water turbulence to contain floating spills. The equipment used to construct this barrier consists of a large air compressor, hoses, and perforated tubing. The perforated tubing



TYPE A

TYPE B

TYPE C

Redrawn from Oil Spill Cleanup and Protection Techniques for Shoreline and Marshlands, A. Breuel

FIGURE 4.10. CROSS SECTION OF THREE HIGHLY STABLE BOOMS

can be deployed on the bottom of the water body in strategic positions around the spill. Raising air bubbles create head waves and turbulence, hindering the movement of the spills.

This containment technique is limited by available quantities of hoses. The surface current and wave height should be minimal for efficient use. This type of containment technique would be applicable in areas where navigable traffic needs to remain open.

There are several limitations to pneumatic barriers. The water surface should be quiescent with surface currents less than 0.5 knots. The spill situation may require large air compressors to accomplish containment. Pneumatic barriers are only applicable to thin spill thicknesses (this may not be indicative of a small spill). Pneumatic barriers will only contain the spill material, and contaminated debris may be able to escape the isolated area. The depth of deployment should not exceed 15 feet. For water bodies greater than 15 feet in depth, the perforated tubes can be suspended from floats.

4.1.3.2 Underflow Barriers

Underflow barriers are used to isolate the floating spill while allowing the flow of uncontaminated water to continue. This type of barrier makes use of a constructed berm or dam with a pipe through it to allow the passage of uncontaminated water. Figure 4.11 shows an example of an underflow barrier. The pipe is angled so the upstream end is lower than the downstream end, drawing water from beneath the spill.

Underflow barriers are limited to applications on quiet, slow-moving waters where the total flow of water can be controlled through the dam. Applications are also limited by spill volume. It is recommended that underflow barriers not be used on spills exceeding 5,000 gallons.

Construction of an underflow barrier requires the use of earth moving equipment such as backhoes, bulldozers, and shovels, and some hose or pipe to allow the passage of uncontaminated water. Recommended personnel requirements are influenced by the characteristics of the spill site, spill volume, and environmental conditions. The underflow type barrier requires 3 to 5 trained personnel to accomplish isolation of the spill.

Cleanup personnel must consider possible contamination of the soil used to construct the dam. Cleanup operations need to include treatment of the contaminated soil of the dam. Considerations also need to be given to the solubility of the spilled chemical in water and the extent of possible contamination of water flowing through the pipe. If the contamination is extensive, response personnel may need to pass the water through some sorbent material to remove undesirable contaminations.

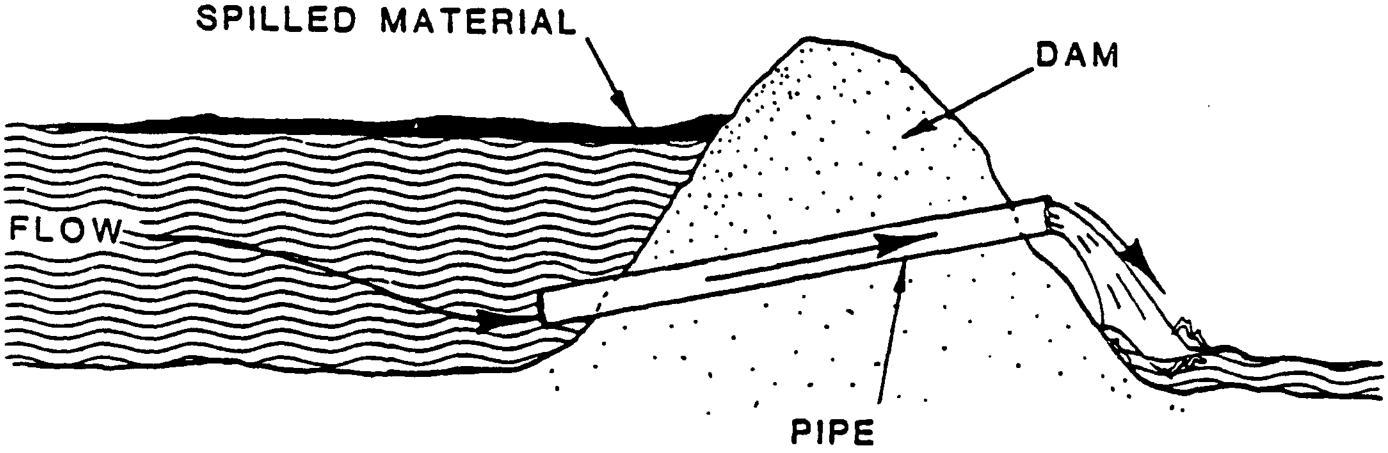


FIGURE 4.11. DIAGRAM OF A CONSTRUCTED UNDERFLOW BARRIER

4.1.3.3 Weir Separation

Weir separation is similar to an underflow barrier in that it blocks the floating spill while allowing the passage of uncontaminated water. Weir separation techniques consist of the construction of an impermeable barrier to isolate the floating spill as uncontaminated material passes beneath the barrier. Figure 4.12 shows an example of this type of barrier.

The barrier can be constructed from lumber and requires some posts or stakes for holding the barrier in place. No special training is required for the construction of a weir separation barrier.

Recommended uses for this technique are limited to small, shallow, slow-moving watercourses. If the body of water does not meet these requirements, the barrier will be inefficient in its separation. This type of isolation technique is only applicable for spills of 5,000 gallons or less.

4.1.3.4 Filter Fences

Filter fences or permeable barriers are constructed in the path of a moving spill to hold sorbent material in place. Figure 4.13 shows a possible construction of a filter fence. The apparatus consists of two rows of wire screen used to isolate sorbent material. The screens allow the floating material to contact the sorbent material where it is isolated.

Construction of this type of barrier will require wire screen, posts or stakes, and floating sorbent material. The manpower and equipment requirements will depend on the spill situation. For large or continuous spills, the sorbent material may become saturated and require replacement.

Filter fences are recommended for use on small, slow-moving waterways. Fast moving waterways will limit the efficiency of the sorbent by reducing contact time between sorbent and spilled material. Filter fences are also limited to small spills of less than 5,000 gallons.

4.1.3.5 Gels

Gels are materials which solidify when applied to specific chemicals. Gels are useful in containing spills on water surfaces. Applied around the edges of the spill, gels limit the spreading of the spill. The gelling agent solidifies the spilled chemical, creating a small barrier around the edges of the spill.

Response personnel must ensure that the chosen gelling agent is suitable for application on the chemical involved. Manufacturers' specifications give classes of chemicals which can be gelled by the product. Application of gels can be accomplished by using pressurized tanks, sandblasting equipment, or pneumatic-conveyor equipment.

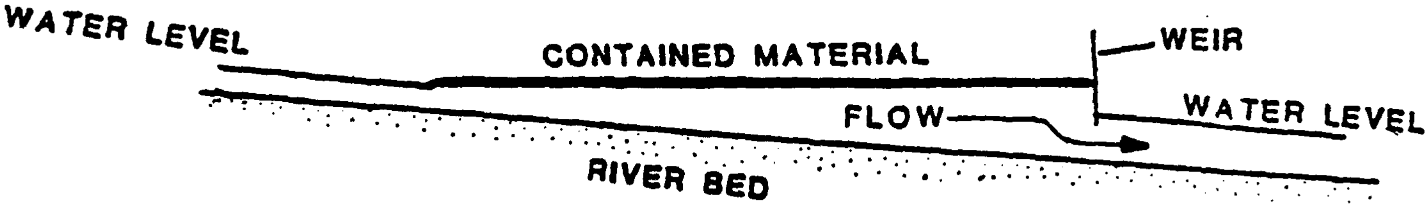


FIGURE 4.12. DIAGRAM OF CONTAINMENT OF FLOATING SPILLS WITH A WEIR

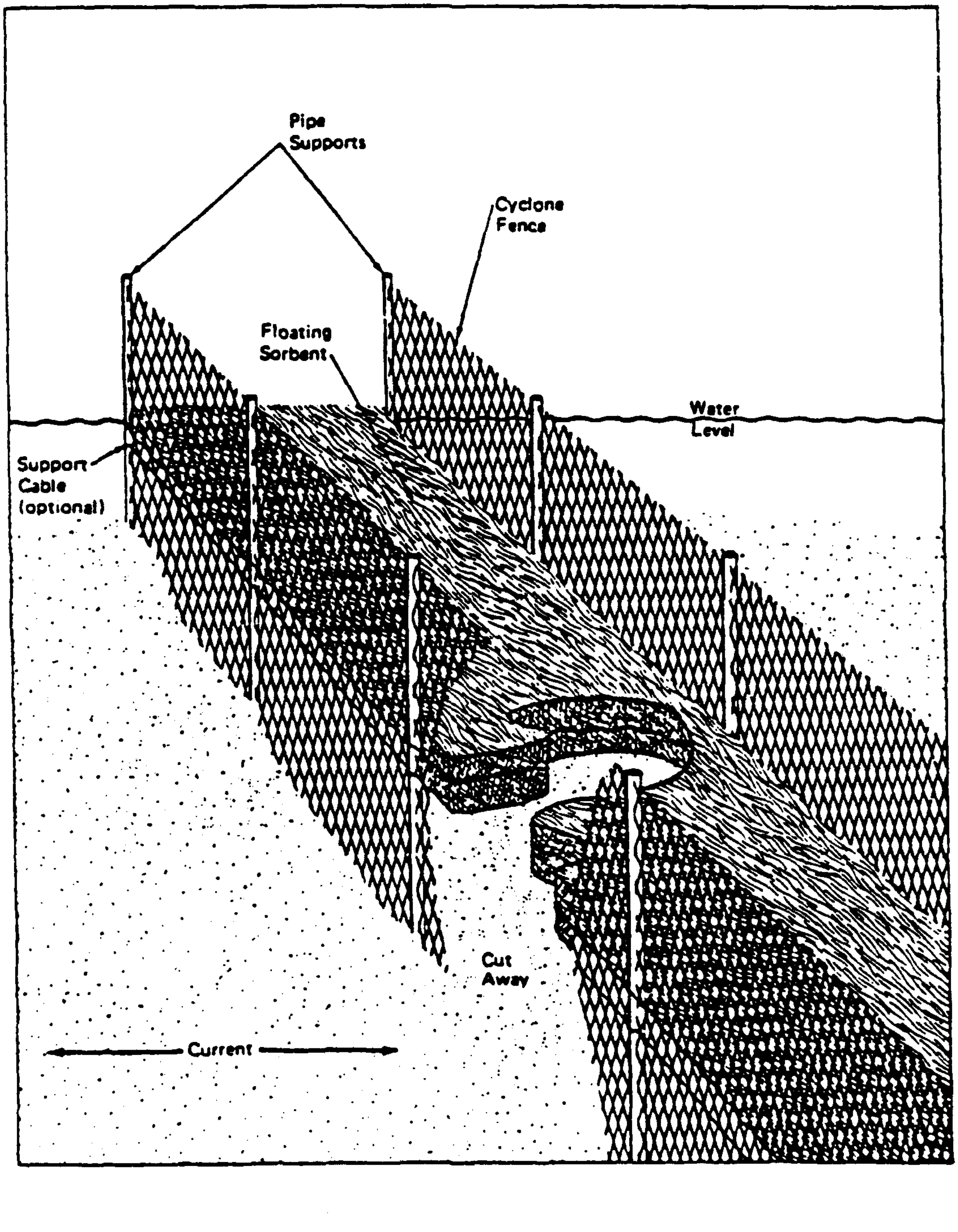


FIGURE 4.13. POSSIBLE CONFIGURATION OF A FILTER FENCE

The application of gelling agents is limited to small spills. Using gelling agents for containment of continuous spills is not applicable unless the gelling agent is reapplied to thicken the barrier around the edge of the spill. Gelling agents are most applicable when used in conjunction with other containment devices.

4.2 Spill Isolation on Land

Spill isolation on land is much simpler than on water because the mobility of the spill is reduced. The primary goals of spill isolation on land are to reduce the area of contamination, facilitate cleanup operations, and prevent the spill from entering waterways or drainage systems. Isolation can be accomplished on land by making use of excavation techniques and earth and commercial dikes.

There are some inherent problems associated with isolation techniques. As the spilled chemical contacts surface soils, the surface soil becomes contaminated. The extent of contamination will be dependent on the contact time of the spilled chemical and the nature of the chemical. In some situations, it may be practical to seal the soil to prevent contamination. Another problem involves spills which may emit flammable vapors. Plumes of flammable vapors can extend far beyond the actual spill site, creating a potential for ignition and trail back to the original spill location.

The following sections will discuss available methods for land containment of spilled material. Techniques for containment will be outlined for applicability, equipment requirements, and limitations for each method. Inherent problems associated with land based spills will also be addressed. Table 4.8 provides a summary of spill isolation techniques on water.

4.2.1 Earth Dikes

Earth dikes consist of a barriers constructed at the site to isolate the spill, thereby limiting the area of contamination, and aiding in removal of the spilled material. The actual configuration of the earth dike will be dependent on the surface features of the spill site. Response personnel will have to analyze the terrain of the area surrounding the spill site to determine the position and purpose of the dike.

The purpose of an earth dike can range from diversion to containment of the spilled material. Earth dikes can be strategically positioned to prevent spill material from contaminating environmentally sensitive areas, or to divert spills away from drainage or sewer systems. The purpose of constructing an earth dike may be to keep a spill from entering a watercourse. Earth dikes can be used to divert a spill to a natural depression (avoid sinkholes) or to an excavated area for isolation and cleanup. A confined spill area can be created by making use of an earth dike across a valley or drainage ditch.

TABLE 4.8. SUMMARY OF SPILL ISOLATION TECHNIQUES ON WATER

Exclusion Booms:	- Used to prevent the entrance or exit of hazardous material for small bays, harbor entrances, inlets, rivers, and creeks. - Limited to areas of water currents of less than 1 knot and wave heights of less than 25 cm. - Water depth should be twice the depth of the boom.
Diversion Booms:	- Used to guide spills to a recovery area or away from sensitive areas. - Applicable for water currents greater than 1 knot. - Limited use for high water currents where the limit for boom angle reduction has been reached and high wave height.
Containment Booms:	- Used in open water to encapsulate the spill. - Limited available booms may limit the usefulness of containment for large spills. - Adverse environmental conditions such as high water currents and wave height will limit the effectiveness of containment booms.
Pneumatic Barriers:	- Minimal surface currents (< 0.5 knots) plus wave height. - Only applicable to thin spills. - For use in areas where navigable traffic needs to remain open.
Underflow Barriers:	- Limited to quiet, slow-moving waters where the total flow can be controlled. - Limited to spills of less than 5,000 gallons.
Weir Separation:	- Limited to small, shallow, slow-moving water courses. - Limited to spills of 5,000 gallons or less.
Filter Fences:	- Limited to small, shallow, slow-moving water courses. - Limited to spills of 5,000 gallons or less. - Limited to situations where a suitable floating sorbent material can be matched to the spilled chemical.
Gels:	- Limited to spills for which a suitable gelling agent is available. - Limited to small spills.

Construction of earth dikes requires the use of backhoes or shovels. Larger spills may require the use of larger earth moving equipment. Sandbags may be useful for patching and reinforcing the earth dike. If time is available, the holding area and earth dike surface can be sealed with a commercial sealing agent. This will protect the soil from contamination and reduce contamination of groundwater by percolation of the spilled chemical. Sealing techniques will be discussed in Section 4.2.4.

The equipment and personnel requirements will depend primarily on the spill size, soil characteristics, and the terrain of the spill site. Other considerations can be given to environmental conditions. Construction of earth dikes will be more difficult under rainy conditions than clear.

Earth dikes are limited in their application by soil types and availability of equipment. Some soil types are not suitable for construction of earth dikes. Soil may be too hard to excavate or may be sandy and permit easy passage of spilled material. The location of the spill site may not be readily accessible for heavy equipment, or equipment may be unavailable. The use of earth dikes may increase the amount of material to be cleaned up.

4.2.2 Excavation

Excavation involves the construction of ponds, pits, and ditches to guide and confine a spill to an area for cleanup. If time permits, the area should be sealed to protect soil and groundwater from contamination. For spills isolated for extended times, it would be advisable to seal the confinement area because long contact time increases the possibility of leaching and contamination of soil and groundwater. Techniques for sealing are discussed in Section 4.2.4.

Excavation techniques to create holding areas are applicable to any spill volume. However, as the spill volume increases, the amount of material needed to contain the spill volume increases. This may exceed the capabilities of available equipment and manpower. In this case, it may be possible to excavate trenches to guide the spill to natural depressions (avoid sinkholes) or to alter natural depressions to accommodate the large spill volume.

Equipment and manpower requirements are dependent on the spill volume and the characteristics of the spill site. Needed equipment would include earth moving equipment such as backhoes and shovels, and equipment required for sealing the confined area, if applicable. Response personnel must consider equipment and manpower requirements to redeposit material which has been excavated. The amount of cleanup material may increase due to the removal of sealing material or contaminated soil.

4.2.3 Commercial Dikes

Over the last several years efforts have been made to develop a quick setting material to serve as a physical barrier that does not require the construction of forms. Materials which can be used to form a barrier are bentonite clay granular mixtures combined with water, rigid polyurethane foams, and foamed concrete, and gels. The bentonite mixture and foamed concrete will require a short time for the material to set up. The rigid polyurethane foam requires only a very short time for the material to rise, usually less than 10 seconds.

The purpose for deployment of these various commercial dikes will be dependent on the spill volume. In the case of a large spill, the barriers will be used to divert discharge from watercourses or to redirect spills to a containment area. Total containment by commercial barriers can be accomplished only for small spills.

The requirements for producing commercial barriers are the materials which constitute the barrier, a supply of fresh water, and barrier generators. Personnel require no special training for the production of commercial barriers. They can be used to create a barrier around the spill.

Commercial barriers have several limitations: (1) the commercial products and generating equipment may not be available to cleanup personnel; (2) polyurethane foams have a limited shelf life and a low temperature storage limit and do not adhere to wet surfaces; (3) bentonite clays require mixing with water which may not be available, and dry over time forming cracks susceptible to leaking; (4) foamed concrete requires the longest time to setup (10-15 minutes under undesirable environmental conditions), and will require special generating units; and (5) the construction material of the commercial barrier may not be compatible with all spilled chemicals.

4.2.4 Problems of Land Containment

There are two problems associated with land containment: (1) possible contamination of soil and groundwater due to the percolation of the chemical and (2) possible ignition of flammable vapors by containment activities.

The extent of groundwater contamination will depend on the physical properties of the spilled chemical, soil permeability, and the contact time Under most situations, isolation pools are created to facilitate cleanup operations. Soil contamination will result from any contact with the spilled material and will be more extensive with increased contact times and for soil with a high permeability for the spilled chemical. Making use of commercially available soil sealing products will protect both soil and groundwater from contamination.

Soil sealing products are applied by spraying. There are a variety of such products on the market. Response personnel will need to match the type of chemical spilled with a compatible sealant. Consideration will also have to be given to availability of equipment needed to apply it.

