F&E INDEX

~~CURRENT YEAR~~ (UNTIL SUPERSEDED)

DO A 044582
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OPT: WOE_____ BROWSE WORK REQUESTS/ORDERS BY PLANT 09/18/95
WOE

PLANT: POPG1 GLYCOL I W.O. STATUS: REQUEST_

WORK ORDER	REQUEST --DATE---	JOB DONE	REQUISITIONER NAME	SERVICE GROUP	P
_ 72412900	09/18/95	N	PREJEAN	GLYCOL #1	
PROBLEM DESCRIPTION: STEAM FLOW PRESSURES AND FLOWS					
_ 72411300	09/18/95	N	PREJEAN	GLYCOL #1	
PROBLEM DESCRIPTION: OIL SAMPLES , NEED CATCHING ON MRU-1,3,5					
_ 72411250	09/18/95	N	PREJEAN	GLYCOL #1	
PROBLEM DESCRIPTION: AR-593 R-102D MIXER PH PROBE ON BTM					
_ 72406600	09/18/95	N	PREJEAN	GLYCOL #1	
PROBLEM DESCRIPTION: AR-287A R2D MIXER PROBE ON BOTTOM					
_ 72406550	09/18/95	N	PREJEAN	GLYCOL #1	
PROBLEM DESCRIPTION: ARC-593A R-102D BTMS PH PROBE ON BOTTOM					
_ 72406500	09/18/95	N	PREJEAN	GLYCOL #1	
PROBLEM DESCRIPTION: FFRC-972 T-400 WATER FLOW METER WENT TO ZERO					
_ 72406300	09/18/95	N	ANDERSON	GLYCOL #1	1
PROBLEM DESCRIPTION: LRC-582>					

1:XFR 2:BBWD 3:BFWD 4:DEL 5:HOLD 8:SS LIST 9:OPEN WO
PF KEY: __ 10:HELP 11:M15 A1:LMNU ENTR:UPD/DETAIL

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0022 END OF DATA REACHED
 OPT: WOE_____        BROWSE WORK REQUESTS/ORDERS BY PLANT                09/18/95
                                                                               WOE
     PLANT: POPG1      GLYCOL I                         W.O. STATUS: REQUEST_

 WORK ORDER  REQUEST   JOB  REQUISITIONER NAME        SERVICE GROUP             P
 ----------  --DATE--- DONE ----------------------    ---------------------     -
_  72406300  09/18/95   N   ANDERSON                  GLYCOL #1                 1
  PROBLEM DESCRIPTION: LRC-582>
_  72406250  09/18/95   N   ANDERSON                  GLYCOL #1
  PROBLEM DESCRIPTION: LRC 22562 ,>
_  72385450  09/16/95   N   THERIOT                   GLYCOL #1
  PROBLEM DESCRIPTION: P-1261A SEAL LEAK
_  66513401  06/03/95   N   GLAVIANO JR                                         3
  PROBLEM DESCRIPTION: T/T OPEN PLAN
_
  PROBLEM DESCRIPTION:  _
_
  PROBLEM DESCRIPTION:  _
_
  PROBLEM DESCRIPTION:  _
                1:XFR 2:BBWD 3:BFWD 4:DEL 5:HOLD 8:SS LIST 9:OPEN WO
PF KEY: __      10:HELP 11:M15 A1:LMNU ENTR:UPD/DETAIL
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DO A 044584
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MANUFACTURING UNIT RISK ANALYSIS SUMMARY

DOW

AREA/COUNTRY	DIVISION	LOCATION
North America / USA	Louisiana Division	Plaquemine, La.
SITE	MANUFACTURING UNIT	TYPE OF OPERATION
Louisiana Division	Glycol 1	Propylene Oxide / Glycol
PREPARED BY	TOTAL MFG. UNIT REPLACEMENT VALUE	DATE
Leigh Hill	$111.6 MM	Dec. 12, 1996

Process Unit / Major Material	Material Factor	F&EI	Value of Area of Exposure $MM	Base MPPD (1) $MM	Actual MPPD (1) $MM	Days Outage MPDO (2)	BI (3) Loss $MM
70 PO Storage / Propylene Oxide	24	68	2.00	1.30	0.71	16	0.86
PO Reactor / Propylene	21	51	12	6.21	2.91	36	5.1
PO Distillation /T-102B / Propylene Oxide	24	105	15	11.45	6.16	57	7.96
PO Distillation /T-102C / Propylene Oxide	24	97	15	11.11	5.95	56	7.8
PO Distillation /T-300 / Propylene Oxide	24	117	22.40	17.84	8.27	68	9.48
PO Filter / Propylene Oxide	24	110	3.00	2.34	1.20	22	0.50
PDC Storage /DV-900 / Propylene Dichloride	16	98	2.00	1.18	0.71	16	0.37
TPG Hydrogenator / Tri-Propylene Glycol	21	55	12.50	6.86	4.20	45	6.95
PO Truck Loading / Propylene Oxide	24	140	2.00	1.67	0.98	19	0.89
PDC Distillation/T-1000 / Propylene Dichloride	16	48	1.00	0.39	0.23	8	0.19

(1) Base Maximum Probable Property Damage (2) Actual Maximum Probable Property Damage (3) Business Interruption

Process Unit / Major Material	Material Factor	F&EI	Value of Area of Exposure $MM	Base MPPD (1) $MM	Actual MPPD (1) $MM	Days Outage MPDO (2)	BI (3) Loss $MM
PDC Distillation / Propylene Dichloride	16	46	1.00	0.39	0.24	8	0.19
Thermal Oxidizer / Propylene Dichloride	16	115	11.00	7.03	3.53	41	11.44

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FIRE & EXPLOSION INDEX

DOW

AREA/COUNTRY	DIVISION	LOCATION	DATE
USA	LAD	PLAQUEMINE	11/12/96
SITE	**MANUFACTURING UNIT**	**PROCESS UNIT**	
LAD	GLYCOL-1	70 PO STORAGE	

PREPARED BY:	APPROVED BY: (Superintendent)	BUILDING
LEIGH HILL	CHARLES JACKSON	1501
REVIEWED BY: (Management)	**REVIEWED BY: (Technology Center)**	**REVIEWED BY: (Safety & Loss Prevention)**
LEIGH HILL	STEVE JANDA	BUCK BAILEY

MATERIALS IN PROCESS UNIT

PROPYLENE OXIDE

STATE OF OPERATION	BASIC MATERIAL(S) FOR MATERIAL FACTOR
__DESIGN __START UP _X_NORMAL OPERATION __SHUTDOWN	Propylene Oxide

MATERIAL FACTOR (See Table 1 or Appendices A or B) Note requirements when unit temperatures over 140 °F (60 °C)			24
1. General Process Hazards		**Penalty Factor Range**	**Penalty Factor Used (1)**
Base Factor		1.00	1.00
A. Exothermic Chemical Reactions		0.30 to 1.25	0.00
B. Endothermic Processes		0.20 to 0.40	0.00
C. Material Handling and Transfer		0.25 to 1.05	0.00
D. Enclosed or Indoor Process Units		0.25 to 0.90	0.00
E. Access		0.20 to 0.35	0.00
F. Drainage and Spill Control	0 gallons	0.25 to 0.50	0.00
General Process Hazards Factor (F1)			1.00
2. Special Process Hazards			
Base Factor		1.00	1.00
A. Toxic Material(s)		0.20 to 0.80	0.60
B. Sub-Atmospheric Pressure (< 500 mm Hg)		0.50	0.00
C. Operation In or Near Flammable Range	INERTED X NOT INERTED		
1. Tank Farms Storage Flammable Liquids		0.50	0.50
2. Process Upset or Purge Failure		0.30	0.00
3. Always in Flammable Range		0.80	0.00
D. Dust Explosion (See Table 3)		0.25 to 2.00	0.00
E. Pressure (See Figure 2)	Operating Pressure 5 psig Relief Setting 50 psig		0.12
F. Low Temperature		0.20 to 0.30	0.00
G. Quantity of Flammable/Unstable Material	Quantity 260,000 lb Hc = 13,200 BTU/lb		
1. Liquids or Gases in Process (See Figure 3)			0.00
2. Liquids or Gases in Storage (See Figure 4)			0.61
3. Combustible Solids in Storage, Dust in Process (See Figure 5)			0.00
H. Corrosion and Erosion		0.10 to 0.75	0.00
I. Leakage - Joints and Packing		0.10 to 1.50	0.00
J. Use of Fired Equipment (See Figure 6)			0.00
K. Hot Oil Heat Exchange System (See Table 5)		0.15 to 1.15	0.00
L. Rotating Equipment		0.50	0.00
Special Process Hazards Factor (F2)			2.83
Process Unit Hazards Factor (F1 x F2) = F3			2.83
Fire and Explosion Index (F3 x MF = F&EI)			68

(1) For no penalty use 0.00.

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LOSS CONTROL CREDIT FACTORS

1. **Process Control Credit Factor (C1)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Emergency Power	0.98	0.98	f. Inert Gas	0.94 to 0.96	0.96
b. Cooling	0.97 to 0.99	1.00	g. Operating Instructions/Procedures	0.91 to 0.99	0.95
c. Explosion Control	0.84 to 0.98	1.00	h. Reactive Chemical Review	0.91 to 0.98	0.91
d. Emergency Shutdown	0.96 to 0.99	0.98	i. Other Process Hazard Analysis	0.91 to 0.98	0.98
e. Computer Control	0.93 to 0.99	1.00			

C1 Value (3) 0.784

2. ***Material Isolation Credit Factor (C2)***

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Remote Control Valves	0.96 to 0.98	0.96	c. Drainage	0.91 to 0.97	0.95
b. Dump/Blowdown	0.96 to 0.98	1.00	d. Interlock	0.98	1.00

C2 Value (3) 0.912

3 **Fire Protection Credit Factor (C3)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Leak Detection	0.94 to 0.98	0.98	f. Water Curtains	0.97 to 0.98	0.97
b. Structural Steel	0.95 to 0.98	0.98	g. Foam	0.92 to 0.97	1.00
c. Fire Water Supply	0.94 to 0.97	0.97	h. Hand Extinguishers/Monitors	0.93 to 0.98	0.97
d. Special Systems	0.91	1.00	i. Cable Protection	0.94 to 0.98	1.00
e. Sprinkler Systems	0.74 to 0.97	0.87			

C3 Value (3) 0.763

Loss Control Credit Factor = C1 x C2 x C3 (3) = 0.545

PROCESS UNIT RISK ANALYSIS SUMMARY

1.	Fire and Explosion Index (F&EI) .... (See Front)	68		
2.	Radius of Exposure .... (Figure 7)	57 ft		
3.	Area of Exposure	10,193 sq.ft.		
4.	Value of Area of Exposure 1993 Dollars...		$MM	2.00
5.	Damage Factor .... (Figure 8)	0.65		
6.	Base Maximum Probable Property Damage - (Base MPPD) [4 x 5]		$MM	1.30
7.	Loss Control Credit Factor ....(See Above)	0.55		
8.	Actual Maximum Probable Property Damage - (Actual MPPD) [6 x 7]		$MM	0.71
9.	Maximum Probable Days Outage - (MPDO) (Figure 9)	16 days		
10.	Business Interruption - (BI)		$MM	0.85

(2) For no credit factor enter 1.00 (3) Product of all factors used

Refer to "Fire & Explosion Index Hazard Classification Guide" (Form #471-00001) for details

BACK OF FORM C-22380 Rev/01-94 (471-00036) - (FIE-7 System Ver-2..5 - 4/4/96

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FIRE & EXPLOSION INDEX

DOW

AREA/COUNTRY	DIVISION	LOCATION	DATE
USA	LA	PLAQUEMINE	11/12/96
SITE	MANUFACTURING UNIT	PROCESS UNIT	
LAD	GLYCOL-1	PO REACTOR	

PREPARED BY:	APPROVED BY: (Superintendent)	BUILDING
LEIGH HILL	CHARLES JACKSON	1501
REVIEWED BY: (Management)	REVIEWED BY: (Technology Center)	REVIEWED BY: (Safety & Loss Prevention)
LEIGH HILL	STEVE JANDA	BUCK BAILEY

MATERIALS IN PROCESS UNIT

PROPYLENE

STATE OF OPERATION	BASIC MATERIAL(S) FOR MATERIAL FACTOR
__DESIGN __START UP _X_NORMAL OPERATION __SHUTDOWN	Propylene

MATERIAL FACTOR (See Table 1 or Appendices A or B) Note requirements when unit temperatures over 140 °F (60 °C)		21
1. General Process Hazards	**Penalty Factor Range**	**Penalty Factor Used (1)**
Base Factor	1.00	1.00
A. Exothermic Chemical Reactions	0.30 to 1.25	0.30
B. Endothermic Processes	0.20 to 0.40	0.00
C. Material Handling and Transfer	0.25 to 1.05	0.00
D. Enclosed or Indoor Process Units	0.25 to 0.90	0.00
E. Access	0.20 to 0.35	0.00
F. Drainage and Spill Control 0 gallons	0.25 to 0.50	0.25
General Process Hazards Factor (F1)		**1.55**
2. Special Process Hazards		
Base Factor	1.00	1.00
A. Toxic Material(s)	0.20 to 0.80	0.20
B. Sub-Atmospheric Pressure (< 500 mm Hg)	0.50	0.00
C. Operation In or Near Flammable Range __ INERTED _X_ NOT INERTED		
1. Tank Farms Storage Flammable Liquids	0.50	0.00
2. Process Upset or Purge Failure	0.30	0.00
3. Always in Flammable Range	0.80	0.00
D. Dust Explosion (See Table 3)	0.25 to 2.00	0.00
E. Pressure (See Figure 2) Operating Pressure 6 psig; Relief Setting 10 psig		0.16
F. Low Temperature	0.20 to 0.30	0.00
G. Quantity of Flammable/Unstable Material Quantity 100 lb; Hc = 19,700 BTU/lb		
1. Liquids or Gases in Process (See Figure 3)		0.00
2. Liquids or Gases in Storage (See Figure 4)		0.00
3. Combustible Solids in Storage, Dust in Process (See Figure 5)		0.00
H. Corrosion and Erosion	0.10 to 0.75	0.10
I. Leakage - Joints and Packing	0.10 to 1.50	0.10
J. Use of Fired Equipment (See Figure 6)		0.00
K. Hot Oil Heat Exchange System (See Table 5)	0.15 to 1.15	0.00
L. Rotating Equipment	0.50	0.00
Special Process Hazards Factor (F2)		**1.56**
Process Unit Hazards Factor (F1 x F2) = F3		**2.42**
Fire and Explosion Index (F3 x MF = F&EI)		**51**

(1) For no penalty use 0.00.

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FORM C-22380 Rev/01-94 (471-00036) - (FE-7 System Ver-2.5 - 4/4/96)

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LOSS CONTROL CREDIT FACTORS

1. Process Control Credit Factor (C1)

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Emergency Power	0.98	0.98	f. Inert Gas	0.94 to 0.96	0.96
b. Cooling	0.97 to 0.99	1.00	g. Operating Instructions/Procedures	0.91 to 0.99	0.92
c. Explosion Control	0.84 to 0.98	1.00	h. Reactive Chemical Review	0.91 to 0.98	0.91
d. Emergency Shutdown	0.96 to 0.99	0.98	i. Other Process Hazard Analysis	0.91 to 0.98	0.98
e. Computer Control	0.93 to 0.99	0.93			

C1 Value (3) 0.703

2. Material Isolation Credit Factor (C2)

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Remote Control Valves	0.96 to 0.98	0.96	c. Drainage	0.91 to 0.97	0.91
b. Dump/Blowdown	0.96 to 0.98	1.00	d. Interlock	0.98	1.00

C2 Value (3) 0.874

3 Fire Protection Credit Factor (C3)

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Leak Detection	0.94 to 0.98	0.98	f. Water Curtains	0.97 to 0.98	1.00
b. Structural Steel	0.95 to 0.98	0.98	g. Foam	0.92 to 0.97	1.00
c. Fire Water Supply	0.94 to 0.97	0.94	h. Hand Extinguishers/Monitors	0.93 to 0.98	0.97
d. Special Systems	0.91	1.00	i. Cable Protection	0.94 to 0.98	1.00
e. Sprinkler Systems	0.74 to 0.97	0.87			

C3 Value (3) 0.762

Loss Control Credit Factor = C1 x C2 x C3 (3) = 0.468

PROCESS UNIT RISK ANALYSIS SUMMARY

1. Fire and Explosion Index (F&EI) .... (See Front)	51			
2. Radius of Exposure .... (Figure 7)	43	ft		
3. Area of Exposure	5,738	sq.ft.		
4. Value of Area of Exposure 1993 Dollars..			$MM	12.00
5. Damage Factor .... (Figure 8)	0.52			
6. Base Maximum Probable Property Damage - (Base MPPD) [4 x 5]			$MM	6.21
7. Loss Control Credit Factor ....(See Above)	0.47			
8. Actual Maximum Probable Property Damage - (Actual MPPD) [6 x 7]			$MM	2.91
9. Maximum Probable Days Outage - (MPDO) (Figure 9)	36	days		
10. Business Interruption - (BI)			$MM	5.10

(2) For no credit factor enter 1.00 (3) Product of all factors used

Refer to "Fire & Explosion Index Hazard Classification Guide" (Form #471-00001) for details

BACK OF FORM C-22380 Rev/01-94 (471-00036) - (FIE-7 System Ver-2..5 - 4/4/96

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FIRE & EXPLOSION INDEX

DOW

AREA/COUNTRY	DIVISION	LOCATION	DATE
USA	LA	PLAQUEMINE	11/12/96
SITE: LAD	MANUFACTURING UNIT: GLYCOL-1	PROCESS UNIT: T-102B	
PREPARED BY: LEIGH HILL	APPROVED BY: (Superintendent) CHARLES JACKSON	BUILDING: 1501	
REVIEWED BY: (Management) LEIGH HILL	REVIEWED BY: (Technology Center) STEVE JANDA	REVIEWED BY: (Safety & Loss Prevention) BUCK BAILEY	

MATERIALS IN PROCESS UNIT

PROPYLENE OXIDE

STATE OF OPERATION

__ DESIGN __ START UP _X_ NORMAL OPERATION __ SHUTDOWN

BASIC MATERIAL(S) FOR MATERIAL FACTOR

Propylene Oxide

		Penalty Factor Range	Penalty Factor Used (1)
MATERIAL FACTOR (See Table 1 or Appendices A or B) Note requirements when unit temperatures over 140 °F (60 °C)			24
1. General Process Hazards			
Base Factor		1.00	1.00
A. Exothermic Chemical Reactions		0.30 to 1.25	0.00
B. Endothermic Processes		0.20 to 0.40	0.00
C. Material Handling and Transfer		0.25 to 1.05	0.00
D. Enclosed or Indoor Process Units		0.25 to 0.90	0.00
E. Access		0.20 to 0.35	0.00
F. Drainage and Spill Control	0 gallons	0.25 to 0.50	0.25
General Process Hazards Factor (F1)			1.25
2. Special Process Hazards			
Base Factor		1.00	1.00
A. Toxic Material(s)		0.20 to 0.80	0.60
B. Sub-Atmospheric Pressure (< 500 mm Hg)		0.50	0.50
C. Operation In or Near Flammable Range			
1. Tank Farms Storage Flammable Liquids		0.50	0.00
2. Process Upset or Purge Failure		0.30	0.00
3. Always in Flammable Range		0.80	0.00
D. Dust Explosion (See Table 3)		0.25 to 2.00	0.00
E. Pressure (See Figure 2)	Operating Pressure 0 psig Relief Setting 0 psig		0.00
F. Low Temperature		0.20 to 0.30	0.00
G. Quantity of Flammable/Unstable Material	Quantity 50,000 lb Hc = 13,200 BTU/lb		
1. Liquids or Gases in Process (See Figure 3)			1.21
2. Liquids or Gases in Storage (See Figure 4)			0.00
3. Combustible Solids in Storage, Dust in Process (See Figure 5)			0.00
H. Corrosion and Erosion		0.10 to 0.75	0.10
I. Leakage - Joints and Packing		0.10 to 1.50	0.10
J. Use of Fired Equipment (See Figure 6)			0.00
K. Hot Oil Heat Exchange System (See Table 5)		0.15 to 1.15	0.00
L. Rotating Equipment		0.50	0.00
Special Process Hazards Factor (F2)			3.51
Process Unit Hazards Factor (F1 x F2) = F3			4.38
Fire and Explosion Index (F3 x MF = F&EI)			105

(1) For no penalty use 0.00.

FORM C-22380 Rev/01-94 (471-00036) - (FIE-7 System Ver-2.5 - 4/4/96)

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DO A 044590
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LOSS CONTROL CREDIT FACTORS

1. Process Control Credit Factor (C1)

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Emergency Power	0.98	0.98	f. Inert Gas	0.94 to 0.96	1.00
b. Cooling	0.97 to 0.99	1.00	g. Operating Instructions/Procedures	0.91 to 0.99	0.93
c. Explosion Control	0.84 to 0.98	1.00	h. Reactive Chemical Review	0.91 to 0.98	0.91
d. Emergency Shutdown	0.96 to 0.99	1.00	i. Other Process Hazard Analysis	0.91 to 0.98	0.98
e. Computer Control	0.93 to 0.99	0.99			

C1 Value (3) 0.808

2. Material Isolation Credit Factor (C2)

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Remote Control Valves	0.96 to 0.98	0.96	c. Drainage	0.91 to 0.97	0.91
b. Dump/Blowdown	0.96 to 0.98	1.00	d. Interlock	0.98	1.00

C2 Value (3) 0.874

3 Fire Protection Credit Factor (C3)

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Leak Detection	0.94 to 0.98	0.98	f. Water Curtains	0.97 to 0.98	1.00
b. Structural Steel	0.95 to 0.98	0.98	g. Foam	0.92 to 0.97	1.00
c. Fire Water Supply	0.94 to 0.97	0.94	h. Hand Extinguishers/Monitors	0.93 to 0.98	0.97
d. Special Systems	0.91	1.00	i. Cable Protection	0.94 to 0.98	1.00
e. Sprinkler Systems	0.74 to 0.97	0.87			

C3 Value (3) 0.762

Loss Control Credit Factor = C1 x C2 x C3 (3) = 0.537

PROCESS UNIT RISK ANALYSIS SUMMARY

1.	Fire and Explosion Index (F&EI) .... (See Front)	105		
2.	Radius of Exposure .... Figure 7	88 ft		
3.	Area of Exposure	24,498 sq.ft.		
4.	Value of Area of Exposure 1993 Dollars........................		$MM	15.00
5.	Damage Factor .... Figure 8	0.76		
6.	Base Maximum Probable Property Damage - (Base MPPD) [4 x 5]		$MM	11.45
7.	Loss Control Credit Factor ....(See Above)	0.54		
8.	Actual Maximum Probable Property Damage - (Actual MPPD) [6 x 7]		$MM	6.16
9.	Maximum Probable Days Outage - (MPDO) Figure 9	57 days		
10.	Business Interruption - (BI)		$MM	7.96

(2) For no credit factor enter 1.00 (3) Product of all factors used

Refer to "Fire & Explosion Index Hazard Classification Guide" (Form #471-00001) for details

BACK OF FORM C-22380 Rev/01-94 (471-00036) - (FIE-7 System Ver-2..5 - 4/4/96

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DO A 044591
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FIRE & EXPLOSION INDEX

DOW

AREA/COUNTRY	DIVISION	LOCATION	DATE
USA	LA	PLAQUEMINE	11/12/96
SITE	MANUFACTURING UNIT	PROCESS UNIT	
LADD	GLYCOL-1	T-102C	

PREPARED BY:	APPROVED BY: (Superintendent)	BUILDING
LEIGH HILL	CHARLES JACKSON	1501
REVIEWED BY: (Management)	REVIEWED BY: (Technology Center)	REVIEWED BY: (Safety & Loss Prevention)
LEIGH HILL	STEVE JANDA	BUCK BAILEY

MATERIALS IN PROCESS UNIT

PROPYLENE OXIDE

STATE OF OPERATION	BASIC MATERIAL(S) FOR MATERIAL FACTOR
__DESIGN __START UP _X_NORMAL OPERATION __SHUTDOWN	Propylene Oxide

MATERIAL FACTOR (See Table 1 or Appendices A or B) Note requirements when unit temperatures over 140 °F (60 °C)		24
1. General Process Hazards	**Penalty Factor Range**	**Penalty Factor Used (1)**
Base Factor	1.00	1.00
A. Exothermic Chemical Reactions	0.30 to 1.25	0.00
B. Endothermic Processes	0.20 to 0.40	0.00
C. Material Handling and Transfer	0.25 to 1.05	0.00
D. Enclosed or Indoor Process Units	0.25 to 0.90	0.00
E. Access	0.20 to 0.35	0.00
F. Drainage and Spill Control 0 gallons	0.25 to 0.50	0.25
General Process Hazards Factor (F1)		1.25
2. Special Process Hazards		
Base Factor	1.00	1.00
A. Toxic Material(s)	0.20 to 0.80	0.60
B. Sub-Atmospheric Pressure (< 500 mm Hg)	0.50	0.50
C. Operation in or Near Flammable Range		
1. Tank Farms Storage Flammable Liquids	0.50	0.00
2. Process Upset or Purge Failure	0.30	0.00
3. Always in Flammable Range	0.80	0.00
D. Dust Explosion (See Table 3)	0.25 to 2.00	0.00
E. Pressure (See Figure 2) Operating Pressure 0 psig Relief Setting 0 psig		0.00
F. Low Temperature	0.20 to 0.30	0.00
G. Quantity of Flammable/Unstable Material Quantity 34,200 lb Hc = 13,200 BTU/lb		
1. Liquids or Gases in Process (See Figure 3)		0.94
2. Liquids or Gases in Storage (See Figure 4)		0.00
3. Combustible Solids in Storage, Dust in Process (See Figure 5)		0.00
H. Corrosion and Erosion	0.10 to 0.75	0.10
I. Leakage - Joints and Packing	0.10 to 1.50	0.10
J. Use of Fired Equipment (See Figure 6)		0.00
K. Hot Oil Heat Exchange System (See Table 5)	0.15 to 1.15	0.00
L. Rotating Equipment	0.50	0.00
Special Process Hazards Factor (F2)		3.24
Process Unit Hazards Factor (F1 x F2) = F3		4.04
Fire and Explosion Index (F3 x MF = F&EI)		97

(1) For no penalty use 0.00.

DO A 044592
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FORM C-22380 Rev/01-94 (471-00036) - (FIE-7 System Ver-2.5 - 4/4/96)

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LOSS CONTROL CREDIT FACTORS

1. **Process Control Credit Factor (C1)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Emergency Power	0.98	0.98	f. Inert Gas	0.94 to 0.96	1.00
b. Cooling	0.97 to 0.99	1.00	g. Operating Instructions/Procedures	0.91 to 0.99	0.93
c. Explosion Control	0.84 to 0.88	1.00	h. Reactive Chemical Review	0.91 to 0.98	0.91
d. Emergency Shutdown	0.96 to 0.99	1.00	i. Other Process Hazard Analysis	0.91 to 0.98	0.98
e. Computer Control	0.93 to 0.99	0.99			

C1 Value (3) 0.805

2. **Material Isolation Credit Factor (C2)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Remote Control Valves	0.96 to 0.98	0.96	c. Drainage	0.91 to 0.97	0.91
b. Dump/Blowdown	0.96 to 0.98	1.00	d. Interlock	0.98	1.00

C2 Value (3) 0.874

3 **Fire Protection Credit Factor (C3)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Leak Detection	0.94 to 0.98	0.98	f. Water Curtains	0.97 to 0.98	1.00
b. Structural Steel	0.95 to 0.98	0.98	g. Foam	0.92 to 0.97	1.00
c. Fire Water Supply	0.94 to 0.97	0.94	h. Hand Extinguishers/Monitors	0.93 to 0.98	0.97
d. Special Systems	0.91	1.00	i. Cable Protection	0.94 to 0.98	1.00
e. Sprinkler Systems	0.74 to 0.97	0.87			

C3 Value (3) 0.762

Loss Control Credit Factor = C1 x C2 x C3 (3) = 0.536

PROCESS UNIT RISK ANALYSIS SUMMARY

1.	Fire and Explosion Index (F&EI) .... (See Front)	97		
2.	Radius of Exposure .... Figure 7)	82 ft		
3.	Area of Exposure	20,877 sq.ft.		
4.	Value of Area of Exposure 1993 Dollars....................		$MM	15.00
5.	Damage Factor .... Figure 8)	0.74		
6.	Base Maximum Probable Property Damage - (Base MPPD) [4 x 5]		$MM	11.11
7.	Loss Control Credit Factor ....(See Above)	0.54		
8.	Actual Maximum Probable Property Damage - (Actual MPPD) [6 x 7]		$MM	5.95
9.	Maximum Probable Days Outage - (MPDO) Figure 9)	56 days		
10.	Business Interruption - (BI)		$MM	7.80

(2) For no credit factor enter 1.00 (3) Product of all factors used

Refer to "Fire & Explosion Index Hazard Classification Guide" (Form #471-00001) for details

BACK OF FORM C-22380 Rev/01-94 (471-00036) - (FIE-7 System Ver-2..5 - 4/4/96

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DO A 044593
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FIRE & EXPLOSION INDEX

DOW

AREA/COUNTRY	DIVISION	LOCATION	DATE
USA	LA	PLAQUEMINE	11/13/96
SITE	MANUFACTURING UNIT	PROCESS UNIT	
LAD	GLYCOL-1	T-300	
PREPARED BY:	APPROVED BY: (Superintendent)	BUILDING	
LEIGH HILL	CHARLES JACKSON	1501	
REVIEWED BY: (Management)	REVIEWED BY: (Technology Center)	REVIEWED BY: (Safety & Loss Prevention)	
LEIGH HILL	STEVE JANDA	BUCK BAILEY	

MATERIALS IN PROCESS UNIT

PROPYLENE OXIDE

STATE OF OPERATION	BASIC MATERIAL(S) FOR MATERIAL FACTOR
__DESIGN __START UP _X_NORMAL OPERATION __SHUTDOWN	Propylene Oxide

MATERIAL FACTOR (See Table 1 or Appendices A or B) Note requirements when unit temperatures over 140 °F (60 °C)			24
1. General Process Hazards		Penalty Factor Range	Penalty Factor Used (1)
Base Factor		1.00	1.00
A. Exothermic Chemical Reactions		0.30 to 1.25	0.00
B. Endothermic Processes		0.20 to 0.40	0.00
C. Material Handling and Transfer		0.25 to 1.05	0.00
D. Enclosed or Indoor Process Units		0.25 to 0.90	0.00
E. Access		0.20 to 0.35	0.00
F. Drainage and Spill Control	0 gallons	0.25 to 0.50	0.25
General Process Hazards Factor (F1)			1.25
2. Special Process Hazards			
Base Factor		1.00	1.00
A. Toxic Material(s)		0.20 to 0.80	0.60
B. Sub-Atmospheric Pressure (< 500 mm Hg)		0.50	0.50
C. Operation In or Near Flammable Range			
1. Tank Farms Storage Flammable Liquids		0.50	0.00
2. Process Upset or Purge Failure		0.30	0.00
3. Always in Flammable Range		0.80	0.00
D. Dust Explosion (See Table 3)		0.25 to 2.00	0.00
E. Pressure (See Figure 2)	Operating Pressure 0 psig Relief Setting 0 psig		0.00
F. Low Temperature		0.20 to 0.30	0.00
G. Quantity of Flammable/Unstable Material	Quantity 90,000 lb Hc = 13,200 BTU/lb		
1. Liquids or Gases in Process (See Figure 3)			1.59
2. Liquids or Gases in Storage (See Figure 4)			0.00
3. Combustible Solids in Storage, Dust in Process (See Figure 5)			0.00
H. Corrosion and Erosion		0.10 to 0.75	0.10
I. Leakage - Joints and Packing		0.10 to 1.50	0.10
J. Use of Fired Equipment (See Figure 6)			0.00
K. Hot Oil Heat Exchange System (See Table 5)		0.15 to 1.15	0.00
L. Rotating Equipment		0.50	0.00
Special Process Hazards Factor (F2)			3.89
Process Unit Hazards Factor (F1 x F2) = F3			4.86
Fire and Explosion Index (F3 x MF = F&EI)			117

(1) For no penalty use 0.00.

DO A 044594
CONFIDENTIAL

FORM C-22380 Rev/01-94 (471-00036) - (FIE-7 System Ver-2.5 - 4/4/96)
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LOSS CONTROL CREDIT FACTORS

1. **Process Control Credit Factor (C1)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Emergency Power	0.98	0.98	f. Inert Gas	0.94 to 0.96	1.00
b. Cooling	0.97 to 0.99	1.00	g. Operating Instructions/Procedures	0.91 to 0.99	0.92
c. Explosion Control	0.84 to 0.88	1.00	h. Reactive Chemical Review	0.91 to 0.98	0.91
d. Emergency Shutdown	0.96 to 0.99	1.00	i. Other Process Hazard Analysis	0.91 to 0.98	0.98
e. Computer Control	0.93 to 0.99	0.93			

C1 Value (3) **0.748**

2. **Material Isolation Credit Factor (C2)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Remote Control Valves	0.96 to 0.98	0.98	c. Drainage	0.91 to 0.97	0.91
b. Dump/Blowdown	0.96 to 0.98	1.00	d. Interlock	0.98	1.00

C2 Value (3) **0.892**

3 **Fire Protection Credit Factor (C3)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Leak Detection	0.94 to 0.98	0.98	f. Water Curtains	0.97 to 0.98	0.98
b. Structural Steel	0.95 to 0.98	0.98	g. Foam	0.92 to 0.97	1.00
c. Fire Water Supply	0.94 to 0.97	0.94	h. Hand Extinguishers/Monitors	0.93 to 0.98	0.97
d. Special Systems	0.91	1.00	i. Cable Protection	0.94 to 0.98	1.00
e. Sprinkler Systems	0.74 to 0.97	0.81			

C3 Value (3) **0.695**

Loss Control Credit Factor = C1 x C2 x C3 (3) = **0.464**

PROCESS UNIT RISK ANALYSIS SUMMARY

1.	Fire and Explosion Index (F&EI) .... (See Front)	117			
2.	Radius of Exposure .... Figure 7)	98	ft		
3.	Area of Exposure	30,205	sq.ft.		
4.	Value of Area of Exposure 1993 Dollars....................................			$MM	22.40
5.	Damage Factor .... Figure 8)	0.80			
6.	Base Maximum Probable Property Damage - (Base MPPD) (4 x 5)			$MM	17.84
7.	Loss Control Credit Factor ....(See Above)	0.46			
8.	Actual Maximum Probable Property Damage - (Actual MPPD) (6 x 7)			$MM	8.27
9.	Maximum Probable Days Outage - (MPDO) Figure 9)	68	days		
10.	Business Interruption - (BI)			$MM	9.48

(2) For no credit factor enter 1.00 (3) Product of all factors used

DO A 044595
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Refer to "Fire & Explosion Index Hazard Classification Guide" (Form #471-00001) for details

BACK OF FORM C-22380 Rev/01-94 (471-00036) - (FIE-7 System Ver-2..5 - 4/4/96

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FIRE & EXPLOSION INDEX

DOW

AREA/COUNTRY	DIVISION	LOCATION	DATE
USA	LA	PLAQUEMINE	11/13/96
SITE	MANUFACTURING UNIT	PROCESS UNIT	
LAD	GLYCOL-1	AD-6201A	

PREPARED BY:	APPROVED BY: (Superintendent)	BUILDING
LEIGH HILL	CHARLES JACKSON	1501
REVIEWED BY: (Management)	REVIEWED BY: (Technology Center)	REVIEWED BY: (Safety & Loss Prevention)
LEIGH HILL	STEVE JANDA	BUCK BAILEY

MATERIALS IN PROCESS UNIT

PROPYLENE OXIDE

STATE OF OPERATION	BASIC MATERIAL(S) FOR MATERIAL FACTOR
__DESIGN __START UP _X_NORMAL OPERATION __SHUTDOWN	Propylene Oxide

MATERIAL FACTOR (See Table 1 or Appendices A or B) Note requirements when unit temperatures over 140 °F (60 °C)		24
1. General Process Hazards	**Penalty Factor Range**	**Penalty Factor Used (1)**
Base Factor	1.00	1.00
A. Exothermic Chemical Reactions	0.30 to 1.25	0.00
B. Endothermic Processes	0.20 to 0.40	0.00
C. Material Handling and Transfer	0.25 to 1.05	0.00
D. Enclosed or Indoor Process Units	0.25 to 0.90	0.00
E. Access	0.20 to 0.35	0.00
F. Drainage and Spill Control 0 gallons	0.25 to 0.50	0.25
General Process Hazards Factor (F1)		1.25
2. Special Process Hazards		
Base Factor	1.00	1.00
A. Toxic Material(s)	0.20 to 0.80	0.60
B. Sub-Atmospheric Pressure (< 500 mm Hg)	0.50	0.00
C. Operation In or Near Flammable Range _X_ INERTED ___ NOT INERTED		
1. Tank Farms Storage Flammable Liquids	0.50	0.00
2. Process Upset or Purge Failure	0.30	0.30
3. Always in Flammable Range	0.80	0.00
D. Dust Explosion (See Table 3)	0.25 to 2.00	0.00
E. Pressure (See Figure 2) Operating Pressure 80 psig Relief Setting 150 psig		0.26
F. Low Temperature	0.20 to 0.30	0.00
G. Quantity of Flammable/Unstable Material Quantity 80,700 lb Hc = 13,200 BTU/lb		
1. Liquids or Gases in Process (See Figure 3)		1.53
2. Liquids or Gases in Storage (See Figure 4)		0.00
3. Combustible Solids in Storage, Dust in Process (See Figure 5)		0.00
H. Corrosion and Erosion	0.10 to 0.75	0.00
I. Leakage - Joints and Packing	0.10 to 1.50	0.00
J. Use of Fired Equipment (See Figure 6)		0.00
K. Hot Oil Heat Exchange System (See Table 5)	0.15 to 1.15	0.00
L. Rotating Equipment	0.50	0.00
Special Process Hazards Factor (F2)		3.68
Process Unit Hazards Factor (F1 x F2) = F3		4.60
Fire and Explosion Index (F3 x MF = F&EI)		110

(1) For no penalty use 0.00.

DO A 044596
CONFIDENTIAL

FORM C-22380 Rev/01-94 (471-00036) - (FIE-7 System Ver-2.5 - 4/4/96)

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LOSS CONTROL CREDIT FACTORS

1. Process Control Credit Factor (C1)

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Emergency Power	0.98	0.98	f. Inert Gas	0.94 to 0.96	1.00
b. Cooling	0.97 to 0.99	1.00	g. Operating Instructions/Procedures	0.91 to 0.99	0.93
c. Explosion Control	0.84 to 0.88	1.00	h. Reactive Chemical Review	0.91 to 0.98	0.91
d. Emergency Shutdown	0.96 to 0.99	0.98	i. Other Process Hazard Analysis	0.91 to 0.98	0.98
e. Computer Control	0.93 to 0.99	0.93			

C1 Value (3) 0.743

2. Material Isolation Credit Factor (C2)

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Remote Control Valves	0.96 to 0.98	0.96	c. Drainage	0.91 to 0.97	0.91
b. Dump/Blowdown	0.96 to 0.98	1.00	d. Interlock	0.98	1.00

C2 Value (3) 0.874

3 Fire Protection Credit Factor (C3)

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Leak Detection	0.94 to 0.98	0.98	f. Water Curtains	0.97 to 0.98	1.00
b. Structural Steel	0.95 to 0.98	1.00	g. Foam	0.92 to 0.97	1.00
c. Fire Water Supply	0.94 to 0.97	0.97	h. Hand Extinguishers/Monitors	0.93 to 0.98	0.97
d. Special Systems	0.91	1.00	i. Cable Protection	0.94 to 0.98	1.00
e. Sprinkler Systems	0.74 to 0.97	0.86			

C3 Value (3) 0.792

Loss Control Credit Factor = C1 x C2 x C3 (3) = 0.514

PROCESS UNIT RISK ANALYSIS SUMMARY

1.	Fire and Explosion Index (F&EI) .... (See Front)	110		
2.	Radius of Exposure .... (Figure 7)	93 ft		
3.	Area of Exposure	27,049 sq.ft.		
4.	Value of Area of Exposure 1993 Dollars..		$MM	3.00
5.	Damage Factor .... (Figure 8)	0.78		
6.	Base Maximum Probable Property Damage - (Base MPPD) [4 x 5]		$MM	2.34
7.	Loss Control Credit Factor ....(See Above)	0.51		
8.	Actual Maximum Probable Property Damage - (Actual MPPD) [6 x 7]		$MM	1.20
9.	Maximum Probable Days Outage - (MPDO) (Figure 9)	22 days		
10.	Business Interruption - (BI)		$MM	0.50

DO A 044597
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(2) For no credit factor enter 1.00 (3) Product of all factors used

Refer to "Fire & Explosion Index Hazard Classification Guide" (Form #471-00001) for details

BACK OF FORM C-22380 Rev/01-94 (471-00036) - [FIE-7 System Ver-2..5 - 4/4/96

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FIRE & EXPLOSION INDEX

DOW

AREA/COUNTRY	DIVISION	LOCATION	DATE
USA	LA	PLAQUEMINE	11/13/96
SITE	MANUFACTURING UNIT	PROCESS UNIT	
LA	GLYCOL-1	DV-900	

PREPARED BY:	APPROVED BY: (Superintendent)	BUILDING
LEIGH HILL	CHARLES JACKSON	1501
REVIEWED BY: (Management)	REVIEWED BY: (Technology Center)	REVIEWED BY: (Safety & Loss Prevention)
LEIGH HILL	STEVE JANDA	BUCK BAILEY

MATERIALS IN PROCESS UNIT

PDC

STATE OF OPERATION	BASIC MATERIAL(S) FOR MATERIAL FACTOR
__DESIGN __START UP _X_NORMAL OPERATION __SHUTDOWN	Propylene Dichloride

MATERIAL FACTOR (See Table 1 or Appendices A or B) Note requirements when unit temperatures over 140 °F (60 °C)		16
1. General Process Hazards	**Penalty Factor Range**	**Penalty Factor Used (1)**
Base Factor	1.00	1.00
A. Exothermic Chemical Reactions	0.30 to 1.25	0.00
B. Endothermic Processes	0.20 to 0.40	0.00
C. Material Handling and Transfer	0.25 to 1.05	0.00
D. Enclosed or Indoor Process Units	0.25 to 0.90	0.00
E. Access	0.20 to 0.35	0.35
F. Drainage and Spill Control — 0 gallons	0.25 to 0.50	0.50
General Process Hazards Factor (F1)		**1.85**
2. Special Process Hazards		
Base Factor	1.00	1.00
A. Toxic Material(s)	0.20 to 0.80	0.40
B. Sub-Atmospheric Pressure (< 500 mm Hg)	0.50	0.00
C. Operation In or Near Flammable Range — X INERTED __ NOT INERTED		
1. Tank Farms Storage Flammable Liquids	0.50	0.00
2. Process Upset or Purge Failure	0.30	0.00
3. Always in Flammable Range	0.80	0.80
D. Dust Explosion (See Table 3)	0.25 to 2.00	0.00
E. Pressure (See Figure 2) — Operating Pressure 0 psig; Relief Setting 2 psig		0.16
F. Low Temperature	0.20 to 0.30	0.00
G. Quantity of Flammable/Unstable Material — Quantity 1,200,000 lb; Hc = 6,300 BTU/lb		
1. Liquids or Gases in Process (See Figure 3)		0.00
2. Liquids or Gases in Storage (See Figure 4)		0.77
3. Combustible Solids in Storage, Dust in Process (See Figure 5)		0.00
H. Corrosion and Erosion	0.10 to 0.75	0.10
I. Leakage - Joints and Packing	0.10 to 1.50	0.10
J. Use of Fired Equipment (See Figure 6)		0.00
K. Hot Oil Heat Exchange System (See Table 5)	0.15 to 1.15	0.00
L. Rotating Equipment	0.50	0.00
Special Process Hazards Factor (F2)		**3.32**
Process Unit Hazards Factor (F1 x F2) = F3		**6.15**
Fire and Explosion Index (F3 x MF = F&EI)		**98**

(1) For no penalty use 0.00.

DO A 044598
CONFIDENTIAL

LOSS CONTROL CREDIT FACTORS

1. **Process Control Credit Factor (C1)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Emergency Power	0.98	0.98	f. Inert Gas	0.94 to 0.96	0.96
b. Cooling	0.97 to 0.99	1.00	g. Operating Instructions/Procedures	0.91 to 0.99	0.94
c. Explosion Control	0.84 to 0.88	1.00	h. Reactive Chemical Review	0.91 to 0.98	0.91
d. Emergency Shutdown	0.96 to 0.99	1.00	i. Other Process Hazard Analysis	0.91 to 0.98	0.98
e. Computer Control	0.93 to 0.99	0.99			

C1 Value (3) 0.778

2. **Material Isolation Credit Factor (C2)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Remote Control Valves	0.96 to 0.98	1.00	c. Drainage	0.91 to 0.97	0.97
b. Dump/Blowdown	0.96 to 0.98	1.00	d. Interlock	0.98	1.00

C2 Value (3) 0.970

3 ***Fire Protection Credit Factor (C3)***

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Leak Detection	0.94 to 0.98	0.98	f. Water Curtains	0.97 to 0.98	1.00
b. Structural Steel	0.95 to 0.98	1.00	g. Foam	0.92 to 0.97	1.00
c. Fire Water Supply	0.94 to 0.97	0.97	h. Hand Extinguishers/Monitors	0.93 to 0.98	0.97
d. Special Systems	0.91	1.00	i. Cable Protection	0.94 to 0.98	1.00
e. Sprinkler Systems	0.74 to 0.97	0.86			

C3 Value (3) 0.792

Loss Control Credit Factor = C1 x C2 x C3 (3) = 0.597

PROCESS UNIT RISK ANALYSIS SUMMARY

1. Fire and Explosion Index (F&EI) .... (See Front)	98		
2. Radius of Exposure .... (Figure 7)	83 ft		
3. Area of Exposure	21,422 sq.ft.		
4. Value of Area of Exposure 1993 Dollars................................		$MM	2.00
5. Damage Factor .... (Figure 8)	0.59		
6. Base Maximum Probable Property Damage - (Base MPPD) (4 x 5)		$MM	1.18
7. Loss Control Credit Factor ....(See Above)	0.60		
8. Actual Maximum Probable Property Damage - (Actual MPPD) (6 x 7)		$MM	0.71
9. Maximum Probable Days Outage - (MPDO) (Figure 9)	16 days		
10. Business Interruption - (BI)		$MM	0.37

DO A 044595
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(2) For no credit factor enter 1.00 (3) Product of all factors used

Refer to "Fire & Explosion Index Hazard Classification Guide" (Form #471-00001) for details

BACK OF FORM C-22380 Rev/01-94 (471-00036) - (FIE-7 System Ver-2..5 - 4/4/96

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FIRE & EXPLOSION INDEX

DOW

AREA/COUNTRY	DIVISION	LOCATION	DATE
USA	LA	PLAQUEMINE	11/12/96

SITE	MANUFACTURING UNIT	PROCESS UNIT
LAD	GLYCOL-1	TPG HYDROGENATOR

PREPARED BY:	APPROVED BY: (Superintendent)	BUILDING
LEIGH HILL	CHARLES JACKSON	1501
REVIEWED BY: (Management)	REVIEWED BY: (Technology Center)	REVIEWED BY: (Safety & Loss Prevention)
LEIGH HILL	STEVE JANDA	BUCK BAILEY

MATERIALS IN PROCESS UNIT

PROPYLENE GLYCOL / HYDROGEN

STATE OF OPERATION	BASIC MATERIAL(S) FOR MATERIAL FACTOR
__DESIGN __START UP __NORMAL OPERATION _X_SHUTDOWN	Hydrogen

MATERIAL FACTOR (See Table 1 or Appendices A or B) Note requirements when unit temperatures over 140 °F (60 °C)			21
1. General Process Hazards		Penalty Factor Range	Penalty Factor Used (1)
Base Factor		1.00	1.00
A. Exothermic Chemical Reactions		0.30 to 1.25	0.30
B. Endothermic Processes		0.20 to 0.40	0.00
C. Material Handling and Transfer		0.25 to 1.05	0.00
D. Enclosed or Indoor Process Units		0.25 to 0.90	0.00
E. Access		0.20 to 0.35	0.00
F. Drainage and Spill Control	0 gallons	0.25 to 0.50	0.25
General Process Hazards Factor (F1)			**1.55**
2. Special Process Hazards			
Base Factor		1.00	1.00
A. Toxic Material(s)		0.20 to 0.80	0.00
B. Sub-Atmospheric Pressure (< 500 mm Hg)		0.50	0.00
C. Operation In or Near Flammable Range	___ INERTED _X_ NOT INERTED		
1. Tank Farms Storage Flammable Liquids		0.50	0.00
2. Process Upset or Purge Failure		0.30	0.30
3. Always in Flammable Range		0.80	0.00
D. Dust Explosion (See Table 3)		0.25 to 2.00	0.00
E. Pressure (See Figure 2)	perating Pressure 100 psig Relief Setting 175 psig		0.28
F. Low Temperature		0.20 to 0.30	0.00
G. Quantity of Flammable/Unstable Material	Quantity 10 lb Hc = 51,600 BTU/lb		
1. Liquids or Gases in Process (See Figure 3)			0.00
2. Liquids or Gases in Storage (See Figure 4)			0.00
3. Combustible Solids in Storage, Dust in Process (See Figure 5)			0.00
H. Corrosion and Erosion		0.10 to 0.75	0.00
I. Leakage - Joints and Packing		0.10 to 1.50	0.10
J. Use of Fired Equipment (See Figure 6)			0.00
K. Hot Oil Heat Exchange System (See Table 5)		0.15 to 1.15	0.00
L. Rotating Equipment		0.50	0.00
Special Process Hazards Factor (F2)			**1.68**
Process Unit Hazards Factor (F1 x F2) = F3			**2.61**
Fire and Explosion Index (F3 x MF = F&EI)			**55**

(1) For no penalty use 0.00.

DO A 044600
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FORM C-22380 Rev/01-94 (471-00036) - [FIE-7 System Ver-2.5 - 4/4/96]

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LOSS CONTROL CREDIT FACTORS

1. **Process Control Credit Factor (C1)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Emergency Power	0.98	0.98	f. Inert Gas	0.94 to 0.96	1.00
b. Cooling	0.97 to 0.99	1.00	g. Operating Instructions/Procedures	0.91 to 0.99	0.94
c. Explosion Control	0.84 to 0.88	1.00	h. Reactive Chemical Review	0.91 to 0.98	0.91
d. Emergency Shutdown	0.96 to 0.99	0.98	i. Other Process Hazard Analysis	0.91 to 0.98	0.98
e. Computer Control	0.93 to 0.99	0.97			

C1 Value (3) 0.784

2. **Material Isolation Credit Factor (C2)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Remote Control Valves	0.96 to 0.98	0.98	c. Drainage	0.91 to 0.97	0.91
b. Dump/Blowdown	0.96 to 0.98	1.00	d. Interlock	0.98	1.00

C2 Value (3) 0.892

3 **Fire Protection Credit Factor (C3)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Leak Detection	0.94 to 0.98	0.98	f. Water Curtains	0.97 to 0.98	1.00
b. Structural Steel	0.95 to 0.98	0.98	g. Foam	0.92 to 0.97	1.00
c. Fire Water Supply	0.94 to 0.97	0.97	h. Hand Extinguishers/Monitors	0.93 to 0.98	0.97
d. Special Systems	0.91	1.00	i. Cable Protection	0.94 to 0.98	1.00
e. Sprinkler Systems	0.74 to 0.97	0.97			

C3 Value (3) 0.877

Loss Control Credit Factor = C1 x C2 x C3 (3) = 0.613

PROCESS UNIT RISK ANALYSIS SUMMARY

1.	Fire and Explosion Index (F&EI) .... (See Front)	55		
2.	Radius of Exposure .... Figure 7	46 ft		
3.	Area of Exposure	6,646 sq.ft.		
4.	Value of Area of Exposure 1993 Dollars............		$MM	12.50
5.	Damage Factor .... Figure 8	0.55		
6.	Base Maximum Probable Property Damage - (Base MPPD) [4 x 5]		$MM	6.86
7.	Loss Control Credit Factor ....(See Above)	0.61		
8.	Actual Maximum Probable Property Damage - (Actual MPPD) [6 x 7]		$MM	4.20
9.	Maximum Probable Days Outage - (MPDO) Figure 9	45 days		
10.	Business Interruption - (BI)		$MM	6.95

(2) For no credit factor enter 1.00 (3) Product of all factors used

Refer to "Fire & Explosion Index Hazard Classification Guide" (Form #471-00001) for details

BACK OF FORM C-22380 Rev/01-94 (471-00036) - (FIE-7 System Ver-2..5 - 4/4/96

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DO A 044601
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FIRE & EXPLOSION INDEX

DOW

AREA/COUNTRY	DIVISION	LOCATION	DATE
USA	LA	PLAQUEMINE	11/14/96
SITE	MANUFACTURING UNIT	PROCESS UNIT	
LAD	GLYCOL-1	PO TANK TRUCK LOADING	

PREPARED BY:	APPROVED BY: (Superintendent)	BUILDING
LEIGH HILL	CHARLES JACKSON	1501
REVIEWED BY: (Management)	REVIEWED BY: (Technology Center)	REVIEWED BY: (Safety & Loss Prevention)
LEIGH HILL	STEVE JANDA	BUCK BAILEY

MATERIALS IN PROCESS UNIT

PROPYLENE OXIDE

STATE OF OPERATION	BASIC MATERIAL(S) FOR MATERIAL FACTOR
__DESIGN __START UP _X_NORMAL OPERATION __SHUTDOWN	Propylene Oxide

		Penalty Factor Range	Penalty Factor Used (1)
MATERIAL FACTOR (See Table 1 or Appendices A or B) Note requirements when unit temperatures over 140 °F (60 °C)			24
1. General Process Hazards			
Base Factor		1.00	1.00
A. Exothermic Chemical Reactions		0.30 to 1.25	0.00
B. Endothermic Processes		0.20 to 0.40	0.00
C. Material Handling and Transfer		0.25 to 1.05	0.50
D. Enclosed or Indoor Process Units		0.25 to 0.90	0.00
E. Access		0.20 to 0.35	0.35
F. Drainage and Spill Control	0 gallons	0.25 to 0.50	0.50
General Process Hazards Factor (F1)			2.35
2. Special Process Hazards			
Base Factor		1.00	1.00
A. Toxic Material(s)		0.20 to 0.80	0.60
B. Sub-Atmospheric Pressure (< 500 mm Hg)		0.50	0.00
C. Operation In or Near Flammable Range	_X_ INERTED __ NOT INERTED		
1. Tank Farms Storage Flammable Liquids		0.50	0.00
2. Process Upset or Purge Failure		0.30	0.30
3. Always in Flammable Range		0.80	0.00
D. Dust Explosion (See Table 3)		0.25 to 2.00	0.00
E. Pressure (See Figure 2)	Operating Pressure 20 psig Relief Setting 265 psig		0.07
F. Low Temperature		0.20 to 0.30	0.00
G. Quantity of Flammable/Unstable Material	Quantity 40,000 lb Hc = 13,200 BTU/lb		
1. Liquids or Gases in Process (See Figure 3)			0.00
2. Liquids or Gases in Storage (See Figure 4)			0.31
3. Combustible Solids in Storage, Dust in Process (See Figure 5)			0.00
H. Corrosion and Erosion		0.10 to 0.75	0.10
I. Leakage - Joints and Packing		0.10 to 1.50	0.10
J. Use of Fired Equipment (See Figure 6)			0.00
K. Hot Oil Heat Exchange System (See Table 5)		0.15 to 1.15	0.00
L. Rotating Equipment		0.50	0.00
Special Process Hazards Factor (F2)			2.48
Process Unit Hazards Factor (F1 x F2) = F3			5.83
Fire and Explosion Index (F3 x MF = F&EI)			140

(1) For no penalty use 0.00.

FORM C-22380 Rev/01-94 (471-00036) - (FIE-7 System Ver-2.5 - 4/4/96)

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DO A 044602
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LOSS CONTROL CREDIT FACTORS

1. Process Control Credit Factor (C1)

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Emergency Power	0.98	0.98	f. Inert Gas	0.94 to 0.96	0.96
b. Cooling	0.97 to 0.99	1.00	g. Operating Instructions/Procedures	0.91 to 0.99	0.94
c. Explosion Control	0.84 to 0.88	1.00	h. Reactive Chemical Review	0.91 to 0.98	0.91
d. Emergency Shutdown	0.96 to 0.99	0.98	i. Other Process Hazard Analysis	0.91 to 0.98	0.98
e. Computer Control	0.93 to 0.99	0.97			

C1 Value (3) 0.752

2. Material Isolation Credit Factor (C2)

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Remote Control Valves	0.96 to 0.98	0.96	c. Drainage	0.91 to 0.97	0.91
b. Dump/Blowdown	0.96 to 0.98	1.00	d. Interlock	0.98	1.00

C2 Value (3) 0.874

3 Fire Protection Credit Factor (C3)

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Leak Detection	0.94 to 0.98	0.98	f. Water Curtains	0.97 to 0.98	1.00
b. Structural Steel	0.95 to 0.98	1.00	g. Foam	0.92 to 0.97	1.00
c. Fire Water Supply	0.94 to 0.97	0.97	h. Hand Extinguishers/Monitors	0.93 to 0.98	0.97
d. Special Systems	0.91	1.00	i. Cable Protection	0.94 to 0.98	1.00
e. Sprinkler Systems	0.74 to 0.97	0.97			

C3 Value (3) 0.894

Loss Control Credit Factor = C1 x C2 x C3 (3) = 0.588

PROCESS UNIT RISK ANALYSIS SUMMARY

1. Fire and Explosion Index (F&EI) .... (See Front)	140			
2. Radius of Exposure .... (Figure 7)	118	ft		
3. Area of Exposure	43,435	sq.ft.		
4. Value of Area of Exposure 1993 Dollars..			$MM	2.00
5. Damage Factor .... (Figure 8)	0.83			
6. Base Maximum Probable Property Damage - (Base MPPD) [4 x 5]			$MM	1.67
7. Loss Control Credit Factor ....(See Above)	0.59			
8. Actual Maximum Probable Property Damage - (Actual MPPD) [6 x 7]			$MM	0.98
9. Maximum Probable Days Outage - (MPDO) (Figure 9)	19	days		
10. Business Interruption - (BI)			$MM	0.89

DO A 044603
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(2) For no credit factor enter 1.00 (3) Product of all factors used

Refer to "Fire & Explosion Index Hazard Classification Guide" (Form #471-00001) for details

BACK OF FORM C-22380 Rev/01-94 (471-00036) - (FIE-7 System Ver-2..5 - 4/4/96

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FIRE & EXPLOSION INDEX

DOW

AREA/COUNTRY	DIVISION	LOCATION	DATE
USA	LA	PLAQUEMINE	11/13/96
SITE	MANUFACTURING UNIT	PROCESS UNIT	
LAD	GLYCOL-1	T-1000	

PREPARED BY:	APPROVED BY: (Superintendent)	BUILDING
LEIGH HILL	CHARLES JACKSON	1501
REVIEWED BY: (Management)	REVIEWED BY: (Technology Center)	REVIEWED BY: (Safety & Loss Prevention)
LEIGH HILL	STEVE JANDA	BUCK BAILEY

MATERIALS IN PROCESS UNIT

PDC

STATE OF OPERATION	BASIC MATERIAL(S) FOR MATERIAL FACTOR
__DESIGN __START UP _X_NORMAL OPERATION __SHUTDOWN	Propylene Dichloride

		Penalty Factor Range	Penalty Factor Used (1)
MATERIAL FACTOR (See Table 1 or Appendices A or B) Note requirements when unit temperatures over 140 °F (60 °C)			16
1. General Process Hazards			
Base Factor		1.00	1.00
A. Exothermic Chemical Reactions		0.30 to 1.25	0.00
B. Endothermic Processes		0.20 to 0.40	0.00
C. Material Handling and Transfer		0.25 to 1.05	0.00
D. Enclosed or Indoor Process Units		0.25 to 0.90	0.00
E. Access		0.20 to 0.35	0.00
F. Drainage and Spill Control	0 gallons	0.25 to 0.50	0.50
General Process Hazards Factor (F1)			1.50
2. Special Process Hazards			
Base Factor		1.00	1.00
A. Toxic Material(s)		0.20 to 0.80	0.40
B. Sub-Atmospheric Pressure (< 500 mm Hg)		0.50	0.50
C. Operation In or Near Flammable Range			
1. Tank Farms Storage Flammable Liquids		0.50	0.00
2. Process Upset or Purge Failure		0.30	0.00
3. Always in Flammable Range		0.80	0.00
D. Dust Explosion (See Table 3)		0.25 to 2.00	0.00
E. Pressure (See Figure 2)	Operating Pressure 0 psig		
.	Relief Setting 0 psig		0.00
F. Low Temperature		0.20 to 0.30	0.00
G. Quantity of Flammable/Unstable Material	Quantity 11,700 lb		
	Hc = 6,300 BTU/lb		
1. Liquids or Gases in Process (See Figure 3)			0.08
2. Liquids or Gases in Storage (See Figure 4)			0.00
3. Combustible Solids in Storage, Dust in Process (See Figure 5)			0.00
H. Corrosion and Erosion		0.10 to 0.75	0.00
I. Leakage - Joints and Packing		0.10 to 1.50	0.00
J. Use of Fired Equipment (See Figure 6)			0.00
K. Hot Oil Heat Exchange System (See Table 5)		0.15 to 1.15	0.00
L. Rotating Equipment		0.50	0.00
Special Process Hazards Factor (F2)			1.98
Process Unit Hazards Factor (F1 x F2) = F3			2.97
Fire and Explosion Index (F3 x MF = F&EI)			48

(1) For no penalty use 0.00.