The circumstances surrounding the spill situation will determine the feasibility of using sealants. (Actually, sealing of containment surfaces will be feasible for only a limited number of cases.) Response personnel will have only a short time to implement corrective actions to bring the situation under control. For example, time may not be available to excavate a containment area and apply the sealant before the spill situation becomes uncontrollable.

Another method for protecting groundwater and soil from contamination from spills of floating chemicals is to flood the isolation area with water. The spill will float on the water minimizing contact with soil. This method is limited to availability of water and potential contamination or reaction of the water used to flood the area by the spilled chemical. Response personnel will have to consider the spill situation and determine if this method is feasible or if the benefits of groundwater and soil protection by flooding outweigh the water contamination problems.

Response personnel must refrain from igniting flammable vapors. Possible sources of ignition are hot mufflers on earth moving equipment or sparks from tools. Response activity should be located upwind from the spill site whenever possible. If the terrain requires that the response activity must be performed downwind of the spill site response activities may have to be located where vapor concentrations are below the LEL.

4.3 Flow Reduction Techniques

Probably the most effective way to reduce hazardous impacts of spilled material is to reduce the volume of flow from the damaged container. In some instances, flow reduction can be accomplished by simply turning off a valve. However, in most cases material is lost from a container due to damage from a collision or explosion which requires a more involved response to reduce the volume of flow. There are several commercial products available which have the ability to plug holes in damaged containers. These plugging products range from kits for high pressure containers, to gelling material to simple wooden stakes. The following sections will address variables which influence the selection of a patching technique and discuss various patching technologies.

4.3.1 Variables Affecting Selection of Patching Technology

Response personnel will have to evaluate the spill situation to determine the most applicable patching technology to reduce or stop the flow. Variables influencing the selection of a patching technology will include the container type, involved chemical, and hole shape, size, and location.

Response personnel need to fully characterize the damaged containers or vessel for proper selection of a patching technology. Pressurized containers require specialized kits and materials. Personnel experienced in capping pressurized containers should be in charge of the plugging operation. Some plugs can be used on pressurized containers, but only for limited pressure capacity. In cases where there are leaks from insulated tanks, cars, or containers, the opening on the exterior may not represent the source. The actual source may be hidden by the insulation or be located some distance away from the external opening.

Full characterization of the damaged containers includes consideration of the size and shape of the hole, as well as location. A jagged tear may be more difficult to plug than a gouge or puncture. Leaks along seams frequently require more attention in order to obtain a good seal. The location of the damage will also influence the choice of a patching technology. Damage to the bottom of a container will be more difficult to plug efficiently because of the force exerted by the material above the hole. This is especially true for large and/or pressurized containers.

Compatibility between the patching material and chemical is also important. The chemical may corrode or dissolve the patching material resulting in leakage. Manufacturers' specifications may warn of this behavior for certain chemicals, but it is unlikely that manufacturers are aware of all possible destructive behavior.

4.3.2 Patching Technologies

There are a variety of patching technologies available to response personnel to reduce or stop the flow of material from a damaged container or vessel. Some techniques are quite simple and do not require prior training, while others are more complex and prior training is advised. Easily used plugging technologies include specially-engineered materials (which gel to form a seal), plumbers plugs, a tourniquet-type plug, and various sizes and shapes of wooden stakes.

The most difficult patching problem involves leaks from pressurized containers. Most leaks from pressurized containers originate from faulty valves. Special kits are available which are designed to cap valves. They also include a tourniquet that wraps around the container and is tightened to reduce or stop the flow of material from punctures or tears on the sides of the container. These kits are designed for specific types of pressurized containers. Response personnel will have to match the appropriate kit to the container type and should have some prior experience in patching pressurized containers.

Pressurized containers are used to hold materials that are in the gas phase under ambient environmental conditions. The material inside will be a liquid under pressure or a mixture of liquid and gas in equilibrium. If the container sustains damage, gas, liquid, or a mixture of both, will be vented from the container. Because of high pressures, early response efforts may be unsuccessful in reducing the venting. Allowing the container to vent for some period of time will reduce both the venting pressure and rate at which material is lost. This is due to the auto cooling effect of the vaporization of material in the liquid phase resulting in a lower temperature inside the container. Under these conditions of reduced vaporization, patching may be successful.

There are several commercially available plugging agents and epoxies for sealing leaks. Response personnel will need to be aware of manufacturers' specifications to ensure proper use. Some agents require surface preparation while others do not. Gelling agents can be obtained which are ready to use. They are usually in the form of a putty which can be applied to the damaged container. The various plugging agents are designed for use with specific chemical groups (solvents, acid, etc.) and environments (air or water). Response personnel must select a plugging agent that is applicable for each situation. Epoxies are useful for sealing leaks in pipes. Used in conjunction with strips of fabric, epoxies can form efficient seals for damaged pipes.

Patching rugs are also available which are constructed of reinforced fabric and plugging materials. These rugs come in a variety of sizes. They can be used in conjunction with plugging agents to seal large holes or leaks along seams. For applications requiring more than one rug, the edges of the rugs should be overlapped to insure a good seal.

There are a variety of plumbers plugs which are suitable for patching small holes in containers. There are basically two types. The first type consists of a rubber ball with a toggle bolt arranged so that it can be tightened to expand the rubber ball to fit the hole. It is very important to select the proper size plug to match the hole. The second type consists of a self-tapping screw or T-bolt with washers, gaskets, or metal sheeting to cover and seal the leak. Figure 4-14 shows some examples of these types of plugs.

A tourniquet type seal can be accomplished by making use of a broad inner tube. The inner tube can be placed around a drum and tightened with a rod or stick. This offers a fairly good seal but is limited in its application by the size of the inner tube and the effects of contact with the chemical.

Soft wooden wedges and stakes are an economical means of plugging holes in containers. Stakes and wedges can be obtained in a variety of sizes to meet specific needs. Wedges are useful for plugging cracks in containers while stakes are applicable for more circular holes. The stakes can be either square or conical in shape. Large holes can be plugged by using a combination of square, conical, and wedge-shaped wooden plugs.

Oakum, mastic, cloth, sorbent pads, plugging agents, and plug rugs can be used in combination with wooden stakes to form a very effective seal. These materials can be used to fill small areas left after plugging with wooden plugs. The wooden plugs can be wrapped or coated with some kind of material then driven into the hole forming an effective seal.

Response personnel may have to be creative to invent a plug which will fit the situation encountered. After a seal has been attained, it will be necessary to inspect it periodically to insure that the leakage is still being minimized.

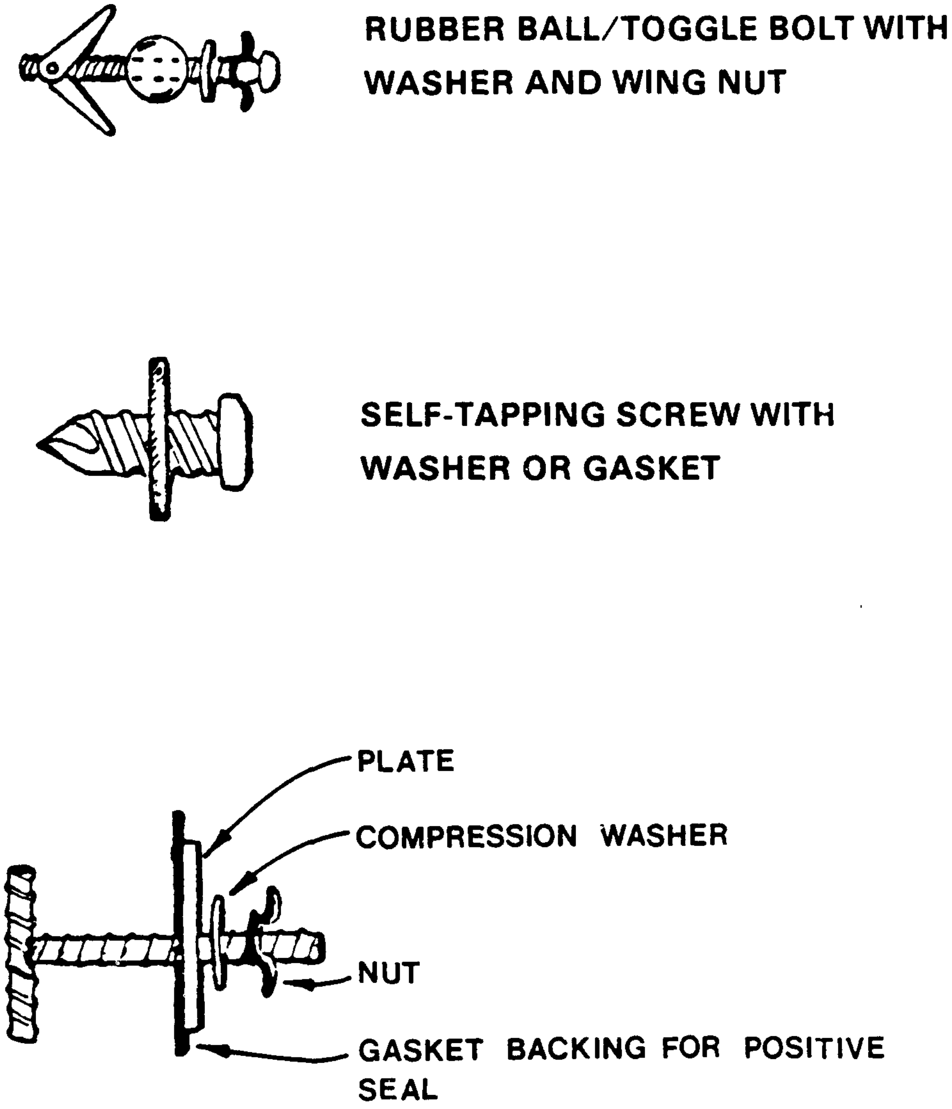


FIGURE 4.14. VARIOUS SCREWS USED FOR PLUGGING LEAKS

5.0 SPILL MITIGATION AND REMOVAL TECHNIQUES

Once the spilled material has been contained, the next step for response personnel is to mitigate the associated hazards to ensure the safety of cleanup personnel before cleanup operations begin. Spill mitigation techniques involve reducing vapor production from the pool of hazardous material using one of several vapor reduction techniques. Vapors issuing from a spill can be toxic and/or flammable. Reduction of vapor concentrations below the toxic or flammable concentrations will reduce the risk to cleanup personnel.

Removal techniques cover a wide range of technologies including equipment which mechanically removes isolated spill material, removal products which absorb or solidify spilled materials, and in situ techniques which change hazardous material to nonhazardous material by chemical reaction.

Techniques for implementation of cleanup operations differ for land and water based spills. Vapor suppression methods are the same for both land and water based spills.

Both vapor suppression and cleanup operations have limitations which are dependent on the chemical(s) involved, spill volume, available equipment and products, and environmental conditions. Response personnel will need to fully characterize the spill situation to insure proper and efficient vapor suppression and cleanup operations.

5.1 Vapor Suppression

Vapor suppression involves creating a barrier over the contained hazardous materials, in an attempt to reduce vapor concentration to safe levels. Although safe levals can be achieved by the implementation of a vapor suppression technique, response personnel should not abandon the use of protective clothing or equipment and the practice of limiting ignition sources. This will ensure a safe response in the event that toxic or flammable concentration levels are reached again during the response activities. Useful methods for reduction of vapor concentrations include foam barriers and gels. A description of each technique, guidelines for their use, and limitations will be covered in the following sections.

5.1.1 Foam Barriers

Research in recent years has identified application of foam as a means to suppress vapors from hazardous material to mitigate the associated hazards to cleanup personnel. The use of foam for vapor suppression is still in the developmental stage with exact guidelines on the proper foam to use with every chemical not available. Limited testing has provided recommendations for a small number of chemicals and guidelines for selecting foams based on the physical properties of the chemical.

Foams are produced by using manufactured foam concentrates and foam generating equipment. By mixing foam concentrates with water in the proper proportions and entraining air, foam can be produced. The result is an agglomeration of air bubbles with an interstitial mixture of water and foam concentrates. Application of foam to a volatile chemical reduces the amount of vaporization by the creation of a barrier less favorable for diffusion than air and by insulating the chemical against radiant and convective heat transfer, resulting in a lower vapor concentration of hazardous chemical.

There are a variety of foam concentrates available. Each concentrate has its own characteristics and suitable applications. Some foam manufacturers have developed special hazardous material (Hazmat) foams designed primarily for vapor suppression.

Foam barriers are temporary. Immediately after production, excess water drains from the foam, weakening its structure. The weakened structure is susceptible to collapse from vibrations from wind or wave action or by the vaporizing chemical. The persistence of the foam is dependent on the foam type, environmental conditions, proportioning concentration, and chemical compatibility between the foam and chemical.

The following sections will discuss foam types, foam generating equipment, variables which effect vapor suppression, and guidelines for foam application.

5.1.1.1 Foam Types

There are a variety of foams manufactured. In the past, foams have been designed to control and extinguish fires from a variety of flammable materials. Due to recent interests in developing response methods to releases of hazardous materials, research has identified that foam is effective in controlling vapors from hazardous materials. Foam types can be categorized under six general types: (1) regular protein foams; (2) fluoroprotein foams; (3) surfactant foams; (4) aqueous film forming foams (AFFF); (5) alcohol type or polar solvent type foam (ATF); and (6) special foams.

Regular protein foams represent the oldest firefighting foams. They were developed in the 1950's and are derived from animal protein (keratin hydrolyzate) with polyvalent cations added as stabilizers. Regular protein foams have slower knockdown than other types of foams, but once the fire has been extinguished protein foams guard against reignition.

Protein foams have a strong tendency to absorb both liquids and vapors from hydrocarbons thus becoming saturated more quickly than other foams. This quality increases the probability of explosions within the foam and reduces the efficiency and duration of vapor control.

Protein foams have poor fluid properties complicating both application and cleanup operations. They are limited to low expansion ratios and have a limited shelf-life.

Protein foams will have only limited applications for vapor suppression. Protein foams offer some limited vapor suppression to chemicals with boiling points much higher than ambient temperatures and with low affinity for water. Chemicals to avoid application of protein foam with a high affinity for water are alcohols, acids, amines, and aldehydes, and to a lesser degree, kebenes, esters, and ethers. Use of protein foams should also be avoided for chemicals that cause shifts in pH.

Fluoroprotein foams were developed for better fluidity and resistance to absorption of hydrocarbons. Fluoroprotein foams are protein foams with synthetic fluorocarbon surfactant additives. The resulting foam concentrate has improved fluidity properties and resistance to absorption of hydrocarbons over protein foams.

Fluoroprotein foams have good knockdown characteristics but have poorer reignition qualities than protein foams. Fluoroprotein foams have a limited shelf-life.

Fluoroprotein foams have shown satisfactory results for vapor suppression for a limited number of chemicals with an affinity for water. Again, chemicals with an ability to cause pH shifts will not be compatibility with fluoroprotein foams.

Surfactant foams contain synthetic detergent-type surface active agents and stabilizers. Foam concentrates of this type are applicable to low-, medium-, and high-expansion foams. Low-expansion is seldom used because it has poor knockdown and resistance to burnback. Surfactant foams were developed for complete flooding of fires in contained volumes.

Surfactant foams are available in a wide variety of foam concentrates with a broad range of properties. Medium and high expansion surfactant foams have good knockdown and resistance to burnback. Surfactant foam concentrates have an unlimited shelf-life if stored properly.

Medium- and high-expansion surfactants are applicable to vapor suppression. High-expansion is limited to application where wind speeds are less than approximately 9 mph to avoid displacement of the foam. Surfactant foams are not compatible with chemicals with an affinity for water or chemicals that cause pH shifts.

The next group of foams is a mixture of fluorocarbon surfactants and conventional surfactants. These are termed aqueous film forming foams (AFFF) because of the thin film which develops over the applied liquid surface. They were developed in the 1960's to achieve fast knockdown of hydrocarbon fires. AFFF were designed to collapse at a high rate. AFFF have the ability to suppress vapors but their application is limited because of the fast collapse rates. AFFF's are not compatible with chemicals with a strong affinity for water or chemicals with an ability to cause shifts in pH. These foams can be applied as low-, medium-, and high-expansion foams.

Alcohol type foams (ATF) were developed to combat hydrocarbon and polar solvent fuel fires. These foam concentrates consist of an AFFF, regular protein, fluorocarbon surfactant, or fluoroprotein base with a metal stearate and polysaccharide additive. The metal stearate is added as a foam stabilizer.

When applied to a chemical with an affinity for water, the polysaccharide additive coalesces into a polymeric gel at the chemical/foam interface. This protects the foam from the destructive action of the chemical.

The ATF foam concentrates can also be used as an AFFF, depending on the proportioning concentration and the chemical involved. Foam manufacturers' specifications will supply proportioning concentration information for difficult classes of chemicals. The polymeric gel also accomplishes suppression of vapors. In limited tests, ATF foams have shown very good results for the suppression of hazardous vapors. The ATF foams are the best foams suited for controlling vapors produced from a wide range of flammable and toxic liquids. ATF foams are usually applicable for low- and medium-expansion ratios and do not tolerate large shifts in pH.

Several special engineered foams have been developed for specific applications. Hazmat #1® and Hazmat #2® have been marketed for use on alkali or acid spills, respectively. Type V® can tolerate a pH between 2 and 10 and is marketed for applicability for vapor control of spills of water reactive, volatile chemicals. Type V® foam can be applied as low-, medium-, or high-expansion ratios.

5.1.1.2 Foam Production Equipment

Foam can be generated by a variety of equipment. The type of generating equipment used will determine the expansion ratio (low, medium, or high). Foam generating equipment consists of a means of proportioning foam concentrates and water at the desired concentrates and some type of apparatus to entrain air which forms foam. The devices used for proportioning foam are in-line enductors or compact proportioning foam systems.

An in-line proportioner (enductor) mixes foam concentrate into the water stream much the same way as a carburetor mixes gasoline into an air stream. Enductors consist of an apparatus used to connect two sections of water hose together and a suction hose for supplying the foam concentrate. Response personnel must ensure that the selected enductor matches the nozzle. Manufacturers supply information on compatible enductors and nozzles and recommend hose distances between the enductor and nozzle. Manufacturers' information also includes guidelines for applications where the nozzle is positioned at a higher level than the proportioner.

Compact proportioning foam systems consist of a storage tank for foam concentrates, an inlet water connection, and a proportioning control value. This type of system is used on firefighting trucks with self-contained foam generating capabilities or on portable foam generating equipment.

There are a variety of nozzles available which can produce foam. Regular firefighting nozzles can be used to make foam, but it is a poor quality foam. For best results, foam should be generated with air-aspirated nozzles designed for foam generation. The choice of nozzle along with proportioning concentration will determine the expansion ratio. Low- and medium-expansion foam can be generated from nozzles with screens and blades to efficiently entrain air. High expansion foams are generated by blowing the foam concentrate and water mixture against a screen mesh with a fan. The expansion ratio of high expansion foam is determined by the mesh size of the screen and flow rate of the water concentrate mixture.