DO A 044604
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FORM C-22380 Rev/01-94 (471-00036) - [FIE-7 System Ver-2.5 - 4/4/96]

Print Date: 1/14/97, Work File: A:\FEI7CALC\[T1000.xls]FEI7_TMP MF DataFile:C:\FEI7V2.5V\FEI7DEN\FEI7_DAT.XLS

LOSS CONTROL CREDIT FACTORS

1. **Process Control Credit Factor (C1)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Emergency Power	0.98	0.98	f. Inert Gas	0.94 to 0.96	1.00
b. Cooling	0.97 to 0.99	1.00	g. Operating Instructions/Procedures	0.91 to 0.99	0.93
c. Explosion Control	0.84 to 0.88	1.00	h. Reactive Chemical Review	0.91 to 0.98	0.91
d. Emergency Shutdown	0.96 to 0.99	1.00	i. Other Process Hazard Analysis	0.91 to 0.98	0.98
e. Computer Control	0.93 to 0.99	0.97			

C1 Value (3) 0.791

2. **Material Isolation Credit Factor (C2)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Remote Control Valves	0.96 to 0.98	0.98	c. Drainage	0.91 to 0.97	1.00
b. Dump/Blowdown	0.96 to 0.98	1.00	d. Interlock	0.98	1.00

C2 Value (3) 0.980

3 **Fire Protection Credit Factor (C3)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Leak Detection	0.94 to 0.98	0.98	f. Water Curtains	0.97 to 0.98	1.00
b. Structural Steel	0.95 to 0.98	1.00	g. Foam	0.92 to 0.97	1.00
c. Fire Water Supply	0.94 to 0.97	0.94	h. Hand Extinguishers/Monitors	0.93 to 0.98	0.97
d. Special Systems	0.91	1.00	i. Cable Protection	0.94 to 0.98	1.00
e. Sprinkler Systems	0.74 to 0.97	0.86			

C3 Value (3) 0.767

Loss Control Credit Factor = C1 x C2 x C3 (3) = 0.595

PROCESS UNIT RISK ANALYSIS SUMMARY

1.	Fire and Explosion Index (F&EI) .... (See Front)	48		
2.	Radius of Exposure .... Figure 7	40 ft		
3.	Area of Exposure	5,001 sq.ft.		
4.	Value of Area of Exposure 1993 Dollars........................		$MM	1.00
5.	Damage Factor .... Figure 8	0.39		
6.	Base Maximum Probable Property Damage - (Base MPPD) [4 x 5]		$MM	0.39
7.	Loss Control Credit Factor ....(See Above)	0.59		
8.	Actual Maximum Probable Property Damage - (Actual MPPD) [6 x 7]		$MM	0.23
9.	Maximum Probable Days Outage - (MPDO) Figure 9	8 days		
10.	Business Interruption - (BI)		$MM	0.19

(2) For no credit factor enter 1.00 (3) Product of all factors usec

DO A 044605
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Refer to "Fire & Explosion Index Hazard Classification Guide" (Form #471-00001) for details

BACK OF FORM C-22380 Rev/01-94 (471-00036) - (FIE-7 System Ver-2..5 - 4/4/96

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FIRE & EXPLOSION INDEX

DOW

AREA/COUNTRY	DIVISION	LOCATION	DATE
USA	LA	PLAQUEMINE	11/16/96
SITE	MANUFACTURING UNIT	PROCESS UNIT	
LAD	GLYCOL-1	T-1200	

PREPARED BY:	APPROVED BY: (Superintendent)	BUILDING
LEIGH HILL	CHARLES JACKSON	1501
REVIEWED BY: (Management)	REVIEWED BY: (Technology Center)	REVIEWED BY: (Safety & Loss Prevention)
LEIGH HILL	STEVE JANDA	BUCK BAILEY

MATERIALS IN PROCESS UNIT

PDC

STATE OF OPERATION	BASIC MATERIAL(S) FOR MATERIAL FACTOR
__DESIGN __START UP _X_NORMAL OPERATION __SHUTDOWN	Propylene Dichloride

		Penalty Factor Range	Penalty Factor Used (1)
MATERIAL FACTOR (See Table 1 or Appendices A or B) Note requirements when unit temperatures over 140 °F (60 °C)			16
1. General Process Hazards			
Base Factor		1.00	1.00
A. Exothermic Chemical Reactions		0.30 to 1.25	0.00
B. Endothermic Processes		0.20 to 0.40	0.00
C. Material Handling and Transfer		0.25 to 1.05	0.00
D. Enclosed or Indoor Process Units		0.25 to 0.90	0.00
E. Access		0.20 to 0.35	0.00
F. Drainage and Spill Control	0 gallons	0.25 to 0.50	0.50
General Process Hazards Factor (F1)			1.50
2. Special Process Hazards			
Base Factor		1.00	1.00
A. Toxic Material(s)		0.20 to 0.80	0.40
B. Sub-Atmospheric Pressure (< 500 mm Hg)		0.50	0.50
C. Operation In or Near Flammable Range			
1. Tank Farms Storage Flammable Liquids		0.50	0.00
2. Process Upset or Purge Failure		0.30	0.00
3. Always in Flammable Range		0.80	0.00
D. Dust Explosion (See Table 3)		0.25 to 2.00	0.00
E. Pressure (See Figure 2)	Operating Pressure 0 psig Relief Setting 0 psig		0.00
F. Low Temperature		0.20 to 0.30	0.00
G. Quantity of Flammable/Unstable Material	Quantity 6,700 lb Hc = 6,300 BTU/lb		
1. Liquids or Gases in Process (See Figure 3)			0.02
2. Liquids or Gases in Storage (See Figure 4)			0.00
3. Combustible Solids in Storage, Dust in Process (See Figure 5)			0.00
H. Corrosion and Erosion		0.10 to 0.75	0.00
I. Leakage - Joints and Packing		0.10 to 1.50	0.00
J. Use of Fired Equipment (See Figure 6)			0.00
K. Hot Oil Heat Exchange System (See Table 5)		0.15 to 1.15	0.00
L. Rotating Equipment		0.50	0.00
Special Process Hazards Factor (F2)			1.92
Process Unit Hazards Factor (F1 x F2) = F3			2.88
Fire and Explosion Index (F3 x MF = F&EI)			46

(1) For no penalty use 0.00.

DO A 044606
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FORM C-22380 Rev/01-94 (471-00036) - (FIE-7 System Ver-2.5 - 4/4/96)

Print Date: 1/14/97, Work File: A:\FEI7CALC\[T1200.xls]FEI7_TMP MF DataFile:C:\FEI7V2.5V\FEI7DEN\FEI7_DAT.XLS

LOSS CONTROL CREDIT FACTORS

1. Process Control Credit Factor (C1)

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Emergency Power	0.98	0.98	f. Inert Gas	0.94 to 0.96	1.00
b. Cooling	0.97 to 0.99	1.00	g. Operating Instructions/Procedures	0.91 to 0.99	0.93
c. Explosion Control	0.84 to 0.98	1.00	h. Reactive Chemical Review	0.91 to 0.98	0.91
d. Emergency Shutdown	0.96 to 0.99	1.00	i. Other Process Hazard Analysis	0.91 to 0.98	0.98
e. Computer Control	0.93 to 0.99	0.97			

C1 Value (3) **0.791**

2. Material Isolation Credit Factor (C2)

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Remote Control Valves	0.96 to 0.98	0.98	c. Drainage	0.91 to 0.97	1.00
b. Dump/Blowdown	0.96 to 0.98	1.00	d. Interlock	0.98	1.00

C2 Value (3) **0.980**

3 Fire Protection Credit Factor (C3)

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Leak Detection	0.94 to 0.98	0.98	f. Water Curtains	0.97 to 0.98	1.00
b. Structural Steel	0.95 to 0.98	1.00	g. Foam	0.92 to 0.97	1.00
c. Fire Water Supply	0.94 to 0.97	0.94	h. Hand Extinguishers/Monitors	0.93 to 0.98	1.00
d. Special Systems	0.91	1.00	i. Cable Protection	0.94 to 0.98	1.00
e. Sprinkler Systems	0.74 to 0.97	0.87			

C3 Value (3) **0.801**

Loss Control Credit Factor = C1 x C2 x C3 (3) = **0.621**

PROCESS UNIT RISK ANALYSIS SUMMARY

1. Fire and Explosion Index (F&EI) .... (See Front)	46			
2. Radius of Exposure .... Figure 7)	39	ft		
3. Area of Exposure	4,707	sq.ft.		
4. Value of Area of Exposure 1993 Dollars................................			$MM	1.00
5. Damage Factor .... Figure 8)	0.39			
6. Base Maximum Probable Property Damage - (Base MPPD) [4 x 5]			$MM	0.39
7. Loss Control Credit Factor ....(See Above)	0.62			
8. Actual Maximum Probable Property Damage - (Actual MPPD) [6 x 7]			$MM	0.24
9. Maximum Probable Days Outage - (MPDO) Figure 9)	8	days		
10. Business Interruption - (BI)			$MM	0.19

(2) For no credit factor enter 1.00 (3) Product of all factors used

Refer to "Fire & Explosion Index Hazard Classification Guide" (Form #471-00001) for details

BACK OF FORM C-22380 Rev/01-94 (471-00036) - (FE-7 System Ver-2..5 - 4/4/96

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DO A 044607
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FIRE & EXPLOSION INDEX

DOW

AREA/COUNTRY	DIVISION	LOCATION	DATE
USA	LA	PLAQUEMINE	11/13/96
SITE	MANUFACTURING UNIT	PROCESS UNIT	
LAD	GLYCOL-1	THROX	

PREPARED BY:	APPROVED BY: (Superintendent)	BUILDING
LEIGH HILL	CHARLES JACKSON	1501
REVIEWED BY: (Management)	REVIEWED BY: (Technology Center)	REVIEWED BY: (Safety & Loss Prevention)
LEIGH HILL	STEVE JANDA	BUCK BAILEY

MATERIALS IN PROCESS UNIT

PDC

STATE OF OPERATION	BASIC MATERIAL(S) FOR MATERIAL FACTOR
__DESIGN __START UP _X_NORMAL OPERATION __SHUTDOWN	Propylene Dichloride

MATERIAL FACTOR (See Table 1 or Appendices A or B) Note requirements when unit temperatures over 140 °F (60 °C)		16
1. General Process Hazards	**Penalty Factor Range**	**Penalty Factor Used (1)**
Base Factor	1.00	1.00
A. Exothermic Chemical Reactions	0.30 to 1.25	0.50
B. Endothermic Processes	0.20 to 0.40	0.00
C. Material Handling and Transfer	0.25 to 1.05	0.00
D. Enclosed or Indoor Process Units	0.25 to 0.90	0.00
E. Access	0.20 to 0.35	0.00
F. Drainage and Spill Control 0 gallons	0.25 to 0.50	0.50
General Process Hazards Factor (F1)		2.00
2. Special Process Hazards		
Base Factor	1.00	1.00
A. Toxic Material(s)	0.20 to 0.80	0.40
B. Sub-Atmospheric Pressure (< 500 mm Hg)	0.50	0.50
C. Operation In or Near Flammable Range		
1. Tank Farms Storage Flammable Liquids	0.50	0.00
2. Process Upset or Purge Failure	0.30	0.00
3. Always in Flammable Range	0.80	0.00
D. Dust Explosion (See Table 3)	0.25 to 2.00	0.00
E. Pressure (See Figure 2) Operating Pressure 0 psig Relief Setting 0 psig		0.00
F. Low Temperature	0.20 to 0.30	0.00
G. Quantity of Flammable/Unstable Material Quantity 100 lb Hc = 6,300 BTU/lb		
1. Liquids or Gases in Process (See Figure 3)		0.00
2. Liquids or Gases in Storage (See Figure 4)		0.00
3. Combustible Solids in Storage, Dust in Process (See Figure 5)		0.00
H. Corrosion and Erosion	0.10 to 0.75	0.10
I. Leakage - Joints and Packing	0.10 to 1.50	0.10
J. Use of Fired Equipment (See Figure 6)		1.00
K. Hot Oil Heat Exchange System (See Table 5)	0.15 to 1.15	0.00
L. Rotating Equipment	0.50	0.50
Special Process Hazards Factor (F2)		3.60
Process Unit Hazards Factor (F1 x F2) = F3		7.20
Fire and Explosion Index (F3 x MF = F&EI)		115

(1) For no penalty use 0.00.

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FORM C-22380 Rev/01-94 (471-00036) - (FIE-7 System Ver-2.5 - 4/4/96)
Print Date: 1/14/97, Work File: A:\FEI7CALC\[THROX.xls]FEI7_TMP MF DataFile:C:\FEI7V2.5V\FEI7DEN\FEI7_DAT.XLS

LOSS CONTROL CREDIT FACTORS

1. **Process Control Credit Factor (C1)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Emergency Power	0.98	0.98	f. Inert Gas	0.94 to 0.96	0.94
b. Cooling	0.97 to 0.99	1.00	g. Operating Instructions/Procedures	0.91 to 0.99	0.92
c. Explosion Control	0.84 to 0.88	1.00	h. Reactive Chemical Review	0.91 to 0.98	0.91
d. Emergency Shutdown	0.96 to 0.99	0.96	i. Other Process Hazard Analysis	0.91 to 0.98	0.98
e. Computer Control	0.93 to 0.99	0.93			

C1 Value (3) 0.672

2. **Material Isolation Credit Factor (C2)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Remote Control Valves	0.96 to 0.98	0.96	c. Drainage	0.91 to 0.97	1.00
b. Dump/Blowdown	0.96 to 0.98	1.00	d. Interlock	0.98	1.00

C2 Value (3) 0.960

3 **Fire Protection Credit Factor (C3)**

Feature	Credit Factor Range	Credit Factor Used (2)	Feature	Credit Factor Range	Credit Factor Used (2)
a. Leak Detection	0.94 to 0.98	0.98	f. Water Curtains	0.97 to 0.98	1.00
b. Structural Steel	0.95 to 0.98	1.00	g. Foam	0.92 to 0.97	1.00
c. Fire Water Supply	0.94 to 0.97	0.94	h. Hand Extinguishers/Monitors	0.93 to 0.98	0.97
d. Special Systems	0.91	1.00	i. Cable Protection	0.94 to 0.98	1.00
e. Sprinkler Systems	0.74 to 0.97	0.87			

C3 Value (3) 0.777

Loss Control Credit Factor = C1 x C2 x C3 (3) = 0.502

PROCESS UNIT RISK ANALYSIS SUMMARY

1.	Fire and Explosion Index (F&EI) .... (See Front)	115		
2.	Radius of Exposure .... Figure 7	97 ft		
3.	Area of Exposure	29,403 sq.ft.		
4.	Value of Area of Exposure 1993 Dollars............		$MM	11.00
5.	Damage Factor .... Figure 8	0.64		
6.	Base Maximum Probable Property Damage - (Base MPPD) [4 x 5]		$MM	7.03
7.	Loss Control Credit Factor ....(See Above)	0.50		
8.	Actual Maximum Probable Property Damage - (Actual MPPD) [6 x 7]		$MM	3.53
9.	Maximum Probable Days Outage - (MPDO) Figure 9	41 days		
10.	Business Interruption - (BI)		$MM	11.44

(2) For no credit factor enter 1.00 (3) Product of all factors used

Refer to "Fire & Explosion Index Hazard Classification Guide" (Form #471-00001) for details

BACK OF FORM C-22380 Rev/01-94 (471-00036) - (FIE-7 System Ver-2..5 - 4/4/96

Print Date: 1/14/97, Work File: A:\FEI7CALC\[THROX.xls]FEI7_TMP MF DataFile:C:\FEI7V2.5V\FEI7DEN\FEI7_DAT.XLS

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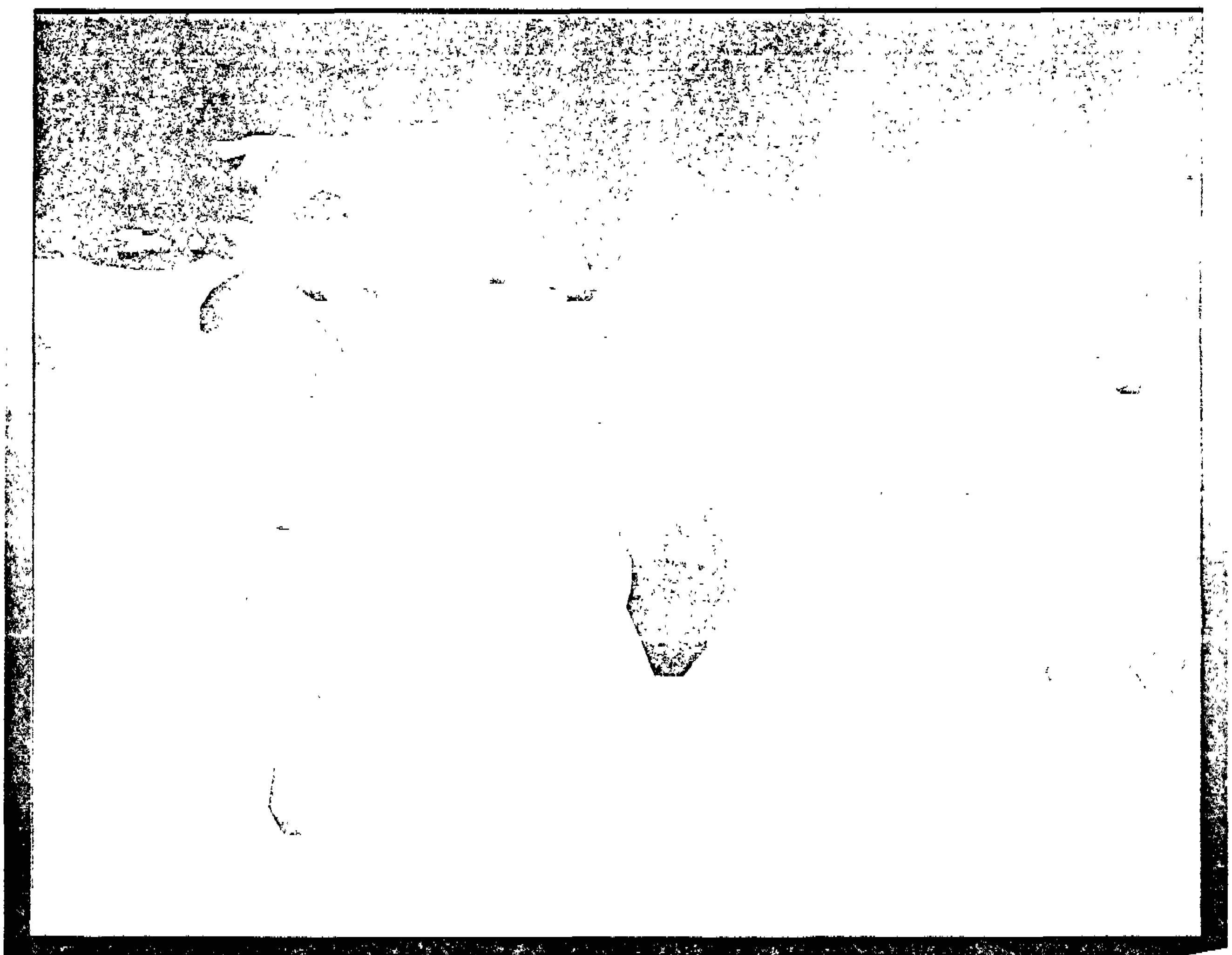
DOW

CORPORATE SAFETY & LOSS PREVENTION
SAFETY · LOSS PREVENTION · SECURITY
REACTIVE CHEMICALS
THE DOW CHEMICAL COMPANY

FIRE & EXPLOSION INDEX
HAZARD CLASSIFICATION GUIDE



DO A 044610
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JANUARY 1994
7th Edition

TABLE OF CONTENTS

DO A 044612
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PREFACE

Since the first edition of this guide was issued in 1964, the Fire & Explosion Index (F&EI) has evolved through the past 29 years into a comprehensive index that gives a relative value to the risk of individual process unit losses due to potential fires and explosions. The primary purpose of the F&EI is to serve as a guide to the selection of fire protection methods. Its broader purpose was to have a method for the relative ranking of individual process units focused on key items of equipment.

This index has been widely used in Dow and outside of Dow. It is the leading hazard index recognized by the chemical industry. The present F&EI provides key information to help evaluate the overall risk from fire and explosion. The F&EI can be used in conjunction with the *Chemical Exposure Index Guide*, 2nd ed. and other process information to form a Risk Analysis Package to better understand the potential risks to a manufacturing unit. This package is an important part of the Consolidated Audit process.

The F&EI is one of the tools used for evaluation of realistic fire, explosion and reactivity potential of process equipment and its contents as described in the Corporate *Process Risk Management Guidelines for Facilities and Distribution.* A facility with an F&EI greater than 128 will require further risk review. The F&EI is also tied into the Distribution Ranking Index (DRI); see *Guidelines for Determining the Distribution Ranking Index.*

The seventh edition is primarily an update of the sixth edition, and there are no major conceptual changes. Improvements have been made in wording and updating has been done to remain consistent with Codes and Loss Prevention Principles. A major update has been made in Appendix A, Material Factors, which gives the latest NFPA ratings, flash points, boiling points and, most importantly, Material Factors.

Improvements in the seventh edition include:

- Correction of the errata which had been noted in the sixth edition.
- Incorporation of a table of F&EI versus Degree of Hazard.
- Major updating of Appendix A to give most recent NFPA ratings and Material Factors which agree with Table 1.
- Revision of F&EI forms that have been streamlined and put into computerized spreadsheet formats.
- Updating of the Determination of Material Factor and Toxic Materials NFPA ratings in accordance with the latest NFPA 704 definitions.
- Addition of equations for the curves in the figures to aid in the calculation of factors and allow for computer determination of values.
- Inclusion of SI (International System of Units) units in addition to US/British units.
- Improvement and addition of examples.
- Some revamping in the Loss Control Credit Factors area with elimination of buried tank credit and reference to halons and new credit for process hazard reviews.
- Reorganization of Process Unit Risk Analysis Summary section.
- Updating discussion regarding Maximum Probable Property Damage and plant layout considerations.
- Minor revisions to the Loss Prevention Checklist.

It is a requirement of the Dow Corporate *Minimum Requirements* for Safety, Loss Prevention and Security that the *Fire & Explosion Index Hazard Classification Guide* shall be used to assess the hazard potential of all installations.

The *Fire & Explosion Index Hazard Classification Guide* has been made available as an edited version to all interested parties through the American Institute of Chemical Engineers (AIChE), 345 East 47th Street, New York, NY 10017 [Phone (212) 705-7657]. Various countries have referenced the F&EI guide in their respective governmental regulations.

INTRODUCTION: THE FIRE AND EXPLOSION INDEX

The Fire and Explosion Risk Analysis System is a step-by-step objective evaluation of the realistic fire, explosion and reactivity potential of process equipment and its contents. The quantitative measurements used in the analysis are based on historic loss data, the energy potential of the material under study, and the extent to which loss prevention practices are currently applied.

The purpose of the F&EI system is to:

1. QUANTIFY the expected damage of potential fire, explosion and reactivity incidents in realistic terms.
2. IDENTIFY equipment that would be likely to contribute to the creation or escalation of an incident.
3. COMMUNICATE the F&EI risk potential to management.

Beneath all the numbers, graphs and figures, however, lies the most important goal of the F&EI System — ***to make the engineer aware of the loss potential of each process area*** and to help the engineer identify ways to lessen the severity and resultant dollar loss of potential incidents in an efficient and cost effective manner.

The F&EI is used in the Dow Risk Review Process as described in the *Process Risk Management Guidelines for Facilities and Distribution.* Determination of the F&EI must be done in conducting a Process Hazard Analysis or Level I Risk Review. Further risk review is to be done for facilities with an F&EI greater than 128.

Insurance company assessments of potential exposures are typically based on the worst imaginable incident. They might anticipate, for example, that the complete contents of a reactor dump could vaporize instantaneously and ignite; and their insurance loss estimates, which are determined in part from this kind of analysis, can be extremely large. From a realistic point of view, this kind of situation is rare.

The Dow F&EI system attempts to determine the ***realistic*** maximum loss that can occur to a process plant (or process unit) or related facility — a loss that could ***actually*** be experienced under the most adverse operating conditions. The calculation is based on quantifiable data. Finite spill rates, process temperature in relation to material flash points and boiling points and reactivity are just a few of the many contributors to a probable incident.

Although the F&EI system is primarily designed for any operation in which a flammable, combustible or reactive material is stored, handled or processed, it may also be used in analyzing the loss potential of sewage treating facilities, distribution systems, pipelines, rectifiers, transformers, boilers, thermal oxidizers and certain elements of power plants. The system can also be used for risk evaluations of small processes with modest inventories of potentially hazardous materials; its application to pilot plants is strongly recommended. The system can be applied if handling a minimum of approximately 1,000 lb (454 kg) of a flammable or reactive material.

A ***word of caution*** is in order for those planning to use the F&EI system for the risk evaluation of facilities. Common sense and good judgment must be used during the actual calculation and in the interpretation of its results. Process hazards that contribute to the magnitude and probability of losses have been quantified as "penalties" to provide factors for computation. Not every penalty may be applicable to a specific situation and perhaps some may have to be adjusted. The Loss Prevention Contact Person can serve as a valuable resource to assist in the calculations.

PROCEDURE FOR RISK ANALYSIS CALCULATIONS

To develop an F&EI and Risk Analysis Summary, the following are needed:

a. An accurate plot plan of the plant (manufacturing unit)
b. A process flow sheet
c. A *Fire & Explosion Index Hazard Classification Guide*, Seventh Edition
d. An Fire & Explosion Index Form (page 5 – F&EI, Seventh Edition)
e. A Loss Control Credit Factors Form (page 6 – F&EI, Seventh Edition)
f. A Process Unit Analysis Summary Form (page 6 – F&EI, Seventh Edition)
g. A Manufacturing Unit Risk Analysis Summary Form (page 7 – F&EI, Seventh Edition)
h. Replacement cost data for the installed process equipment under study.

The procedure to be followed is listed below. Figure 1, page 4, presents a flowchart outlining the procedure for risk analysis calculations.

1. Selection should be made on the plot plan of the Pertinent Process Units that are considered of key importance to the process and that would have the greatest impact on the magnitude of a potential fire or explosion.
2. Determination is to be made of the Material Factor (MF) for each Process Unit. The MF for a particular material in the Process Unit is to be obtained from Table 1, page 13 or Appendices A or B, pages 60 to 73.
3. Calculation is to be completed for the General Process Hazards Factor with application of the appropriate penalties according to the F&EI Form, page 5.
4. Calculation is to be completed for the Special Process Hazards Factor with application of the appropriate penalties according to the F&EI Form, page 5.
5. Determination of the Process Unit Hazards Factor is to be done by calculating the product of the General and Special Process Hazards Factors.
6. Determination of the F&EI is to be done by calculating the product of the Process Unit Hazards Factor and the Material Factor.
7. Determination of the Area of Exposure surrounding the Process Unit being evaluated is to be performed based on Radius of Exposure from Figure 7, page 48, and pages 47 to 50.
8. Determination of the replacement value of all equipment within the Area of Exposure and the inventory is to be done.
9. Determination of the Damage Factor, which represents the degree of loss exposure, is to be done using Figure 8, page 53, based on the MF and the Process Unit Hazards Factor (F_3).
10. Determination of the Base Maximum Probable Property Damage (Base MPPD) is to be made by multiplying the Value of the Area of Exposure by the Damage Factor.
11. Application of the Loss Control Credit Factor to the Base MPPD allows for the determination of the Actual MPPD.
12. Determination of the Maximum Probable Days Outage (MPDO) is performed by using Figure 9, page 55, knowing the Actual MPPD.
13. Determination of the Business Interruption (BI) is done by using the equation given on page 56 where the MPDO is multiplied by the Value of Production for the Month (VPM) and by 0.70/30.

Each of the steps given above is outlined and explained in the following pages of this guide. Appendix C, Basic Preventive and Protective Features, and Appendix D, Loss Prevention Checklist, are also provided for use in assessing the important loss control areas in a plant or manufacturing unit.

When developing the F&EI, it is recommended that people with a working knowledge of the plant's history/experiences be contacted to discuss probable incident scenarios to assure the most viable F&EIs are developed.

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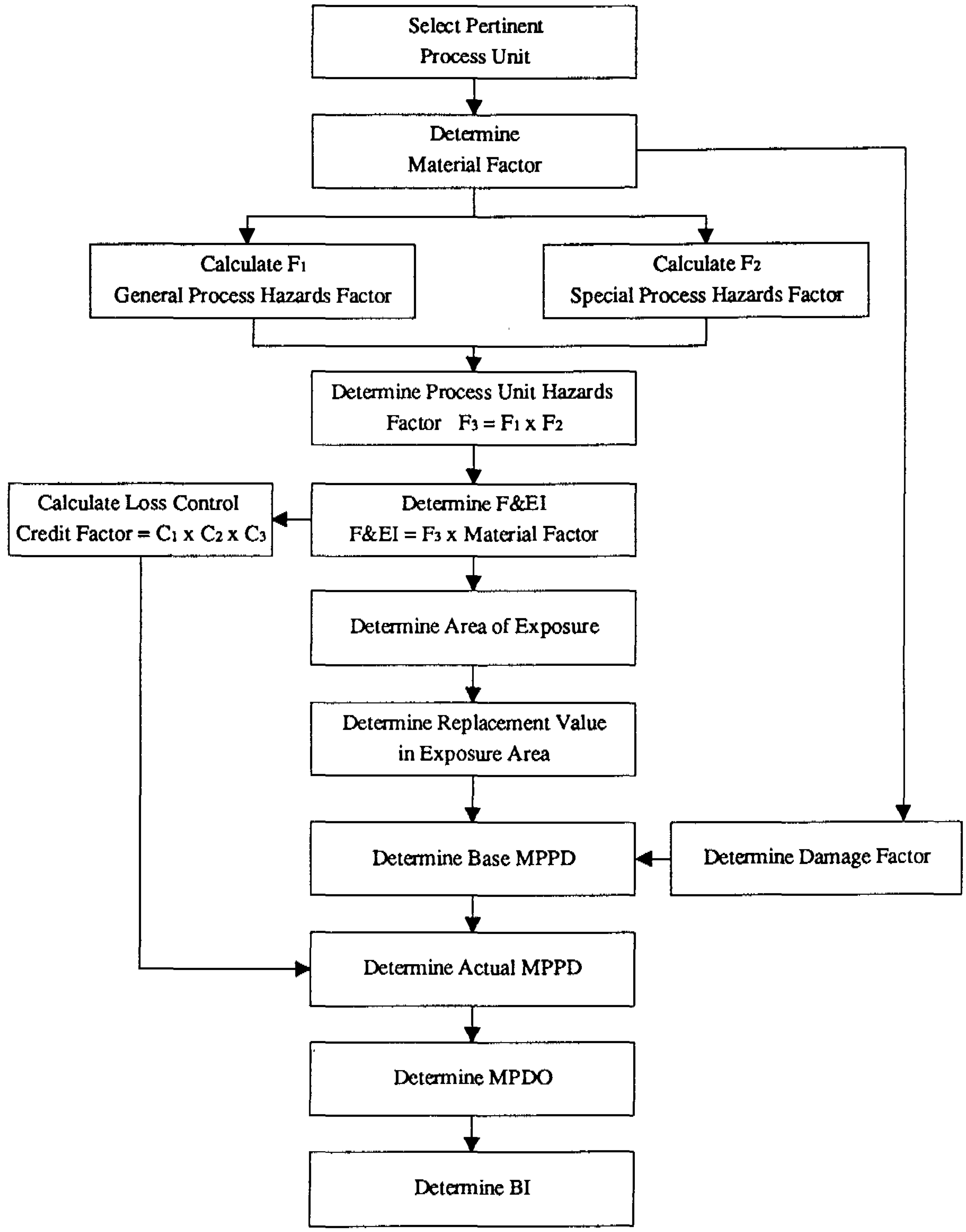
FIGURE 1

PROCEDURE FOR CALCULATING FIRE & EXPLOSION INDEX AND OTHER RISK ANALYSIS INFORMATION



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FIRE & EXPLOSION INDEX

AREA / COUNTRY	DIVISION	LOCATION	DATE
SITE	MANUFACTURING UNIT	PROCESS UNIT	

PREPARED BY:	APPROVED BY: (Superintendent)	BUILDING
REVIEWED BY: (Management)	REVIEWED BY: (Technology Center)	REVIEWED BY: (Safety & Loss Prevention)

MATERIALS IN PROCESS UNIT

STATE OF OPERATION	BASIC MATERIAL(S) FOR MATERIAL FACTOR
__ DESIGN __ START UP __ NORMAL OPERATION __ SHUTDOWN	

MATERIAL FACTOR (See Table 1 or Appendices A or B) Note requirements when unit temperature over 140 °F (60 °C)

1. General Process Hazards	Penalty Factor Range	Penalty Factor Used(1)
Base Factor	1.00	1.00
A. Exothermic Chemical Reactions	0.30 to 1.25	
B. Endothermic Processes	0.20 to 0.40	
C. Material Handling and Transfer	0.25 to 1.05	
D. Enclosed or Indoor Process Units	0.25 to 0.90	
E. Access	0.20 to 0.35	
F. Drainage and Spill Control ________ gal or cu.m.	0.25 to 0.50	
General Process Hazards Factor (F_1)		
2. Special Process Hazards		
Base Factor	1.00	1.00
A. Toxic Material(s)	0.20 to 0.80	
B. Sub-Atmospheric Pressure (< 500 mm Hg)	0.50	
C. Operation In or Near Flammable Range ___ Inerted ___ Not Inerted		
1. Tank Farms Storage Flammable Liquids	0.50	
2. Process Upset or Purge Failure	0.30	
3. Always in Flammable Range	0.80	
D. Dust Explosion (See Table 3)	0.25 to 2.00	
E. Pressure (See Figure 2) Operating Pressure ________ psig or kPa gauge Relief Setting ________ psig or kPa gauge		
F. Low Temperature	0.20 to 0.30	
G. Quantity of Flammable/Unstable Material: Quantity _____ lb or kg H_C = _____ BTU/lb or kcal/kg		
1. Liquids or Gases in Process (See Figure 3)		
2. Liquids or Gases in Storage (See Figure 4)		
3. Combustible Solids in Storage, Dust in Process (See Figure 5)		
H. Corrosion and Erosion	0.10 to 0.75	
I. Leakage – Joints and Packing	0.10 to 1.50	
J. Use of Fired Equipment (See Figure 6)		
K. Hot Oil Heat Exchange System (See Table 5)	0.15 to 1.15	
L. Rotating Equipment	0.50	
Special Process Hazards Factor (F_2)		
Process Unit Hazards Factor ($F_1 \times F_2$) = F_3		
Fire and Explosion Index ($F_3 \times MF$ = F&EI)		

(1) For no penalty use 0.00.