5.1.1.3 Variables Affecting Foam Vapor Suppression Efficiency

The variables affecting foam vapor suppression efficiency are foam quality, physical properties of the spilled chemical, foam characteristics, compatibility between the foam and chemical, and environmental conditions. Foam quality refers to the distribution of bubble sizes and the mixing of the foam concentrate with water. Foams with a broad distribution of bubble sizes do not suppress vapor as well as foams with uniform small bubble sizes. Good quality foam is also distinguished by a homogenous mixture of foam concentrate and water. Good foam quality can be achieved by using proper generating equipment.

The physical properties of the spilled chemical will also affect the efficiency of the vapor suppression. The two most important physical properties are the vapor pressure and the solubility of the chemical in water. The higher the vapor pressure, the higher the amount of material vaporizing. Water solubility can be used to measure the permeability of the chemical through the foam. As a rule of thumb, the higher the water solubility, the greater the rate of permeation through the foam. The boiling point can also be used to determine the amount of vapors that will be emitted from the spill. Lower boiling is indicative of high evaporation rates. Chemicals with high boiling points have low evaporation rates.

Characteristics of the foam are also important to vapor suppression efficiency. The characteristics of importance are the drainage rate and expansion ratio. The drainage rate of foam is the rate of excess water which drains from the foam. This is quantified as quarter-drainage time. More specifically, quarter-drainage time is the time needed for 25 percent of the liquid volume to drain from the foam. Longer quarter-drainage times are usually reflective of more efficient vapor suppression foams. High expansion foams are generally more efficient at suppressing vapor than lower expansion foams. Expansion ratio is related to drainage rates. That is, for a given foam, increasing the expansion ratio will increase quarter-drainage times thereby improving vapor suppression efficiency.

Compatibility between the foam and spilled chemical is probably the most important consideration in foam efficiency. Prediction of compatibility between the spilled chemical and foam is also difficult to predict. Only a limited amount of testing is available, and the interaction between the foam and spilled chemical is not completely understood. Table 5.1 provides a summary of recommended foams for some selected chemicals for which data are available from The Handbook for Using Foams to Control Vapors from Hazardous Spills (Evans and Carrol, 1986). A study by Szluha, et al. (1985) has identified two types of chemicals which can collapse foam. The two types of chemicals are chemicals with an affinity for water or chemicals with an ability to cause pH shifts. Guidelines on foam use for these types are available from foam manufacturers, Appendix A, for floating CHRIS chemicals, and general guidelines in Section 5.1.1.4.

TABLE 5.1. RECOMMENDATIONS FOR VAPOR CONTROL FOAMS

Chemical	P	FP	S-L	S-H	AFF	A	NF1	NF2	V
Acetone	0	0	0	0	0	1	--	--	--
Ammonia	2	2	1	2	2	2	--	--	--
Benzene	2	2	2	0	0	1	--	--	--
Bromine	X	X	1	X	X	X	X	1	1
Butanol	0	0	0	0	0	1	--	--	--
n-Butyl acetate	1	1	0	1	1	1	--	--	--
Carbon disulfide	0	0	0	0	0	0	--	1	1
Chlorine	X	X	1	X	X	X	X	1	1
Cyclohexane	1	1	2	2	2	1	--	--	--
Ethane	2	2	1	2	X	2	--	--	--
Ethyl ether	0	0	0	0	0	1	--	--	--
Ethylamines	0	0	0	0	0	1	1	--	1
Ethylbenzene	1	1	2	1	1	1	--	--	--
Ethylene	2	2	1	2	X	2	--	--	--
Ethylene diamine	0	0	0	0	0	1	1	--	1
Ethylene oxide	0	0	0	0	0	2	--	--	--
Gasoline	1	1	1	1	2	1	--	--	--
Heptane	1	1	1	1	2	1	--	--	--
Hexane	2	2	2	2	2	1	--	--	--
Hydrazine	0	0	0	0	0	1	1	--	1
Hydrochloric acid	0	0	0	0	0	0	--	1	1
Hydrogen chloride	0	0	0	0	0	0	--	1	1
Kerosene	1	1	1	1	2	1	--	--	--
Methane	0	0	1	0	0	0	--	--	--
Methanol	0	0	0	0	0	1	--	--	--
Methyl acrylate	0	0	0	0	0	1	--	--	--
Methyl butyl ketone	0	0	0	0	0	1	--	--	--
Methyl ethyl ketone	0	0	0	0	0	1	--	--	--
Methylamines	0	0	0	0	0	1	1	--	1
Naptha	1	1	1	1	2	1	--	--	--
Nitric acid	--	0	0	0	0	0	--	1	1
Octane	2	2	2	2	2	1	--	--	--
Octanol	2	2	2	2	2	1	--	--	--
Paint thinner	1	1	2	2	2	1	--	--	--
Propanol	0	0	0	0	0	1	--	--	--
Silicon tetrafluoride	X	X	1	X	X	X	--	--	--
Sulfur trioxide	X	X	1	X	X	X	--	--	--
Titanium tetrachloride	0	0	0	0	0	0	--	1	1
Toluene	1	1	2	2	2	1	--	1	1
Vinyl acetate	0	1	0	0	2	1	--	--	--

1=Recommended 2=Satisfactory 0=Ineffective or untested X=Dangerous P=Protein FP=Fluoroprotein S-H=High expansion surfactant S-L=Low expansion surfactant AFF=Aqueous film forming A=Alcohol NF1=Hazmat NF#1 NF2=Hazmat NF#2 V=MSA type V

Source: Mark Evans and Holly Carrol, *The Handbook for Using Foams to Control Vapors from Hazardous Spills*, EPA/600/8-86/019, 1986.

Environmental conditions affect vapor suppression in several ways. For example, wave action vibrates the foam increasing the rate of foam collapse. Temperature, humidity, and intensity of sunlight determine the amount of water lost from the foam due to evaporation. (Loss of water causes foams to be susceptible to collapse.) In addition, rain can also cause foam to collapse.

Wind speed is important in determining the expansion ratio to use. High expansion foams are easily displaced by winds greater than 9 mph. In very high wind, foam application of any type will be difficult and easily displaced from the surface of the contained spill. Response personnel need to be aware of the environmental conditions, assess their impact on foams, and adjust the vapor suppression techniques.

5.1.1.4 Guidelines on Foam Use

The determination of the type of foam to suppress vapors from a spilled chemical is the first consideration for foam use. The factor influencing the choice of foam is the physical properties of the spilled chemical. The physical properties of the spilled chemical will determine what type of foam is compatible with the spilled chemical. Physical properties to consider are water solubility and polarity. These properties are characterized in Appendix A for the floating CHRIS chemicals. Non-polar chemicals or chemicals with low water solubility (less than 10%) are likely to be compatible with any foam. The exception to this rule is chemicals with a strong affinity for water. Chemicals can have a strong affinity for water and have relatively low water solubility. These chemicals have a strong potential to degrade foam or quickly permeate through the foam. Functional groups which exhibit this type of behavior are alcohols, amines, and aldehydes and to a lesser degree, ketones, esters, and ethers. If specific guidance is not available for the type of foam to use on chemicals within the aforementioned functional groups, response personnel should assume that the chemical will not be compatible with most foams. Under these circumstances, the most effective vapor suppression will be accomplished by applying an ATF foam. Appendix A provides recommendation on foams suitable for vapor suppression for the floating CHRIS chemicals. Table 5.2 provides a summary for selecting suitable foam types for various physical characteristics of chemicals. The guidance provided in many cases is based on qualitative considerations because the vast majority of chemicals have not been tested, and the compatibility with foam is not known. Since the use of foam for vapor suppression is being developed, it would be helpful for the OSC to develop contacts with foam manufacturers research and development personnel. From these contacts, the OSC can obtain the most current results from testing and recommendations.

Applying foam to cryogenic materials or low boiling point materials may not be an effective method for controlling vapors. Water drainage from the foam acts as a heat source increasing vaporization. The rapid vaporization of the chemical can cause chimneys in the foam or foam collapse. In situations where control of vapors from cryogens or low boiling point materials is crucial, some vapor control may be accomplished by using a slow-draining, high-expansion foam. The initial drainage from the foam will increase vaporization but then drop off as the drainage slows. After the initial increase in vapor production, tests (Gross et al., 1982) have shown some vapor reduction by using a slow-draining, high-expansion foam.

TABLE 5.2 SUMMARY OF FOAM RECOMMENDATIONS FOR VARIOUS CHEMICAL BEHAVIORS

Chemical Behavior	Foam Recommendation
Affinity for Water - alcohols, amines, aldehydes, and to a lesser degree, ketones, esters, and ethers	Unless testing suggests otherwise, avoid all foams except ATF or fluoroprotein. ATF is the recommended choice and fluoroprotein as a second choice. Foam collapse likely for all other foams except ATF and fluoroprotein.
High Water Solubility/Polar	ATF is the recommended choice with fluoroprotein as second choice. All other foams are likely to collapse or have short break through times.
Low Water Solubility/Nonpolar	Any foam will provide vapor suppression provided that the chemical has a boiling point well above ambient temperatures and does not exhibit a strong affinity for water.
Boiling Point Near or Below Ambient Temperatures	Increase the expansion ratio of the foam and the quarter drainage time Increasing the proportioning concentration can sometimes increase the quarter drainage time.
Boiling Point Well Above Ambient Temperature	Any foam will accomplish vapor suppression as long as the foam is compatible with the spilled chemical.
Acidic pH Shifts	Use HAZMAT #2 or Type V foam.
Alkali pH Shifts	Use HAZMAT #1 or Type V foam.
Water Reactive	Use Type V foam.

To insure the most efficient suppression of vapor, response personnel need to follow some guidelines for foam application. After the selection of a proper foam concentrate, the foam should be generated with air aspirating nozzles or foam generating units to obtain good quality. Foam should be applied indirectly to the spilled chemical surface to avoid mixing the foam and chemical. By making use of a backboard, foam can be gently applied to the chemical. This can also be accomplished by "rolling" the foam onto the chemical surface by aiming at the ground or a ramp in front of the spill. Response personnel may be required to construct some makeshift ramp or backboard to accomplish foam application. The first 15 to 30 seconds of foam generated should not be used because it is of poor quality. Early generated foam is poorly mixed, reducing its ability to suppress vapors. (Norman and DiMaio, 1986)

A complete cover over the contained spill is important for suppression of vapor. If the spill is not contained, a complete cover of foam may be difficult to obtain because the spill will spread, exposing chemicals to the atmosphere. Loss of a complete cover of foam due to wind or wave action (or aging) will require a reapplication of foam. Wind or wave action can displace foam, exposing chemicals to the atmosphere and increasing the hazards to response personnel. High-expansion foams are more susceptible to displacement because the foam layer is thicker than that of low- or medium-expansion foams. For a high-expansion foam layer of 4 inches, a 9 mph wind could displace the foam. A 5 mph wind could displace a 6-inch foam layer. (Robinson, 1979)

Foams lose their ability to suppress vapors due to aging or environmental effects. Response personnel can judge effectiveness of the foam through observations or by monitoring vapor concentrations. Applying another layer of foam is necessary to insure the safety of response personnel. In the case of flammable chemicals, foam can become saturated with vapors, creating the potential for ignition. A reapplication of foam on top of the saturated foam would provide a barrier of protection against ignition, as well as suppress vapors issuing from the saturated foam.

Application of foam is similar whether spills are land or water based. However, the behavior of the spill may be quite different. Spills contained on land tend to decrease vapor production due to an auto cooling effect. This reduction in vapors is accomplished because the ground offers insulation. With the application of foam to block radiant and convection heat transfer, a stable situation can be created. Spills isolated on water surfaces do not have the benefit of insulation against added heat from the body of water. Actually, the water will serve as a source of heat, maintaining the production of vapors.

Foam manufacturers' results for vapor suppression efficiency are based on a small bench scale apparatus or a beaker test. Due to the experimental setup, these results are probably more indicative of land based spills. Response personnel should be skeptical of manufacturers' results for vapor suppression when considering foam applications to spills on water surfaces.

The following is a summary of guidelines for foam applications:

- Foams must be compatible with the chemical;
- Insure a complete foam cover of the spill;

- Foams should only be applied to isolated spills;
- Foams should not be applied directly to the spill surface;
- Avoid applying early generated foam;
- Consideration should be given to environmental conditions and location of isolated spills when using vapor suppression techniques;
- Increased vapor pressure and water solubility will decrease the efficiency of the vapor suppression; and
- Low- and medium-expansion foams are not effective for the suppression of vapors from cryogenics.

5.1.2 Gels

Gelling agents consist of materials which solidify when applied to chemicals. There is a variety of gelling agents available to match application needs. The primary benefit of gelling of the spilled chemical is isolation, although some degree of vapor suppression can be accomplished.

Rates of evaporation can be reduced by the formation of a continuous layer over the spill. This creates a barrier encapsulating the volatile chemical and, consequently, reduces vapor concentrations. Gelling agents which form a thin layer are more efficient at vapor suppression than those gelling a thick mass of material. This layer of gelled material forms an encapsulating barrier, reducing vapor concentrations. Gels forming a thick mass tend to become saturated with chemical and emit vapors. The ability of the gel to limit the spread of hazardous chemicals also reduces the vapor concentration by decreasing the area available for evaporation.

Most gelling agents were designed for application to a limited number of specific chemicals. However, a Multipurpose Gelling Agent (MGA) was developed which has the ability to gel a variety of chemicals (Michalovic et al., 1977). This study consisted of developing an optimal blend of commercial products to gel various chemicals, determining the most efficient partical size, and investigating various modes of delivery. The study concluded that a blend of polyacrylamide, poly-tert-butyl styrene, polyacrylonitrile rubber, poly-carboxymethyl cellulose, and a fumed silica formed the optimum gelling agent based on its ability to immobilize the greatest variety of hazardous liquids with the least amount of material. Small particles of MGA (0.5 to 2.0 mm) should be delivered by pressurized tanks, sandblasting equipment, or conveyor-type equipment. In some cases, all of the components necessary to formulate MGA may not be available. The study investigates some alternative product which can be used. The study also provides guidelines for storage for future use.

Gelling agents are most applicable to small spills (less than 500 gallons). They can be used for large spills to seal leaks at boom joints. In addition, gelling agents can be combined with foam applications to isolate the spill and provide a protective layer between the chemical and foam. Application of gels may be limited by unavailability of equipment and gelling products.

Sometimes the time required to complete the gelling reaction may limit its use. A few gels form within minutes but most gelling reactions are measured in hours. The polymerization reaction involved in gelling is often exothermic, increasing vaporization and adversely affecting spill stability.

Adverse weather conditions can cause inefficient or impracticable application of gelling agents. Rain can cause some gels to solidify. Gels should be applied upwind from the spill because of the likelihood of vapors from the spill gelling the product in the nozzle, complicating application operations.

5.2 Removal Techniques

After the spill has been immobilized, response personnel will choose some technique to remove the hazardous chemical. Commercial techniques for cleanup use various methods of recovery. Mechanical recovery devices constitute the broadest category. Mechanical recovery involves some apparatus which physically pumps the spilled chemical from the water surface to a storage area. Chemical recovery techniques consist of sorbents or gels which adsorb and isolate spilled chemicals for removal or reduce the chemical hazards of the spill. There are a variety of other techniques used in cleanup operations, including natural materials and biological reduction. Appendix B provides a summary of the various removal techniques.

5.2.1 Mechanical Removal Devices

Response personnel can choose from a variety of mechanical removal devices suitable for cleanup operations. Most were developed for response to oil spills, but some are applicable to spills of hazardous materials. For convenience, mechanical recovery devices are categorized according to the method employed by the device. The categories are moving plane skimmers, belt skimmers, and weir skimmers which are explained in further detail in the next three sections.

5.2.1.1 Moving Plane Skimmers

A moving plane skimmer is a self-contained removal device which is deployed by a crane into the contained area. The unit consists of a moving disc made of metal or polymer, a recovery area, and a motor for operating the device. Floating chemicals are removed by a rotating drum which is lowered into the water. Viscous materials adhere to the surface of the drum and are then wiped off and stored in a reservoir.

There are several factors which limit the use of moving plane skimmers. They can remove viscous (> 8 centipoise [CP]) materials quite efficiently. However, floating chemicals may have viscosities too low for efficient recovery. A recovery rate of 5 gpm was estimated for chemicals with viscosities in the range of 0.65 to 1.2 cp (Robinson, 1979). For a spill of 100,000 gallons, cleanup efforts would take approximately 14 days by a moving plane skimmer, which is impractical. Another limitation of the removal device is the possibility that parts of the equipment which contact the spilled chemical may not be compatible. This could damage the equipment making it useless for future use or adversely affect the equipment causing it to malfunction during deployment.

Refer to section 4.1.2.5 for guidance on compatibility between polymer materials and spilled chemicals. Rough seas will also limit their usefulness.

When responding to spills that are flammable, cleanup personnel must insure that no ignition sources are present with the removal equipment. Some manufacturers have furnished moving plane skimmers with explosion proof pumps and controls. These modified devices would be suitable for removal of flammable materials if their viscosities are in the proper range. Response personnel should also be aware of the possibility of the spilled chemical destroying recovery equipment if parts with low solvent resistance come in contact with the spilled material. Moving plane skimmers are not applicable for removal of floating solids.

5.2.1.2 Belt Skimmers

Belt skimmers use a moving, continuous belt which picks up the floating material and delivers it to a holding tank. The belt is made of an absorbent floating material which has an affinity for oil and oil derivatives or a polymer belt onto which a thin film of spilled material adheres. The absorbed or adhered chemical is removed by squeezing or sweeping the belt.

Belt skimmers recover at greater rates when used on chemicals with high viscosities. Because of the different designs used by belt skimmers, the lowest recoverable viscosity will vary. Response personnel need to make sure that areas exposed to the chemical are resistant to solvent action. Motors used to move the belts should be explosion proof if a flammable hazard exists.

Belt skimmers are not applicable for recovery of solid floating particles. Units are usually designed to be mounted on a vessel deck or a water bank. Belt skimmers perform optimally in calm water, although they can be useful in rough water. Again, the problem of compatibility must be addressed. Refer to section 4.1.2.5 for guidance.

5.2.1.3 Weir Skimmers

Weir skimmers are floating units which collect material into a depressed reservoir to be pumped to a holding area. They are designed to be highly portable and can recover floating liquids regardless of viscosity. The height of the weir can be varied to accommodate the thickness of the spill by adjustable floats. Some weir skimmers can operate in water as shallow as 3 inches.

Floating materials flow over the weir into the collection reservoir under their own gravitational head. The material is then pumped to a holding tank by remote pumps or pumps located on the weir skimmer. The rate of recovery will depend largely on the size of the weir skimmer and the environmental conditions. High waves could decrease efficiency by the inclusion of water with the spilled material. Weir skimmers are subject to clogging by foating debris.

Another type of weir skimmer separates the chemical and water. The separation is accomplished by a centrifuge action within the device. There are units available to fit all conventional craft. The power needed to create the centrifuge action can be supplied by pumps or the energy of the craft moving through the water. The separation is accomplished because of the difference in density between the spilled chemical and water.