FORM C-22380 Rev/01-94 (471-00036)

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LOSS CONTROL CREDIT FACTORS

1. Process Control Credit Factor (C_1)

F ature	Credit Factor Range	Credit Fact r Used(2)	Feature	Credit Factor Range	Credit Factor Used(2)
a. Emergency Power	0.98		f. Inert Gas	0.94 to 0.96	
b. Cooling	0.97 to 0.99		g. Operating Instructions/Procedures	0.91 to 0.99	
c. Explosion Control	0.84 to 0.98		h. Reactive Chemical Review	0.91 to 0.98	
d. Emergency Shutdown	0.96 to 0.99		i. Other Process Hazard Analysis	0.91 to 0.98	
e. Computer Control	0.93 to 0.99				

C_1 Value(3) ______

2. Material Isolation Credit Factor (C_2)

Feature	Credit Factor Range	Credit Factor Used(2)	Feature	Credit Factor Range	Credit Factor Used(2)
a. Remote Control Valves	0.96 to 0.98		c. Drainage	0.91 to 0.97	
b. Dump/Blowdown	0.96 to 0.98		d. Interlock	0.98	

C_2 Value(3) ______

3. Fire Protection Credit Factor (C_3)

Feature	Credit Factor Range	Credit Factor Used(2)	Feature	Credit Factor Range	Credit Factor Used(2)
a. Leak Detection	0.94 to 0.98		f. Water Curtains	0.97 to 0.98	
b. Structural Steel	0.95 to 0.98		g. Foam	0.92 to 0.97	
c. Fire Water Supply	0.94 to 0.97		h. Hand Extinguishers/Monitors	0.93 to 0.98	
d. Special Systems	0.91		i. Cable Protection	0.94 to 0.98	
e. Sprinkler Systems	0.74 to 0.97				

C_3 Value(3) ______

Loss Control Credit Factor = C_1 X C_2 X $C_{3(3)}$ = ______ (Enter on line 7 below)

PROCESS UNIT RISK ANALYSIS SUMMARY

1. Fire & Explosion Index (F&EI) .... (See Front)		
2. Radius of Exposure ....(Figure 7)	ft or m	
3. Area of Exposure	ft² or m²	
4. Value of Area of Exposure		$MM
5. Damage Factor ....(Figure 8)		
6. Base Maximum Probable Property Damage – (Base MPPD) [4 x 5]		$MM
7. Loss Control Credit Factor............................(See Above)		
8. Actual Maximum Probable Property Damage – (Actual MPPD) [6 x 7]		$MM
9. Maximum Probable Days Outage – (MPDO)......(Figure 9)	days	
10. Business Interruption – (BI)		$MM

(2) For no credit factor enter 1.00. (3) Product of all factors used.

Refer to *Fire & Explosion Index Hazard Classification Guide* (Form #471-00001) for details.

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MANUFACTURING UNIT RISK ANALYSIS SUMMARY

DOW

AREA / COUNTRY	DIVISION	LOCATION
SITE	MANUFACTURING UNIT	TYPE OF OPERATION
PREPARED BY	TOTAL MFG. UNIT REPLACEMENT VALUE	DATE

Process Unit / Major Material	Material Factor	F&EI	Value of Area of Exposure $MM	Base MPPD[1] $MM	Actual MPPD[1] $MM	Days Outage MPDO[2]	BI[3] Loss $MM

1 Maximum Probable Property Damage
2 Maximum Probable Days Outage
3 Business Interruption

FORM C-50010 REV/01-94 (471-00037)

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SELECTION OF PERTINENT PROCESS UNITS

The F&EI calculation is a tool to help determine the areas of greatest loss potential in a particular process. It also enables one to predict the physical damage and business interruption that would occur in the event of an incident.

The first step in making the F&EI calculation requires using an efficient and logical procedure to determine which process units should be studied. A process unit is defined as any major item of process equipment. The following process units could be identified in a furnace/quench section of a vinyl chloride monomer/ethylene dichloride plant: ethylene dichloride preheater, ethylene dichloride evaporator, furnace, quench column, ethylene dichloride absorber and tarpot.

A designation of the Process Unit must be entered in the appropriate space on the F&EI form, page 5. The Manufacturing Unit designation must also be entered on the F&EI form. A Manufacturing Unit is the entire production facility including chemical processes, mechanical processes, warehouse, packaging lines, etc. For example, manufacturing units may be a latex plant, DOWANOL® plant or DowElanco Formulations plant.

The process area of a latex plant could have the following process units: raw material storage tank/s, process stream storage tank/s, aqueous tank, reactor feed pumps, reactor, stripper, recovery tank/s, latex storage tank/s.

A warehouse may also be treated as a process unit. The materials stored within a fire-walled area, or within the total storage area where fire walls are not provided, would constitute a Process Unit.

It is quite clear that most manufacturing units have many process units. To calculate the Fire and Explosion Index, however, only process units that could have an impact from a loss prevention standpoint should be evaluated. These are known as Pertinent Process Units.

Important factors for selecting Pertinent Process Units include:
a. Chemical energy potential (Material Factor)
b. Quantity of hazardous material in the Process Unit
c. Capital density (dollars per square foot)
d. Process pressure and process temperature
e. Past history of problems that resulted in a fire and explosion incident
f. Units critical to plant operation, i.e., thermal oxidizer

Generally, the greater the magnitude of any of these factors, the greater the likelihood that the process unit needs to be evaluated.

The destruction of scarce, critical or one-of-a-kind equipment in or near a process area could produce many days of downtime. Even with minimal fire and explosion damage, this could create large losses due to business interruption. The loss of such critical equipment is a valid reason for selecting a Pertinent Process Unit.

There are no hard and fast rules governing the choice of Process Units for evaluation. For help in determining which pieces of equipment have the greatest potential for fire and explosion, consult with Technology Centers, experienced plant engineers, process safety and loss prevention specialists or others with process experience.

Important Considerations

A. The Fire and Explosion Index system assumes that a process unit handles a minimum of 5,000 lb (2,268 kg), or about 600 gal (2.27 m^3) of a flammable, combustible or reactive material. If less material is involved, generally the ***risk will be overstated.*** However, F&EI calculations can provide meaningful results for pilot plants if they handle at least 1,000 lb (454 kg) or about 120 gal (0.454 m^3) of combustible or reactive material.

B. Careful consideration is needed when equipment is arranged in series and the items are ***not*** effectively isolated from each other. An example would be a reaction train without an intermediate pump. In such situations, the type of process determines whether several vessels or just a single vessel should be considered as the Process Unit.

In a polystyrene train, for example, where the main hazard is from unreacted material in the first stage reactor, it is inappropriate to apply any penalties for vacuum operation in the flash tank or devolatilizer (which is effectively the third or fourth stage) because ***it is inconceivable to have both hazards occurring at the same point in the process.*** In this case, it would be reasonable to carry out two separate F&EI calculations, treating the first stage and fourth stage reactors as separate Process Units.

It should rarely be necessary to calculate the F&EI for more than three or four Process Units in a single process area of a Manufacturing Unit. The number of Process Units will vary according to the type of process and the configuration of the Manufacturing Unit.

A separate F&EI form (pages 5 and 6) must be completed for each process unit evaluated. The results of each calculation must also be listed on the Manufacturing Unit Risk Analysis Summary (page 7).

C. It is also important to give careful consideration to the state or point in time of the operation. By their nature, such normal stages as start-up, steady-state operation, shutdown, filling, emptying, adding catalyst, etc., often create unique conditions having an impact on the F&EI. Generally, good judgment will enable selection of the point in time of operation to perform the F&EI calculation. Occasionally more than one point in time will have to be studied to determine the significant risk.

DETERMINATION OF MATERIAL FACTOR

The Material Factor (MF) is the basic starting value in the computation of the F&EI and other risk analysis values. The MF is a measure of the intrinsic rate of potential energy release from fire or explosion produced by combustion or chemical reaction.

The MF is obtained from N_F and N_R. The N_F and N_R are NFPA ratings or "signals" expressing flammability and reactivity (or instability) respectively, as discussed below under "Unlisted Substances."

Generally, N_F and N_R are for ambient temperatures. It is recognized that the fire and reaction hazards of a material increase markedly with temperature. The fire hazard from a combustible liquid at a temperature above its flash point is equivalent to that from a flammable liquid at ambient temperature. Reaction rates also increase very markedly with temperature. If the temperature of the material on which the MF is based is over 140 °F (60 °C), a certain adjustment may be required, as discussed below under C. "Temperature Adjustment of Material Factor."

Appendix A provides a listing of MFs for a number of chemical compounds and materials, and these values will be used in most cases. If Appendix A does not list the material, N_F and N_R may possibly be found in NFPA 325M or NFPA 49 adjusted for temperature, if appropriate, and used with Table I to determine the MF. If the material is a combustible dust, use the Dust Hazard Class Number (St number) rather than the N_F.

A. **Unlisted Substances**

If neither Appendix A, NFPA 49, nor NFPA 325M contains values for the substance, mixture or compound in question, these values will have to be determined from the flammability value (N_F) or dust class (St) (see Table I, page 13.). First, the parameters shown in the left column of the table on page 13 will have to be determined. The N_F of liquids and gases is obtained from flash point data, and the St of dusts or mists is determined by dust explosion testing. The N_F of combustible solids depends on the nature of the material as categorized in the left column.

The reactivity value (N_R) can be obtained from a qualitative description of the instability (or reactivity with water) of the substance, mixture or compound at ambient temperature, as follows based on NFPA 704:

$N_R = 0$ Materials that in themselves are normally stable, even under fire conditions. This degree usually includes:

- Materials that do not react with water;
- Materials that exhibit an exotherm at temperatures >300 °C (572 °F) but ≤500 °C (932 °F) when tested by Differential Scanning Calorimeter (DSC);
- Materials that do not exhibit in exotherm at temperatures ≤500 °C (932 °F) when tested by DSC.

$N_R = 1$ Materials that in themselves are normally stable but that can become unstable at elevated temperatures and pressures. This degree usually includes:

- Materials that change or decompose on exposure to air, light or moisture;
- Materials that exhibit an exotherm at temperatures >150 °C (302 °F), but ≤300 °C (572 °F).

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$N_R = 2$ Materials that readily undergo violent chemical change at elevated temperatures and pressures. This degree usually includes:

- Materials that exhibit an exotherm at temperatures ≤150 °C (302 °F) when tested by DSC;
- Materials that may react violently with water or form potentially explosive mixtures with water.

$N_R = 3$ Materials that in themselves are capable of detonation of explosive decomposition or explosive reaction but that require a strong initiating source or that must be heated under confinement before initiation. This degree usually includes:

- Materials that are sensitive to thermal or mechanical shock at elevated temperatures and pressures;
- Materials that react explosively with water without requiring heat or confinement.

$N_R = 4$ Materials that in themselves are readily capable of detonation of explosive decomposition or explosive reaction at normal temperatures and pressures. This degree usually includes materials that are sensitive to localized thermal or mechanical shock at normal temperatures and pressures.

Note that reactivity includes self-reactivity (instability) and reactivity with water.

A guideline for the reactivity value (N_R) is looking at the peak temperature of the lowest Differential Thermal Analysis (DTA) or Differential Scanning Calorimeter (DSC) exotherm value as follows:

Exotherm, °C	Exotherm, °F	N_R
>300 to ≤500	>572 to ≤932	0
>150 to ≤300	>302 to ≤572	1
≤150	≤302	2, 3, & 4

A couple of additional qualifiers are:

1. If the substance or compound is an oxidizer, increase N_R by one (but not over $N_R = 4$).
2. Any shock-sensitive material should be $N_R = 3$ or 4.
3. If the N_R obtained seems inconsistent with known properties of the substance, mixture or compound, additional reactive chemicals testing should be done.
4. Assistance in interpreting the significance of DSC or DTA data can be obtained from the site Reactive Chemicals contact person.

Once the N_F or St has been obtained and determined, the N_R, the resulting N_F (or St) and N_R are used with Table 1 to determine the MF. Make the necessary adjustments as discussed below under "Temperature Adjustment of Material Factor."

B. Mixtures

Mixtures of various kinds can be troublesome under certain conditions. Normally, materials that react violently – for example, fuel and air or hydrogen and chlorine – are mixed under controlled conditions. The reactions generally take place continuously and rapidly, producing nonflammable, stable products that are safely contained within a process unit such as a reactor. The combustion of fuel and air in a furnace is a good example of this sort of controlled reaction. However, since "flame-outs" and other breakdowns can still occur, the MF should be based on the initial reactive mixture, which fits the description of "most hazardous material present during a realistic operating scenario." For additional information see Appendix B, page 72.

Mixtures of solvents or of a solvent with a reactive material can also create troublesome situations. The best MF for mixtures should be obtained from reactive chemical testing data, as recommended in Appendix B. If reactive chemical testing data is not available, an approximation can be obtained by using the MF of the component with the highest MF value. This component should be one of significant concentration such as 5% or more.

One particularly troublesome mixture is the "hybrid." This is a mixture of combustible dust and flammable gas, which can form an explosive mixture in air. The Material Factor must adequately reflect the material hazard present in this ***unique situation***, and reactive chemical testing data ***must*** be employed to determine the proper MF. It is recommended that a reactive chemicals specialist be consulted.

C. Mists

One special condition can lead to explosions similar to having a flammable or combustible vapor above its flash point. A suspension of finely divided drops of flammable or combustible liquid in air can give a flammable mixture that has many of the characteristics of a flammable gas/air mixture. Mists of flammable or combustible liquids at temperatures well below their flash points can be as explosive as flammable vapor/air mixtures. For example, for suspensions in which the droplet diameter is less than 0.01 mm (0.0004 in), the lower flammability limit of the suspension is nearly the same at ambient temperature as that of the substance at its flash point.

It is important that mists not be processed inside enclosed process structures because flammable concentrations are more easily attained and overpressures from explosions can result in structural damage.

The best defense against mist explosions is to avoid the conditions where a mist will form. If a mist is possible, the material factor can be raised one step (ref. Table 1, page 13) to account for the increased risk, and it is also recommended that a loss prevention specialist be consulted.

TABLE 1

MATERIAL FACTOR DETERMINATION GUIDE

		Reactivity or Instability				
Liquids & Gases Flammability or Combustibility[1]	NFPA 325M or 49	$N_R = 0$	$N_R = 1$	$N_R = 2$	$N_R = 3$	$N_R = 4$
Non-combustible[2]	$N_F = 0$	1	14	24	29	40
F.P. > 200 °F (> 93.3 °C)	$N_F = 1$	4	14	24	29	40
F.P. > 100 °F (> 37.8 °C) ≤ 200 °F (≤ 93.3 °C)	$N_F = 2$	10	14	24	29	40
F.P. ≥ 73 °F (≥ 22.8 °C) < 100 °F (< 37.8 °C) or F.P. < 73 °F (< 22.8 °C) & BP. ≥ 100 °F (≥ 37.8 °C)	$N_F = 3$	16	16	24	29	40
F.P. < 73 °F (< 22.8 °C) & B.P. < 100 °F (< 37.8 °C)	$N_F = 4$	21	21	24	29	40
Combustible Dust or Mist[3]						
St-1 (K_{St} ≤ 200 bar m/sec)		16	16	24	29	40
St-2 (K_{St} = 201-300 bar m/sec)		21	21	24	29	40
St-3 (K_{St} > 300 bar m/sec)		24	24	24	29	40
Combustible Solids						
Dense > 40 mm thick[4]	$N_F = 1$	4	14	24	29	40
Open < 40 mm thick[5]	$N_F = 2$	10	14	24	29	40
Foam, fiber, powder, etc.[6]	$N_F = 3$	16	16	24	29	40

F.P. = Flash Point, closed cup   B.P. = Boiling Point at Standard Temperatures and Pressure (STP)

Notes:

[1]Includes volatile solids.

[2]Will not burn in air when exposed to a temperature of 1500 °F (816 °C) for a period of five minutes.

[3]K_{St} values are for a 16 liter or larger closed test vessel with strong ignition source. See NFPA 68, *Guide for Venting of Deflagrations*.

[4]Includes wood – 2 inches nominal thickness, magnesium ingots, tight stacks of solids and tight rolls of paper or plastic film. Example: SARAN WRAP®.

[5]Includes coarse granular material such as plastic pellets, rack storage, wood pallets and non-dusting ground material such as polystyrene.

[6]Includes rubber goods such as tires and boots, STYROFOAM® brand plastic foam and fine material such as METHOCEL® cellulose ethers in dust/leak-free packages.

D. **Temperature Adjustment of Material Factor**

It is important to recognize that the MF represents the hazard of the selected material at **ambient temperature** and **pressure**. If the material has a flash point less than 140 °F (60 °C) or exhibits reactivity at temperatures less than 140 °F (60 °C), no adjustment is required. This is because the flammability and reactivity hazard have already been incorporated in the Material Factor. The effect of pressure is discussed in detail later under "Special Process Hazards." If the Process Unit temperature is above 140 °F (60 °C), the MF itself will require adjustment. If the material is above its flash point at ambient temperature, the material factor is not adjusted. The temperature adjustment of the material factor is determined using Table 2:

TABLE 2

MATERIAL FACTOR TEMP. ADJUSTMENT	N_F	St	N_R
a. Enter N_F (St for dusts) and N_R.			
b. If temperature less than 140 °F (60 °C), go to "e."			
c. If temperature above flash point or if temperature greater than 140 °F (60 °C), enter "1" under N_F.			
d. If temperature above exotherm start (see paragraph below) or autoignition, enter "1" under N_R.			
e. Add each column, but enter 4 where total is 5.			
f. Using "e." and Table I, determine Material Factor (MF) and enter on F&EI Form (page 5) and Manufacturing Unit Risk Analysis Summary (page 7).			

Note: 140 °F (60 °C) can be reached in storage due to layering and solar heat.

Flash point and autoignition data are generally available and understood, but **"Exotherm Start"** requires explanation. **Exotherm Start** is the temperature at which a heat-generating chemical reaction is first detected in Accelerating Rate Calorimetry (ARC) or similar calorimeter. **Exotherm Start** can be estimated from data secured by Differential Thermal Analysis (DTA) or Differential Scanning Calorimetry (DSC) either by:

a. subtracting 70 °C (126 °F) from the first exotherm start temperature or
b. subtracting 100 °C (180 °F) from the first exotherm peak temperature.

The use of "a." is preferred. Of course, if the "real" exotherm start temperature is known from operating experience (with a reactor in a plant, for example), the "real" temperature should be used. Consultation with a reactive chemicals testing person can be of great help in interpreting test data.

If the Process Unit is a reactor, the exotherm from the intended reaction is disregarded for purposes of temperature adjustment due to reactivity. This is because the various reaction penalties take this into account.

Example:

DOWTHERM®, a heat transfer fluid, has a flash point of 255 °F (124 °C) and an autoignition temperature of 1150 °F (621 °C). It has no DSC exotherm below 752 °F (400 °C) (the usual limit of testing). When in drums in storage, it has an MF of 4 (N_F = 1 and N_R = 0). When used as a solvent above 140 °F (60 °C), the MF is still 4 up to 255 °F (124 °C). When it is used at temperatures above its flash point of 255 °F (124 °C), its N_F is increased to 2, making MF = 10.

PROCESS UNIT HAZARDS FACTORS

After the appropriate Material Factor has been determined, the next step is to calculate the Process Unit Hazards Factor (F_3), which is the term that is multiplied by the Material Factor to obtain the F&EI.

The numerical value of the Process Unit Hazards Factor is determined by first determining the General Process Hazards Factor and Special Process Hazards Factor listed on the F&EI form. Each item which contributes to the Process Hazards Factors contributes to the development or escalation of an incident that could cause a fire or an explosion.

When calculating the penalties comprising the Process Unit Hazards Factor, F_3, pick a single specific instant in time during which the material under consideration is in the most hazardous **normal operation state** associated with the Process Unit. Startup, continuous operation and shutdown are among the operational states that may be considered.

This rather strict definition is intended to prevent double or triple counting of hazards occurring during the process. Since the MF is taken to be that of the most hazardous substance present in the Process Unit, it can be certain that the Fire and Explosion analysis will really be based upon a "worst case" when focus is placed on the most hazardous operational point involving the MF, and this will be a realistic worst case — one that could actually occur.

In the F&EI system, only one hazard may be evaluated at a time. If the MF is based on a flammable liquid present in the Process Unit, ***do not take penalties relating to combustible dusts***, even though dust may be present at a different time. A reasonable approach might be to evaluate the Process Unit once using the MF of the flammable liquid and a second time using the MF of the dust. Only the calculation resulting in the highest F&EI and Actual Maximum Probable Property Damage need to be reported.

One important exception is the hybrid, described previously under "Mixtures." If a hybrid mixture is selected as the most hazardous material present, it is penalized both as a dust and as a flammable vapor in the Process Unit Hazards Factor sections of this manual.

Some items on the F&EI form have fixed penalty values. For those that do not, determine the appropriate penalty by consulting the text that follows. ***Remember – analyze only one hazard at a time***, relating the analysis to a specific, most hazardous time (e.g., startup, normal operation or shutdown). Keep the focus on the Process Unit and Material Factor selected for analysis and keep in mind that the results of the final calculation are only as valid as the appropriateness of the penalty assessments.

GENERAL PROCESS HAZARDS

General Process Hazards are factors that play a primary role in determining the magnitude of a loss incident.

The six items listed in this section as contributing hazards are applicable to most process situations. Although it may not be necessary to take penalties for each part of this section, these items have historically played large roles in fire and explosion incidents, and careful evaluation of the particular Process Unit in question is of paramount importance.

Remember, to evaluate the exposure risk of any Process Unit realistically, each General Process Hazard Penalty must be applied under the most hazardous normal operating conditions that might occur during the association of a specific Material Factor with the Process Unit being analyzed.

A. Exothermic Chemical Reactions

Take this penalty only if the Process Unit in question is a reactor in which a chemical reaction takes place. The reactivity hazard of the material being evaluated is inherent in the Material Factor.

1. MILD EXOTHERMS require a **penalty of 0.30**. Examples include:
   a. **Hydrogenation** – Addition of hydrogen atoms to both sides of a double or triple bond.
   b. **Hydrolysis** – Reaction of a compound with water, as in the manufacture of sulfuric or phosphoric acids from oxides.
   c. **Isomerization** – Rearrangement of the atoms of an organic molecule such as a change from a straight chain to a branched molecule.
   d. **Sulfonation** – Introduction of an SO_3H radical into an organic molecule through reaction with H_2SO_4.
   e. **Neutralization** – Reaction between an acid and a base to produce a salt and water or of a base and an alcohol to produce the corresponding alcoholate and water.
2. MODERATE EXOTHERMS require a **penalty of 0.50**. Examples include:
   a. **Alkylation** – Addition of an alkyl group to a compound to form various organic compounds.
   b. **Esterification** – Reaction between an organic acid and an alcohol.
   c. **Addition reactions** – Reactions occurring between inorganic acids and unsaturated hydrocarbons. When the acid is a strongly reactive material, **increase the penalty to 0.75.**
   d. **Oxidation** – Combination of substances with oxygen by combustion, releasing CO_2 and H_2O or a controlled reaction of some substances with oxygen that does not result in CO_2 and H_2O. For combustion processes and where vigorous oxidizing agents such as chlorates, nitric acid, hypochlorous acids and salts are used, **increase the penalty to 1.00.**
   e. **Polymerization** – Joining together of molecules to form chains or other linkages.
   f. **Condensation** – Joining together of two or more organic molecules with the splitting off of H_2O, HCl or other compounds.
3. CRITICAL-TO-CONTROL EXOTHERMS require a **penalty of 1.00**. These are a class of reactions in which a significant fire and explosion potential would exist if control was lost. Example:
   a. **Halogenation** – Introduction of a halogen or halogens into an organic molecule.
4. PARTICULARLY SENSITIVE EXOTHERMS, which are quite hazardous exothermic reactions, require a **penalty of 1.25**. Example:
   a. **Nitration** – The replacement of a hydrogen atom in a compound with a nitro group.

B. Endothermic Processes

A **penalty of 0.20** is taken for any endothermic process taking place in a reactor. ***Note: This penalty applies only to reactors.*** When the energy input for the endothermic process is provided by the combustion of a solid, liquid or gaseous fuel, the **penalty is increased to 0.40.** Examples include:

1. **Calcination** – Heating a material to remove chemically bonded water or other volatile material. This generally requires a **penalty of 0.40.**
2. **Electrolysis** – Separation of ions by means of an electric current. This generally requires a **penalty of 0.20.**
3. **Pyrolysis** or **Cracking** – Thermal decomposition of molecules to smaller ones by use of high temperatures, high pressures and/or a catalyst. The **penalty is 0.20** for electric or remote hot gas heat or **0.40** for direct fired heat.

C. Material Handling and Transfer

This item is evaluated with regard to the potential for fire involving the pertinent Process Unit during the handling, transfer and warehousing of materials.

1. Any loading or unloading operation involving Class I flammables or LPG-type materials where transfer lines are connected and disconnected receives a **penalty of 0.50.**
2. Where the introduction of air during manual addition of some ingredients into centrifuges, batch reactors or batch mixers may create a flammability or reactivity hazard, a **penalty of 0.50** is applied. *Note:* These penalties apply whether or not the equipment vapor space is inerted.
3. Ranges of penalties based on material fire hazards are applied to warehouse storage or yard storage of various items.
   a. A **penalty of 0.85** is applied for $N_F = 3$ or 4 flammable liquids or gases. This category includes drums, cylinders, portable flexible containers and aerosol cans.
   b. A **penalty of 0.65** is applied for $N_F = 3$ combustible solids as identified in Table 1, page 13.
   c. A **penalty of 0.40** is applied for $N_F = 2$ combustible solids as identified in Table 1.
   d. A **penalty of 0.25** is taken for combustible liquids (closed cup flash point above 100 °F (37.8 °C) and below 140 °F (60 °C)).

   If any of the above are stored on racks without in-rack sprinklers, **add 0.20 to the penalty.** This area of consideration is not for normal storage tanks.

D. Enclosed or Indoor Process Units

The maintenance of open and freely ventilated construction for areas in which flammable liquids and gases are processed will permit rapid dissipation of any vapors released, thereby reducing the explosion potential of the unit. Dust collectors and filters should also be located in an open area away from other equipment.

An enclosed area is identified as any roofed area with three or more sides or an area enclosed by a roofless structure with walls on all sides.

Even properly designed mechanical ventilation is not as effective as open construction; but if a mechanically ventilated system is designed in such a way that all flammables are collected and dispersed, the penalty can be reduced.

The penalty categories are as follows:

1. When dust filters or collectors are located inside an enclosed area, a **penalty of 0.50** is applied.
2. Any process in which flammable liquids are handled at temperatures above their flash point in an enclosed area receives a **penalty of 0.30.** For quantities of liquid in excess of 10M lb. (= 1,000 gallons), a **penalty of 0.45** is used.
3. Any process in which liquefied petroleum gas (LPG) or any flammable liquids are handled at temperatures above their boiling point within an enclosed area **requires** a **penalty of 0.60.** For quantities of liquid in excess of 10,000 lb (4,535 kg) (= 1,000 gal)[3.785 m^3], a **penalty of 0.90** is used.
4. Where properly designed mechanical ventilation has been installed, the **penalties** listed in 1. and 3. above may be **reduced by 50%.**

E. Access

Emergency equipment must have ready access to the area housing the pertinent Process Unit. Access from at least two sides is considered the "Minimum Requirement." **Strong consideration** should be given to this penalty for major Process Units located in enclosed areas.

At least one of the access approaches must be from a roadway. A monitor nozzle that would remain easily accessible and operational during a fire could be considered a second access.

All process areas over 10,000 ft^2 (925 m^2) not having adequate access receive a **penalty of 0.35.** All warehouses over 25,000 ft^2 (2,312 m^2) not having adequate access receive a **penalty of 0.35.**

For areas smaller than those listed above, judgment must be used in assessing the access requirement. Such areas **may be penalized 0.20** if sound engineering judgment indicates the potential for fire control problems due to inadequate access.

F. Drainage and Spill Control

This section lists penalties for design conditions that could cause large spills of flammable or combustible liquids to be retained around or near process equipment. Inadequate design of drainage has been a contributing factor in a large number of losses involving liquid spills.

These penalties are to be applied only if the material in the Process Unit has a flash point below 140°F (60 °C) or if the material is being processed above its flash point.

To evaluate the adequacy of drainage and spill control, it is necessary to estimate the combined volume of flammable/combustible material as well as fire fighting water that would have to be safely drained away or handled in an actual incident.

1. The F&EI calculation of drainage capacity will be based on the following guidelines:
   a. For process and storage facilities, use 100% of the unit's largest tank capacity plus 10% of the next largest tank.
   b. Assume 30 minute flow rate of fire fighting water. (i.e., 30 min x gpm = gal fire water) [Assume 60 min flow rate for agricultural chemicals or environmentally harmful chemicals - see LPP 4.5.6. Discuss with the site environmental contact person.]

   Enter the sum of a. and b. above into the appropriate space under General Process Hazards — Item 1.F on page 5.

2. Penalty Selection:
   a. Diking, which is designed to prevent a spill from going to other areas but exposes all the equipment within the dike, receives a **penalty of 0.50.**
   b. Generally, a flat area around the process unit will allow spills to spread out, exposing large areas to fire if ignited. A **penalty of 0.50** is required for this situation.
   c. A diking design that surrounds three sides of an area and directs spills to an impounding basin or non-exposing drainage trench receives **no penalty** if the following criteria are met:
      i. Slope to basin or trench is a minimum of 2% for earthen surfaces or 1% for hard surfaces.
      ii. Distance to equipment from nearest edge of trench or basin is at least 50 ft (15 m). This distance can be reduced if a fire wall is installed.
      iii. The impounding basin must have the capacity at least equal to the sum of 1.a. and 1.b. above.
   d. If a basin or trench exposes utility lines or does not meet the distance requirements, a **penalty of 0.50** is applied.

In short, excellent drainage is required if penalties are to be avoided.

Once all of the general process hazards have been evaluated, a calculation is to be made of the sum of the base factor and all penalty factors applied in this section on General Process Hazards. The total is to be entered in the box labeled "General Process Hazards Factor (F_1)" on the F&EI Form, page 5.

SPECIAL PROCESS HAZARDS

Special process hazards are factors that contribute primarily to the probability of a loss incident. They consist of specific process conditions that have shown themselves to be major causes of fire and explosion incidents. There are twelve items listed in this section as follows:

A. Toxic Material(s)

Toxic materials can complicate the response of emergency personnel, thereby reducing their ability to investigate or mitigate damage during an incident. **Use 0.20 x N_H as the penalty.** For mixtures, use the component with the highest N_H.