The depth of the weir can be adjusted to ensure that all of the spilled material is removed without the concern of increasing the amount of material for disposal. Separation of the chemical and water is effective as long as the difference in density is large enough. Response personnel can check reference manufacturers' specifications for limits.

Weir skimmers appear to be the best technology for cleanup of the CHRIS floating hazardous chemicals because they can recover materials with low viscosities. For larger spills, several weir skimmers may be required to accomplish a timely cleanup operation. Response personnel will need to be aware of the possibility of explosion from pumping equipment if a flammability hazard exists. Weir skimmers may be subject to solvent action by the recovered chemical; refer to section 4.1.2.5 for guidance.

5.2.2 Chemical Removal Techniques

There is a variety of chemical removal techniques available to assist in cleanup operations. Chemical removal products include adsorbents and gels which isolate spilled materials. Some of the removal products solidify the spilled chemical while others adsorb the spilled chemical. Response personnel must select a chemical removal agent that is compatible with the spilled material.

When responding to spills in water bodies, the chemical removal agent should have the ability to float. Several products sink when applied to water surfaces. Manufacturers have designed special packages which increase buoyancy, making these materials applicable to spills of floating chemicals.

In general, chemical removal techniques are applicable to small spills. Most sorbents have low capacities and require the acquisition and transportation of large amounts of sorbent for large spills. The use of sorbents and gels is limited by economic considerations and environmental conditions. Application and recovery may be difficult in high current, or under adverse weather conditions such as high winds and rain

5.2.2.1 Sorption

Sorption is commonly applied in water treatment processes. Being a surface process, sorption is controlled by the physical and chemical properties of the sorbent. Sorbents are used to recover spilled materials by either: (1) adsorption, in which the material is attracted to the sorbent surface and adheres to it; or (2) absorption, in which the material penetrates into the voids of the sorbent material. Sorption is normally expressed as a capacity, mass of sorbate per unit mass of sorbent. In general, sorption applies to both liquid and vapor for a chemical. Sorbents are marketed in a variety of forms including sheets, rolls, pillows, or booms.

Sorption is influenced by these factors: (1) physical and chemical attraction; (2) surface geometry; (3) surface area; (4) contact time; and (5) density ratio of sorbate to sorbent. Environmental factors such as ambient temperature, pH, and salinity of the water may affect the chemical and physical interactions thus influencing sorbent capacity.

The following list of feasible sorbents to floating hazardous materials has been identified: (1) activated carbon; (2) polyurethane foam; (3) propylene fibers.

Activated carbon is the most commonly used sorbent material, and its usage has been researched extensively. Activated carbons have potential application to a wide variety of hazardous chemicals but are limited in their ability to float. The main application for activated carbon is for removal of dilute organic contamination of water (Pilie, et al., 1975). Activated carbon would be useful for treating organic contamination downstream from containment resulting from losses of material from spill isolation activities or organic contamination from streams and creeks. It is not applicable for application to concentrated organic chemicals as a means for removing the material.

Work with floating activated carbon (Mercer et al., 1973) using the concept of subsurface injection was shown to be feasible in field demonstrations. Spill collection of the spent floating media in a static body of water was accomplished using existing oil spill cleanup equipment. The effectiveness of the spill treatment decreased as the spilled hazardous material became more diluted. Mercer et al. (1973) proposed the use of weighted packages of floating media for treating hazardous material spills, whereas Dawson et al. (1977) demonstrated better recovery with free floating carbon. Fiber bag efficiency is limited, but it may be improved with higher flow rates or increased contact time. The investigators arrived at the following conclusions regarding buoyant activated carbon and porus fiber bags:

- Buoyant carbon can be employed effectively in flowing streams without the use of ballasted packages. Buoyant carbon may be applied directly to the surface, or it can be slurried and injected beneath the surface;

- Natural turnover provides sufficient contact with contaminated water in shallow streams;

- Floating carbon is capable of a 40% removal rate using a carbon-to-contaminant ratio of 10:1 for the flow and spill conditions studied;

- Floating carbon recovery is generally greater than 90%;

- Up to 25% of fiber bags were lost during the tests due to shore capture or snagging in shallow areas;

- Buoyant carbon was superior in removal efficiency to porous fiber bags for the flow and spill conditions studied;

- Fiber bags can be loaded, unloaded, and handled more easily than buoyant carbon;

- Buoyant carbon will be more greatly affected in bad weather than will fiber bags; and

- Both methods present the logistics problem of transporting large amounts of carbon.

Activated carbon can be obtained from numerous manufacturers and distributors. The price of activated carbon depends on the size of particle required and type of carbon purchased. Regeneration of the spent carbon is difficult and may not be cost effective for those chemicals that may be hard to desorb.

Polyurethane foam is produced in open- or closed-pore forms and as a nonporous particulate foam. Although polyurethane does not demonstrate the versatility of activated carbon, it is the best sorbent for benzene, chlorine, kerosene, naptha solvent, hexane, n-Butyraldehyde, dimethylsulfoxide, epichlorohydrin, and phenol. It could possibly prove feasible for most of the CHRIS floaters. Polyurethane belts have been constructed to adsorb some floating chemicals and many dissolved solutes. When laden with the adsorbed chemical, polyurethane belts may be squeezed to remove the sorbate into a storage facility. Using polyurethane in this way, it is feasible to completely remove contained spills.

The sorption rate and capacity of polyurethane are dependent on the viscosity of the spilled chemical. Polyurethane foams have been shown to pick up from 0.1 to 80 times their weight of hazardous spilled chemicals in one operation.

Polypropylene is a linear hydrocarbon polymer that has the ability to adsorb organic liquids. It has been shown useful for cleanup of kerosene, naptha solvent, dimethyl sulfoxide, and epichlorohydrin, and can be employed in the same manner as polyurethane. Polypropylene fibers are less versatile polyurethanes and are susceptible to decomposition by strong solvents.

Polypropylene may be procured from many manufacturers in a variety of forms. Polypropylene fibers can be produced in a wide range of molecular weights. High molecular weight polypropylene fibers are more resistant to degradation from solvents than low molecular weight polypropylene fibers. Such improved resistance widens their application but may increase the cost.

Based on economic considerations, polypropylene is feasible for use as a sorbent. Basic polypropylene costs $0.24 to $0.29 per pound (Bauer et al., 1975). Byproduct and recycled polypropylene can be obtained much cheaper than new polymer. Waste polypropylene is sometimes usable with little loss of capability.

The following list ranks sorbents in order of feasibility based on their range of application:

- Activated carbon
- Polyurethane foam
- Polypropylene fiber

Application of sorbents can best be accomplished by pneumatic equipment. Snow blowers and forage blowers are generally available for the deployment of a sorbent. Size of the equipment and/or number of units required will depend on the characteristics of the sorbent and amount of cover required. Removal of saturated sorbent can be accomplished by skimmers having the ability to pump liquids mixed with solids, by some type of conveyor belt apparatus designed for removal of floating solid particles from water surfaces, or if the volume of sorbent is small, by hand with some type of long-handled scoop which allows water to drain.

Natural materials such as straw, sawdust, corn cob, and vermiculite can be used as sorbents in emergency situations. These materials are widely available and do not require any special equipment for application. Natural sorbents are more applicable to spills on land because they may adsorb water and sink in water. They are generally impractical for spills greater than 500 gallons, and application of natural sorbents to a spill may increase the volume of hazardous material requiring disposal. Another limitation of using natural sorbents is they are not specific for any chemical class and may not be compatible with the spilled material.

5.2.2.2 Gels

Gelling agents aid in cleanup operations by immobilizing spilled material for removal. Gelling agents solidify the spilled material into a solid mass which can be removed by response personnel. There are several commercially available gelling agents. Section 5.1.2 covers some general information about the use of gelling agents.

Because of economic considerations, gels are only applicable for small spills. For the gelling agent to solidify the spilled material, it has to come in contact with the it. Applications to spills which form a thick layer may only accomplish gelling the surface because the gelling agent does not come in contact with the entire spill. This is not a desirable cleanup situation because removal of the gelled material would only remove the gelled surface. Mixing could possibly be used to increase the volume of the spill which contacts the gelling agent. This is only applicable in a small number of cases with limited associated hazards.

Gelling agents are only designed to solidify certain spilled chemicals. Manufacturers supply gelling agents which are applicable to specific chemical groups, such as fuels, chlorinated hydrocarbons, or alcohols. Gelling hazardous chemicals does not remove the hazards. Flammable and toxic characteristics of the spilled chemical will remain after the gel is applied, although they may be reduced.

5.3 In Situ Treatment Techniques

In situ treatment techniques are used to ameliorate the hazardous chemical without actually removing the chemical. Chemical or biological methods may be used to accomplish the mitigation of the spilled material. Most of the in situ treatment techniques are still in the experimental stages. Techniques discussed under in situ treatment include neutralization, biodegradation, and controlled burning.

5.3.1 Neutralization

Neutralization of a hazardous chemical involves the application of a neutralizing agent, resulting in a more stable and less toxic substance. Neutralization of a hazardous chemical is a difficult task. It is one of the most difficult and potentially dangerous corrective responses. This technique should only be employed if an experienced environmental chemist is available to oversee the operation.

Neutralization has been used to respond to spills of hazardous chemicals in only a limited number of cases. Consequently, there is little or no guidance available from previous experiences. Neutralization techniques will be a viable response alternative only in a limited number of cases.

A good neutralizing agent should have as many of the following characteristics as possible (Akers et al., 1981).

1. It should not cause large pH shifts. By applying buffers such as $NaHCO_3$ or NaH_2PO_4 to the spill, these shifts can be minimized.
2. It should be relatively nontoxic to aquatic life.
3. Its biological oxygen demand should be small.
4. It should be safe to handle and store.
5. It should be low in cost and available in bulk.

The following items should be considered when neutralization is one of the methods being proposed to combat an acidic or basic spill (Akers et al., 1981).

1. **Volume of the spill.** With a large spill it may not be logistically feasible to try to neutralize the entire volume. Care should be taken to neutralize those areas that are biologically sensitive to the greatest extreme.
2. **Dilution rate.** In high current areas, it may be cost effective to allow dilution to take care of most of the spill. Any regions with low flow could then be neutralized with available chemicals.
3. **Monitoring.** The On-Scene Coordinator should have some means at his disposal to monitor pH changes. Neutralization of hazardous chemical spills in waterways should not be attempted unless proper monitoring and control of the neutralization reaction is possible.

Spills of acids and bases are the most viable situations for neutralization. The general mechanism for a neutralization reaction is: Acid + Base Salt + Water. Usually the salt produced is less toxic than the material being produced.

5.3.2 Biodegradation

Biodegradation has long been the method applied in wastewater treatment systems and landfill sites. Spilled chemicals, especially organics, can be biologically degraded either by natural or laboratory grown bacteria. Degradation by bacteria can temporarily impact the dissolved oxygen demand. These techniques are not well developed or widely available.

Research is continuing on biodegradation techniques. Bacteria cultures have been developed that are applicable to specific compounds. Presently, these cultures are not readily available, although a recent development of a synergistic blend of adapted bacteria capable of breaking down the major components of gasoline at accelerated rates is being marketed. The manufacturer is currently consolidating data from research efforts and field trials into technical literature.

Biodegradation is limited to treatment of small spills. Large spills would create a significant demand on dissolved oxygen for natural decomposition and require the acquisition and application of large amounts of bacteria cultures. Temperature is also an important consideration in biodegradation. Decreased metabolic rates at low temperatures could seriously affect biodegradation.

6.0 SPECIAL PROBLEMS

Some situations encountered by response personnel may pose problems which are difficult to remedy. Previous chapters have offered only a brief discussion of some of these problems. This chapter contains a more detailed description of problems and some possible alternatives. Sections include discussions for partially water soluble chemicals, night spills, submerged sources, and materials which rapidly form monolayers.

6.1 Partially Water Soluble Chemicals

The upper limit for solubility of floating chemicals is 25g/liter. In some cases, enough of the floating chemical could solubilize into the water causing an adverse environmental impact. Response personnel will need to be aware of the possibility of contamination to the water body and, if the contamination is not within acceptable limits, employ some type of preventive or corrective actions.

Chemicals that are partially water soluble will dissolve more quickly in water bodies with some current. At the chemical/water interface, water currents will constantly replenish saturated water with fresh water. The saturated water will flow downstream from the contained spill forming a contaminated plume. The shape of the plume will vary with different flow patterns but, in general, the concentration decreases as the plume is dispersed downstream from the source.

Response personnel can consult AWQC for the acceptable concentrations permitted in the waterbody. The type of waterbody, along with its usage, is necessary for establishing the AWQC. If recreational areas or water intakes are located downstream and close enough to be impacted, appropriate authorities should be notified.

Establishing an acceptable concentration for the spilled chemical will probably be easier than determining the actual concentration of the plume. Portable analytical detectors are not designed to identify concentrations of a variety of chemicals. Physical detection would require taking many samples and sending them to a laboratory for analysis to determine the position and concentration of the plume. Time constraints on response activities would not permit such detailed study.

Estimations for impact due to dissolution can be obtained from HACS. After supplying it with the proper data (see Section 3.3.1 or HACS Operation Manual), the spreading and dispersion model can produce a plot of concentration versus time at a user specifed point. The spreading part of the model is applicable to spills, both instantaneous and continuous, onto the water surface. The dispersion part of the model is only applicable for instantaneous spills. Response personnel can consult the HACS Operation Manual for more details.

If the contaminated plume is not within acceptable limits, responses may be limited to evaluations of impacted areas or warning industrial and utility water intakes of the contamination. In some limited circumstances, it may be possible to use secondary sorbent booms or filter fences to remove surface contamination.

6.2 Submerged Sources

Response efforts to submerged sources could cause some difficulties to personnel. Submerged sources could result from damaged underwater vessels, derailed tank cars, or trucks. Due to a difference in density between the chemical and water, leaking material will rise to the surface. Currents can disperse the material over a large area. If the chemical is of a high enough solubility, material can dissolute, resulting in a contaminated plume.

The first response activity to submerged sources should involve some technique to limit the loss of material to the water body. Underwater divers can be used to employ a patching technology. Some epoxy resins are applicable for underwater use. Response personnel can consult manufacturers' specifications to ensure that the product is applicable.

Containment of material that has risen to the surface may be difficult if the material has been dispersed by water currents. The configuration of the booms will be dependent on size of the spill and water current. In water bodies with high currents, diversion booms should be employed. Containment booms can be employed in water bodies with low currents. Booms should be located downstream from the point that material is observed surfacing. For large spills affecting extensive areas, several booming configurations can be employed in parallel to increase the efficiency of containing the spill.

Contaminated plumes from submerged sources will most likely be more difficult to mitigate than contaminated plumes discussed in Section 6.1. The depth of contamination can be as deep as the source. Response activities may be limited to warning affected areas of the contaminate. Characterization of the impact may be difficult because HACS does not offer a model which can calculate estimates of concentration for submerged sources.

6.3 Night Spills

Responses to hazardous materials at night pose a serious problem due to low visibility of the slick. Research (Bannister, 1983) has been conducted for techniques which increase visibility of spills to aid in cleanup operations. The techniques include using fluorescent agents and acoustic sensing for locating and tracking floating spilled materials.

Fluorescent agents can be applied as liquid solutions or powder formulations. Although both are applicable, tests suggest that powdered formulations are the most feasible. Powdered fluorescent agents consist of gypsum ($CaSO_4$) or finely powdered limestone. These fluorescent agents can be applied by crop dusting equipment to the water surface in very low concentrations (about 50 ppm). The agent landing on the water surface is dispersed in the water column within an hour. The agent retained by the spilled material provides an excellent night-time visibility when illuminated with a UV light.

Fluorescent agents are nontoxic and have low fire hazards. Spray formulations contain gylcol ether solvents which have very low fire and toxicity effects and would probably present no significant hazard in the low concentration proposed for applications.

Underwater acoustical sensing equipment can be used to locate floating spilled material at night. This technique is particularly useful in situations where it is necessary to estimate the rate of dissipation of material into the water column.

Either method can provide a means of locating and tracking slicks of hazardous materials. A compound benefit was shown when the two methods were employed together (Bannister, 1983).

6.4 Materials Which Rapidly Form Monolayers

One major area of concern with spills of floating hazardous chemicals is their mobility. Besides movement by wind and water currents, the spilled material can spread over the water surface from effects caused by gravity, viscosity, and surface tension.

Some chemicals have the ability to rapidly form a monolayer (a layer of chemical one molecule thick). Pentadecanol is an example of such a chemical. The formation of a monolayer occurs because the molecule has a water soluble and water insoluble end. The water soluble end is attracted to the water while the insoluble end is repelled, resulting in a rapid spreading of chemical over the water surface.

The material will continue to spread until a nonaqueous boundry is contacted. If a nonaqueous boundry is not contacted, the material will continue to spread until a film one molecule thick is formed. For large spills, the potential exists for impacting an extensive area.

Response activities to materials which form monolayers should commence as quickly as possible to contain the spill. Material which has already formed a monolayer may prove difficult to clean up. The application of sorbents over a large area is not feasible. Dilution and dispersion are possibly the best action if the material poses a hazard. Appendix A alerts response personnel of floating CHRIS chemicals which exhibit this behavior.

6.5 Burning Spills

Spills which are burning pose a significant danger to response personnel. In some cases, extinguishing the fire may be difficult or may not be the best action. The chemical and physical properties, as well as the spill situation, will determine the proper response.

For chemicals with low flash points (below 100°F), water may not be an effective extinguishing method. The lower the flash point, the less effective water will be. Much of the effectiveness of using water is dependent on the method of application. In some cases, burning low flash point liquids can be extinguished by a water spray or by sweeping flames off the surface of the liquid. Application of a water spray is also useful in cooling and diluting flammable liquids or protecting exposed materials from damage.

The application of foam can be useful in smothering flames. The proper choice of foam is dependent on the type of chemical involved. Some vapor suppression foams are not designed for application on burning spills. Response personnel may have to apply one type of foam for extinguishing the fire, then another type to suppress vapors, although there are foams available which can accomplish both.

The temperature of spilled chemical will undoubtedly be elevated due to its burning. The amount of vapor issuing from the pool will also increase, causing secondary foaming. Secondary foaming is the entrainment of vaporizing gases, increasing the expansion ratio of the foam. This can quickly saturate the foam with flammable vapors. Foams saturated with flammable vapors pose an explosion hazard. A reapplication of foam will reduce the possibility of igniting the saturated foam.

The source of the spill should be eliminated before the fire is extinguished. Extinguishing the fire before stopping the spill will allow the buildup of flammable vapor, and an explosive mixture may be formed. If ignited, the damage could be far greater than the damage from original fire. In some situations, it may not be possible to stop the source of the spill without extinguishing the fire. For example, the source of the spill may be so engulfed with flames that access to the area may be impossible. Under these circumstances, response personnel will have to determine which hazard is the greatest in formulating a response action.