N_H is the health factor of a material as defined in NFPA 704 or given in NFPA 325M or NFPA 49. The N_H for many materials may be found in Appendix A. An Industrial Hygiene Specialist can be of assistance in determining a N_H for new materials.

Listed below is a summary of N_H value definitions from NFPA 704:

N_H = 0 Materials that on short exposure under fire conditions would offer no hazard beyond that of ordinary combustible materials.
N_H = 1 Materials that on short exposure could cause irritation but only minor residual injury, including those requiring the use of an approved air-purifying respirator.
N_H = 2 Materials that on intense or short exposure could cause temporary incapacitation or possible residual injury, including those requiring the use of respiratory protective equipment that has an independent air supply.
N_H = 3 Materials that on short exposure could cause serious temporary or residual injury, including those requiring protection form all bodily contact.
N_H = 4 Materials that on very short exposure could cause death or major residual injury,

Note: These factors are intended to represent emergency response limitations which can cause additional loss. They are not intended to be applied as industrial hygiene or environmental considerations.

B. Sub-Atmospheric Pressure

This section applies to a process condition where air leakage in a system could create a hazard. A hazard may result from air contact with moisture-sensitive or oxygen-sensitive materials or from the formation of flammable mixtures upon the introduction of air. This penalty is applied only if the absolute pressure is less than 500 mm Hg (equivalent to 10 in Hg vacuum). **The penalty is 0.50.**

If the penalty is applied, do not duplicate or repeat the penalty specified in Section C below, "Operation In or Near Flammable Range," or in Section E, "Relief Pressure."

Most stripping operations, some compressor operations and a few distillation operations are the major Process Units penalized in this category.

C. Operation In or Near Flammable Range

There are certain operating conditions which can cause air to enter and be entrained into the system. The introduction or entry of air could lead to the formation of a flammable mixture and create a hazard. This section is intended to cover the following conditions for flammable and combustible liquids:

1. Tank storage of N_F = 3 or 4 flammable liquids, where air can be breathed into the tank during pump-out or sudden cooling of the tank. The **penalty is 0.50.**
   Open vent or non-inert gas padded operating pressure-vacuum relief system would require a **penalty of 0.50.**
   Storage of combustible liquids at temperatures above their closed cup flash points without inerting would also require a **penalty of 0.50.**
   If an inerted, closed vapor recovery system is used and its air-tightness can be assured, **no penalty is applied**. See next paragraph.
2. Process equipment or process storage tanks that could be in or near the flammable range only in the event of instrument or equipment failure would require a **penalty of 0.30.**
   Any process unit that relies on inert purge to keep it out of the flammable range requires a **penalty of 0.30**. This penalty also applies to padded barges or tank cars. No penalty is applied here if the penalty specified in B., "Sub-Atmospheric Pressure" has already been taken.
3. Processes or operations that are by nature always in or near the flammable range, either because purging is not practical or because it was elected not to purge, receive a **penalty of 0.80.**

D. Dust Explosion

The maximum rate of pressure rise and maximum pressure generated by a dust are largely influenced by the particle size. In general, the finer the dust, the greater the hazard because of the rapid rate of pressure rise and maximum pressures attained.

The penalties listed in this section are intended to apply to any Process Unit involving dust handling operations: transferring, blending, grinding, bagging, etc.

All dusts have a particle size range. For determination of the penalty, **use the 10% size**; that is, the particle size at which 90% of the dust is coarser and 10% is finer. See Table 3 for appropriate penalties.

Unless dust explosion testing has shown that no dust explosion hazard exists, dust penalties should be applied.

TABLE 3

DUST EXPLOSION PENALTY		
Particle Size Microns	**Tyler Mesh Size**	**Penalty** (Use 1/2 if in an inert gas)
175+	60 to 80	0.25
150 to 175	80 to 100	0.50
100 to 150	100 to 150	0.75
75 to 100	150 to 200	1.25
<75	>200	2.00

E. Relief Pressure

Where operating pressures are above atmospheric, a penalty is applied for the higher release rates caused by higher pressure in the event of a leak. The concern is the possibility of failure of some component in the Process Unit causing the release of flammable materials.

Example:

The release of hexane liquid through a one-square-inch (6.5 cm^2) orifice at 75 psig (517 kPa gauge) would be almost 600 lb/min (272 kg/min). At 300 psig (2,069 kPa gauge), the release would be 2-1/2 times as great or 1,500 lb/min (680 kg/min). The relief pressure penalty evaluates the specific spill hazard potential at different pressure levels. Relief pressure also affects dispersion characteristics.

Since the spill potential greatly increases at higher pressures, equipment design and maintenance become more critical as the operating pressure increases.

Systems operating at pressures above 3,000 psig (20,685 kPa gauge) are outside the range of standard codes (ASME Code for Unfired Pressure Vessels, Section VIII, Division 1). For such systems, lens ring joints, cone seals or equivalent closures must be used in flange design.

To determine the appropriate penalty, consult Figure 2, page 23, and use the operating pressure to determine an initial penalty value. The equation below applies from 0 to 1,000 psig (0 to 6,895 kPa gauge).

$$Y = 0.16109 + \frac{1.61503X}{1000} - 1.42879\left(\frac{X}{1000}\right)^2 + 0.5172\left(\frac{X}{1000}\right)^3 \quad \text{or}$$

Y = 0.16109 + 1.61503*(X/1000) – 1.42879*(X/1000)^2 + 0.5172*(X/1000)^3

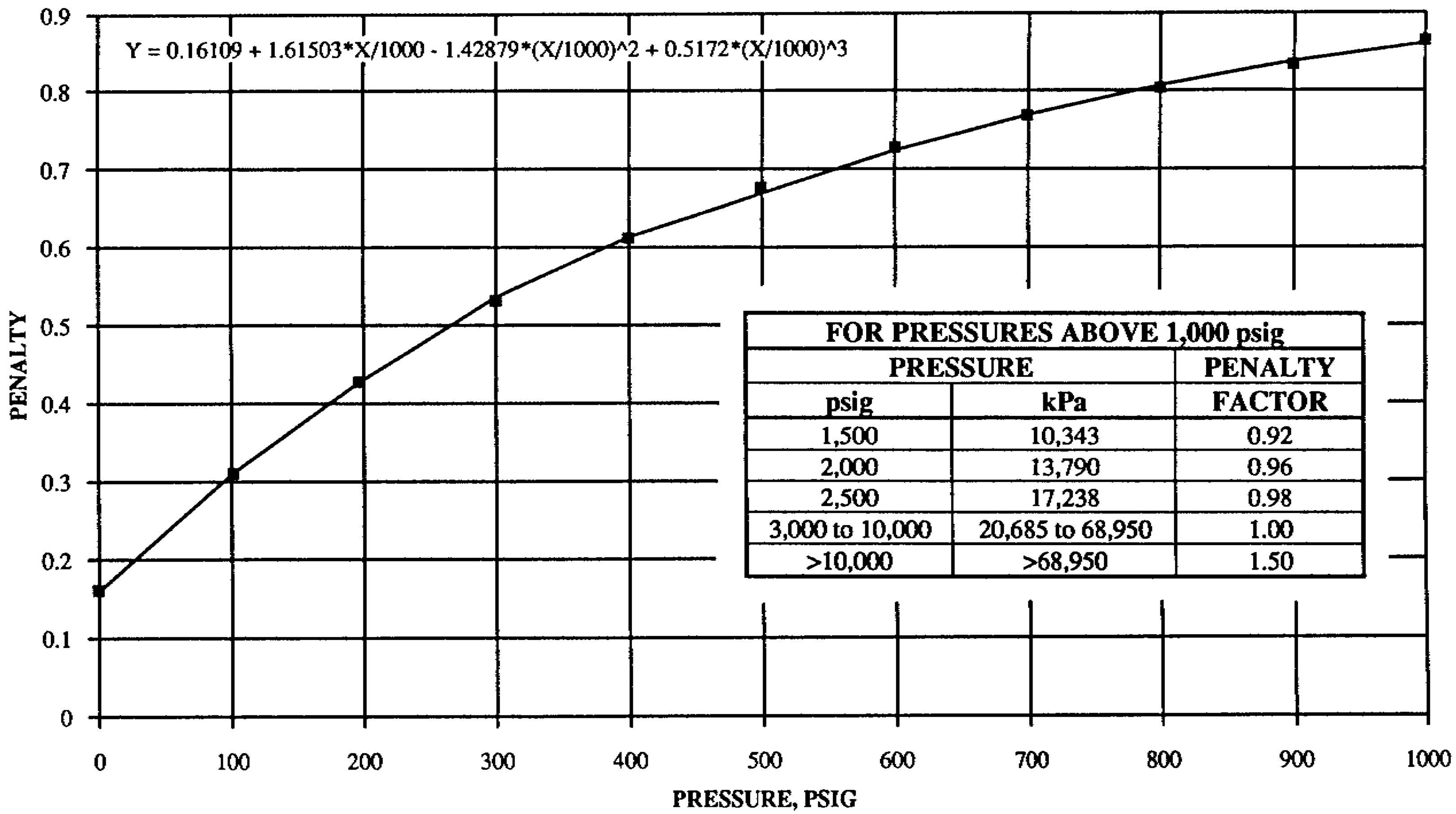
For pressures from 0 to 1,000 psig (0 to 6,895 kPa gauge) determine the penalty from Table 4 below (also included in Figure 2, page 23):

TABLE 4

HIGH PRESSURE PENALTY FOR FLAMMABLE & COMBUSTIBLE LIQUIDS		
Pressure psig	Pressure kPa gauge	Penalty
1,000	6,895	0.86
1,500	10,343	0.92
2,000	13,790	0.96
2,500	17,238	0.98
3,000 to 10,000	20,685 to 68,950	1.00
> 10,000	> 68,950	1.50

The curve in Figure 2 can be used directly to determine penalties for flammable and combustible liquids with a flash point below 140 °F (60 °C). For other materials, the penalty provided by the curve must be adjusted as follows:

FIGURE 2 - PRESSURE PENALTY FOR FLAMMABLE & COMBUSTIBLE LIQUIDS



FOR PRESSURES ABOVE 1,000 psig		
PRESSURE		PENALTY
psig	kPa	FACTOR
1,500	10,343	0.92
2,000	13,790	0.96
2,500	17,238	0.98
3,000 to 10,000	20,685 to 68,950	1.00
>10,000	>68,950	1.50

For kPa multiply by 6.895.

1. For highly viscous materials such as tars, bitumen, heavy lubricating oils and asphalts, multiply the penalty by 0.70.
2. For compressed gases used alone or flammable liquids pressurized with any gas above 15 psig (103 kPa gauge), multiply the penalty by 1.2.
3. For liquefied flammable gases (including all other flammable materials stored above their boiling point), multiply the penalty by 1.3.

There is no penalty for extrusion and molding operations.

To determine the final penalty, first find the penalty associated with the operating pressure from Figure 2. Then find the penalty associated with the set pressure of the relief device. Divide the operating pressure penalty by the set pressure penalty to get a final pressure penalty adjustment factor. Multiply the operating pressure penalty by this adjustment factor to get the final pressure penalty. Thus, credit is given for having a relatively high set pressure and vessel design pressure.

Note that it is often advantageous to set the relief pressure close to the vessel design pressure. For example, reactions in a volatile solvent, especially if a gassy, unwanted higher temperature reaction can be avoided by setting the relief pressure so that the solvent can boil and remove heat before the higher temperature is reached. Computer simulation is generally used, based on reactive chemicals or other kinetic data, to decide whether a low relief pressure is desirable. However, this is not always desirable in some reactive systems.

For some special situations, it is advantageous to increase the design pressure of a pressure vessel to minimize the likelihood of release and in some special cases perhaps containment of the maximum expected pressure can be obtained.

See the following example of a vessel holding a viscous material.

Example:

Vessel design pressure is 150 psig (1,034 kPa gauge)
Normal operation is at 100 psig (690 kPa gauge)
Rupture disk is set at 125 psig (862 kPa gauge)

From Figure 2, the 100 psig (690 kPa gauge) operating pressure has a penalty of 0.31 and 125 psig (862 kPa gauge) set pressure has a penalty of 0.34.

Viscous materials receive an adjustment of 0.7, so the penalty becomes:

0.31 X 0.7 = 0.22 adjusted penalty

The final penalty is determined by multiplying this penalty by the pressure adjustment factor:

0.22 X (0.31/0.34) = 0.20 = final penalty

See the second example of an emulsion polymerization reactor showing the difference between a low and a high design pressure.

Examples:

A.	Reactor design pressure is 150 psig (1,034 kPa gauge) Normal operating is at 120 psig (827 kPa gauge) Relief device set pressure at 150 psig (1,034 kPa gauge)

From Figure 2, the operating pressure penalty is 0.34. The set pressure penalty of 0.37. The pressure adjustment factor is 0.34/0.37. The final penalty is:

0.34 X (0.34/0.37) = 0.312 = final penalty

B.	Reactor design pressure is 300 psig (2,068 kPa gauge) Normal operating is at 120 psig (827 kPa gauge) Relief device set pressure at 300 psig (2,068 kPa gauge)

From Figure 2, the operating pressure penalty is 0.34. The set pressure penalty of 0.53. The pressure adjustment factor is 0.34/0.53. The final penalty is:

0.34 X (0.34/0.53) = 0.218 = final penalty

F. Low Temperature

This section makes allowances for the possible brittleness of carbon steel or other metals that may be exposed to temperatures at or below their ductile/brittle transition temperatures. If a careful evaluation has been made and no possibility of temperatures below the transition temperature exists due to normal and abnormal operating conditions, no penalty is applied. It would be very rare to have a vessel designed with this potential. New vessel design would avoid the low temperature hazard.

The usual method of determining the transition temperature is to test samples of the metal used in the fabrication of the Process Unit, using a standard Charpy Impact test to determine that the design and, therefore, operating temperature is above the transition temperature. Proper design should avoid these low temperature process conditions.

The following penalties are applied:

1. For processes utilizing carbon steel construction and operated at or below the ductile/brittle transition temperature, a **penalty of 0.30** is applied. If no data are available, a 50 °F (10 °C) transition temperature should be assumed.
2. For materials other than carbon steel where the operating temperature is at or below the transition temperature, use a **penalty of 0.20.** Remember that no penalty is applied if the material is appropriate for the lowest possible operating temperature.

G. Quantity of Flammable/Unstable Material

This section considers the additional exposure to an area as quantities of flammable and unstable material in the process unit are increased. There are three categories in this section, each evaluated by a separate penalty curve. Apply only one penalty for the entire section, based on the material that was selected as the Material Factor.

1. Liquids or Gases in Process (Figure 3, page 27).

This section applies a penalty to a quantity of material that might be spilled and create a fire hazard, or that might, on exposure to fire, create a reactive chemical event. The penalty applies to any process operation, including pumping into holding tanks, and is valid for the following materials when they are selected as the MF:

a. Flammable liquids and those combustible liquids with a flash point below 140 °F (60 °C).
b. Flammable gases.
c. Liquefied flammable gases.
d. Combustible liquids with closed cup flash points above 140 °F (60 °C) when the process temperature is above the flash point of the material.
e. Reactive materials regardless of their flammability (N_R = 2, 3 or 4).

In using this penalty section, the first task is to determine the pounds of materials in process.

The penalty is based upon the amount of fuel for a fire that can be released from the Process Unit or a connected line within 10 minutes. Common sense must be used in judging how much material might be released. Experience has shown that this amount can be reasonably estimated by taking the larger of the following:

i. The quantity of material in the Process Unit or
ii. The quantity of material in the largest connected unit.

Any connected unit that can be isolated by closure valves operable from a remote location in times of emergency is removed from consideration.

Before accepting this approximation of the quantity of material in process, the question to be asked is "What is the maximum probable quantity that could be spilled?" If, using good engineering judgment and familiarity with the process, it is determined that a number which is significantly different from the above, use the latter number, being sure to document its validity. Remember, ***good judgment and process familiarity*** will always lead to a more realistic approximation. Note, however, that if instability (reactivity) is involved, the quantity of concern is the quantity of material normally inside the Process Unit.

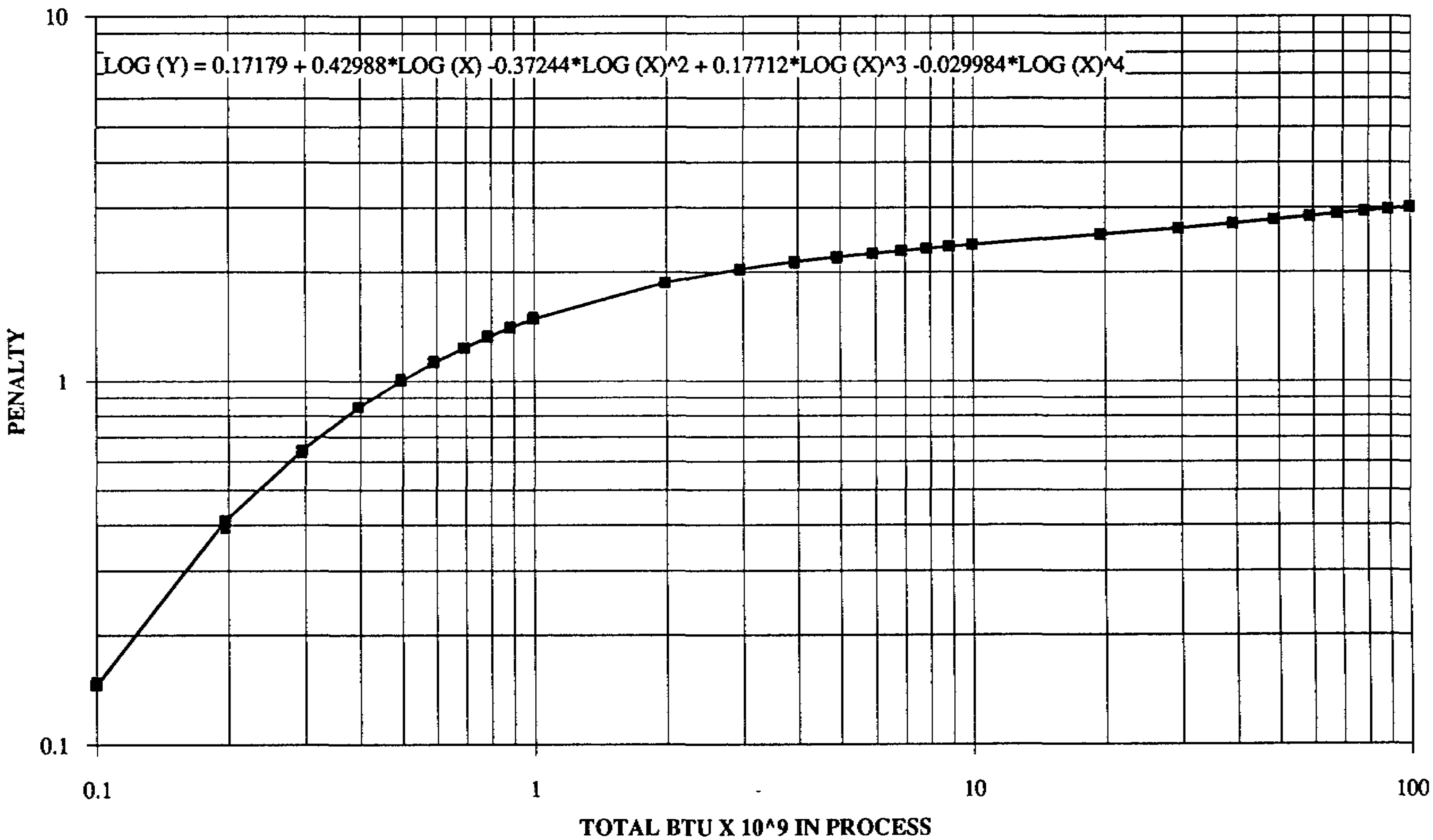
Example:

Charge drums, surge drums and reflux vessels are types of connected equipment that might possibly contain more material than the Process Unit being evaluated. However, if such vessels are equipped with remote-controlled shut off valves, they should not be considered as "vessels connected to a Process Unit."

Enter the appropriate quantity of flammable/unstable material on the space provided, Item "G" of Special Process Hazards, page 5.

To establish the value to be applied in using Figure 3, multiply the appropriate quantity of flammable/unstable material by a factor H_C (in BTU/lb) and obtain total BTU x 10^9. The factor H_C is the heat of combustion of the material. This can be taken from Appendix A or obtained from reactive chemical test data.

FIGURE 3 - LIQUIDS OR GASES IN PROCESS



For kcal multiply by 0.2520. For Joules (J) multiply by 1.05506 x 10^3.

The H_C for unstable materials (N_R of 2 or more) is taken as (1) six times the heat of decomposition or (2) the heat of combustion, whichever is larger. Heats of decomposition can also be obtained from reactive chemical test data.

Enter the factor H_C (BTU/lb) on the appropriate space, Item "G" of Special Process Hazards, page 5.

The penalty is determined by entering Figure 3 with the Process Unit energy content (BTU x 10^9). The point of intersection with the curve indicates the penalty. The equation for this plot to Total BTU x 10^9 in Process (X) versus Penalty (Y) is:

$$\log Y = 0.17179 + 0.42988(\log X) - 0.37244(\log X)^2 + 0.17712(\log X)^3 - 0.029984(\log X)^4 \quad \text{or}$$

logY = 0.17179 + 0.42988*logX – 0.37244*logX^2 + 0.17712*log X^3 – 0.029984*logX^4

2. Liquids or Gases in Storage (Outside the Process Area) (Figure 4, page 29)

Flammable and combustible liquids, gases or liquefied gases in storage outside the process area receive a lower penalty than those in the "in process" or 2. G.1 category (page 5), since there is no process involvement. Process involvement contributes to the probability of an incident. MF materials in the 2.G.2 (page 5) category include raw material feedstock in drums or tanks, material in tank farms and material in portable containers and containers.

This penalty is determined by entering Figure 4 with the total BTU (quantity of material in storage times a factor H_C) in any single storage vessel. In the case of portable containers, use the total quantity of material in all stored containers.

When two or more vessels are located in a common dike which would not drain into an adequately sized impounding basin, use the total BTU content of all the tanks within the dike to obtain the penalty from the curve in Figure 4.

Unstable materials should be evaluated in the same fashion as in 2.G.1 (page 5) taking as the H_C factor either (1) six times the heat of decomposition or (2) the heat of combustion (whichever is larger) and using Curve A of Figure 4 to determine the appropriate penalty.

Example:

Three vessels containing process chemicals (750,000 lb [340,100 kg] of styrene monomer, 750,000 lb [340,100 kg] of diethyl benzene and 600,000 lb [272,100 kg] of acrylonitrile) are located in a common dike that does not drain to an impounding basin.

Ambient storage temperature of 100 °F (38 °C) is assumed, and all H_C factors are taken as heats of combustion.

750,000 lb styrene X 17.4 X 10^3 BTU/lb	=	13.0 X 10^9 BTU
750M lb diethyl benzene X 18.0 X 10^3 BTU/lb	=	13.5 X 10^9 BTU
600M lb acrylonitrile X 13.7 X 10^3 BTU/lb	=	8.2 X 10^9 BTU
TOTAL BTU	=	34.7 X 10^9 BTU

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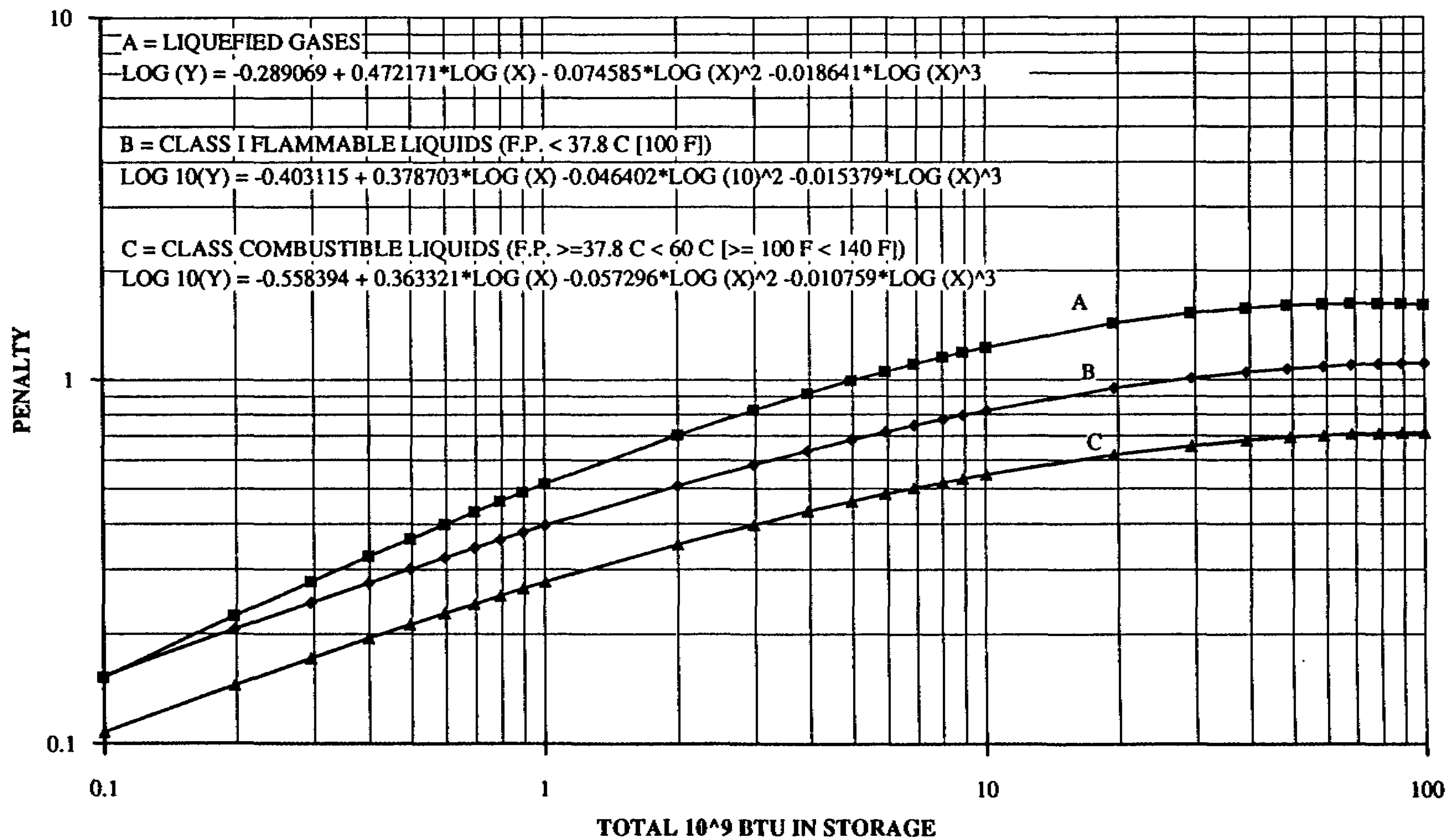
FIGURE 4 - LIQUIDS OR GASES IN STORAGE



For kcal multiply by 0.2520. For Joules (J) multiply by 1.05506 x 10^3.

Curves Indicated by the Materials

Styrene	Class I Flammable Liquid (Curve B, Figure 4)
Acrylonitrile	Class I Flammable Liquid (Curve B, Figure 4)
Diethyl Benzene	Class II Combustible Liquid (Curve C, Figure 4)

If more than one substance is being dealt with, use the TOTAL BTU and find the penalty shown at the point of intersection with the highest curve indicated for any individual material using Figure 4.

In this example, the highest curve referenced by a single material is Curve B and the appropriate **penalty is 1.00**. *Note:* NFPA 30 calls for subdivision by diking of these types of materials.

The equations for Curves A, B and C in Figure 4 for BTU X 10^9 in Process (X) versus Penalty (Y) are:

Curve A:

$$\log Y = -0.289069 + 0.472171(\log X) - 0.074585(\log X)^2 - 0.018641(\log X)^3 \quad \text{or}$$

logY = – 0.289069 + 0.472171*log X – 0.074585*log X^2 – 0.018641*logX^3

Curve B:

$$\log Y = -0.403115 + 0.378703(\log X) - 0.046402(\log X)^2 - 0.015379(\log X)^3 \quad \text{or}$$

logY = – 0.403115 + 0.378703*log X – 0.046402*log X^2 – 0.015379*log X^3

Curve C:

$$\log Y = -0.558394 + 0.363321(\log X) - 0.057296(\log X)^2 - 0.010759(\log X)^3 \quad \text{or}$$

log Y = – 0.558394 + 0.363321*log X – 0.057296*log X^2 – 0.010759*log X^3

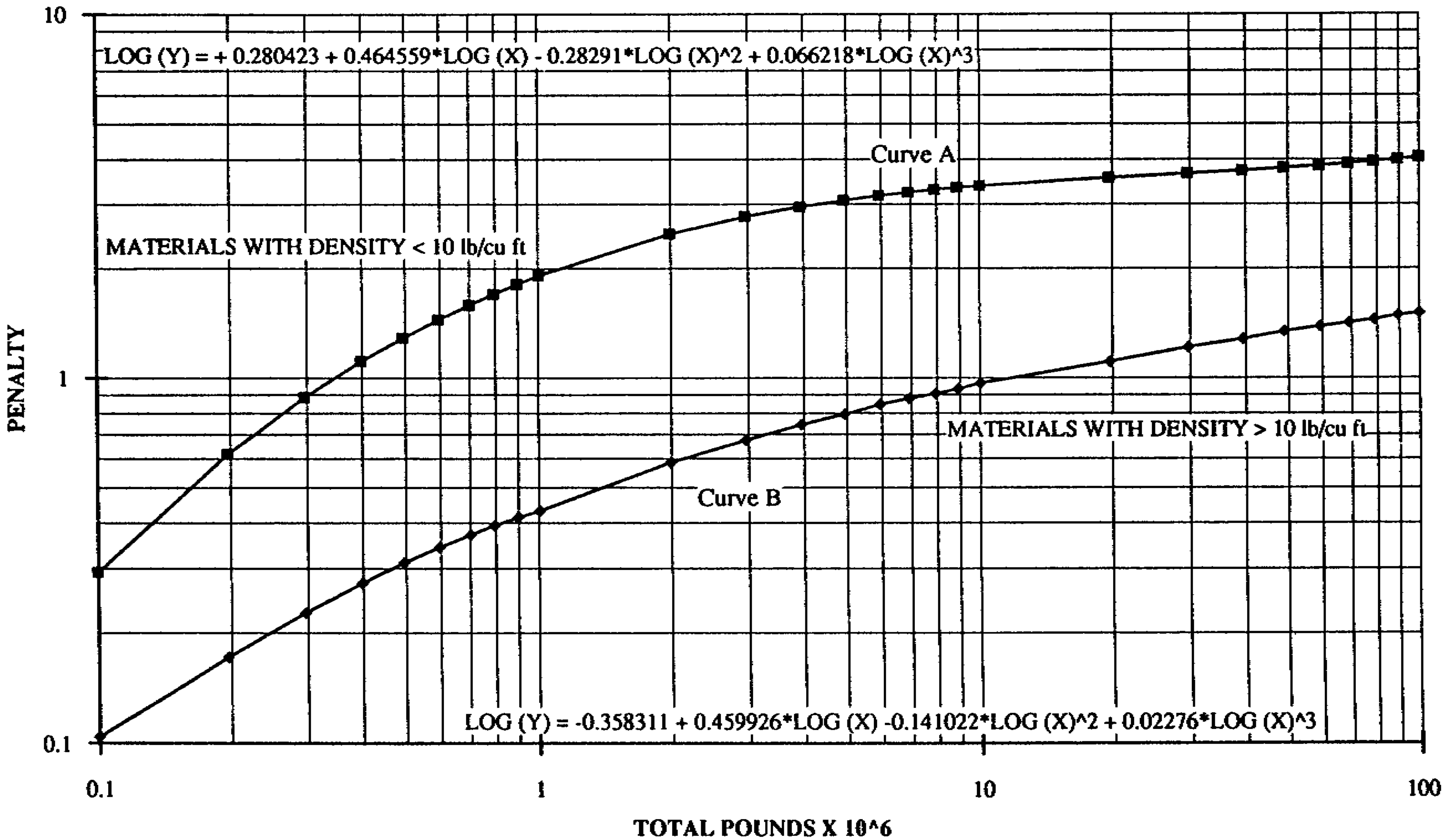
3. Combustible Solids in Storage/Dust in Process (Figure 5, page 31)

This category covers the penalty requirements for various quantities of stored solids and for dusts encountered in a Process Unit when the solid or dust involved is the basis material for the MF. The measurements used in this penalty assessment are the density of the material and ease of ignition and its ability to sustain flame.

The total weight in pounds of stored solid or of dust contained within the process unit is used with Figure 5 to determine the penalty. If the material's bulk density is less than 10 lb/ft^3 (160.2 kg/m^3), use Curve A; if it is greater than 10 lb/ft^3 (160.2 kg/m^3), use Curve B.

For unstable materials (N_R = 2 or higher), take six times the actual weight of material in the Process Unit and use Curve A to determine the appropriate penalty (see the following example).

FIGURE 5 - COMBUSTIBLE SOLIDS IN STORAGE/DUST IN PROCESS



For kg x 10^6 multiply by 0.45359.

Example:

Ignoring aisle space, an area of 20,000 ft^2 (1,860 m^2) with a 15 ft (4.6 m) storage height would contain 300,000 ft^3 (8,500 m^3) of stored material.

If the material being stored in the area (open-cell foam and cardboard boxes with polystyrene tubs) have an average density of 2.2 lb/ft^3 (35.2 kg/m^3):

$$2.2 \text{ lb./ft}^3 \times 300{,}000 \text{ ft}^3 = 660{,}000 \text{ lb}$$

Using Figure 5, Curve A for density < 10 lb/ft^3, we determine that the penalty should be 1.54.

Now compare this with storage of polyethylene pellets or cellulose powder in bags (average density of 28 lb/ft^3 (449 kg/m^2)):

$$28 \text{ lb/ft}^3 \times 300{,}000 \text{ ft}^3 = 8{,}400{,}000 \text{ lb}$$

Using Curve B for density > 10 lb/ft^3, we determine that the penalty should be 0.92.

While it is true that the fire load (in terms of both BTUs and pounds per cubic foot) is much lower for foam or boxes than for bagged polyethylene pellets or methylcellulose powder, foam and cardboard boxes are much easier to ignite and would sustain flame more readily than the denser materials. In short, because these light materials pose a greater fire hazard than the heavier ones, they are assessed a higher penalty, even though fewer pounds are stored.

The equations for Figure 5, page 31, for the plots of Curves A and B of Combustible Solids versus Penalty for Curves A and B are:

Curve A:

$$\log Y = 0.280423 + 0.464559(\log X) - 0.28291(\log X)^2 + 0.066218(\log X)^3 \quad \text{or}$$

log Y = 0.280423 + 0.464559*log X – 0.28291*log X^2 + 0.066218*log X^3

Curve B:

$$\log Y = -0.358311 + 0.459926(\log X) - 0.141022(\log X)^2 + 0.02276(\log X)^3 \quad \text{or}$$

log Y = – 0.358311 + 0.459926*log X – 0.141022*log X^2 + 0.02276*log X^3

H. Corrosion and Erosion

Although good design makes allowances for corrosion and erosion, some corrosion/erosion problems may still occur in certain processes.

The corrosion rate is considered to be the sum of the external and internal corrosion rates. Be sure not to overlook the possible effects of minor impurities in the process stream that might cause greater than normal internal corrosion and the possibility of external corrosion due to the chemical breakdown of paint. Porosity of bricks and imperfections in plastic linings are likely sites for accelerated corrosion.

The following penalties apply:

1. For corrosion rates less than 0.5 mil/yr (0.005 in/yr) [0.127 mm/yr] with risk of pitting or local erosion, the **penalty is 0.10.**
2. For a corrosion rate over 0.5 mil/yr (0.127 mm/yr) and less than 1.00 mil/yr (0.254 mm/yr), the **penalty is 0.20.**
3. For corrosion rates higher than 1 mil/yr (0.254 mm/yr), the **penalty is 0.50.**
4. If there is a risk that stress-corrosion cracking might develop, apply a **penalty of 0.75.** This is common in process areas exposed to contamination by chlorine vapor over prolonged periods.
5. Where a lining is required to **prevent** corrosion, a **penalty of 0.20** is applied. However, if the lining is simply to protect a product from developing color, **no penalty is taken.**

I. Leakage – Joints and Packing

Gaskets, seals of joints or shafts and packing can be sources of leaks of flammable or combustible materials, particularly where thermal and pressure cycling occurs. A penalty factor should be selected according to the design of the Process Unit under study and the material being used in the process. The following penalties should be applied:

1. Where the pump and gland seals are likely to give some leakage of a minor nature, the **penalty is 0.10.**
2. For processes known to give regular leakage problems at pumps, compressors and flange joints, the **penalty is 0.30.**
3. For processes in which thermal and pressure cycling occurs, the **penalty is 0.30.**
4. If the material in the Process Unit is penetrating in nature or is an abrasive slurry which can cause intermittent problems with sealing and if the Process Unit uses a rotating shaft seal or packing, the **penalty is 0.40.**
5. For any Process Unit that has sight glasses, bellows assemblies or expansion joints, the **penalty is 1.50.**

J. Use of Fired Equipment

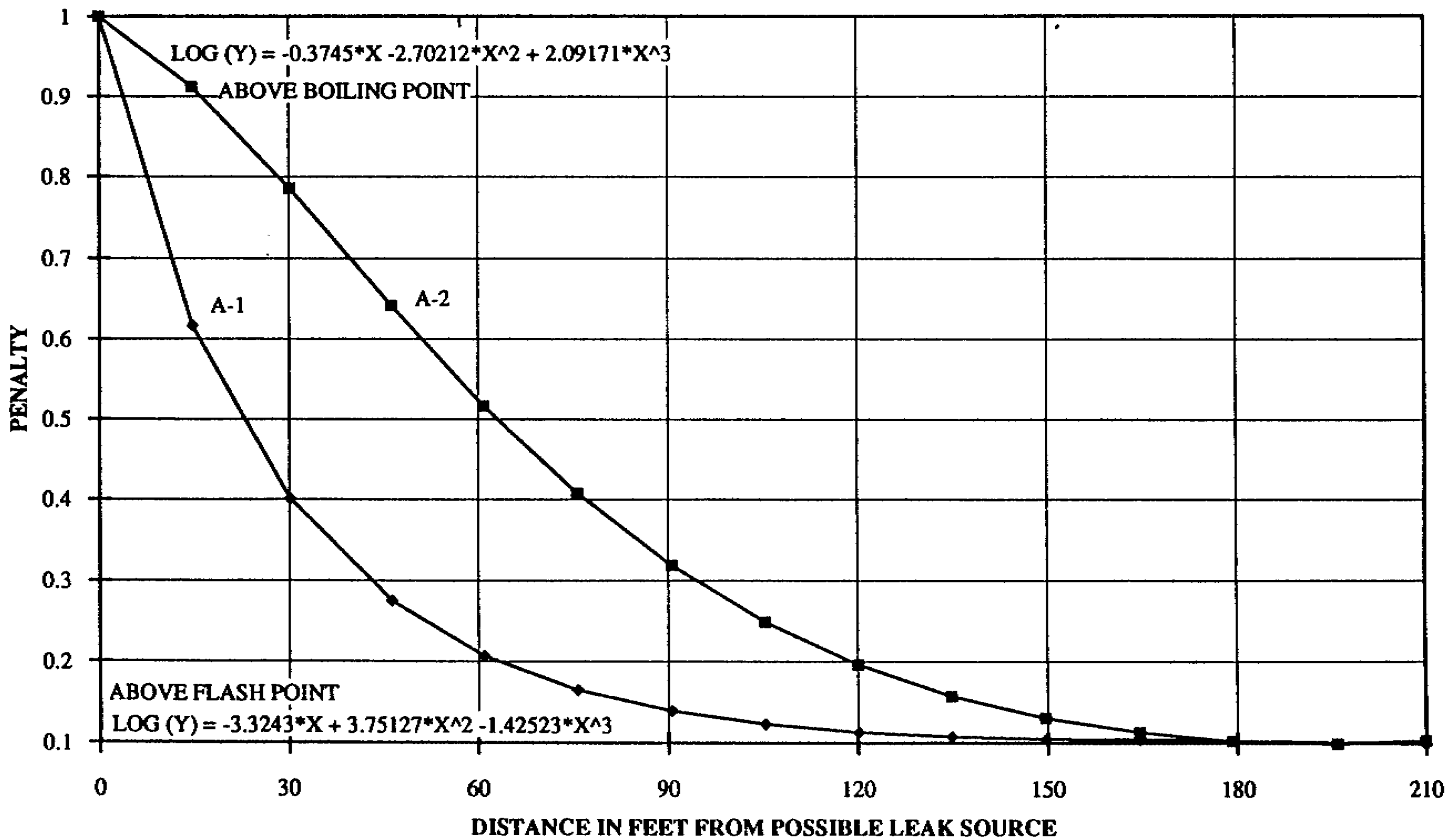
The presence of fired equipment in a process adds an additional probability of ignition when flammable liquids, vapors or combustible dusts are released.

The penalty is applied in one of two ways: first, to the fired equipment itself when it is the Process Unit for the F&EI calculation, and, second, to the various Process Units in the vicinity of the fired equipment. The distance in feet from a probable leak point in the Process Unit being evaluated to the air intake of the fired equipment is the distance referenced in Figure 6, page 34.

1. Curve A-1 (Figure 6) is used:
   a) For any Process Unit in which the material of the Material Factor could be released above its flash point.
   b) For any Process Unit in which the material of the Material Factor is a combustible dust.
2. Curve A-2 (Figure 6) is used:
   a) For any Process Unit in which the material of the Material Factor could be released above its boiling point.

The penalty is determined by entering Figure 6 with the distance from a potential leak source to the air intake of the fired equipment and reading the penalty from the intersection with the appropriate curve (A-1 or A-2) of Figure 6.

FIGURE 6 - FIRED EQUIPMENT PENALTY



For distance in meters multiply by 0.3048.

The equations for Curves A-1 and A-2 for Distance from Possible Leak Source (X) and Penalty (Y) are:

Curve A-1:

$$\log Y = -3.3243\left(\frac{X}{210}\right) + 3.75127\left(\frac{X}{210}\right)^2 - 1.42523\left(\frac{X}{210}\right)^3 \quad \text{or}$$

log Y = – 3.3243*(X/210) + 3.75127*(X/210)^2 – 1.42523*(X/210)^3

Curve A-2:

$$\log Y = -0.3745\left(\frac{X}{210}\right) - 2.70212\left(\frac{X}{210}\right)^2 + 2.09171\left(\frac{X}{210}\right)^3 \quad \text{or}$$

log Y = – 0.3745(X/210) – 2.70212*(X/210)^2 + 2.09171*(X/210)^3

If the fired equipment (process side) itself is the Process Unit being evaluated, the distance from the possible leak source becomes zero. If the equipment is heating a flammable or combustible material, the penalty is **1.00**, ***even if the material is not being heated above its flash point.*** The "J" penalty is not applied to the fire side.

However, ***any other situation covered by this section*** involving a material processed below its flash point receives **no penalty.**

If a piece of fired equipment is located within the process area and there is a possibility that the material in the Process Unit selected as MF could be released above its flash point, a *minimum* **penalty of 0.10** is required, ***regardless of the distance involved.***

Fired equipment with "pressure burner" design will require only 50% of the penalty specified for standard burner design, provided the air intake is 10 ft (3 m) or more above grade and is not exposed to potential sources of spills from overhead. However, the 50% penalty cannot be applied when the fired heater itself is the Process Unit being evaluated.

K. Hot Oil Heat Exchange System

Since most hot oil (heat exchange) fluids will burn and are frequently used above their flash points or boiling points, they represent an additional hazard in any Process Unit that uses them. The penalties in this section are based on the quantity and temperature of the heat exchange fluid used in the unit being evaluated.

No penalty is applied if the hot oil is non-combustible or, if a combustible fluid, is always used below its flash point. However, the possible formation of mists should be considered. (See page 12.)

The quantity to be used with Table 5 to determine the penalty is taken to be the lesser of

1. a 15-minute spill caused by a break in the line servicing the Process Unit or
2. the hot oil inventory within the active circulating hot oil system.

The portion of the hot oil heat exchange system that can be classified as "storage" is ***not*** used in determining the active capacity unless it is connected much of the time to the Process Unit.

It is recommended that the F&EI for the hot oil circulating system itself be determined, including the active (not storage) tank, pumps and distribution/return piping. These determinations have historically led to large F&EI values. If the hot oil exchange system itself is the Process Unit being evaluated, no penalty is taken for this section. However, if a fired hot oil heat exchange system is actually located in the area of the Process Unit being evaluated, the penalty for Section J will apply.

TABLE 5

HOT OIL HEAT EXCHANGE SYSTEM PENALTY		
Quantity Gallons (m^3)	**Above Flash Point Penalty**	**At or Above Boiling Point Penalty**
< 5,000 (< 18.9)	0.15	0.25
5,000 to 10,000 (18.9 to 37.9)	0.30	0.45
10,000 to 25,000 (37.9 to 94.6)	0.50	0.75
> 25,000 (94.6)	0.75	1.15

L. Rotating Equipment

This section recognizes the hazard exposure of Process Units incorporating large pieces of rotating equipment. Although formulas have not been developed for evaluating all types and sizes of rotating equipment, there is statistical evidence indicating that pumps and compressors beyond a certain size are likely to contribute to a loss incident.

A penalty of 0.50 is applied to Process Units that utilize or are:

1. A compressor in excess of 600 hp.
2. A pump in excess of 75 hp.
3. Agitators (mixers) and circulating pumps in which failure could create a process exotherm due to lack of cooling from interrupted mixing or circulation of coolant or due to interrupted and resumed mixing.
4. Other large high speed rotating equipment with a significant loss history; for example, centrifuges.

Once all of the special process hazards have been evaluated, a calculation is to be made of the sum of the base factor and all penalty factors applied in this section. The total is to be entered in the box labeled "Special Process Hazards Factor (F_2)" on the F&EI Form, page 5.

DETERMINATION OF PROCESS UNIT HAZARDS FACTOR

The Process Unit Hazards Factor (F_3) is the product of the General Process Hazards Factor (F_1) and the Special Process Hazards Factor (F_2). The product is used rather than the sum because the "contributing hazards" included in F_1 (General Process Hazards) and F_2 (Special Process Hazards) are known to have a compounding effect on each other. For example, a penalty for poor drainage in F_1 is compounded by the magnitude of the quantity in F_2.

The Process Unit Hazards Factor (F_3), which has a normal range of 1 to 8, is used to determine the Fire & Explosion Index, page 5, and to compute the Damage Factor (Figure 8, page 52).

When penalties are properly applied to various Process Hazards, F_3 is normally not in excess of 8.0. If a higher value is obtained, use a maximum of 8.0. The Process Unit Hazards Factor is to be entered at the bottom of the Fire & Explosion Index Form as shown on page 5.

DETERMINATION OF FIRE AND EXPLOSION INDEX

The Fire and Explosion Index calculation is used for estimating the damage that would probably result from an incident in a process plant. The various contributing factors, such as type of reaction, process temperatures, pressures, quantities of fuel, etc., indicate the probability and potential magnitude of a fuel or energy release resulting from process control failures, equipment failures or from vibration or other sources of stress fatigue.

Effects of a fire and/or fuel-air explosion following the release of a flammable material and its ignition are categorized according to the immediate causes:

a. The blast wave or deflagration,
b. Fire exposure from the original release,
c. Missile impact on piping and equipment from vessel explosion,
d. Other fuel releases as secondary events.

The secondary events become more significant as the Process Unit Hazards Factor and Material Factor increase.

The Fire and Explosion Index (page 5) is the product of the Process Unit Hazards Factor (F_3) and the Material Factor (MF). The F&EI will be related later to a Radius of Exposure (Figure 7, page 48).

Table 6 is a listing of the F&EI values versus a description of the degree of hazard that gives some relative idea of the severity of the F&EI.

TABLE 6

DEGREE OF HAZARD FOR F&EI	
F&EI INDEX RANGE	**DEGREE OF HAZARD**
1 – 60	Light
61 – 96	Moderate
97 – 127	Intermediate
128 – 158	Heavy
159 – up	Severe

The F&EI is summarized on the Fire & Explosion Index Form which is presented on page 5. It is recommended that any backup calculations or documentation be filed with the original F&EI so it is possible to review and reconstruct how the original determination was made.

LOSS CONTROL CREDIT FACTORS

In the construction of any chemical Process Unit (plant) consideration must be given to a number of basic design features (Appendix C, page 74) including compliance with various codes such as building codes or the codes of ASME, NFPA, ASTM, ANSI (see Appendix F) and requirements of local governments.

In addition to these basic design requirements, certain loss control features based on experience have proven beneficial both in preventing serious incidents and in reducing the probability and magnitude of a particular incident. There are three categories of loss control features:

- C_1 **Process Control**
- C_2 **Material Isolation**
- C_3 **Fire Protection**

The Loss Control Credit Factors Form (page 6) is to be used to summarize the Loss Control Credit Factors using the following procedure:

1. Enter the appropriate credit factor immediately to the right of each credit item chosen.
2. If no credit factor is applicable, enter 1.00 for the Credit Factor Used.
3. Note that each category's Loss Control Credit Factor is the product of all factors used in that category.
4. Perform the calculation (C_1 x C_2 x C_3) to determine the overall Loss Control Credit Factor.
5. Enter the Loss Control Credit Factor on Line 7 of the Process Unit Risk Analysis Summary on page 6.

Loss Control features should be selected for the contribution they will actually make to reducing or controlling the unit hazards being evaluated. Selecting credit features to accumulate credits is not the intent of the Risk Analysis approach; the intent is to reduce the dollars at risk or the base MPPD to a more probable, realistic value. The local loss prevention specialist can help determine the appropriateness of various loss control features. The loss control features and their respective credit factors are listed and explained as follows:

1. **Process Control Credit Factor (C_1)**

   a. **Emergency Power – 0.98**

   This credit is given for the provision of emergency power for essential services (instrument air, control instrumentation, agitators, pumps, etc.) with automatic changeover from normal to emergency. The emergency power credit should be taken only if it is relevant to the control of an incident in the specific Process Unit being evaluated. For example, maintaining agitation in certain chemical process reactors is a critical factor in avoiding a runaway reaction, and emergency power supply to such agitators is clearly a protective feature which justifies the credit.

   In other cases, such as agitation in a rubber slurry tank in the polystyrene process, availability of emergency power is not needed either to prevent or to control a possible fire/explosion incident. However, it may be a desirable feature because it permits continued operation when the normal power supply is unreliable. In such cases, no credit should be claimed for the availability of emergency power.

   A credit factor of **0.98** is to be given if applicable or else a factor of **1.00** is to be used which indicates no credit.

b. **Cooling – 0.97 to 0.99**

If process cooling systems are designed with the capability of maintaining normal cooling for at least 10 minutes during an abnormal condition, use a credit factor of **0.99**. If a backup cooling system is designed to provide 150% of the cooling requirement for at least 10 minutes, use **0.97**.

c. **Explosion Control – 0.84 to 0.98**

For explosion suppression systems installed on dust or vapor-handling equipment or equipment designed to contain a deflagration, use a credit factor of **0.84**.

For overpressure relief systems using rupture diaphragms or explosion-relieving vents designed to protect the equipment from possible abnormal conditions, use a credit factor of **0.98**. The credit is applied for any relief device that protects the equipment or building from damage due to rapid overpressure, such as from a deflagration. This credit is not intended to be applied for typical overpressure relief systems such as safety relief valves that are required for all pressure vessels or emergency relief vents on storage tanks.

d. **Emergency Shutdown – 0.96 to 0.99**

For a redundancy system that activates when conditions become abnormal, initiating a shutdown sequence, use **0.98**.

For critical rotating equipment such as compressors, turbines, fans, etc., that are provided with vibration detection equipment, use a credit factor of **0.99** if the equipment only activates an alarm and a credit factor of **0.96** if it initiates a shutdown.

e. **Computer Control – 0.93 to 0.99**

When an on-line computer functions as an aid to operators and is not directly in control of key operations, or where the plant is frequently operated without the computer, use a credit factor of **0.99**.

When a computer with "fail-safe" logic is in direct control of a process, a credit factor of **0.97** is used. If <u>any</u> one of the following options are used, the credit factor will be **0.93**:

1. Redundant critical field inputs
2. Abort feature on critical inputs
3. Backup capability for control system

f. **Inert Gas – 0.94 to 0.96**

When equipment containing flammable vapors is continuously padded with an inert gas, use a credit factor of **0.96**.

If the inert gas system has sufficient capacity to purge the total volume of the unit automatically, use a credit factor of **0.94**. This credit is not applicable if there is an inert purge connection that must be turned on or controlled manually.

g. Operating Instructions/Procedures – 0.91 to 0.99

Adequate written operating instructions and/or a fully documented operating discipline are an important part of maintaining satisfactory control of a unit. The following conditions, listed with point ratings, are considered to be the most important:

1. Startup – **0.5**
2. Routine shutdown – **0.5**
3. Normal operating conditions – **0.5**
4. Turndown operating conditions – **0.5**
5. Standby running conditions (unit running on total recycle or reflux) – **0.5**
6. Uprated operating conditions (above flowsheet capacity) – **1.0**
7. Restarting shortly after a shutdown – **1.0**
8. Restarting plant from a post-maintenance condition – **1.0**
9. Maintenance procedures (work permits, decontamination, lockout, system clearance) – **1.5**
10. Emergency shutdown – **1.5**
11. Manufacturing unit equipment/piping modifications and additions – **2.0**
12. Foreseeable abnormal fault situations – **3.0**

To obtain a credit factor, add all the points for the conditions that have operating instructions. The total points are represented by "X" in the following formula: $1.0 - \frac{X}{150}$

If all conditions have been covered, the credit factor will be: $1.0 - \frac{13.5}{150} = \mathbf{0.91}$

As an alternative, it may be determined what value in the range of **0.91 to 0.99** the engineer thinks best represents the completeness and accuracy of the operating instructions.

h. Reactive Chemical Review – 0.91 to 0.98

The documented use of a total Reactive Chemical Program for reviewing existing and new processes, including process changes and storage and handling of chemicals, is an important loss control function.

Where this program is a continuing part of the operations, a credit factor of **0.91** is used. If the review is done only on an occasional basis, use a credit factor of **0.98**.

As a "minimum requirement" for credit, operators must receive an orientation in Reactive Chemicals as applied to the operator's job at least annually. Unless this orientation is provided regularly, no credit can be taken.

i. Other Process Hazard Analysis – 0.91 to 0.98

Several other process hazard analysis tools can be used in addition to the F&EI evaluation. These include Quantitative Risk Assessments (QRA), Detailed Consequence Analysis, Fault Tree Analysis, Hazard and Operability (HAZOP) Studies, Failure Modes and Effects Analysis (FMEA), Environmental, Health, Safety, and Loss Prevention Reviews, "What If" Studies, Check List Evaluations and Management of Change Reviews. For descriptions of these hazard analysis tools, refer to the Corporate S/LP/S *Process Risk Management Guidelines for Facilities and Distribution.*

The credit factors to be used for this area are as follows:

Quantitative Risk Assessment (QRA)	**0.91**
Detailed Consequence Analysis	**0.93**
Fault Tree Analysis	**0.93**
Hazard and Operability (HAZOP) Studies	**0.94**
Failure Modes and Effects Analysis (FMEA)	**0.94**
Environmental, Health, Safety, and Loss Prevention Reviews	**0.96**
"What If" Studies	**0.96**
Check List Evaluations	**0.98**
Management of Change Review	**0.98**

When any of these process hazard risk analysis programs are done on a regular part of operations, the full credit factor is to be used. The process hazard risk analysis must be consistent with the Corporate S/LP/S *Process Risk Management Guidelines for Facilities and Distribution*. If these analyses are only done on an occasional basis, a higher factor is to be used based on good engineering judgment. For full credit, the results should be shared with employees as is appropriate.

2. **Material Isolation Credit Factor (C_2)**

a. **Remote Control Valves – 0.96 to 0.98**

If the unit is provided with remotely operated isolation valves so that storage tanks, process vessels or major sections of transfer lines can be quickly isolated in an emergency, use a credit factor of **0.98**. If such valves are cycled at least annually, use a credit factor of **0.96**.

b. **Dump/Blowdown – 0.96 to 0.98**

Where an emergency process dump tank can be used directly to receive the contents of the Process Unit safely with adequate quenching and venting, use a credit factor of **0.98**. If the dump tank is located outside the unit area, use a credit factor of **0.96**.

For emergency venting, if gas/vapor material is piped to a flare system or to a closed vent receiver, use a credit factor of **0.96**.

Credit is given for a normal venting system that reduces the exposure of surrounding equipment to released gases or liquids. A vent tied into a flare system or receiver would receive a credit of **0.98**. An example would be blowdown from a polystyrene reactor to a tank or receiver.

c. **Drainage – 0.91 to 0.97**

To remove a large spill from a process or storage unit, it is considered necessary to provide a slope of at least 2% (1% on a hard surface) leading to a drainage trench of adequate size, assuming that 100% of the contents of the largest tank plus 10% of the next largest tank could be released plus 1 hr of deluge/sprinkler fire water. Where this requirement is met, use a credit factor of **0.91**.

If drainage conditions are good such as to drain the contents away from under or near tanks and equipment, a credit factor of **0.91** can also be used.

If the drainage design would allow a pooling of a large spill but could handle small spills (about 50% of the largest tanks contents), use a credit factor of **0.97**. Many drains are capable of handling moderate spills, and many process areas would qualify for a credit factor of **0.95**.

Storage tanks that are diked on four sides to retain spills receive no credit. If the diking design directs the spill to an impounding basin located at least 50 ft (15 m) away and capable of receiving the contents of the largest diked tank plus 10% of the next largest tank plus sprinkler water, a credit factor of **0.95** is used. If the slope is doubtful, or if the impounding basin is closer than 50 ft (15 m) away, no credit is given for drainage.

d. **Interlock – 0.98**

If a process is provided with an interlock system which prevents incorrect material flow that could produce undesirable reactions, use a credit factor of **0.98**. This credit can also be taken for a burner management system that meets the Loss Prevention Principles and code requirements.

3. **Fire Protection Credit Factor (C_3)**

a. **Leak Detection – 0.94 to 0.98**

If gas detectors have been installed that alarm only and identify a zone in the plant area, use a credit factor of **0.98**. When a gas detector both alarms and activates a protective system before the lower flammability limit is reached, use a credit factor of **0.94**.

b. **Structural Steel – 0.95 to 0.98**

The time duration rating of a fireproof coating application is related to the quantity of fuel in the area and the drainage design.

Where fireproofing is used, it should be applied to all load-bearing steel to a minimum height of 15 ft (5 m). Where this has been done, use a credit factor of **0.98**. If fireproofing extends above 15 ft (5 m) but less than 30 ft (10 m), use a credit factor of **0.97**. For fireproofing above 30 ft (10 m), use a credit factor of **0.95** but only if such fireproofing is necessary. Fireproofing systems must be in sound repair, or no credit is to be taken.

Reinforced concrete construction qualifies for the "fireproofing" credit and is the preferred method for fireproofing. Another approach is to install a deluge water spray for cooling the structure only. This should receive a credit factor of **0.98** under the "Structural Steel" category (although water spray cooling of a structure is not specifically mentioned), rather than a credit factor of **0.97** under "Sprinkler Systems."

c. **Fire Water supply – 0.94 to 0.97**

When the delivery pressure is 100 psig (690 kPa) or more, use a credit factor of **0.94.** If the delivery pressure is less than 100 psig (690 kPa), use a credit factor of **0.97**.

A plant's supply of fire fighting water should be capable of delivering the maximum calculated demand for a period of four hours. Less than four hours of fire water may be appropriate for low hazard operations. If this requirement is satisfied, use a credit factor of **0.97**.

Unless the fire water supply can be provided by alternative power sources which are independent of normal electric service and capable of delivering the maximum calculated demand, no credit factor can be applied. A diesel-driven fire pump is an example of an alternative power source.

d. **Special Systems – 0.91**

Special systems include CO_2, halon, smoke and flame detectors and blast walls or cubicles. The installation of new halon systems is discouraged because of potential harm to the environment. Credit can be given to existing halon systems if deemed appropriate for life safety or other special situations.

It is important to be certain that the loss control credits taken for the Process Unit being studied are those that truly apply to that particular Process Unit. A credit factor of **0.91** can be used for special systems.

If a double wall, above ground tank is designed so that the outer wall will contain the total contents after a leak in the primary wall, a credit factor of **0.91** can be used. However, double wall tanks are usually not cost effective and additional integrity in the primary wall is often a better answer to minimizing risk.

Formerly, a credit was given for underground buried and double wall tanks. There is no doubt that from the standpoint of fire protection that a buried tank is safer; however, a more important concern is the possibility for leakage of buried tanks and the difficulty of being able to detect and control leakage. Due to this environmental concern, the construction of new buried tanks is discouraged.

e. **Sprinkler Systems – 0.74 to 0.97**

Deluge systems receive a credit factor of **0.97**. A deluge system (open head) gets the minimum credit because such systems have many components, any one of which could fail completely or partially, producing a negative effect on the operation and effectiveness of the system. Also the deluge system is used in combination with other loss control features on relatively hazardous unit operations so its individual benefit is less.

Credit factors for wet pipe or dry pipe systems used in indoor manufacturing areas and warehouses are calculated as follows:

	Design		**Credit Factor**	
Occupancy	**gpm/ft²**	**lpm/m²**	**Wet Pipe**	**Dry Pipe**
Light	0.15-0.20	6.11-8.15	**0.87**	**0.87**
Ordinary	0.21-0.34	8.56-13.8	**0.81**	**0.84**
Extra Hazard	$\geq$ 0.35	$\geq$ 14.3	**0.74**	**0.81**

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Wet and dry pipe sprinkler systems (closed head) are 99.9%-plus reliable, with very few of the variables encountered with deluge valves, which are subject to failure.

Multiply the above factors by the following penalty factors, which are based on the size of the floor area confined within firewalls:

Area > 10,000 ft^2 (929 m^2)	=	**1.06**
Area > 20,000 ft^2 (1,858 m^2)	=	**1.09**
Area > 30,000 ft^2 (2,787 m^2)	=	**1.12**

Note that as the possible fire area is increased (e.g., a warehouse), the credit factor is increased by a penalty factor (**1.06** to **1.12**), which increases the loss control credit factor and increases the MPPD, as it should. Large fire areas offer greater exposure to fire loss than small fire areas.

f. Water Curtains – 0.97 to 0.98

The use of automatic water spray curtains between a source of ignition and a potential vapor release area can be effective in reducing the vapor cloud ignition potential.

To be effective, the curtain should be located at least 75 ft (23 m) from the vapor release point to allow time for detection of the release and automatic activation of the water curtain. A single tier of nozzles at a maximum elevation of 15 ft (5 m) will receive a credit factor of **0.98**. A second tier of nozzles, not exceeding 6 ft (2 m) above the first tier, will receive a credit factor of **0.97**.

g. Foam – 0.92 to 0.97

If the area protection system includes the capability of injecting foam liquid into a standard deluge sprinkler system from a remote manual control station, use a credit factor of **0.94**. This credit is in addition to the credit taken for the deluge system itself. A totally automatic foam system receives a credit of **0.92**. Totally automatic means the foam valve is automatically actuated when fire is detected.