6.6 Boiling Liquid Expanding Vapor Explosion

Another scenario which may be encountered by response personnel is a Boiling Liquid Expanding Vapor Explosion (BLEVE). A BLEVE is possible when containers of materials, especially cylinders of compressed or liquefied gas, are exposed to excessive heat, resulting in an explosion. The mechanism for such an explosion is as follows.

Containers are impinged with flames, heating the surface of the container. The heat vaporizes some of the liquid inside the container. Areas of the container which are in contact with liquid on the inside increase only slightly in temperature. For areas not contacted by liquid, the impinging flames cause a large increase in temperature. After some time, the increase temperature of the container walls leads to localized metal failure. The combination of a weakened metal structure and increased internal pressure results in rupture of the container and possible ignition of the released vapor.

The occurrence of a BLEVE poses an extreme hazard to personnel and property in the surrounding area. A BLEVE can engulf the immediate area in flames and propel shrapnel hundreds of feet from the original site.

Once a BLEVE has occurred, response efforts are limited to controlling the spread of the fire. It is extremely important for response personnel to recognize situations where BLEVEs are possible and implement a preventive response action. A preventive response action would involve cooling the surface of the containers with water. This would result in reducing the internal pressure and the likelihood of metal failures due to excessive heat.

APPENDIX A. PHYSICAL-CHEMICAL CHARACTERISTICS OF FLOATING CHRIS CHEMICALS

To properly assess the potential hazards and difficulties that could be encountered in combating a hazardous floating chemical, it was necessary to compile a table of data listing key physical properties, develop criteria for toxicity and flammability, and present pertinent response information. The following is a description of the physical properties and keys for interpreting the hazardous criteria and response action.

A.1 Boiling Point

The boiling poing is defined as the temperature at which the vapor pressure and atmospheric pressure are in equilibrium. Boiling points given in the table are reported in ^{o}C. It is included because it can be used to gauge the potential hazards due to the production of vapors. Low boiling point liquids produce more vapor than high boiling point liquids.

A.2 Solubility

This property provides information for a chemical's tendency to dissolute in water. Since the floating criteria limits solubility to an upper limit of 25g/100g of H_2O, there are only two classifications of solubility possible - immiscible and slightly soluble. The interpretation of these classifications are as follows:

immiscible - $0 < \text{solubility} > 10g/100g$ of H_2O

slightly soluble - $10 < \text{solubility} > 25g/100g$ of H_2O

The importance of solubility is twofold. First, it is a measure of how much material will dissolve with contact with the water. Secondly, it is important in estimating the duration of the vapor suppression. Chemicals with high water solubility permeate through the foam more quickly than chemicals with low water solubility, exposing the environment and response personnel to the associated hazards.

A.3 Flash Point

The flash point is the lowest temperature at which a chemical produces a flammable mixture with air. Flash points at ambient temperatures alert personnel that the potential for ignition exists, and steps should be taken to mitigate the hazard.

A.4 Vapor Pressure

The vapor pressure is the pressure exerted by a solid or liquid in equilibrium with its own vapor. The vapor pressure is a function of temperature, increasing with increased temperature. The vapor pressure can be used to estimate the amount of vapor being produced by the chemical. The vapor pressure is proportional to the vapor concentration of the chemical. Higher vapor pressures indicate higher vapor concentrations and alerts response personnel of potential hazardous impacts.

A.5 Flammability

The flammability data was based primarily on NFPA ratings and secondarily on the material's respective flash point and are classified as follows:

Noncombustible: Materials having an NFPA rating of 1 or 0 and/or those having a flash point greater than 200F.

Combustible: Materials having an NFPA rating of 2 and/or those having a flash point of 100-200F.

Flammable: Materials having an NFPA rating of 3 and/or having a flash point of less than 100F.

Highly Flammable: Materials having an NFPA rating of 4.

A.6 Toxicity

Information obtained from Threshold Limit Values (TLV's) and Short Term Exposure Limits (STEL's) was given first priority in the ranking process. The following criteria, which are based on regression analyses, were used as a guideline in the grouping.

Group	TLV (ppm)	STEL (ppm)
Practically Nontoxic	1000	5500
Slightly Toxic	100	130
Moderately Toxic	5	3
Highly Toxic	0.1	0.1

Data from the OHM-TADS, LD-50's, and NFPA health codes were also considered. In some instances, it was necessary to assign a chemical to a category based on limited toxicity information. In other cases, contradictory data led to a grouping decision based on the more conservative piece of information. The following is a description of the different classifications.

Practically Nontoxic: Poses a health hazard only at high concentrations.

Slightly Toxic: Indicates chemicals which on exposure would cause irritation but only minor residual injury even without medical treatment. Chemicals which irritate, but do not destroy tissue, and materials which require the use of canister-type gas masks are included in this category,

Moderately Toxic: Indicates those materials which cause temporary incapacitation or possible residual injury unless prompt medical attention is given. Materials included in this category require the use of protective respiratory equipment with independent air supply.

Highly Toxic: Indicates materials which on short exposure could cause serious temporary or residual damage (possibly death) even with prompt medical attention. Materials that are corrosive to living tissue or toxic by skin absorption and materials requiring protection from all bodily contact are included in this category.

A.7 Response Information

Under the heading labeled Response Information are a series of messages which provide response personnel with a description of the chemicals' behavior in the environment, potential hazards, and response alternatives. The following is a list of the messages and an explanation of their meaning where necessary.

Compressed gas - highly volatile. Describes how the material is stored and indicates that under ambient conditions the material exists as a gas. When released into the environment, the material is a gas.

Liquefied gas - extremely volatile. This differs from the above classification in that the material is stored under sufficient pressures for the material to exist as a liquid. These materials are extremely cold and, when released into the environment, exist as a liquid for a short period then boil away.

Spreads rapidly across a water surface, contain as quickly as possible. Describes materials with low surface tensions and interact with the air and water to quickly form a thin layer on the water surface.

Freezing point at ambient temperatures. Indicates that chemicals may solidify at ambient temperatures.

May not float on fresh water or at low ambient temperatures. For chemicals which have specific gravities at the upper limit of the floating criteria, environmental conditions can influence the floatability. This message alerts response personnel that the chemical may not float in all situations.

A solid with appreciable vapor pressure. Alerts response personnel to potential hazards due to the production of vapors from a solid.

Materials can violently decompose due to heat or light. Indicates potential hazards due to chemicals decomposing into vapors or other materials in a potentially hazardous manner. This alerts personnel to protect these materials from heat or light if possible.

Low vapor production. Indicates low hazardous impacts from toxic or flammable vapors.

Limited data on hazardous impacts.

Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Vapors more dense than air remain near the surface where they can contact an ignition source. This creates a serious threat for hazardous impacts because mixtures of air and vapors can remain in the explosive range far from the original spill site.

High potential for water contamination from dissolution. Alerts response personnel of possible water contamination which needs mitigation.

High potential for hazardous impacts. A qualitative summary which considers the hazards associated with a chemical and the degree to which they are present. This alerts response personnel that a serious situation exists in the event of a spill.

Moderate potential for hazardous impacts.

Low potential for hazardous impacts.

No hazardous impact. No toxic or flammable hazards associated with a release. The spill presents only a asthetic impact.

Forms explosive mixtures with air over a wide range. Alerts response personnel of a serious flammable hazard.

May polymerize at elevated temperatures possibly causing a violent rupture of the container. Some organic chemicals polymerize with the addition of heat. Polymerization is accompanied with heat and expansion, creating the potential for the container to rupture. The rupture could be accompanied with flying shrapnel.

Flammability limits of vapor-air mixtures unknown.

Hydrogen is produced by contact with moisture creating a high potential for explosion. Hydrogen is produced by a reaction between water and the chemical. The produced hydrogen, which is highly flammable, creates a high potential for hazardous impacts.

Any foam will provide vapor suppression (based on testing). Potential for producing vapors and the chemical's tendency to degrade foam is low. The guidelines in Chapter 6 for producing and applying foam should be followed. This classification is based on results from testing.

Any foam will provide vapor suppression (qualitative analysis). Same as the preceding except that the classification is based on qualitative considerations.

Suppress vapors with the application of an alcohol type or polar solvent type foam (based on testing). Alert response personnel that the chemical has the potential to degrade most foams and designates the proper selection. The selection is based on results from testing.

Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Same as the preceding except that the classification is based on qualitative considerations.

Some vapor suppression may be accomplished by applying a high expansion, slow-draining foam. This applies to chemicals which produce large amounts of vapors. This high vapor production usually degrades most foams. If suppression of vapors is crucial, some may be accomplished with high expansion, slow-draining foam. The application of this type of foam is limited to situations with wind speeds less than 9 mph.

Vapor suppression may not be possible. The physical properties of the chemical are much that vapor suppression may not be possible.

Low viscosity - remove material with pumps or weir skimmers. Because of the low viscosity of the liquid, belt and moving plane skimmers are not applicable.

Floating solid - contain and remove with a mechanical device.

Contain and remove.

Removal probably not possible. This applies to compressed and liquefied gases. Since the material exists as a gas or super cooled liquid, removal of the material may not be possible. The response is limited to attempts to mitigate the hazardous impacts.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
ACETOPHENONE	ACP	201.7	Immisible	Polar	170	10.00	20	Combustible	Md Toxic	May not float on fresh water or at low ambient temperatures. Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
ACETYL ACETONE	ATA	140.4	Sl Soluble	Nonpolar	93	39.50	20	Combustible	Md Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
ACETYLENE	ACE	-84	Immisible	Polar	N/A	996.90	-80	Hi Flammable	PN Toxic	Compressed gas - highly volatile. High potential for hazardous impacts. Vapor suppression may not be possible. Removal probably not possible.
ADIPONITRILE	ADN	290	Immisible	Polar	199	No data		Combustible	Hi Toxic	Freezing point at ambient temperatures Low vapor production. Moderate potential for hazardous impacts. Low viscoscity - remove material with pumps or weir skimmers.
ALLYL CHLORIDE	ALC	45	Immisible	Polar	-25	360.00	20	Flammable	Hi Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a violent rupture of the container. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
ALLYL CHLORIDE	ALC(continued)									pumps or weir skimmers.
n-AMYL ACETATE	AML	146	Immisible	Sl Polar	71	5.00	0	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
sec-AMYL ACETATE	AAS	133	Sl Soluble	Sl Polar	89	9.00	0	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
tert-AMYL ACETATE	AYA	124.7	Immisible	Sl Polar	25	380.00	0	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
n-AMYL ALCOHOL	AAN	137.9	Immisible	Polar	91	2.80	0	Flammable	Sl Toxic	Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
n-AMYL CHLORIDE	AMY	108	Immisible	Polar	55	4.28	0	Flammable	Sl Toxic	Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
n-AMYL MERCAPTAN	AMM	120	Immisible	Sl Polar	64	10.50	20	Flammable	Md Toxic	Moderate potential for hazardous impacts. Flammability limits of vapor-air mixtures unknown. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
n-AMYL METHYL KETONE	AMK	151.5	Immisible	Polar	120	2.00	20	Combustible	Md Toxic	Low vapor production. Low potential for hazardous impacts. Contain and remove.
n-AMYL NITRATE	ANT	144	Immisible	Polar	118	No data		Combustible	Md Toxic	Low vapor production. Low potential for hazardous impacts. Contain and remove.
iso-AMYL NITRITE	ANI	99	Immisible	Polar	50	No data		Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
AMYL PHTHALATE	ATL	No data	Immisible	Polar	245	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.
ANILINE	ANL	184.2	Immisible	Polar	158	15.00	0	Combustible	Hi Toxic	May not float on fresh water or at low

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
ANILINE	ANL(continued)									ambient temperatures. Low vapor production. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
ASPHALT	ASP	V. High	Immisible	Nonpolar	400	No data		Noncombust.	Md Toxic	May not float on fresh water or at low ambient temperatures. Low vapor production. Contain and remove.
BENZALDEHYDE	BZD	179	Immisible	Polar	145	75.00	20	Combustible	Md Toxic	May not float on fresh water or at low ambient temperatures. Low potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers. Toxic ozides are produced during combustion.
BENZENE	BNZ	80.1	Immisible	Nonpolar	12	74.66	20	Flammable	Hi Toxic	Freezing point at ambient temperatures High potential for hazardous impacts. Any foam will provide vapor suppression (based on testing). Low viscoscity - remove material with pumps or weir skimmers.
BENZONITRILE	BZN	191	Immisible	Polar	167	3.50	50	Combustible	Md Toxic	May not float on fresh water or at low ambient temperatures. Low potential for hazardous impacts. Low viscoscity - remove material with pumps or weir skimmers. Contain and remove.
BENZYL ALCOHOL	BAL	205	Immisible	Polar	200	0.00	20	Noncombust.	Md Toxic	May not float on fresh water or at low ambient temperatures.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
BENZYL ALCOHOL	BAL(continued)									Low vapor production. Low potential for hazardous impacts. Contain and remove.
BUTADIENE	BDI	-4.4	Immisible	Nonpolar	-103	900.70	0	Hi Flammable	Sl Toxic	Liquefied gas - extremely volatile. High potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a violent rupture of the container. Some vapor suppression may be accomplished by applying a high expansion, slow draining foam. Removal probably not possible.
BUTANE	BUT	-0.48	Immisible	Nonpolar	-76	1500.00	20	Hi Flammable	Sl Toxic	Liquefied gas - extremely volatile. High potential for hazardous impacts. Low potential for hazardous impacts. Some vapor suppression may be accomplished by applying a high expansion, slow draining foam. Removal probably not possible.
n-BUTYL ACETATE	BCN	126	Immisible	Sl Polar	72	15.00	20	Flammable	Md Toxic	High potential for hazardous impacts. Any foam will provide vapor suppression (based on testing). Low viscoscity - remove material with pumps or weir skimmers.
sec-BUTYL ACETATE	BTA	112	Immisible	Sl Polar	91	10.00	20	Flammable	Md Toxic	High potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
tert-BUTYL ACETATE	BYA	97.8	Immisible	Sl Polar	88	16.30	20	Flammable	Sl Toxic	High potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
iso-BUTYL ACRYLATE	BAI	137.9	Immisible	Nonpolar	49	10.70	20	Flammable	Md Toxic	High potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
n-BUTYL ACRYLATE	BTC	148.8	Immisible	Nonpolar	120	5.00	20	Combustible	Md Toxic	Low potential for hazardous impacts. Contain and remove.
BUTYL BUTYRATE	BUB	No data	Sl Soluble	Sl Polar	128	65.00	20	Combustible	Md Toxic	Limited data on hazardous impacts. Low potential for hazardous impacts. Contain and remove.
BUTYLENE	BTN	6.3	Immisible	Nonpolar	-112	967.60	0	Hi Flammable	Sl Toxic	Liquefied gas - extremely volatile. Moderate potential for hazardous impacts. Some vapor suppression may be accomplished by applying a high expansion, slow draining foam. Removal probably not possible.
tert-BUTYL HYDROPEROXIDE	BHP	N/A	Immisible	Polar	100	No data		Flammable	Md Toxic	High potential for hazardous impacts. Flammability limits of vapor-air mixtures unknown. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
n-BUTYL MERCAPTAN	BTM	98.5	Immisible	Sl Polar	35	35.64	0	Flammable	Hi Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
iso-BUTYL METHACRYLATE	BMI	No data	Immisible	Nonpolar	126	No data		Combustible	No Data	Limited data on hazardous impacts.

	CHRIS	Boiling			Flash	Vapor Pressure				
Chemical	Code	Point	Solubility	Polarity	Point	mmHg	temp	Flammability	Toxicity	Response Information
iso-BUTYL METHACRYLATE	BMI(continued)									Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
n-BUTYL METHACRYLATE	BMN	163	Immisible	Nonpolar	126	No data		Combustible	Sl Toxic	Low vapor production. Low potential for hazardous impacts. Contain and remove.
p-tert-BUTYLPHENOL	BTP	239.5	Immisible	Polar	205	1.00	70	Noncombust.	Sl Toxic	May not float on fresh water or at low ambient temperatures. Low potential for hazardous impacts. Floating solid - contain and remove with a mechanical device.
iso-BUTYRALDEHYDE	BAD	64.1	Immisible	Sl Polar	-40	137.90	20	Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
n-BUTYRALDEHYDE	BTR	74.8	Immisible	Sl Polar	20	20.00	0	Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
CAMPHENE	CPH	154	Immisible	Nonpolar	90	0.60	0	Flammable	No Data	A solid with appreciable vapor pressure. Limited data on hazardous impacts. Floating solid - contain and remove with a mechanical device.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
CAMPHOR OIL	CPO	>200	Immisible	Polar	117	1.00	42	Combustible	Md Toxic	Moderate potential for hazardous impacts. Contain and remove.
CARBON MONOXIDE	CMO	-191.5	Immisible	Polar	No data	No data		Hi Flammable	Md Toxic	Liquefied gas - extremely volatile. Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Vapor suppression may not be possible. Removal probably not possible.
CARENE	CAR	170	Immisible	Nonpolar	120	0.29	0	Combustible	Md Toxic	Low vapor production. Low potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
CETYL EICOSYL METHACRYLATE	CEM	No data	Immisible	Nonpolar	No data	No data		No Data	No Data	No data
CHLOROPRENE	CRP	59.4	Sl Soluble	Sl Polar	-4	142.80	20	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a violent rupture of the container. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis).
COLLODION	CLD	34	Immisible	Polar	-80	No data		Hi Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis).
COPPER NAPTHENATE(IC) COPPER(II)NAPTH	CNN	154	Immisible	Sl Polar	100	No data		Combustible	Sl Toxic	May not float on fresh water or at low

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
COPPER NAPTHENATE(IC) COPPER(II)NAPTH	CNN(continued)									ambient temperatures. Low potential for hazardous impacts. Low viscoscity - remove material with pumps or weir skimmers.
CREOSOTE, COAL TAR	CCT	180	Immisible	Nonpolar	165	No data		Combustible	Md Toxic	May not float on fresh water or at low ambient temperatures. Low potential for hazardous impacts. Contain and remove.
p-CRESOL	CSO	201.9	Immisible	Polar	187	4.00	0	Combustible	Hi Toxic	Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
CRESOLS	CRS	>177	Immisible	Polar	178	No data		Combustible	Hi Toxic	Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
CRESYLATE SPENT CAUSTIC	CSC	No data		Sl Polar	No data	No data		No Data	No Data	No data
CROTONALDEHYDE	CTA	102.2	Sl Soluble	Sl Polar	55	19.00	0	Flammable	Hi Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for water contamination from dissolution. High potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a violent rupture of the container. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
CUMENE	CUM	152.4	Immisible	Nonpolar	111	10.00	20	Combustible	Md Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
CUMENE HYDROPEROXIDE	CMH	Decomp	Sl Soluble	Polar	175	No data		Combustible	Md Toxic	May not float on fresh water or at low ambient temperatures. Low potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Spontaneous reaction, ignition, and/or explosion may occur if mixed with oxidizable, organic, or flammable materials.
CYCLOHEXANE	CHX	80.7	Immisible	Nonpolar	-4	75.90	20	Flammable	Sl Toxic	Freezing point at ambient temperatures Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Any foam will provide vapor suppression (based on testing). Low viscoscity - remove material with pumps or weir skimmers.
CYCLOHEXANONE	CCH	155.8	Immisible	Polar	111	20.20	20	Combustible	Md Toxic	Low potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
CYCLOHEXANONE PEROXIDE	CHP	Decomp	Immisible	Polar	111	4.00	20	Combustible	Md Toxic	May not float on fresh water or at low ambient temperatures. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis).