Manual foam application systems for the protection of seal rings on open-top floating roof tanks receive a credit of **0.97**. Use a factor of **0.94** when fire detection devices are used for actuating the foam system.

Subsurface foam systems and foam chambers on cone roof tanks receive a credit factor of **0.95**. Foam application around the outer shell of a flammable liquid tank receives a credit factor of **0.97** if manually applied, **0.94** if automatic.

h. Hand Extinguishers/Monitors – 0.93 to 0.98

If there is an adequate supply available of hand and portable fire extinguishers suitable for the fire risk involved, use a credit factor of **0.98**. Where there is potential for a large spill of flammable material that, if ignited, could not be controlled effectively with hand extinguishers, do not take a credit. Hand extinguisher credit is not appropriate for process areas where large quantities of flammable or combustible liquids can be spilled.

If monitor guns have also been installed, use a credit factor of **0.97**. Monitor guns that can be remotely operated from a safe vantage point receive a credit factor of **0.95**. Monitors equipped with foam injection capability receive a credit factor of **0.93**.

i. Cable Protection – 0.94 to 0.98

Instrument and electrical cable trays are very vulnerable to damage from fire exposure when installed in pipeways and operating structures. The use of 14 to 16 gauge metal sheet below the tray with a water spray directed onto the top side will provide reasonable protection which justifies a credit of **0.98**. The use of fireproofing material on the metal sheet in lieu of the water spray also receives a credit of **0.98**. If the cable raceway is buried below grade in a trench (either flooded or dry), use a credit of **0.94**.

The product of C_1 x C_2 x C_3 constitutes the Loss Control Credit Factor for the Process Unit and is to be entered into line 7 of the Process Unit Analysis Summary, page 6.

PROCESS UNIT RISK ANALYSIS SUMMARY

The Process Unit Risk Analysis Summary, page 6, gives a summary of all of the important Process Unit Risk Analysis information. This starts with the F&EI and gives additional risk information which is determined from the F&EI, the Loss Control Credit Factor, the Area of Exposure, the Damage Factor and the Value of Production for the Month.

The Process Unit Risk Analysis Summary, along with the F&EI, is a good risk analysis tool to be used in making decisions regarding the risk management program for the Manufacturing Unit of which the Process Unit is a part.

The remainder of this guideline presents the process for determination of the additional risk factors which are to be considered for the Process Unit which then leads to an overall view of the risk factors for the total Manufacturing Unit.

1. **The Fire and Explosion Index (F&EI)**

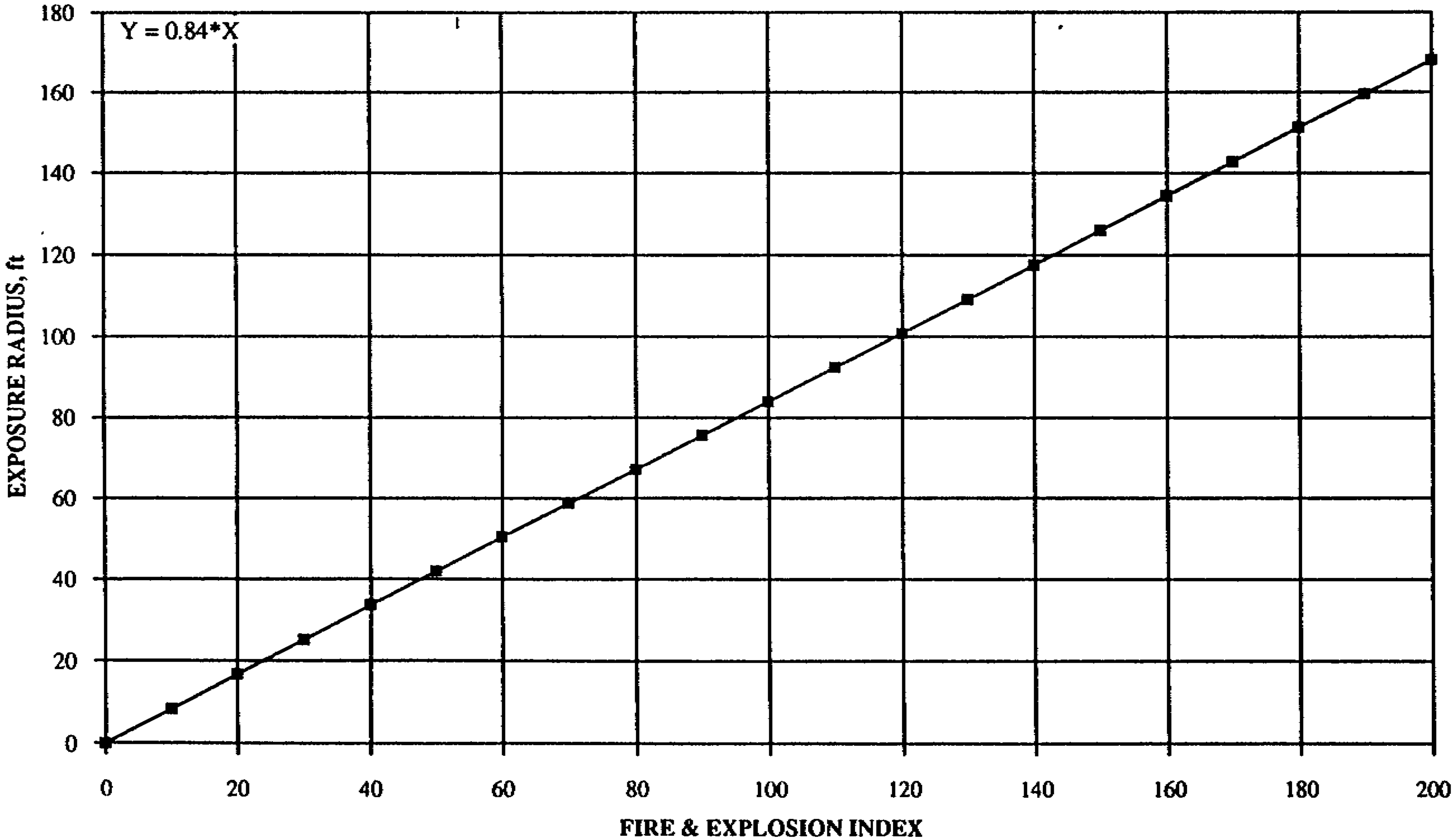
   The Fire and Explosion Index calculation is used for estimating the damage that would probably result from an incident in a process plant. A summary of a description of the F&EI is given on page 38 along with Table 6 which lists the degree of hazard for the various ranges of F&EI. All of the key information and calculations which go to determine the F&EI are list in the form on page 4. The F&EI value is to be entered on line 1 of the Process Unit Risk Analysis Summary, page 6, and in the Manufacturing Unit Risk Analysis Summary, page 7.

2. **The Radius Of Exposure**

   The F&EI, which was determined on page 5, is converted to a Radius of Exposure by multiplying the F&EI by a factor of 0.84 or by using Figure 7, page 48. This is determined in either feet or meters. This radius of exposure is to be shown on plot plans for the Manufacturing Unit with the primary item of process equipment as the center of a circle using the Radius of Exposure. Circles should be drawn for each of the Process Units being analyzed in the Manufacturing Unit. The Radius of Exposure should be entered in the Process Unit Risk Analysis Summary on page 6, line 2.

   When the Process Unit being evaluated is a small piece of equipment, the Radius of Exposure can be considered to start at the center of the item concerned. The Radius of Exposure for large pieces of equipment would extend outward from the equipment surface for a distance equal to what should be considered as the "radius." The additional area is added to the original area of the Process Unit being evaluated to determine the Area of Exposure. For specific cases, the center of the Area of Exposure is very often a leak point. Examples of likely leak points include vents, expansion joints, loading/ unloading connections, etc. These would be the center of the Area of Exposure circle.

FIGURE 7 - RADIUS OF EXPOSURE



For Exposure Radius in meters multiply by 0.3048.

3. The Area Of Exposure

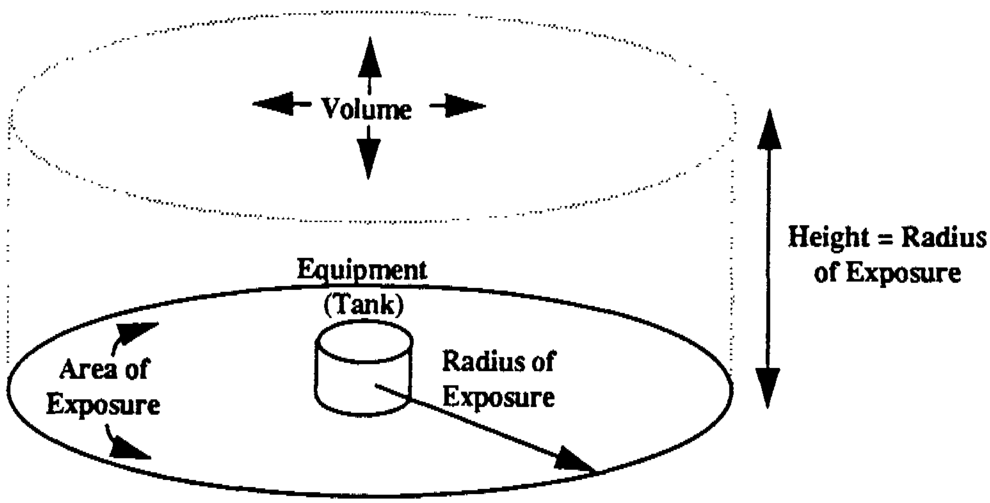
The Radius of Exposure defines an Area of Exposure. The Area of Exposure is calculated with the equation:

$$\text{Area} = \pi R^2 \qquad \text{or} \qquad \text{Area} = \pi(R\verb|^|2) \qquad ft^2 \text{ or } m^2$$

The Area of Exposure should be entered in the Process Unit Risk Analysis Summary on page 6, line 3.

The area is that which contains equipment that could be exposed to a fire or to a fuel-air explosion generated in the Process Unit being evaluated. For evaluation of equipment that could be damaged in a fire or explosion, actually a volume is considered. This volume is a cylindrical volume of the plant surrounding the Process Unit with the area being the Area of Exposure and the height being equal to the Radius of Exposure. In some cases a spherical volume is appropriate. The volume is expected to be the amount of the Manufacturing Unit at risk in the event of a fire or explosion caused by an incident in the Process Unit under study.

Below is a sketch of a vertical tank considered as a Process Unit; and the Radius of Exposure, Area of Exposure and volume are shown as an example.



F&EI = 100
Radius of Exposure = 84 ft (25.6 m)
Area of Exposure = 22,170 ft^2 (2,060 m^2)
Height of Cylindrical Volume = 84 ft (25.6 m)

It is recognized that a fire and/or explosion incident does not spread out into a perfect circle producing equal damage in all directions. The actual damage can be affected by positioning of the equipment, wind direction and drainage layout, all of which are important factors influencing loss prevention design. However, the circle affords a good basis for later calculation of values.

As a matter of interest, the Radius of Exposure was computed in early studies for the F&EI by considering the probable effects of spills of various flammable materials 3 in (8 cm) deep as well as the potential effects of vapor air mixtures and fire, considering several different sets of ambient conditions.

If the Area of Exposure is external to, but includes walls of buildings that are resistant to fire or explosion or both, the building may not be at risk and may be excluded from the Area of Exposure. If there is a blast wall or fire wall within the Area of Exposure, the area behind the wall would not be included.

When the material is stored in a warehouse or other building, the above reasoning leads naturally to the conclusion that only the volume of that building itself is at risk, provided the risk is fire only, not explosion, and the construction is such that the walls and roof will not propagate fire. If the building does not have fire-resistant or at least non-combustible construction, the Area of Exposure will extend beyond its walls.

Some additional considerations are:

1. The entire area of a single building containing a Process Unit is considered to be an Area of Exposure unless various parts of the building are separated from each other by vertical fire walls. If the risk of explosion exists, the entire building is considered to be an exposure area, even if its parts are separated by fire walls.
2. A multi-story building containing fire-resistant floors would be divided into exposure areas by floor levels.
3. Fire-resistant walls are an adequate barrier to exclude a building from fire exposure penalties if the fire source is external. However, where an explosion hazard exists, a fire-resistant wall cannot be considered an adequate barrier.
4. Blast resistant walls are considered adequate for establishing any Area of Exposure boundaries provided the protection from blasts is oriented in the correct direction.

The real effect of the F&EI on the final evaluation can be seen by referring to the following:

Example:

Process Unit "A"	Process Unit "B"
Process Unit Hazards Factor = 4.0	Process Unit Hazards Factor = 4.0
Material Factor = 16	Material Factor = 24
Damage Factor = 0.45	Damage Factor = 0.74
F&E Index = 64	F&E Index = 96
Radius of Exposure = 54 ft (16.4 m)	Radius of Exposure = 81 ft (24.6 m)
Area of Exposure = 9,161 ft^2 (845 m^2)	Area of Exposure = 20,612 ft^2 (1,901 m^2)

Although both Process Units have a Process Unit Hazards Factor (F_3) of 4.0, the final measurement of their probable loss exposure must include the hazard of the material being processed or handled.

The conditions in Process Unit "A" represent 45% damage to 9,161 ft^2 (845 m^2) of surrounding area. The conditions in Process Unit "B" represent 74% damage to 20,612 ft^2 (1,901 m^2) of surrounding area.

If Process Unit "B" had a Process Unit Hazards Factor of 2.7 instead of 4.0, the F&EI would be the same as that of Process Unit "A," 64. However, the Damage Factor for Process Unit "B" would be 0.64 (based on a Material Factor of 24), compared to a Damage Factor of 0.45 (based on a Material Factor of 16) for Process Unit "A."

4. Value Of the Area Of Exposure

The value of the Area of Exposure is obtained from the Replacement Value of the property contained within it, including the inventory of material.

Replacement Value = Original Cost X 0.82 X Escalation Factor

The factor 0.82 is an allowance for items of cost not subject to loss or replacement, such as site preparation, roads, underground lines and foundations, engineering expenses, etc. This factor may be changed if a more accurate estimate exists.

The Escalation Factor is determined from the value obtained from an engineering estimator who keeps the most currently accepted values. See page 54 for escalation values from 1986.

The Value of the Area of Exposure is to be entered on line 4, Process Unit Risk Analysis Summary, page 6, and in the Manufacturing Unit Risk Analysis Summary on page 7.

The Replacement Value may be calculated in several ways:

1. Use Replacement Value of the equipment in the Area of Exposure. The current value may be determined as outlined above. Accounting records, if properly constructed, can provide this information.
   Note: Accounting may have an insurable value or Actual Cash Value (ACV), which is computed from current Replacement Value. While the dollars recovered in the event of loss are based on insurable value, the best estimate of risk is based on the current Replacement Value.
2. Make a current engineering cost estimate of the Replacement Value (excluding foundations and other cost items not subject to loss) of everything within the Area of Exposure. This can be quite time-consuming for all but new plants. To simplify the procedure, use major equipment cost only in estimating and correct to installed cost using Engineering Estimating Installation Factors. Technology Centers may have the most current cost data on both existing and recently constructed plants.
3. Derive an equipment cost per square foot from the overall manufacturing unit Replacement Value. Multiply this cost by the ground floor area within the plan view of the Area of Exposure. While this is likely to be the least accurate method, it may be the most practical for older plants.

When the Replacement Value for the Area of Exposure is computed, it is necessary to use the value of the product inventory along with the equipment value. For storage tanks, use 80% of tank capacity; for columns, towers, pumps, reactors, etc., use the product inventory or connected source of supply. Use 15 min flow process or the volume available, whichever is less.

The product value should be based on cost of manufacture for work-in-process, on the sales value of saleable products or on the cost for scrap. All products within the Area of Exposure are to be included.

Note: When this Area of Exposure encompasses part of another Area of Exposure, the values for the two areas are not additive.

5. Determination Of Damage Factor

The Damage Factor is determined from the Process Unit Hazards Factor (F_3) and the Material Factor (MF) with the use of Figure 8, page 53.

The Damage Factor represents the overall effect of fire plus blast damage resulting from a release of fuel or reactive energy from a Process Unit.

For any calculation in which F_3 exceeds 8.00, do not extrapolate from Figure 8. Use 8.00 as the F_3 for obtaining the Damage Factor.

As the Material Factor (MF) and the Process Unit Hazards Factor (F_3) increase, the Damage Factor will increase from 0.01 to 1.00. The Damage Factor is to be listed on line 5, page 6.

For example, two Process Units, A and B, may be found to have a Process Unit Hazards Factor (F_3) of 4.00. Unit A has an MF of 16 and Unit B has an MF of 24. Using Figure 8, it can be determined that the Damage Factor for Unit A is 0.45 and the Damage Factor for Unit B is 0.74.

The equations for the data presented in Figure 8 are given in Appendix E, page 81. Note that there is no meaning for the intermediate Material Factors other than the nine defined cases of Material Factors that equal 1, 4, 10, 14, 16, 21, 24, 29, and 40 for which nine equations have been defined. See Appendix E for additional information.

6. Base Maximum Probable Property Damage (Base MPPD)

With the Area of Exposure, the Value of the Area of Exposure and the Damage Factor determined, it is necessary to obtain some appropriate dollar value for the plant equipment within the theoretical Area of Exposure (really volume of exposure) which represents the Base Maximum Probable Property Damage (Base MPPD). The Base MPPD is obtained by multiplying the values of lines 4 and 5 of the Process Unit Risk Analysis Summary, page 6. This gives a result which is based on loss experiences from many years of data. The Base MPPD is to be entered on line 6, page 6 and in the Manufacturing Unit Risk Analysis Summary, page 7. The Base MPPD assumes none of the loss control features mitigates the loss.

7. Loss Control Credit Factor

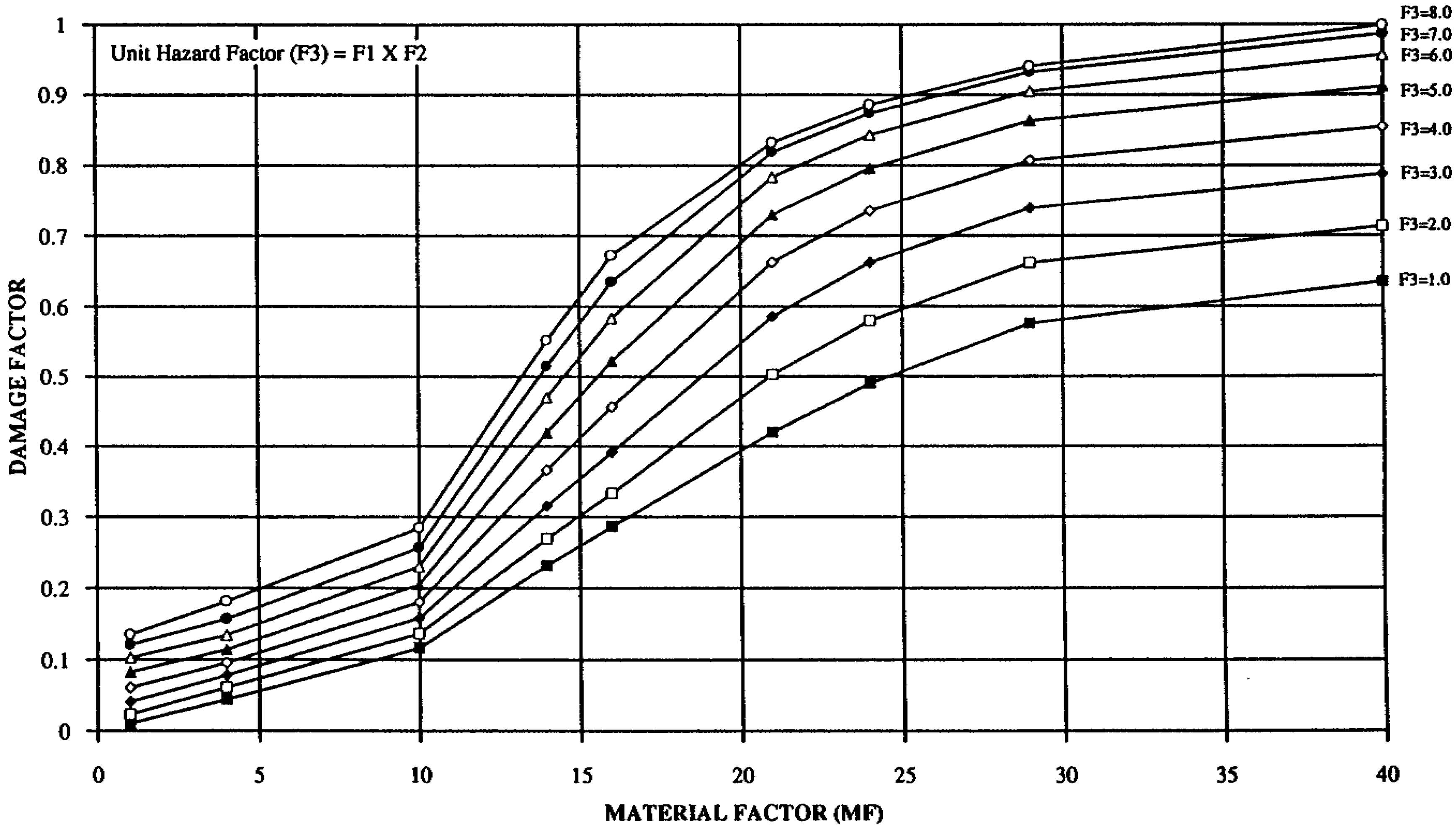
The Loss Control Credit Factor is entered as determined from the top of page 6 of the forms. This is the product of numerous credit factors which are described in the previous section on Loss Control Credit Factors, pages 39 to 46. The final Loss Control Credit Factor is to be entered on line 7 of the Process Unit Risk Analysis Summary, page 6.

8. Actual Maximum Probable Property Damage (Actual MPPD)

The product of the Base MPPD and the Loss Control Credit Factor from the Loss Control Credit Factors Section, page 6, will provide the Actual Maximum Probable Property Damage (Actual MPPD). This product represents the property damage loss that could result from an incident of reasonable magnitude with adequate (but not perfect) functioning of protective features as listed on page 6. If any of these protective systems were to fail, the loss might approach the Base MPPD.

The value of the Actual MPPD is to be entered on line 8 of the Process Unit Risk Analysis Summary, page 6, and in the Manufacturing Unit Risk Analysis Summary, page 7.

FIGURE 8 - DAMAGE FACTOR



See Appendix E for data equations.

9. Maximum Probable Days Outage (MPDO)

As noted in the introduction, the estimate of Maximum Probable Days Outage (MPDO) is a necessary step in assessing the potential Business Interruption (BI) from a loss incident. The dollar impact of Business Interruption can often times equal or exceed that of property damage, depending on inventory levels and product demand. A number of different conditions can cause variations in the relationship of MPDO to property damage. For example:

1. Repair of damaged cable in a cable tray could require as much time as the repair or replacement of small electric motors, pumps and instruments, although the property damage would be smaller.
2. Failure of a vital raw material supply line, such as a brine line or a hydrocarbon line, would be a low property damage incident with a high MPDO.
3. Availability of hard-to-get or one-of-a-kind items will have an impact on the number of days a process will be down.
4. Ability to make up the lost product at a remote production facility.
5. Plant interdependence: loss of profit and continuing costs of a plant due to lack of material from the plant in question.

To obtain the MPDO value, it is necessary to have determined the Actual MPPD of the area and then to refer to Figure 9, page 55.

Figure 9 gives a correlation between MPDO and Actual MPPD. The data are derived from historical fire and explosion loss incidents, which also provided a basis for the Damage Factor. Such a correlation is imprecise because there is a considerable spread of data. Many times, people have simply read the MPDO value directly from the central correlation line. The intention is that judgment should be used in selecting the MPDO and that the value will generally fall within the upper and lower 70% probability levels in the absence of any other controlling factor. However, the value for the MPDO could deviate considerably from 70% if there were clearly some strong overriding consideration. If there is a better estimate of days outage based on delivery times or engineering schedules, use the better estimate of MPDO instead of Figure 9.

In some instances, the MPDO may not be realistic for the known conditions. For example, critical component parts for a compressor might be kept in stock or a spare pump or rectifier might be in stock. This would justify using the MPDO obtained from the lower line of the normal range bracketing the 70% probability level. On the other hand, hard-to-get or one-of-a-kind items would usually require using an MPDO near the upper line of that range. Alternatively, an individual analysis of the effect of fire and/or explosion might be substituted for the use of Figure 9, page 55.

The value of the Actual MPPD is given in 1986 dollars in Figure 9. Escalation needs to be made to present day values. The current relative escalation values from Chemical Engineering Plant Cost Index is as follows:

1986	318.4	1991	361.3
1987	323.8	1992	358.2
1988	342.5	1993	359.9*
1989	355.4	1994	368.4**
1990	357.6	1995	378.3**

*Based on August 1993 index
**Best Estimate

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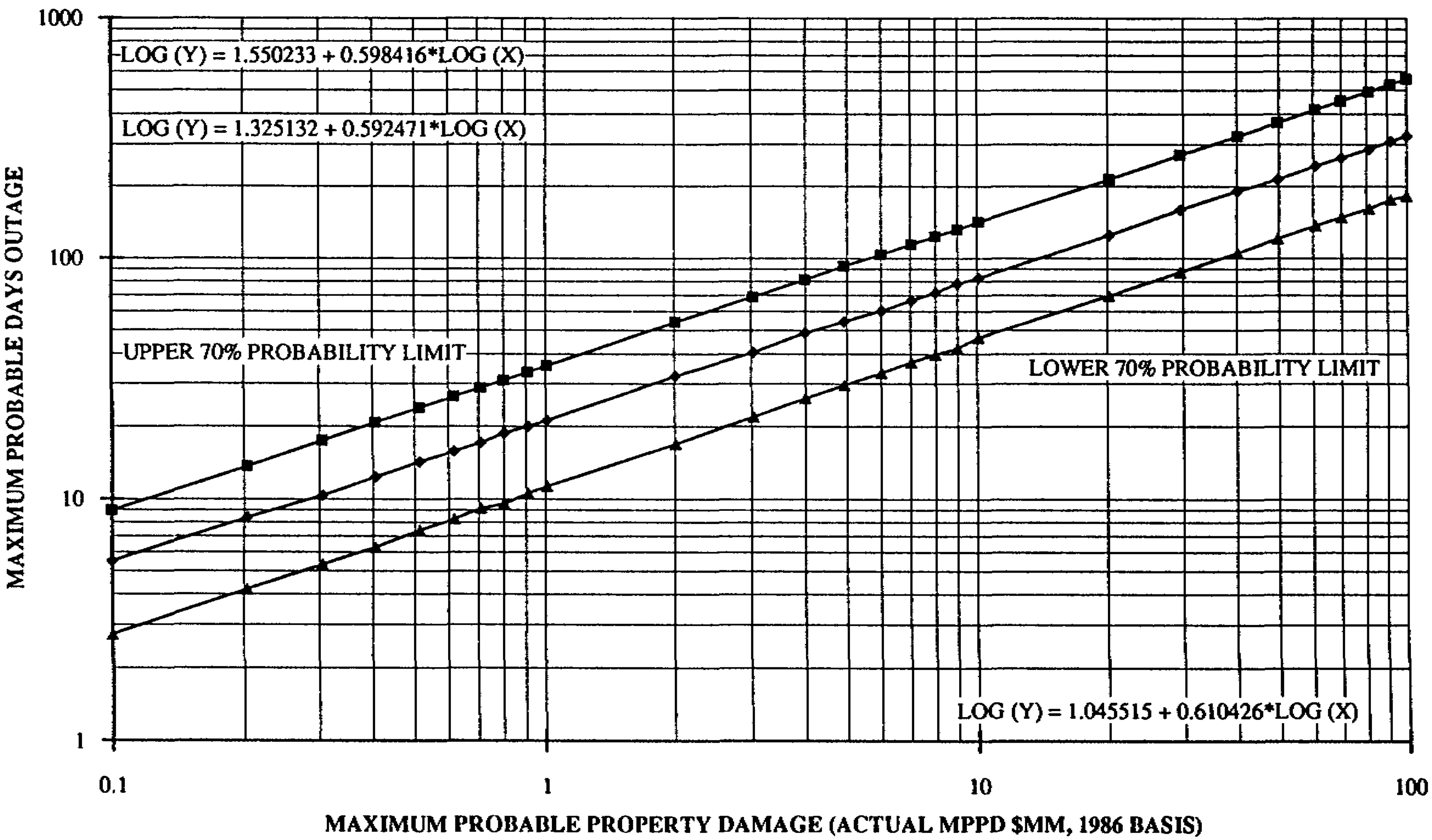
FIGURE 9 - MAXIMUM PROBABLE DAYS OUTAGE (MPDO)



For update to 1993 basis multiply by 359.9/318.4 = 1.130, based on Chemical Engineering Plant Cost Index.

Thus, for an escalation from 1986 to 1994 the following factor would be used:

$$\frac{368.4}{318.4} = 1.157$$

These values many need to be adjusted in the future for the best possible estimate of Actual MPPD.

The equations for the curves in Figure 9 for MPPD (X) versus Days Outage (Y) are as follows:

Curve for UPPER 70% PROBABILITY LIMIT

$\log Y = 1.550233 + 0.598416(\log X)$ or $\log Y = 1.550233 + 0.598416*\log X$

Curve for NORMAL PROBABILITY LIMIT

$\log Y = 1.325132 + 0.592471(\log X)$ or $\log Y = 1.215132 + 0.592471*\log X$

Curve for LOWER 70% PROBABILITY LIMIT

$\log Y = 1.045515 + 0.610426(\log X)$ or $\log Y = 1.045515 + 0.610426*\log X$

The MPDO is to be entered on line 9 of the Process Unit Risk Analysis Summary, page 6 and in the Manufacturing Unit Risk Analysis Summary, page 7.

10. Business Interruption (BI)

The calculation for Business Interruption (BI) in U. S. dollars is done as follows:

$$BI = \frac{MPDO}{30} x\,VPM\,x\,0.70$$

VPM is the Value of Production for the Month, and 0.70 represents the fixed costs plus profits.

The BI loss is to be entered on line 10 of the Process Unit Risk Analysis Summary, page 6 and in the Manufacturing Risk Analysis Summary, page 7.

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DISCUSSION OF MPPD, BI AND PLANT LAYOUT

What is an acceptable Maximum Probable Property Damage (MPPD) and Business Interruption (BI) risk? This is not an easy question to answer. It depends on the type of plant. For example, the potential loss from a hydrocarbon plant will always exceed the loss of a STYROFOAM® plant. The best approach is to compare plants in similar technology areas. The predicted loss from a new plant should not exceed that of similar plants in the same technology. Another approach would be to set an acceptable MPPD value at 10% of the Manufacturing Unit (Plant) Replacement Value.

Another issue is that of market conditions and the ability to supply product if a plant is down. With multiple plants making the same product, Business Interruption can be minimal. If the damaged plant is a single source of the product and market position is vulnerable, the potential business impact can be great.

Plants relying on a critical unit operation, e.g., waste water treatment facilities, thermal oxidizers, etc., can also have large business interruption impact if there is a significant property damage incident.

The important consideration is what action will or can be taken if the MPPD is not acceptable.

A. The risk analysis should be carried out during the design phase of a new capital project, and there should be opportunity for action to reduce MPPD. The most effective way to achieve this is by a change in layout, an increase in separation distances and a reduction of total capital within the Area of Exposure. In certain cases, where the inventory penalty is a major item in the F&EI, a reduction in inventory may be feasible and effective. Other possibilities may be found in specific cases. It will quickly become apparent that preventative measures that eliminate or reduce hazards and reduce the F&EI have more impact on the MPPD than the addition of more protective features (credit factors).

B. When the review is carried out on an existing operating plant, changes in layout or inventory are much less likely to be economically feasible, and the opportunities to achieve a significant reduction in MPPD may be limited. Emphasis should be placed on the addition of appropriate loss control features.