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
CYCLOHEXANONE PEROXIDE	CHP(continued)									Contain and remove.
CYCLOHEXENE	CYH	No data	Immisible	Nonpolar	20	No data		Flammable	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.
CYCLOPENTANE	CYP	49.3	Immisible	Nonpolar	20	119.60	20	Flammable	Sl Toxic	High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
CYCLOPROPANE	CPR	-32.9	Sl Soluble	Nonpolar	-160	698.40	-35	Hi Flammable	Sl Toxic	Liquefied gas - extremely volatile. Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Some vapor suppression may be accomplished by applying a high expansion, slow draining foam. Removal probably not possible.
p-CYMENE	CMP	177	Immisible	Nonpolar	117	2.00	0	Combustible	Md Toxic	Low potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
DECABORANE	DBR	213	Immisible	Nonpolar	176	No data		Combustible	Hi Toxic	A solid with appreciable vapor pressure. Moderate potential for hazardous impacts. Hydrogen is produced by contact with moisture creating a high potential for explosion. Floating solid - contain and remove with a mechanical device.
DECAHYDRONAPHTHALENE	DHN	195	Immisible	Polar	136	2.00	0	Combustible	Md Toxic	Low potential for hazardous impacts.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
DECAHYDRONAPHTHALENE	DHN(continued)									Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
n-DECALDEHYDE	DAL	207	Immisible	Sl Polar	186	3.10	70	Combustible	Md Toxic	Low potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
1-DECENE	DCE	170.6	Immisible	Nonpolar	131	2.00	20	Combustible	Sl Toxic	Low potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
n-DECYL ACRYLATE	DAR	No data	Immisible	Nonpolar	441	No data		Noncombust.	Md Toxic	Low potential for hazardous impacts. Low viscoscity - remove material with pumps or weir skimmers.
n-DECYL ALCOHOL	DAN	230	Immisible	Polar	180	1.00	70	Combustible	Md Toxic	Low potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
n-DECYLBENZENE	DBZ	300	Immisible	Nonpolar	225	No data		Noncombust.	Md Toxic	Low potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
DI-n-AMYL PHTHALATE	DAP	V. High	Immisible	Polar	245	No data		Noncombust.	Md Toxic	Low potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
DIBENZYL ETHER	DBN	No data	Immisible	Nonpolar	275	No data		Noncombust.	Md Toxic	Low potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.
DI-n-BUTYLAMINE	DBA	159.6	Immisible	Sl Polar	117	2.00	0	Combustible	Hi Toxic	Low potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
DI-n-BUTYL ETHER	DBE	142	Immisible	Nonpolar	77	5.30	20	Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
DI-n-BUTYL KETONE	DBK	188	Immisible	Polar	135	0.10	0	Combustible	Hi Toxic	Low potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
DIBUTYLPHENOL	DBT	253	Immisible	Nonpolar	200	No data		Noncombust.	Md Toxic	Can be a solid or a liquid solution. Low potential for hazardous impacts. Floating solid - contain and remove with a mechanical device.
DIBUTYL PHTHALATE	DPA	335	Immisible	Polar	315	7.76	0	Noncombust.	Md Toxic	May not float on fresh water or at low ambient temperatures. Low potential for hazardous impacts. Contain and remove.
4,4-DICHLORO-al-TRICHLOROMETHYLBENZYHDRO	DTM	132	Immisible	Polar	70	No data		Flammable	Md Toxic	Can be a solid or a liquid solution. Moderate potential for hazardous

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
4,4-DICHLORO-al-TRICHLOROMETHYLBENZYHDRO	DTM(continued)									impacts. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.
DICYCLOPENTADIENE	DPT	170	Immisible	Nonpolar	90	3.30	20	Flammable	Md Toxic	Freezing point at ambient temperatures Can be a solid or a liquid solution. Any foam will provide some vapor suppression (qualitative analysis).
DIETHYLBENZENE	DEB	180	Immisible	Nonpolar	132	No data		Combustible	Md Toxic	Low potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.
DIETHYL CARBONATE	DEC	No data	Immisible	Nonpolar	77	8.00	20	Flammable	Md Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
DIETHYLENE GLYCOL MONOBUTYL ETHER ACETAT	DEM	246	Immisible	Polar	240	0.04	20	Noncombust.	Sl Toxic	Low potential for hazardous impacts. Low viscoscity - remove material with pumps or weir skimmers.
DI-(2-ETHYLHEXYL)PHOSPHORIC ACID	DEP	Decomp	Immisible	Polar	385	No data		Noncombust.	Md Toxic	Low potential for hazardous impacts. Contain and remove.
DIETHYL KETONE	DEK	No data	Sl Soluble	Polar	55	27.90	20	Flammable	Sl Toxic	Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
1,1-DIFLUOROETHANE	DFE	11.3	Immisible	Polar	-60	1980.00	0	Flammable	No Data	Compressed gas - highly volatile. Vapor more dense than air creating an ignition hazard considerable distances from the spill site.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
1,1-DIFLUOROETHANE	DFE(continued)									Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Removal probably not possible.
DIHEPTYL PHTHALATE	DHP	Decomp	Immisible	Polar	65	No data		Flammable	No Data	May not float on fresh water or at low ambient temperatures. Limited data on hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis).
DIISOBUTYLAMINE	DBU	No data	Sl Soluble	Sl Polar	85	5.06	0	Flammable	Hi Toxic	High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers. Toxic ozides are produced during combustion.
DIISOBUTYLCARBINOL	DBC	178	Immisible	Polar	165	No data		Combustible	Sl Toxic	Low potential for hazardous impacts. Contain and remove.
DIISOBUTYLENE	DBL	101.5	Immisible	Nonpolar	23	34.30	20	Flammable	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.
DIISOBUTYL KETONE	DIK	163	Immisible	Sl Polar	140	2.00	0	Combustible	Md Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
DIISOBUTYL PHTHALATE	DIT	No data	Immisible	Sl Polar	365	No data		Noncombust.	Sl Toxic	May not float on fresh water or at low ambient temperatures. Low potential for hazardous impacts.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
DIISOBUTYL PHTHALATE	DIT(continued)									Contain and remove.
DIISODECYL PHTHALATE	DID	No data	Immisible	Sl Polar	450	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.
DIISONONYL PHTHALATE	DIN	No data	Immisible	Sl Polar	75	No data		Flammable	No Data	May not float on fresh water or at low ambient temperatures. Limited data on hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
DIISOOCTYL PHTHALATE	DIO	No data	Immisible	Sl Polar	380	No data		Noncombust.	Sl Toxic	May not float on fresh water or at low ambient temperatures. Limited data on hazardous impacts. Contain and remove.
2,2-DIMETHYL OCTANOIC ACID	DMO	No data	Sl Soluble	Sl Polar	80	No data		Flammable	No Data	No data
DIISOPROPYLBENZENE HYDROPEROXIDE	DIH	No data	Sl Soluble	No Data	No data	No data				No data
DIMETHYLPOLYSILOXANE	DMP	>149	Immisible	Nonpolar	275	No data		Noncombust.	Md Toxic	Limited data on hazardous impacts. Contain and remove.
DIMETHYLPOLYSILOXANE	DMP	>149	Immisible	Nonpolar	275	No data		Noncombust.	Md Toxic	Limited data on hazardous impacts. Contain and remove.
DIMETHYL SULFIDE	DSL	37	Immisible	Polar	-1	395.00	0	Hi Flammable	Md Toxic	High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
DIOCTYL ADIPATE	DOA	V. High	Immisible	Sl Polar	402	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.
DIOCTYL PHTHALATE	DOP	386	Immisible	Sl Polar	424	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
DIPENTENE	DPN	178	Immisible	Nonpolar	113	2.00	20	Combustible	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
DI-n-PROPYLAMINE	DNA	No data	Immisible	Polar	63	No data		Flammable	Hi Toxic	High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove. Toxic ozides are produced during combustion.
DISTILLATES: FLASHED FEED STOCKS	DFF	14-135	Immisible	No Data	141	47.60	20	Combustible	Md Toxic	No data
DISTILLATES: STRAIGHT RUN	DSR	14-135	Immisible	No Data	141	47.60	20	Combustible	Md Toxic	No data
DIUNDECYL PHTHALATE	DUP	No data		Polar	20	No data		Flammable	No Data	May not float on fresh water or at low ambient temperatures. Limited data on hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
DODECANOL	DDN	259	Immisible	Sl Polar	260	No data		Noncombust.	Sl Toxic	Freezing point at ambient temperatures Low potential for hazardous impacts. Low viscoscity - remove material with pumps or weir skimmers.
DODECENE	DOD	185-196	Immisible	Nonpolar	120	No data		Combustible	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
1-DODECENE	DDC	213	Immisible	Nonpolar	174	No data		Combustible	Sl Toxic	Moderate potential for hazardous

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
1-DODECENE	DDC(continued)									impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
DODECYLBENZENE	DDB	288	Immisible	Nonpolar	285	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.
DODECYLBENZENESULFONIC ACID,CALCIUM SALT	DCS	No data	Sl Soluble	No Data	No data	No data				No data
DODECYLDIPHENYL OXIDE DISULFONATE	DOS	No data		Polar	No data	No data		No Data	Hi Toxic	No data
DODECYLMETHACRYLATE	DDM	No data	Immisible	No Data	-30	No data		Flammable	No Data	No data
DODECYL PENTA DECYL METHACRYLATE	DDP	No data	Immisible	Sl Polar	No data	No data		No Data	No Data	No data
EPOXIDIZED VEGETABLE OILS	EVO	V. High	Immisible	Nonpolar	585	No data		Noncombust.	PN Toxic	May not float on fresh water or at low ambient temperatures. No hazardous impacts. Contain and remove.
ETHANE	ETH	-88.6	Immisible	Nonpolar	275	4060.00	-50	Hi Flammable	Sl Toxic	Liquefied gas - extremely volatile. Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Vapor suppression may not be possible. Removal probably not possible.
ETHOXYDIHYDROPYRAN	EHP	143	Immisible	Polar	111	No data		Combustible	Md Toxic	Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
ETHOXYLATED DODECANOL	EOD	V. High	Sl Soluble	Sl Polar	470	No data		Noncombust.	Sl Toxic	No data
ETHOXYLATED PENTADECANOL	EOP	V. High	Sl Soluble	Sl Polar	470	No data		Noncombust.	No Data	No data

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
ETHOXYLATED TETRADECANOL	EOT	V. High	Sl Soluble	Sl Polar	470	No data		Noncombust.	No Data	No data
ETHOXYLATED TRIDECANOL	ETD	V. High	Sl Soluble	Sl Polar	385	No data		Noncombust.	Md Toxic	No data
ETHYL ACETATE	ETA	77	Immisible	Sl Polar	24	100.00	0	Flammable	Sl Toxic	High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
ETHYL ACETOACETATE	EAA	184	Sl Soluble	Polar	135	0.77	0	Combustible	Md Toxic	May not float on fresh water or at low ambient temperatures. High potential for water contamination from dissolution. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
ETHYL ACRYLATE	EAC	99.6	Immisible	Nonpolar	60	30.00	0	Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a violent rupture of the container. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
ETHYLBENZENE	ETB	136.2	Immisible	Nonpolar	59	9.00	20	Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Any foam will provide vapor suppression (based on testing). Low viscoscity - remove material with

	CHRIS	Boiling			Flash	Vapor Pressure				
Chemical	Code	Point	Solubility	Polarity	Point	mmHg	temp	Flammability	Toxicity	Response Information
ETHYLBENZENE	ETB(continued)									pumps or weir skimmers.
ETHYL BUTANOL	EBT	146	Immisible	Sl Polar	135	6.84	20	Combustible	Sl Toxic	Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
n-ETHYL-n-BUTYLAMINE	EBA	No data	Immisible	Sl Polar	64	No data		Flammable	Hi Toxic	High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers. Toxic ozides are produced during combustion.
ETHYL BUTYRATE	EBR	121	Immisible	Sl Polar	75	27.80	0	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
ETHYL CHLORIDE	ECL	12.2	Immisible	Polar	58	456.80	0	Hi Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
ETHYL CYCLOHEXANE	ECY	No data	Immisible	Nonpolar	95	10.00	0	Flammable	Sl Toxic	High potential for water contamination

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
ETHYL CYCLOHEXANE	ECY(continued)									from dissolution. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
n-ETHYL CYCLOHEXYLAMINE	ECC	No data	Sl Soluble	Sl Polar	86	No data		Flammable	Hi Toxic	No data
ETHYLENE GLYCOL DIETHYL ETHER	EEE	122	Immisible	Polar	95	No data		Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
ETHYLENE GLYCOL MONOBUTYL ETHER ACETATE	EMA	192.2	Immisible	Polar	160	0.30	20	Combustible	Md Toxic	Low potential for hazardous impacts. Low viscoscity - remove material with pumps or weir skimmers.
ETHYLENEDIAMINE TETRACETIC ACID	EDT	No data	Immisible	No Data	No data	No data				No data
ETHYL ETHER	EET	34.6	Immisible	Sl Polar	-49	181.10	0	Hi Flammable	Md Toxic	High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
ETHYL FORMATE	EFM	54.2	Immisible	Sl Polar	-4	195.20	0	Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis).

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
ETHYL FORMATE	EFM(continued)									Low viscoscity - remove material with pumps or weir skimmers.
ETHYLHEXALDEHYDE	EHA	164	Sl Soluble	Nonpolar	112	No data		Combustible	Md Toxic	Low potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.
2-ETHYL HEXANOL	EHX	184.7	Immisible	Sl Polar	164	No data		Combustible	Md Toxic	Low potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
2-ETHYLHEXYL ACRYLATE	EAI	214	Sl Soluble	Nonpolar	180	No data		Combustible	Md Toxic	Moderate potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a violent rupture of the container. Low viscoscity - remove material with pumps or weir skimmers.
ETHYLHEXYL TALLATE	EHT	V. High	Immisible	No Data	395	No data		Noncombust.	No Data	Limited data on hazardous impacts. Low potential for hazardous impacts.
ETHYLIDENENORBORNENE	ENB	147.6	Immisible	Nonpolar	90	No data		Flammable	Md Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.
ETHYL MERCAPTAN	EMC	34.4	Immisible	Sl Polar	80	190.00	0	Hi Flammable	Hi Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
ETHYL METHACRYLATE	ETM	No data	Immisible	Nonpolar	68	No data		Flammable	Sl Toxic	Moderate potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a violent rupture of the container. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
ETHYL NITRITE	ETN	17	Immisible	Polar	-31	289.40	0	Hi Flammable	Md Toxic	Material can violently decompose due to heat or light. Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Forms explosive mixtures with air over a wide range. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers. Toxic ozides are produced during combustion.
2-ETHYL-3-PROPYLACROLEIN	EPA	175	Immisible	Nonpolar	155	No data		Combustible	Md Toxic	Low potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.
ETHYL TOLUENE	ETE	No data	Immisible	Nonpolar	110	3.00	0	Combustible	Hi Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.
GAS OIL: CRACKED	GOC	190-399	Immisible	Nonpolar	150	No data		Flammable	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide vapor

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
GAS OIL: CRACKED	GOC(continued)									suppression (based on testing). Low viscoscity - remove material with pumps or weir skimmers.
GASOLINE: AUTOMOTIVE (4.23G Pb/GAL)	GAT	60-199	Immisible	Nonpolar	-49	No data		Flammable	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide vapor suppression (based on testing). Low viscoscity - remove material with pumps or weir skimmers.
GASOLINE: AVIATION (4.86G Pb/GAL)	GAV	71-171	Immisible	Nonpolar	-50	No data		Flammable	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide vapor suppression (based on testing). Low viscoscity - remove material with pumps or weir skimmers.
GASOLINE BLENDING STOCKS: ALKYLATES	GAK	14-135	Immisible	Nonpolar	73	No data		Flammable	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide vapor suppression (based on testing). Low viscoscity - remove material with pumps or weir skimmers.
GASOLINE BLENDING STOCKS: REFORMATES	GRF	14-135	Immisible	Nonpolar	73	No data		Flammable	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide vapor suppression (based on testing). Low viscoscity - remove material with pumps or weir skimmers.
GASOLINE: CASINGHEAD	GCS	14-135	Immisible	Nonpolar	< 0	No data		Flammable	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide vapor suppression (based on testing). Low viscoscity - remove material with pumps or weir skimmers.
GASOLINE: POLYMER	GPL	14-135	Immisible	Nonpolar	73	No data		Flammable	Sl Toxic	Moderate potential for hazardous

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
GASOLINE: POLYMER	GPL(continued)									impacts. Any foam will provide vapor suppression (based on testing). Low viscoscity - remove material with pumps or weir skimmers.
GASOLINE: STRAIGHT RUN	GSR	14-135	Immisible	Nonpolar	73	No data		Flammable	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide vapor suppression (based on testing). Low viscoscity - remove material with pumps or weir skimmers.
HEPTANE	HPT	98.4	Immisible	Nonpolar	25	35.50	20	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Any foam will provide vapor suppression (based on testing). Low viscoscity - remove material with pumps or weir skimmers.
HEPTANOIC ACID	HEP	No data	Sl Soluble	Sl Polar	40	No data		Flammable	Sl Toxic	High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
HEPTANOL	HTN	176	Immisible	Polar	160	0.70	20	Combustible	Sl Toxic	Low potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
1-HEPTENE	HTE	93.6	Immisible	Nonpolar	32	44.19	20	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Any foam will provide some vapor

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	temp	Flammability	Toxicity	Response Information
1-HEPTENE	HTE(continued)									suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
n-HEXALDEHYDE	HAL	128	Immisible	Nonpolar	90	No data		Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
HEXAMETHYLENEIMINE	HMI	132	Immisible	Polar	75	No data		Flammable	Hi Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove. Toxic ozides are produced during combustion.
HEXANE	HXA	68.7	Immisible	Nonpolar	32	120.00	20	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
HEXANOL	HXN	157.1	Immisible	Polar	145	No data		Combustible	Sl Toxic	Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with

	CHRIS	Boiling			Flash	Vapor Pressure				
Chemical	Code	Point	Solubility	Polarity	Point	mmHg	temp	Flammability	Toxicity	Response Information
HEXANOL	HXN(continued)									pumps or weir skimmers.
1-HEXENE	HXE	63.5	Immisible	Nonpolar	20	150.00	20	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Low potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
HYDROGEN, LIQUIFIED	HXX	-253	Immisible	Nonpolar	No data	1500.00	-250	Hi Flammable	Sl Toxic	Liquefied gas - extremely volatile. High potential for hazardous impacts. Forms explosive mixtures with air over a wide range. Vapor suppression may not be possible. Removal probably not possible.
HYDROGEN SULFIDE	HDS	-60.4	Immisible	Sl Polar	-180	1487.90	-45	Hi Flammable	Hi Toxic	Compressed gas - highly volatile. Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Forms explosive mixtures with air over a wide range. Some vapor suppression may be accomplished by applying a high expansion, slow draining foam. Removal probably not possible. Spontaneous reaction, ignition, and/or explosion may occur if mixed with oxidizable, organic, or flammable materials.
ISOAMYL ACETATE	IAT	142	Immisible	Sl Polar	77	6.00	0	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	temp	Flammability	Toxicity	Response Information
ISOAMYL ACETATE	IAT(continued)									type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
ISOAMYL ALCOHOL	IAA	132	Immisible	Polar	67	4.00	0	Combustible	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
ISOBUTANE	IBT	-11.8	Immisible	Nonpolar	-117	1243.90	20	Hi Flammable	Sl Toxic	Liquefied gas - extremely volatile. High potential for hazardous impacts. Some vapor suppression may be accomplished by applying a high expansion, slow draining foam. Removal probably not possible.
ISOBUTYL ACETATE	IBA	117.3	Immisible	Sl Polar	64	20.00	20	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential fur hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
ISOBUTYLENE	IBL	-6.9	Immisible	Nonpolar	-105	987.90	0	Hi Flammable	Sl Toxic	Liquefied gas - extremely volatile. Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Some vapor suppression may be accomplished by applying a high expansion, slow draining foam. Removal probably not possible.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
ISOBUTYRONITRILE	IBN	104	Immisible	Polar	47	No data		Flammable	Hi Toxic	High potential for hazardous impacts. Flammability limits of vapor-air mixtures unknown. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers. Toxic ozides are produced during combustion.
ISODECALDEHYDE	IDA	V. High	Immisible	Nonpolar	185	No data		Combustible	Md Toxic	Low potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.
ISODECYL ACRYLATE	IAI	N/A	Immisible	Nonpolar	240	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a violent rupture of the container. Low viscoscity - remove material with pumps or weir skimmers.
ISODECYL ALCOHOL	ISA	220	Immisible	Sl Polar	170	No data		Combustible	Sl Toxic	Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
ISOHEXANE	IHA	60.3	Immisible	Nonpolar	-20	No data		Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
ISOOCTALDEHYDE	IOC	153-178	Immisible	Nonpolar	95	No data		Flammable	Sl Toxic	Moderate potential for hazardous

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
ISOOCTALDEHYDE	IOC(continued)									impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
ISOOCTANE	IOO	No data	Immisible	Nonpolar	40	No data		Flammable	Sl Toxic	High potential for hazardous impacts. Flammability limits of vapor-air mixtures unknown. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.
ISOOCTYL ALCOHOL	IOA	186	Immisible	Sl Polar	180	No data		Combustible	Md Toxic	Low potential for hazardous impacts. Flammability limits of vapor-air mixtures unknown. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
ISOPENTANE	IPT	27.9	Immisible	Nonpolar	-60	575.00	20	Hi Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
ISOPHORONE	IPH	215.3	Immisible	Polar	184	0.40	0	Combustible	Hi Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis).

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
ISOPHORONE	IPH(continued)									Low viscoscity - remove material with pumps or weir skimmers.
ISOPHORONE DIAMINE	IPI	No data	Immisible	Polar	180	No data		Combustible	Hi Toxic	Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove. Toxic ozides are produced during combustion.
ISOPHORONE DIISOCYANATE	IPD	No data	Immisible	Polar	163	No data		Combustible	Hi Toxic	High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
ISOPRENE	IPR	34.1	Immisible	Nonpolar	-65	198.90	20	Hi Flammable	Md Toxic	High potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a violent rupture of the container. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
ISOPROPYL ACETATE	IAC	88.5	Immisible	Sl Polar	40	47.00	20	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
ISOPROPYL CYLCOHEXANE	IPX	No data	Immisible	Nonpolar	96	No data		Flammable	Sl Toxic	Moderate potential for hazardous impacts. Flammability limits of vapor-air

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
ISOPROPYL CYLCOHEXANE	IPX(continued)									mixtures unknown. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.
ISOPROPYL ETHER	IPE	69	Immisible	Sl Polar	-18	150.00	0	Flammable	Md Toxic	High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
ISOVALERALDEHYDE	IVA	92.5	Immisible	Sl Polar	40	No data		Flammable	Md Toxic	High potential for hazardous impacts. Flammability limits of vapor-air mixtures unknown. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
JET FUEL: JP-1 (KEROSENE)	JPO	200-260	Immisible	Nonpolar	149	194.00	20	Combustible	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
JET FUEL: JP-3	JPT	30-260	Immisible	Nonpolar	110	76.98	20	Combustible	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
JET FUEL: JP-4	JPF	1/6-287	Immisible	Nonpolar	-10	No data		Flammable	Sl Toxic	High potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
JET FUEL: JP-5 (KEROSENE, HEAVY)	JPV	176-287	Immisible	Nonpolar	140	No data		Combustible	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
KEROSENE	KRS	200-260	Immisible	Nonpolar	100	30.00	0	Combustible	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Moderate potential for hazardous impacts. Any foam will provide vapor suppression (based on testing). Low viscoscity - remove material with pumps or weir skimmers.
LAUROYL PEROXIDE	LPO	Decomp	Immisible	Polar	N/A	No data		Combustible	Hi Toxic	High potential for hazardous impacts. Floating solid - contain and remove with a mechanical device. Spontaneous reaction, ignition, and/or explosion may occur if mixed with oxidizable, organic, or flammable materials.
LAURYL MERCAPTAN	LRM	V. High	Immisible	Nonpolar	262	No data		Noncombust.	Md Toxic	Low potential for hazardous impacts. Low viscoscity - remove material with pumps or weir skimmers.
LINEAR ALCOHOLS (12-15 CARBONS)	LAL	> 252	Immisible	Sl Polar	180	No data		Combustible	Sl Toxic	Low potential for hazardous impacts. Flammability limits of vapor-air mixtures unknown. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
LIQUIFIED PETROLEUM GAS	LPG	> -40	Immisible	Nonpolar	-200	1313.20	-30	Hi Flammable	Sl Toxic	Liquefied gas - extremely volatile. Vapor more dense than air creating an

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
LIQUIFIED PETROLEUM GAS	LPG(continued)									ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Vapor suppression may not be possible. Removal probably not possible.
MESITYL OXIDE	MSO	130	Immisible	Polar	87	10.00	0	Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Flammability limits of vapor-air mixtures unknown. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
METHALLYL CHLORIDE	MCL	72.2	Immisible	Polar	11	102.00	20	Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove. Toxic ozides are produced during combustion.
METHANE	MTH	-161.5	Immisible	Nonpolar	-306	1650.00	-150	Hi Flammable	Sl Toxic	Compressed gas - highly volatile. Vapor suppression may not be possible. Removal probably not possible.
METHYL ACETYLENE, PROPADIENE MIXTURE	MAP	-38	Immisible	Nonpolar	No data	3876.00	20	Hi Flammable	Sl Toxic	Compressed gas - highly volatile. Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Some vapor suppression may be accomplished by applying a high

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
METHYL ACETYLENE, PROPADIENE MIXTURE	MAP(continued)									expansion, slow draining foam. Removal probably not possible.
METHYLACRYLATE	MAM	80.6	Immisible	Nonpolar	27	65.00	0	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a violent rupture of the container. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
METHYL AMYL ACETATE	MAC	146.2	Immisible	Sl Polar	113	3.80	0	Combustible	Md Toxic	Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
METHYL AMYL ALCOHOL	MAA	131.8	Immisible	Polar	106	3.62	0	Combustible	Hi Toxic	Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
n-METHYLANILINE	MAN	195.9	Immisible	Sl Polar	185	0.30	20	Combustible	Hi Toxic	Low potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers. Toxic ozides are produced during combustion.

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Feedback Work Sheet

Name: ______________________ Date: ________________ Time: ______

Response Activity: ____

____

Personnel in Charge of the Response Activity: ________________________

____

Results of the Response Activity: _________________________________

____

____

____

____

Required Adjustments to the Response Activity: _____________________

____

____

____

____

Comments: ____

____

____

____

Implementation Work Sheet

Name: Date: Time:

Response Activity:

Equipment or Products Required for the Response Activity and the Source:

Equipment or Products	Source

Personnel in Charge of the Response Activity:

Number of Personnel Required:

Comments:

Decision Analysis Work Sheet (con'd.)

List the Selected Response Actions and the Tactics for Implementation:

	Response	Implementation Tactics
1.		
2.		
3.		
4.		

Decision Analysis Work Sheet

Name: ______________________ **Date:** ____________________ **Time:** ______

What are the hazards associated with the release?

____

____

Who is affected by the hazards? ____________________________________

____

____

List Response Alternatives:

	Response	Purpose	Limitation	Comments
1.				
2.				
3.				
4.				
5.				
6.				

Spill Characterization Work Sheet (con'd.)

State of the Spill

Description of the Source of the Spill, Including Size and Location of the Hole if Applicable: ______________________________

____

____

Description of the Spill Movement: ______________________________

____

____

____

Description of the Spill Site Activity: ______________________________

____

____

____

Comments: ______________________________________

____

____

____

Spill Characterization Work Sheet (con'd.)

Location

Description of the Spill Location: ______________________________

____

____

____

Use of the Location: ______________________________

____

Size and Location of Populated Areas: ______________________________

____

Description of Access Routes: ______________________________

____

____

Comments: ______________________________

____

____

Environmental Conditions

Temperature: Air ______ Water ______

Wind Speed and Direction: ______________________________

Current Velocity: ______________________________

Wave Height: ______________________________

Water Body Dimensions: ______________________________

Tidal Cycle:
Time of High Tide: ______________ Time of Low Tide: ______________
Velocity of Tide: ______________ Amplitude of Tide: ______________

Cloud Cover (Percentage): __________

Comments: ______________________________

____

____

APPENDIX C DECISION-MAKING WORK SHEETS

Spill Characterization Work Sheet

Name: ______________________________

Date: ____________________ **Time:** __________

General Location: ______________________________

Chemical Spilled: ______________________________

Time Discharge Began: ______________________________

Source of the Spill: ______________________________

Physical Properties

Flammability Information:

Flash Point ____ **Flammability Limits:** **LEL** ____ **UEL** ____

NFPA Flammability Rating ____

Flammability Rating: (check one)

Highly Flammable ____ **Flammable** ____

Combustible ____ **Noncombustible** ____

Toxicity Information:

STEL ____ IDLH ____ TLV ____

LD_{50} ____ **NFPA Health Rating** ____

Toxicity Rating: (check one)

Practically Nontoxic ____

Slightly Toxic ____

Moderately Toxic ____

Highly Toxic ____

Other Physical Properties:

Physical State (check one): Solid ____ Liquid ____ Gas ____

Boiling Point ______ Specific Gravity ______

Vapor Specific Gravity ______ Vapor Pressure ______ @ ______

Other ______________________________

____

Comments ______________________________

____

TABLE B-2. EVALUATION OF CHEMICAL REMOVAL TECHNIQUES (Con'd.)

TECHNIQUE	APPLICATION	METHOC OF REMOVAL	LIMITATIONS
Gels	Gelling agents can be matched with spilled chemicals to solidify the spill to immobilize it or facilitate in cleanup operations. Gelling of a spilled chemical can be carried out on land or water.	After the material has been solidified, the material can be removed with shovels or scoops.	Limited to small spills and chemicals for which suitable gelling agents have been produced.
Neutralization	Useful for neutralizing spills of acids or bases into water bodies.	No recovery is required since the result of applying a neutralizing agent is water and the precipitation of a salt.	Care must be taken to ensure that the pH of the water body is returned to the proper level.
Biodegradation	Bacteria cultures have been developed which can break down organic fuels.	No recovery is required.	Limited to small spills. Little information is available since this method is still in the developmental stages.

TABLE B-2. EVALUATION OF CHEMICAL REMOVAL TECHNIQUES

TECHNIQUE	APPLICATION	METHOD OF REMOVAL	LIMITATIONS
Sorbents - Activated Carbon Bouyant	Applicable for removal of dilute contamination from organics in water. Useful as a method of secondary recovery of lost materials in all types of water bodies.	A containment device; a boom or wire mesh is fixed downstream from deployment to catch the floating activated carbon. The saturated carbon is thus removed by a long-handled net which allows the water to drain.	Limited to small spills because a ratio of carbon to spilled chemical of 10:1 is required. Streams with bends and obstructions can prevent the activated carbon from reaching the recovery area. Water bodies with slow water currents will have lower removal efficiencies due to the reduced natural turnover of the activated carbon, limiting the contact between the sorbent and contaminated water.
- Polyurethane Foam	A variety of foams are available suitable for removal of floating chemicals or removal of contamination in water. It is a proven sorbent for benzene, chlorine, kerosene, naptha, solvent, hexane, n-Butyraldehyde, dimethyl sulfoxide, epichlorohyrin, and phenol.	Can be deployed much the same as activated carbon or a continuous loop belt can be pulled through the spill. Saturated polyurethane can be squeezed and reused.	Although polyurethane will be compatible with most floating CHRIS chemicals, a list of chemicals which deteriorate the material is not available.
- Polypropylene Fibers	Applications much the same as for polymethane. A proven sorbent for benzene, kerosene, naphtha solvent, aldrin, dimethylsulfoxide and epichlorohydrin.	Same as for polyurethane.	Polypropylene has lower resistance to solvent action than polyurethane. An extensive list of chemicals which are not compatible with polypropylene is not available.

TABLE B-1. EVALUATION OF SPILL REMOVAL EQUIPMENT (Con'd.)

EQUIPMENT	METHOD OF RECOVERY	DEPLOYMENT	LIMITATIONS
Belt Skimmers (con'd.): Polyurethane Belt	A continuous polyurethane belt is partially immersed into the water to remove the spilled material. Absorbed material is then squeezed from the belt.	Same as above	Deployment is limited for removal of floating chemicals on large water bodies with low water currents. Polyurethane belts are available in a range of pore sizes to match the viscosity of the material to be recovered. Not suitable for removal of solids.
Weir Skimmers	Spilled material is collected into a reservoir over an adjustable lip. The material is then pumped to a recovery area.	These units are usually small and are held in place by a long pole or allowed to float in the contained area.	Some construction materials of the skimmers may be subject to deterioration by solvents. The efficiency of recovery will be reduced in rough waters. Low recovery rates are likely for viscous materials. Can be used for recovery of liquids contained on land but become impractical as the contained pool diminishes in depth.
Water Separator Weir Skimmer	Spilled material is collected into the unit over an adjustable weir. A centrifuge then separates the spill material from the water.	These units are designed for deployment from ships or boats. The unit is equipped with a crane for lowering and recovering the apparatus.	Limited to application in large, relatively calm bodies of water. Materials with densities close to water may have limited use. Manufacturers should be consulted to determine the density limit.

APPENDIX B

TABLE B-1. EVALUATION OF SPILL REMOVAL EQUIPMENT

EQUIPMENT	METHOD OF RECOVERY	DEPLOYMENT	LIMITATIONS
Moving Plane Skimmers	A rotating disc or belt to which material adheres. Material is then scraped off the disc or belt and stored in a recovery area.	Some units require a crane for deployment. Other units are designed for fixed mountings onto docks or floating recovery platforms.	Deployment is limited for removal of floating chemicals on large water bodies with low water currents. Rough waters will reduce the recovery effifiency. This type of device is only applicable for liquids with viscosities greater than 8 cp. Construction materials made of polymer material which come in contact with spilled chemicals may be susceptible to deterioration.
Belt Skimmers: Polypropylene Belt	A continuous floating belt is pulled through the spill, absorbing material. The absorbed material is squeezed from the belt and stored in a recovery area.	The wringer device requires mounting on a platform or deck of a ship. A floating pulley is deployed to guide the belt through the floating spill.	Deployment is limited for removal of floating chemicals on large water bodies with low water currents. Lower recovery efficiency is expected for low viscosity materials. Polypropylene is resistant to damage from solvent materials, although reuse may not be possible. Not suitable for removal of solids.
Cellulose Belt	Same as above	Same as above	Deployment is limited for removal of floating chemicals on large water bodies with low water currents. The cellulose belt is impregnated with oil to resist water and attract hydrocarbons. Squeezing the belt to remove recovered material will remove the oil reducing efficiency. A low recovery rate is expected for low viscosity liquids. Not suitable for removal of solids.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
XYLENOL	XYL	212	Immisible	Sl Polar	170	No data		Noncombust.	Md Toxic	Low potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
VINYL TOLUENE	VNT(continued)									pumps or weir skimmers.
WAX: CARNAUBA	WCA	V. High	Immisible	Nonpolar	540	No data		Noncombust.	PN Toxic	No hazardous impacts. Floating solid - contain and remove with a mechanical device.
WAX: PARAFFIN	WPF	V. High	Immisible	Nonpolar	390	No data		Noncombust.	PN Toxic	No hazardous impacts. Floating solid - contain and remove with a mechanical device.
m-XYLENE	XLM	131.9	Immisible	Nonpolar	84	6.20	20	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
o-XYLENE	XLO	144.4	Immisible	Nonpolar	90	6.60	20	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
p-XYLENE	XLP	138.3	Immisible	Nonpolar	81	6.57	20	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
VINYL FLUORIDE	VFI(continued)									ignition hazard considerable distances from the spill site. High potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a violent rupture of the container. Vapor suppression may not be possible. Contain and remove. Removal probably not possible.
VINYL METHYL ETHER	VME	5.5	Immisible	Nonpolar	-80	1268.60	20	Hi Flammable	Md Toxic	Liquefied gas - extremely volatile. High potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a violent rupture of the container. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Removal probably not possible. Vapors can cause asphyxiation by displacement of air.
VINYL NEODECANATE	VND	No data	Sl Soluble	Nonpolar	No data	No data		No Data	Hi Toxic	Limited data on hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
VINYL TOLUENE	VNT	167.7	Immisible	Nonpolar	140	1.00	0	Combustible	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Moderate potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a violent rupture of the container. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
VINYL ACETATE	VAM(continued)									from the spill site. High potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a violent rupture of the container. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
VINYL CHLORIDE	VCM	13.8	Immisible	Polar	-108	643.20	-20	Hi Flammable	Hi Toxic	Liquefied gas - extremely volatile. Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Low potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a violent rupture of the container. Suppress vapors with the application of an alcohol type or polar solvent type foam (based on testing). Removal probably not possible. Vapors can cause asphyxiation by displacement of air.
VINYL ETHYL ETHER	VEE	35.6	Immisible	Nonpolar	50	441.90	20	Hi Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a violent rupture of the container. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
VINYL FLUORIDE	VFI	-72	Immisible	Polar	-180	2983.10	-40	Hi Flammable	Md Toxic	Compressed gas - highly volatile. Vapor more dense than air creating an

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
TRIETHYLBENZENE	TEB(continued)									Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
TRIMETHYLACETIC ACID	TAA	No data	Immisible	Sl Polar	-30	No data		Combustible	Md Toxic	No data
TURPENTINE	TPT	150-160	Immisible	Nonpolar	95	32.00	20	Flammable	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
UNDECANOL	UND	245	Immisible	Polar	235	0.04	20	Noncombust.	Sl Toxic	Can be a solid or a liquid solution. Low potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
1-UNDECENE	UDC	192.7	Immisible	Nonpolar	130	No data		Combustible	No Data	Low potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
n-UNDECYLBENZENE	UDB	316	Immisible	Nonpolar	265	No data		Noncombust.	No Data	Limited data on hazardous impacts. Low viscoscity - remove material with pumps or weir skimmers.
n-VALERALDEHYDE	VAL	103	Immisible	Sl Polar	54	30.00	20	Flammable	Md Toxic	High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
VINYL ACETATE	VAM	72.9	Immisible	Sl Polar	18	92.00	20	Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
TOLUENE	TOL(continued)									Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
o-TOLUIDINE	TLI	200	Immisible	Polar	185	1.00	0	Combustible	Hi Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers. Toxic ozides are produced during combustion.
TRIDECANOL	TDN	274	Immisible	Sl Polar	250	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.
1-TRIDECENE	TDC	233	Immisible	Nonpolar	170	No data		Combustible	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
TRIETHYLAMINE	TEN	89.5	Immisible	Nonpolar	19	45.00	0	Flammable	Hi Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (based on testing). Contain and remove. Toxic ozides are produced during combustion.
TRIETHYLBENZENE	TEB	216	Immisible	Nonpolar	181	0.00	20	Combustible	Md Toxic	Low potential for hazardous impacts.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
STYRENE	STY(continued)									violent rupture of the container. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers. Spontaneous reaction, ignition, and/or explosion may occur if mixed with oxidizable, organic, or flammable materials.
TALLOW	TLO	V. High	Immisible	Nonpolar	509	No data		Noncombust.	Sl Toxic	Freezing point at ambient temperatures Low potential for hazardous impacts. Contain and remove.
TALLOW FATTY ALCOHOL	TFA	>249	Immisible	Nonpolar	492	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Floating solid - contain and remove with a mechanical device.
TETRADECANOL	TTN	263.2	Immisible	Sl Polar	285	No data		Noncombust.	Sl Toxic	Spreads rapidly across a water surface contain as quickly as possible. Low potential for hazardous impacts. Floating solid - contain and remove with a mechanical device.
1-TETRADECENE	TTD	251.1	Immisible	Nonpolar	230	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Floating solid - contain and remove with a mechanical device.
TETRADECYLBENZENE	TDB	359	Immisible	Nonpolar	310	No data		Noncombust.	No Data	Limited data on hazardous impacts. Contain and remove.
TETRAHYDRONAPHTHALENE	THN	208	Immisible	Nonpolar	160	93.80	0	Combustible	Md Toxic	Moderate potential for hazardous impacts. Low viscoscity - remove material with pumps or weir skimmers.
TOLUENE	TOL	110.6	Immisible	Nonpolar	40	21.90	20	Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
POTASSIUM DICHLORO-S-TRIAZINETRIONE	PDT	No data	Sl Soluble	No Data	No data	No data				No data
n-PROPYL ACETATE	PAT	101.6	Sl Soluble	Sl Polar	58	25.00	0	Flammable	Md Toxic	High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
PROPYLENE BUTYLENE POLYMER	PBP	V. High	Immisible	Nonpolar	No data	No data		No Data	No Data	No data
PROPYLENE TETRAMER	PTT	No data	Immisible	Nonpolar	125	No data		Combustible	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
n-PROPYL MERCAPTAN	PMN	No data	Sl Soluble	Sl Polar	70	No data		Flammable	Md Toxic	Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
PYRETHRINS	PRR	137-200	Immisible	No Data	No data	No data		No Data	Md Toxic	Moderate potential for hazardous impacts. Contain and remove.
STEARIC ACID	SRA	Decomp	Immisible	Nonpolar	385	1.00	174	Noncombust.	Sl Toxic	Low potential for hazardous impacts. Floating solid - contain and remove with a mechanical device.
STYRENE	STY	145.2	Immisible	Nonpolar	90	5.00	0	Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Moderate potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
n-PENTANE	PTA(continued)									of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
1-PENTENE	PTE	29.9	Immisible	Nonpolar	0	550.00	20	Hi Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
PETROLATUM	PTL	V. High	Immisible	Nonpolar	360	No data		Noncombust.	PN Toxic	No hazardous impacts. Contain and remove.
PETROLEUM NAPHTHA	PTN	97.2	Immisible	Nonpolar	-50	No data		Hi Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
POLYBUTENE	PLB	V. High	Immisible	Nonpolar	215	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.
POLYETHYLENE POLYAMINES	PEB	No data	Sl Soluble	Sl Polar	No data	No data		No Data	Hi Toxic	Limited data on hazardous impacts. Contain and remove. Toxic ozides are produced during combustion.
POLYPROPYLENE	PLP	Decomp	Immisible	Nonpolar	No data	No data		No Data	No Data	No data
POLYPROPYLENE GLYCOL	PGC	Decomp	Immisible	Sl Polar	381	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
OIL, MISC: TANNER'S	OTN(continued)									pumps or weir skimmers.
OIL, MISC: TRANSFORMER	OTF	V. High	Immisible	Nonpolar	295	No data		Noncombust.	Md Toxic	Low potential for hazardous impacts. Contain and remove.
OIL, MISC: TURBINE	OTB	No data	Immisible	Nonpolar	400	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.
OLEIC ACID	OLA	222	Immisible	Nonpolar	372	1.00	177	Noncombust.	PN Toxic	No hazardous impacts. Contain and remove.
PENTADECANOL	PDC	300	Immisible	Sl Polar	250	No data		Noncombust.	No Data	Spreads rapidly across a water surface contain as quickly as possible. Limited data on hazardous impacts. Low viscoscity - remove material with pumps or weir skimmers.
1,3-PENTADIENE	PDI	No data	Immisible	Nonpolar	-20	335.00	0	Hi Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
1,4-PENTADIENE	PDN	No data	Immisible	Nonpolar	-180	600.00	0	Hi Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
n-PENTANE	PTA	36.1	Immisible	Nonpolar	-40	425.00	20	Hi Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
OIL, MISC: NEATSFOOT	ONF	V. High	Immisible	Nonpolar	470	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.
OIL, MISC: PENETRATING	OPT	V. High	Immisible	Nonpolar	295	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.
OIL, MISC: RANGE	ORG	200-260	Immisible	Nonpolar	100	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.
OIL, MISC: RESIN	ORS	300-400	Immisible	Nonpolar	255	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.
OIL, MISC: ROAD	ORD	V. High	Immisible	Nonpolar	225	No data		Noncombust.	Sl Toxic	May not float on fresh water or at low ambient temperatures. Low potential for hazardous impacts. Contain and remove.
OIL, MISC: ROSIN	ORN	300-400	Immisible	Nonpolar	266	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Low viscoscity - remove material with pumps or weir skimmers.
OIL, MISC: SPERM	OSP	V. High	Immisible	Nonpolar	428	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.
OIL, MISC: SPINDLE	OSD	V. High	Immisible	Nonpolar	169	No data		Combustible	Sl Toxic	Low potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.
OIL, MISC: SPRAY	OSY	310-371	Immisible	Nonpolar	140	No data		Combustible	Sl Toxic	Low potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
OIL, MISC: TALL	OTL	V. High	Immisible	Nonpolar	380	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.
OIL, MISC: TANNER'S	OTN	V. High	Immisible	Nonpolar	No data	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Low viscoscity - remove material with

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
OIL, FUEL: NO. 5	OFV(continued)									Contain and remove.
OIL, FUEL: NO. 6	OSX	212-588	Immisible	Nonpolar	150	No data		Combustible	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.
OIL, MISC: ABSORPTION	OAS	>260	Immisible	Nonpolar	255	No data		Noncombust.	Md Toxic	Low potential for hazardous impacts. Low viscoscity - remove material with pumps or weir skimmers.
OIL, MISC: CASHEW NUT SHELL (UNTREATED)	OCN	No data	Immisible	Nonpolar	No data	No data		No Data	Sl Toxic	Limited data on hazardous impacts. Contain and remove.
OIL, MISC: COAL TAR	OCT	106-167	Immisible	Nonpolar	60	No data		Flammable	Sl Toxic	High potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.
OIL, MISC: CROTON	OCR	V. High	Immisible	Nonpolar	No data	No data		No Data	Sl Toxic	Limited data on hazardous impacts. Contain and remove.
OIL, MISC: LINSEED	OLS	V. High	Immisible	Nonpolar	432	No data		Noncombust.	PN Toxic	No hazardous impacts. Contain and remove.
OIL, MISC: LUBRICATING	OLB	V. High	Immisible	Nonpolar	300	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.
OIL, MISC: MINERAL	OMN	V. High	Immisible	Nonpolar	380	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.
OIL, MISC: MINERAL SEAL	OMS	>260	Immisible	Nonpolar	275	No data		Combustible	Sl Toxic	Low potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
OIL, MISC: MOTOR	OMT	V. High	Immisible	Nonpolar	300	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
OIL, EDIBLE: VEGETABLE	OVG(continued)									Contain and remove.
OIL, FUEL: NO. 1 (KEROSENE)	OON	193-293	Immisible	Nonpolar	100	No data		Combustible	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide vapor suppression (based on testing). Low viscoscity - remove material with pumps or weir skimmers.
OIL, FUEL: NO. 1-D	OOD	193-293	Immisible	Nonpolar	100	No data		Combustible	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
OIL, FUEL: NO. 2	OTW	282-338	Immisible	Nonpolar	100	No data		Combustible	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
OIL, FUEL: NO. 2-D	OTD	282-338	Immisible	Nonpolar	126	No data		Combustible	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
OIL, FUEL: NO. 4	OFR	101-588	Immisible	Nonpolar	129	No data		Combustible	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.
OIL, FUEL: NO. 5	OFV	218-570	Immisible	Nonpolar	129	No data		Combustible	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis).

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
OIL: DIESEL	OOS	288-338	Immisible	Nonpolar	100	No data		Combustible	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.
OIL, EDIBLE: CASTOR	OCA	Varies	Immisible	Nonpolar	445	No data		Noncombust.	PN Toxic	No hazardous impacts. Contain and remove.
OIL, EDIBLE: COCONUT	OCC	V. High	Immisible	Nonpolar	420	No data		Noncombust.	PN Toxic	No hazardous impacts. Contain and remove.
OIL, EDIBLF: COTTONSEED	OCS	V. High	Immisible	Nonpolar	486	No data		Noncombust.	Sl Toxic	Low potential for hazardous impacts. Contain and remove.
OIL, EDIBLE: FISH	OFS	V. High	Immisible	Nonpolar	420	No data		Noncombust.	PN Toxic	No hazardous impacts. Contain and remove.
OIL, EDIBLE: LARD	OLD	No data	Immisible	Nonpolar	395	No data		Noncombust.	PN Toxic	No hazardous impacts. Contain and remove.
OIL, EDIBLE: OLIVE	OOL	No data	Immisible	Nonpolar	437	No data		Noncombust.	PN Toxic	No hazardous impacts. Contain and remove.
OIL, EDIBLE: PALM	OPM	V. High	Immisible	Nonpolar	421	No data		Noncombust.	PN Toxic	No hazardous impacts. Contain and remove.
OIL, EDIBLE: PEANUT	OPN	V. High	Immisible	Nonpolar	540	No data		Noncombust.	PN Toxic	No hazardous impacts. Contain and remove.
OIL, EDIBLE: SAFFLOWER	OSF	V. High	Immisible	Nonpolar	540	No data		Noncombust.	PN Toxic	No hazardous impacts. Contain and remove.
OIL, EDIBLE: SOYA BEAN	OSB	V. High	Immisible	Nonpolar	540	No data		Noncombust.	PN Toxic	No hazardous impacts. Contain and remove.
OIL, EDIBLE: TUCUM	OTC	V. High	Immisible	Nonpolar	398	No data		Noncombust.	PN Toxic	No hazardous impacts. Contain and remove.
OIL, EDIBLE: VEGETABLE	OVG	V. High	Immisible	Nonpolar	610	No data		Noncombust.	PN Toxic	No hazardous impacts.

	CHRIS	Boiling			Flash	Vapor Pressure				
Chemical	Code	Point	Solubility	Polarity	Point	mmHg	temp	Flammability	Toxicity	Response Information
NONYL PHENOL	NNP(continued)									of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
OCTANE	OAN	125.6	Immisible	Nonpolar	56	11.00	0	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Any foam will provide vapor suppression (based on testing). Low viscoscity - remove material with pumps or weir skimmers.
OCTANOL	OTA	195	Immisible	Polar	178	0.36	0	Combustible	Sl Toxic	Low potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
1-OCTENE	OTE	121.3	Immisible	Nonpolar	70	13.79	0	Flammable	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
OCTYL EPOXY TALLATE	OET	Decomp	Immisible	No Data	450	No data		Noncombust.	Sl Toxic	May not float on fresh water or at low ambient temperatures. Low potential for hazardous impacts. Contain and remove.
OIL: CLARIFIED	OCF	No data	Immisible	Nonpolar	No data	No data		No Data	Sl Toxic	No hazardous impacts. Contain and remove.
OIL: CRUDE	OIL	32->400	Immisible	Nonpolar	No data	No data		Flammable	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
2-NITROPROPANE	NPP(continued)									Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers. Toxic ozides are produced during combustion.
NONANE	NAN	151	Immisible	Nonpolar	88	3.22	0	Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
NONANOL	NNN	213	Immisible	Polar	165	0.30	20	Combustible	Sl Toxic	Low potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
NONENE	NON	135-140	Immisible	Nonpolar	78	No data		Flammable	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
1-NONENE	NNE	147	Immisible	Nonpolar	115	No data		Flammable	Sl Toxic	Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
NONYL PHENOL	NNP	304	Immisible	Sl Polar	285	No data		Noncombust.	Md Toxic	Low potential for hazardous impacts. Suppress vapors with the application

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
NAPTHA:VM & P (75% NAPTHA)	NVM	93-149	Immisible	Nonpolar	50	No data		Flammable	Sl Toxic	High potential for hazardous impacts. Any foam will provide vapor suppression (based on testing). Contain and remove.
NAPHTHENIC ACID	NTI	132-243	Immisible	Polar	300	No data		Noncombust.	Md Toxic	Low potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
NEOHEXANE	NHX	49.7	Immisible	Nonpolar	-54	262.40	20	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
NITROGEN, LIQUIFIED	NXX	-195.6	Immisible	Nonpolar	N/A	3401.00	-180	Noncombust.	No Data	Low potential for hazardous impacts. Vapor suppression may not be possible. Removal probably not possible. Vapors can cause asphyxiation by displacement of air.
1-NITROPROPANE	NPN	120.3	Sl Soluble	Polar	120	No data		Flammable	Md Toxic	May not float on fresh water or at low ambient temperatures. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers. Toxic ozides are produced during combustion.
2-NITROPROPANE	NPP	120.3	Immisible	Polar	103	15.60	20	Flammable	Md Toxic	May not float on fresh water or at low ambient temperatures. High potential for hazardous impacts.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure		Flammability	Toxicity	Response Information
						mmHg	temp			
2-METHYL PENTENE	MPN(continued)									Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
METHYL STYRENE, ALPHA	MSR	165	Immisible	Nonpolar	129	2.00	0	Combustible	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. Moderate potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
MINERAL SPIRITS	MNS	154-202	Immisible	Nonpolar	104	80.00	0	Combustible	Sl Toxic	Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
NAPTHA:COAL TAR	NCT	93-260	Immisible	Nonpolar	100	No data		Combustible	Md Toxic	Moderate potential for hazardous impacts. Any foam will provide vapor suppression (based on testing). Contain and remove.
NAPTHA:SOLVENT	NSV	130-155	Immisible	Nonpolar	138	No data		Combustible	Md Toxic	Moderate potential for hazardous impacts. Any foam will provide vapor suppression (based on testing). Contain and remove.
NAPTHA:STODDARD SOLVENT	NSS	160-199	Immisible	Nonpolar	100	8.00	0	Combustible	Md Toxic	Moderate potential for hazardous impacts. Any foam will provide vapor suppression (based on testing). Contain and remove.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
METHYL ISOBUTYL CARBINOL	MIC(continued)									of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
METHYL ISOBUTYL KETONE	MIK	116.2	Immisible	Polar	73	24.50	20	Flammable	Md Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
METHYL METHACRYLATE	MMM	101	Immisible	Nonpolar	50	31.20	20	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a violent rupture of the container. Any foam will provide some vapor suppression (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
METHYL NAPHTHALENE	MNA	No data	Immisible	Nonpolar	200	No data		Combustible	Md Toxic	May not float on fresh water or at low ambient temperatures. Moderate potential for hazardous impacts. May polymerize at elevated temperatures possibly causing a violent rupture of the container. Floating solid - contain and remove with a mechanical device.
2-METHYL PENTENE	MPN	62	Immisible	No Data	-15	128.46	38	Flammable	Sl Toxic	Vapor more dense than air creating an ignition hazard considerable distances from the spill site. High potential for hazardous impacts.

Chemical	CHRIS Code	Boiling Point	Solubility	Polarity	Flash Point	Vapor Pressure mmHg	Vapor Pressure temp	Flammability	Toxicity	Response Information
METHYL-t-BUTYL ETHER	MBE	No data	Immisible	Sl Polar	90	No data		Flammable	No Data	Limited data on hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove.
METHYL -n-BUTYL KETONE	MBK	127	Immisible	Polar	77	15.00	20	Flammable	Md Toxic	High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Low viscoscity - remove material with pumps or weir skimmers.
METHYLCYCLOPENTANE	MCP	No data	Immisible	Nonpolar	20	110.21	38	Flammable	Sl Toxic	High potential for hazardous impacts. Any foam will provide some vapor suppression (qualitative analysis). Contain and remove.
2-METHYL-6-ETHYL ANILINE	MEN	No data	Sl Soluble	Polar	45	No data		Flammable	Md Toxic	May not float on fresh water or at low ambient temperatures. High potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove. Toxic ozides are produced during combustion.
2-METHYL-5-ETHYLPRYIDINE	MEP	No data	Sl Soluble	Polar	165	No data		Combustible	Md Toxic	Moderate potential for hazardous impacts. Suppress vapors with the application of an alcohol type or polar solvent type foam (qualitative analysis). Contain and remove. Toxic ozides are produced during combustion.
METHYL ISOBUTYL CARBINOL	MIC	131.8	Immisible	No Data	106	5.00	20	Combustible	Md Toxic	Moderate potential for hazardous impacts. Suppress vapors with the application