Plant Layout

The Fire and Explosion Index evaluation can be very useful in developing new plant layouts or adding equipment and buildings to existing plants. The F&EI can be used in conjunction with Loss Prevention Principle, 2.2, to assure adequate separation between process units and critical buildings and equipment. The more severe the F&EI rating, the greater the separation distance required between facilities.

Also, F&EI circles can be superimposed on preliminary plot plans to evaluate the potential impact of a fire or explosion on adjacent buildings and equipment. If the risk appears unacceptable, the separation distances should be increased or consideration given to more sophisticated engineering estimates of the consequences. Evaluation of the F&EI calculations and other layout considerations will result in a safe, maintainable, operable and cost-effective arrangement of equipment and buildings.

MANUFACTURING UNIT RISK ANALYSIS SUMMARY

The Manufacturing Unit Risk Analysis Summary, page 7, documents the probable loss impact of both Base and Actual Maximum Probable Property Damage and Business Interruption for the Manufacturing Unit (plant) being evaluated.

In the first column the name of the Process Unit is to be given followed by the major material of concern from which the Material Factor was determined. An example for a latex plant would be – Reactor Unit/ butadiene. The other values are to be entered from the F&EI Sheet (page 5) and the Process Risk Analysis Summary Sheet (page 6). These include the F&EI, Value of Area of Exposure, Base MPPD, Actual MPPD, MPDO, and BI.

Separate F&EI, Loss Control Credit Factors, and Process Unit Risk Analysis Summary forms are to be completed for all of the pertinent Process Units. The Manufacturing Unit Risk Analysis Summary gives the key information from these forms and is to be included in the Risk Analysis Package.

RISK ANALYSIS PACKAGE

It is necessary to provide fire and extended coverage insurance carriers with a summary of the loss and prevention features on manufacturing units. This summary is called a Risk Analysis Package and includes the following:

1. Manufacturing Unit Risk Analysis Summary
2. F&EI Forms completed for:
   a. The highest Actual MPPD
   b. The highest MPDO and BI
   c. The highest F&EI necessary for the *Process Risk Management Guidelines for Facilities and Distribution*
3. Simplified Block Flowsheet
4. Plot plan showing Areas of Exposure, Gas Detection, Fire Equipment, Emergency Block Valves (EBVs), etc.
5. Business Interruption data, including:
   a. Sources of raw materials and alternates
   b. Packaging and shipping of product or products
   c. Essential utilities and reliability
   d. Critical equipment and plans for coping with breakdowns
   e. Capability of loss control systems such as fire fighting, water supply, deluge water spray, explosion suppression, fire department response, etc.
   f. Interdependencies with Dow and non-Dow facilities.
6. Chemical Exposure Index (CEI) Summary
7. Site Loss Prevention Insurance Report
8. Unit Loss Prevention Insurance Report

Each site needs to maintain a current Risk Analysis Package for each of its manufacturing units. The Risk Analysis Package is used by many sites as a part of the Consolidated Audit.

APPENDIX A MATERIAL FACTORS AND PROPERTIES

COMPOUND	MF	Hc BTU/LB X 10^3	NFPA Classification N(H)	N(F)	N(R)	Flash Point (deg F)	Boiling Point (d g F)
Acetaldehyde	24	10.5	3	4	2	-36	69
Acetic Acid	14	5.6	3	2	1	103	244
Acetic Anhydride	14	7.1	3	2	1	126	282
Acetone	16	12.3	1	3	0	-4	133
Acetone Cyanohydrin	24	11.2	4	2	2	165	203
Acetonitrile	16	12.6	3	3	0	42	179
Acetyl Chloride	24	2.5	3	3	2	40	124
Acetylene	29	20.7	0	4	3	Gas	-118
Acetyl Ethanolamine	14	9.4	1	1	1	355	304 - 308
Acetyl Peroxide	40	6.4	1	2	4	-	(4)
Acetyl Salicylic Acid [8]	16	8.9	1	1	0	-	-
Acetyl Tributyl Citrate	4	10.9	0	1	0	400	343(1)
Acrolein	29	11.8	4	3	3	-15	127
Acrylamide	24	9.5	3	2	2	-	257(1)
Acrylic Acid	24	7.6	3	2	2	124	286
Acrylonitrile	24	13.7	4	3	2	32	171
Allyl Alcohol	16	13.7	4	3	1	72	207
Allylamine	16	15.4	4	3	1	-4	128
Allyl Bromide	16	5.9	3	3	1	28	160
Allyl Chloride	16	9.7	3	3	1	-20	113
Allyl Ether	24	16.0	3	3	2	20	203
Aluminum Chloride	24	(2)	3	0	2	-	(3)
Ammonia	4	8.0	3	1	0	Gas	-28
Ammonium Nitrate	29	12.4(7)	0	0	3	-	410
Amyl Acetate	16	14.6	1	3	0	60	300
Amyl Nitrate	10	11.5	2	2	0	118	306 - 315
Aniline	10	15.0	3	2	0	158	364
Barium Chlorate	14	(2)	2	0	1	-	-

APPENDIX A MATERIAL FACTORS AND PROPERTIES

COMPOUND	MF	Hc BTU/LB X 10^3	NFPA Classification N(H)	N(F)	N(R)	Flash Point (deg F)	Boiling Point (deg F)
Barium Stearate	4	8.9	0	1	0	-	-
Benzaldehyde	10	13.7	2	2	0	148	354
Benzene	16	17.3	2	3	0	12	176
Benzoic Acid	14	11.0	2	1	1	250	482
Benzyl Acetate	4	12.3	1	1	0	195	417
Benzyl Alcohol	4	13.8	2	1	0	200	403
Benzyl Chloride	14	12.6	2	2	1	162	387
Benzyl Peroxide	40	12.0	1	3	4	-	-
Bisphenol A	14	14.1	2	1	1	175	428
Bromine	1	0.0	3	0	0	-	138
Bromobenzene	10	8.1	2	2	0	124	313
o-Bromotoluene	10	8.5	2	2	0	174	359
1,3-Butadiene	24	19.2	2	4	2	-105	24
Butane	21	19.7	1	4	0	-76	31
1-Butanol (Butyl alcohol)	16	14.3	1	3	0	84	243
1-Butene	21	19.5	1	4	0	Gas	21
Butyl Acetate	16	12.2	1	3	0	72	260
Butyl Acrylate	24	14.2	2	2	2	103	300
n-Butylamine	16	16.3	3	3	0	10	171
Butyl Bromide	16	7.6	2	3	0	65	215
Butyl Chloride	16	11.4	2	3	0	15	170
2,3-Butylene Oxide	24	14.3	2	3	2	5	149
Butyl Ether	16	16.3	2	3	1	92	288
t-Butyl Hydroperoxide	40	11.9	1	4	4	< 80 or above	(9)
Butyl Nitrate	29	11.1	1	3	3	97	277
t-Butyl Peracetate	40	10.6	2	3	4	< 80	(4)
t-Butyl Perbenzoate	40	12.2	1	3	4	> 190	(4)
t-Butyl Peroxide	29	14.5	1	3	3	64	176

APPENDIX A MATERIAL FACTORS AND PROPERTIES

COMPOUND	MF	Hc BTU/LB X 10^3	NFPA Classification N(H)	N(F)	N(R)	Flash Point (deg F)	Boiling Point (deg F)
Calcium Carbide	24	9.1	3	3	2	-	-
Calcium Stearate [6]	4	-	0	1	0	-	-
Carbon Disulfide	21	6.1	3	4	0	-22	115
Carbon Monoxide	21	4.3	3	4	0	Gas	-313
Chlorine	1	0.0	4	0	0	Gas	-29
Chlorine Dioxide	40	0.7	3	1	4	Gas	50
Chloroacetyl Chloride	14	2.5	3	0	1	-	223
Chlorobenzene	16	10.9	2	3	0	84	270
Chloroform	1	1.5	2	0	0	-	143
Chloro Methyl Ethyl Ether	14	5.7	2	1	1	-	-
1-Chloro 1-Nitroethane	29	3.5	3	2	3	133	344
o-Chlorophenol	10	9.2	3	2	0	147	47
Chloropicrin	29	5.8(7)	4	0	3	-	234
2-Chloropropane	21	10.1	2	4	0	-26	95
Chlorostyrene	24	12.5	2	1	2	165	372
Coumarin	24	12.0	2	1	2	-	554
Cumene	16	18.0	2	3	1	96	306
Cumene Hydroperoxide	40	13.7	1	2	4	175	(4)
Cyanamide	29	7.0	4	1	3	286	500
Cyclobutane	21	19.1	1	4	0	Gas	55
Cyclohexane	16	18.7	1	3	0	-4	179
Cyclohexanol	10	15.0	1	2	0	154	322
Cyclopropane	21	21.3	1	4	0	Gas	-29
DER* 331	14	13.7	1	1	1	485	878
Dichlorobenzene	10	8.1	2	2	0	151	357
1,2-Dichloroethylene	24	6.9	2	3	2	36 - 39	140
1,3-Dichloropropene	16	6.0	3	3	0	95	219
2,3-Dichloropropene	16	5.9	2	3	0	59	201

APPENDIX A MATERIAL FACTORS AND PROPERTIES

COMPOUND	MF	Hc BTU/LB X 10^3	NFPA Classification N(H)	N(F)	N(R)	Flash Point (deg F)	Boiling Point (d g F)
3,5-Dichloro Salicylic Acid	24	5.3	0	1	2	-	-
Dichlorostyrene	24	9.3	2	1	2	225	-
Dicumyl Peroxide	29[1]	15.4	0	1	3	-	-
Dicyclopentadiene	16	17.9	1	3	1	90	342
Diesel Fuel	10	18.7	0	2	0	100 - 130	315
Diethanolamine	4	10.0	1	1	0	342	514
Diethylamine	16	16.5	3	3	0	-18	132
m-Diethyl Benzene	10	18.0	2	2	0	133	358
Diethyl Carbonate	16	9.1	2	3	1	77	259
Diethylene Glycol	4	8.7	1	1	0	255	472
Diethyl Ether	21	14.5	2	4	1	-49	94
Diethyl Peroxide	40	12.2	-	4	4	(4)	(4)
Diisobutylene	16	19.0	1	3	0	23	214
Diisopropyl Benzene	10	17.9	0	2	0	170	401
Dimethylamine	21	15.2	3	4	0	Gas	44
2,2-Dimethyl-1-Propanol	16	14.8	2	3	0	98	237
1,2-Dinitrobenzene	40	7.2	3	1	4	302	606
2,4-Dinitro Phenol	40	6.1	3	1	4	-	-
1,4-Dioxane	16	10.5	2	3	1	54	214
Dioxolane	24	9.1	2	3	2	35	165
Diphenyl Oxide	4	14.9	1	1	0	239	496
Dipropylene Glycol	4	10.8	0	1	0	250	449
Di-tert-butyl Peroxide	40	14.5	3	2	4	65	231
Divinyl Acetylene	29	18.2	-	3	3	< -4	183
Divinylbenzene	24	17.4	2	2	2	157	392
Divinyl Ether	24	14.5	2	3	2	< -22	102
DOWANOL* DM	10	10.0	2	2	0	197 (Seta)	381
DOWANOL* EB	10	12.9	1	2	0	150	340

APPENDIX A MATERIAL FACTORS AND PROPERTIES

COMPOUND	MF	Hc BTU/LB X 10^3	NFPA Classification N(H)	N(F)	N(R)	Flash Point (deg F)	Boiling Point (d g F)
DOWANOL* PM	16	11.1	0	3	0	90 (Seta)	248
DOWANOL* PnB	10	-	0	2	0	138	338
DOWICIL* 75	24	7.0	2	2	2	-	-
DOWICIL* 200	24	9.3	2	2	2	-	-
DOWFROST*	4	9.1	0	1	0	215 (TOC)	370
DOWFROST* HD	1	-	0	0	0	None	240
DOWFROTH* 250	1	-	0	0	0	300 (Seta)	473
DOWTHERM* 4000	4	7.0	1	1	0	252 (Seta)	330
DOWTHERM* A	4	15.5	2	1	0	232	495
DOWTHERM* G	4	15.5	1	1	0	266 (Seta)	551
DOWTHERM* HT	4	-	1	1	0	322 (TOC)	650
DOWTHERM* J	10	17.8	1	2	0	136 (Seta)	358
DOWTHERM* LF	4	16.0	1	1	0	240	550 - 558
DOWTHERM* Q	4	17.3	1	1	0	249 (Seta)	513
DOWTHERM* SR-1	4	7.0	1	1	0	232	325
DURSBAN*	14	19.8	1	2	1	81 - 110	-
Epichlorohydrin	24	7.2	3	3	2	88	241
Ethane	21	20.4	1	4	0	Gas	-128
Ethanolamine	10	9.5	2	2	0	185	339
Ethyl Acetate	16	10.1	1	3	0	24	171
Ethyl Acrylate	24	11.0	2	3	2	48	211
Ethyl Alcohol	16	11.5	0	3	0	55	173
Ethylamine	21	16.3	3	4	0	< 0	62
Ethyl Benzene	16	17.6	2	3	0	70	277
Ethyl Benzoate	4	12.2	1	1	0	190	414
Ethyl Bromide	4	5.6	2	1	0	None	100
Ethylbutylamine	16	17.0	3	3	0	64	232
Ethyl Butylcarbonate	14	10.6	2	2	1	122	275

APPENDIX A MATERIAL FACTORS AND PROPERTIES

COMPOUND	MF	Hc BTU/LB X 10^3	NFPA Classification N(H)	N(F)	N(R)	Flash Point (deg F)	Boiling Point (deg F)
Ethyl Butyrate	16	12.2	0	3	0	75	248
Ethyl Chloride	21	8.2	1	4	0	-58	54
Ethyl Chloroformate	16	5.2	3	3	1	61	203
Ethylene	24	20.8	1	4	2	Gas	-155
Ethylene Carbonate	14	5.3	2	1	1	290	351
Ethylenediamine	10	12.4	3	2	0	110	239
Ethylene Dichloride	16	4.6	2	3	0	56	181 - 183
Ethylene Glycol	4	7.3	1	1	0	232	387
Ethylene Glycol Dimethyl Ether	10	11.6	2	2	0	29	174
Ethylene Glycol Monoacetate	4	8.0	0	1	0	215	347
Ethylenimine	29	13.0	4	3	3	12	135
Ethylene Oxide	29	11.7	3	4	3	-4	51
Ethyl Ether	21	14.4	2	4	1	-49	94
Ethyl Formate	16	8.7	2	3	0	-4	130
2-Ethylhezanal	14	16.2	2	2	1	112	325
1,1-Ethylidene Dichloride	16	4.5	2	3	0	2	135 - 138
Ethyl Mercaptan	21	12.7	2	4	0	<0	95
Ethyl Nitrate	40	6.4	2	3	4	50	190
Ethyl Propyl Ether	16	15.2	1	3	0	< -4	147
p-Ethyl Toluene	10	17.7	3	2	0	887	324
Fluorine	40	-	4	0	4	Gas	-307
Fluorobenzene	16	13.4	3	3	0	5	185
Formaldehyde (Anhydrous Gas)	21	8.0	3	4	0	Gas	-6
Formaldehyde, solutions (37 - 56%)	10	-	3	2	0	140 - 181	206 - 212
Formic Acid	10	3.0	3	2	0	122	213
Fuel Oil #1	10	18.7	0	2	0	100 - 162	304 - 574
Fuel Oil #2	10	18.7	0	2	0	126 - 204	-
Fuel Oil #4	10	18.7	0	2	0	142 - 240	-

APPENDIX A MATERIAL FACTORS AND PROPERTIES

COMPOUND	MF	Hc BTU/LB X 10^3	NFPA Classification N(H)	N(F)	N(R)	Flash Point (deg F)	Boiling Point (deg F)
Fuel Oil #6	10	18.7	0	2	0	150 - 270	-
Furan	21	12.6	1	4	1	< 32	88
Gasoline	16	18.8	1	3	0	-45	100 - 400
Glycerine	4	6.9	1	1	0	390	340
Glycolonitrile	14	7.6	1	1	1	-	-
Heptane	16	19.2	1	3	0	25	209
Hexachlorobutadiene	14	2.0	2	1	1	-	-
Hexachloro Diphenyl Oxide	14	5.5	2	1	1	-	-
Hexanal	16	15.5	2	3	1	90	268
Hexane	16	19.2	1	3	0	-7	156
Hydrazine (anhydrous)	29	7.7	3	3	3	100	236
Hydrogen	21	51.6	0	4	0	Gas	-423
Hydrogen Cyanide	24	10.3	4	4	2	0	79
Hydrogen Peroxide (40 to 60%)	14	(2)	2	0	1	-	226 - 237
Hydrogen Sulfide	21	6.5	4	4	0	Gas	-76
Hydroxylamine	29	3.2	2	0	3	(4)	158
2-Hydroxyethyl Acrylate	24	8.9	2	1	2	214	410
Hydroxypropyl Acrylate	24	10.4	3	1	2	207	410
Isobutane	21	19.4	1	4	0	Gas	11
Isobutyl Alcohol	16	14.2	1	3	0	82	225
Isobutylamine	16	16.2	2	3	0	15	150
Isobutylchloride	16	11.4	2	3	0	< 70	156
Isopentane	21	21.0	1	4	0	< -60	82
Isoprene	24	18.9	2	4	2	-65	93
Isopropanol	16	13.1	1	3	0	53	181
Isopropenyl Acetylene	24	-	2	4	2	< 19	92
Isopropyl Acetate	16	11.2	1	3	0	34	194
Isopropylamine	21	15.5	3	4	0	-15	93

APPENDIX A MATERIAL FACTORS AND PROPERTIES

COMPOUND	MF	Hc BTU/LB X 10^3	NFPA Classification N(H)	N(F)	N(R)	Flash Point (deg F)	Boiling Point (d g F)
Isopropyl Chloride	21	10.0	2	4	0	-26	95
Isopropyl Ether	16	15.6	2	3	1	-18	156
Jet Fuel A & A-1	10	21.7	0	2	0	110 - 150	400 - 550
Jet Fuel B	16	21.7	1	3	0	-10 to +30	-
Kerosene	10	18.7	0	2	0	100 - 162	304 - 574
Lauryl Bromide	4	12.9	1	1	0	291	356
Lauryl Mercaptan	4	16.8	2	1	0	262	289
Lauryl Peroxide	40	15.0	0	1	4	-	-
LORSBAN* 4E	14	3.0	1	2	1	85	165
Lube Oil (mineral)	4	19.0	0	1	0	300 - 450	680
Magnesuim	14	10.6	0	1	1	-	2025
Maleic Anhydride	14	5.9	3	1	1	215	395
Methacrylic Acid	24	9.3	3	2	2	171	325
Methane	21	21.5	1	4	0	Gas	-258
Methyl Acetate	16	8.5	1	3	0	14	140
Methylacetylene	24	20.0	2	4	2	Gas	-10
Methyl Acrylate	24	18.7	3	3	2	27	177
Methyl Alcohol	16	8.6	1	3	0	52	147
Methylamine	21	13.2	3	4	0	Gas	21
Methyl Amyl Ketone	10	15.4	1	2	0	102	302
Methyl Borate	16	-	2	3	1	< 80	156
Methyl Carbonate	16	6.2	2	3	1	66	192
Methylcellulose (bag storage)	4	6.5	0	1	0	-	-
Methylcellulose Dust [8]	16	6.5	0	1	0	-	-
Methyl Chloride	21	5.5	1	4	0	-50	-12
Methyl Chloroacetate	14	5.1	2	2	1	135	266
Methylcyclohexane	16	19.0	2	3	0	25	214
Methyl Cyclopentadiene	14	17.4	1	2	1	120	163

APPENDIX A MATERIAL FACTORS AND PROPERTIES

COMPOUND	MF	Hc BTU/LB X 10^3	NFPA Classification N(H)	N(F)	N(R)	Flash Point (deg F)	Boiling Point (deg F)
Methylene Chloride	4	2.3	2	1	0	-	104
Methylene Diphenyl Diisocyanate	14	12.6	2	1	1	460	(9)
Methyl Ether	21	12.4	2	4	1	Gas	-11
Methyl Ethyl Ketone	16	13.5	1	3	0	16	176
Methyl Formate	21	6.4	2	4	0	-2	89
Methyl Hydrazine	24	10.9	4	3	2	21	190
Methyl Isobutyl Ketone	16	16.6	2	3	1	64	242
Methyl Mercaptan	21	10.0	4	4	0	Gas	43
Methyl Methacrylate	24	11.9	2	3	2	50	213
2-Methylpropenal	24	15.4	3	3	2	35	154
Methyl Vinyl Ketone	24	13.4	4	3	2	20	179
Mineral Oil	4	17.0	0	1	0	380	680
Mineral Seal Oil	10	17.6	0	2	0	275	480 - 680
Monochlorobenzene	16	11.3	2	3	0	84	270
Monoethanolamine	10	9.6	2	2	0	185	339
Naphtha, V.M. & P, Regular	16	18.0	1	3	0	28	212 - 320
Naphthalene	10	16.7	2	2	0	174	424
Nitrobenzene	14	10.4	3	2	1	190	411
Nitrobiphenyl	4	12.7	2	1	0	290	626
Nitrochlorobenzene	4	7.8	3	1	0	261	457 - 475
Nitroethane	29	7.7	1	3	3	82	237
Nitroglycerine	40	7.8	2	2	4	(4)	(4)
Nitromethane	40	5.0	1	3	4	95	213
Nitropropanes	24	9.7	1	3	2	75 - 93	249 - 269
p-Nitrotoluene	14	11.2	3	1	1	223	460
N-SERV*	14	15.0	2	2	1	102	300
Octane	16	20.5	0	3	0	56	258
t-Octyl Mercaptan	10	16.5	2	2	0	115	318 - 329

APPENDIX A MATERIAL FACTORS AND PROPERTIES

COMPOUND	MF	Hc BTU/LB X 10^3	NFPA Classification N(H)	N(F)	N(R)	Flash Point (deg F)	Boiling Point (deg F)
Oleic Acid	4	16.8	0	1	0	372	547
Pentamethylene Oxide	16	13.7	2	3	1	-4	178
Pentane	21	19.4	1	4	0	< -40	97
Peracetic Acid	40	4.8	3	2	4	105	221
Perchloric Acid	29	(2)	3	0	3	-	66 (9)
Petroleum - Crude	16	21.3	1	3	0	20 - 90	-
Phenol	10	13.4	4	2	0	175	358
2-Picoline	10	15.0	2	2	0	102	262
Polyethylene	10	18.7	-	-	-	NA	NA
Polystyrene Foam	16	17.1	-	-	-	NA	NA
Polystyrene Pellets	10	-	-	-	-	NA	NA
Potassium (metal)	24	-	3	3	2	-	1410
Potassium Chlorate	14	(2)	1	0	1	-	752
Potassium Nitrate	29	(2)	1	0	3	-	752
Potassium Perchlorate	14	-	1	0	1	-	-
Potassium Peroxide	14	-	3	0	1	-	(9)
Propanal	16	12.5	2	3	1	-22	120
Propane	21	19.9	1	4	0	Gas	-44
1,3-Propanediamine	16	13.6	2	3	0	75	276
Propargyl Alcohol	29	12.6	4	3	3	97	237 - 239
Propargyl Bromide	40	13.6 (7)	4	3	4	50	192
Proprionic Nitrile	16	15.0	4	3	1	36	207
Propyl Acetate	16	11.2	1	3	0	55	215
Propyl Alcohol	16	12.4	1	3	0	74	207
Propylamine	16	15.8	3	3	0	-35	120
Propylbenzene	16	17.3	2	3	0	86	319
Propylchloride	16	10.0	2	3	0	< 0	115
Propylene	21	19.7	1	4	1	-162	-54

APPENDIX A MATERIAL FACTORS AND PROPERTIES

COMPOUND	MF	Hc BTU/LB X 10^3	NFPA Classification N(H)	N(F)	N(R)	Flash Point (deg F)	Boiling Point (d g F)
Propylene Dichloride	16	6.3	2	3	0	60	205
Propylene Glycol	4	9.3	0	1	0	210	370
Propylene Oxide	24	13.2	3	4	2	-35	94
n-Propyl Ether	16	15.7	1	3	0	70	194
n-Propyl Nitrate	29	7.4	2	3	3	68	230
Pyridine	16	5.9	2	3	0	68	240
Sodium	24	-	3	3	2	-	1619
Sodium Chlorate	24	-	1	0	2	-	(4)
Sodium Dichromate	14	-	1	0	1	-	(4)
Sodium Hydride	24	-	3	3	2	-	(4)
Sodium Hydrosulfite	24	-	2	1	2	-	(4)
Sodium Perchlorate	14	-	2	0	1	-	(4)
Sodium Peroxide	14	-	3	0	1	-	(4)
Stearic Acid	4	15.9	1	1	0	385	726
Styrene	24	17.4	2	3	2	88	293
Sulfur Chloride	14	1.8	3	1	1 (5)	245	280
Sulfur Dioxide	1	0.0	3	0	0	Gas	14
SYLTHERM* 800	4	12.3	1	1	0	> 320 (10)	398
SYLTHERM* XLT	10	14.1	1	2	0	108	345
TELONE* II	16	3.2	2	3	0	83	220
TELONE* C-17	16	2.7	3	3	1	79	200
Toluene	16	17.4	2	3	0	40	232
Toluene 2,4-Diisocyanate	24	10.6	3	1	2	270	484
Tributylamine	10	17.8	3	2	0	145	417
1,2,4-Trichlorobenzene	4	6.2	2	1	0	222	415
1,1,1-Trichloroethane	4	3.1	2	1	0	None	165
Trichloroethylene	10	2.7	2	1	0	None	189
1,2,3-Trichloropropane	10	4.3	3	2	0	160	313

70

APPENDIX A MATERIAL FACTORS AND PROPERTIES

COMPOUND	MF	Hc BTU/LB X 10^3	NFPA Classification N(H)	N(F)	N(R)	Flash Point (deg F)	Boiling Point (deg F)
Triethanolamine	14	10.1	2	1	1	354	650
Triethylaluminum	29	16.9	3	4	3	-	365
Triethylamine	16	17.8	3	3	0	16	193
Triethylene Glycol	4	9.3	1	1	0	350	546
Triisobutylaluminum	29	18.9	3	4	3	32	414
Triisopropylbenzene	4	18.1	0	1	0	207	495
Trimethylaluminum	29	16.5	-	3	3	Ignites spontaneously in air	
Tripropylamine	10	17.8	2	2	0	105	313
Vinyl Acetate	24	9.7	2	3	2	18	163
Vinyl Acetylene	29	19.5	2	4	3	Gas	41
Vinyl Allyl Ether	24	15.5	2	3	2	< 68	153
Vinyl Butyl Ether	24	15.4	2	3	2	15	202
Vinyl Chloride	24	8.0	2	4	2	-108	7
4-Vinyl Cyclohexene	24	19.0	0	3	2	61	266
Vinyl Ethyl Ether	24	14.0	2	4	2	< -50	96
Vinylidene Chloride	24	4.2	2	4	2	0	89
Vinyl Toluene	24	17.5	2	2	2	125	334
p-Xylene	16	17.6	2	3	0	77	279
Zinc Chlorate	14	(2)	1	0	1	-	-
Zinc Stearate [8]	4	10.1	0	1	0	530	-

Footnotes: The net Heat of Combustion (Hc) is the value obtained when the water formed in the combustion is considered to be in the vapor state. When Hc is given in kcal/gm mole, it can be converted to BTU/lb by multiplying by 1800 and dividing by molecular weight.

[1] Vacuum distillation.
[2] Material oxidized to higher level of oxida
[3] Sublimes.
[4] Explodes on heating.
[5] Decomposes in water.
[6] MF is packaged material.
[7] Hc equivalent to 6 times heat of decomposition. (Hd)
[8] Evaluate as a dust.
[9] Decomposes.
[10] After extended use > 600 deg. F, the flash point can potentially drop to 95 deg. F.

Seta = Setaflash Method (See NFPA 321) NA= Not Applicable TOC = Tag Open Cup Method
Other Flash Points determined by Tag Closed Cup Method (TCC). * Trademark of the Dow Chemical Company

APPENDIX B

SPECIAL MATERIAL FACTOR CONSIDERATIONS FOR MIXTURES

The Material Factor (MF) has two components, flammability and reactivity, and represents the hazard of both. Once these two are established, the Material Factor can be determined, as described in the text and using Table 1, page 13.

The selection of the significant material for determining the Material Factor can be a problem. Pure materials are straightforward. Problems arise when the process has a mixture of materials, particularly in batch reactors where many sequential reactions are done. For example, in a batch process where the composition changes during the batch cycle, it is valid to select the worst condition which normally occurs during the cycle.

If there is a mixture of materials in a Process Unit with MFs of 10, 16 and 24, usually the material with the highest MF, which is of significant concentration (about 5%), should be used as the basis for the MF. The best way to determine the MF of the mixture is to obtain the flash point, boiling point, DTA/DSC exotherm peak temperature of the mixture, thermal and mechanical shock sensitivity and water reactivity by reactive chemicals testing and to use the appropriate data to find MF from Table 1, page 13. The Reactive Chemicals program requires that the flash point, DTA/DSC and other pertinent data be obtained before scale-up. See *Guidelines for a Reactive Chemicals Program*, latest edition.

Some examples of special Material Factor situations are:

1. **Ethylene and Chlorine in an Ethylene Dichloride Reactor to Produce Ethylene Dichloride MF** – The material factor should be selected based on ethylene dichloride and not for ethylene or chlorine. Because the reaction is very fast between the ethylene and chlorine being sprayed into liquid ethylene dichloride, the reactor contains only ethylene dichloride. The hazard is ethylene dichloride in the reactor.

2. **Ethane Cracked in a Furnace to Make Ethylene** – The material factor for ethylene should be used. The most likely leak of contents is a mixture of ethane and ethylene, with the ethylene content significant enough to make the mixture much like ethylene in its reactivity.

3. **Continuous Benzene Alkylation Reactor** – The feed streams to the reactor are ethylene (MF = 24) and benzene (MF = 16), while the bulk of inventory in the reactor is ethyl benzene (MF = 16). There is a minimum of unreacted ethylene present in the reactor. The recommended material factor of use is 16. Although this process involves the potential for release of an ethylene vapor cloud external to the reactor, there is no connection between this and penalty factors applied for conditions in the reactor. It would be wise to consider something in the ethylene feed system as a separate Process Unit and calculate the F&EI for the feed system Process Unit to determine the worst case.

4. **Polyol Reactor (Batch Process)** – The initial charge to the reactor is glycerine (MF = 4). Propylene oxide (MF = 24) and/or ethylene oxide (MF = 29) are added progressively during the batch and react with the glycerine to form the polyol (MF = 4). The reaction depends on the addition of catalyst. If there is a significant chance that none or insufficient catalyst may be added to the reactor, a Material Factor of 29 is appropriate. When ethylene oxide alone is used, it reacts relatively quickly, when catalyst is present, so that there are only small amounts of unreacted ethylene oxide present in the reactor at any time; hence, the reactor MF = 4. However, the propylene oxide reaction is slower and there may be up to about 15% of unreacted propylene oxide present at some stage. The suggested material factor, then, for the F&EI calculation is the factor for the worst case reaction mixture containing 15% propylene oxide (MF = 24).

This is a typical case where it is not appropriate to take a weighted average of factors for individual components in determining the factor for the mixture. This is due to the wide disparity in the properties of components and the high molecular weight of the polyol. It is necessary to consider the actual properties of the mixture which are equivalent to $N_F = 3$ and $N_R = 2$ for a material factor of 24. This compares with a value of about 6.6 which would be wrongly obtained as a weighted average factor. If the properties of the mixture are not known, the approach taken in 3. above may be appropriate while awaiting results of reactive chemicals testing of the mixture.

5. **Electrolytical Production of Chlorine** – Electrolytic production of chlorine presents the need for an atypical approach. The process is endothermic and not theoretically hazardous; the hazards present are due to the presence of flammable hydrogen and reactive chlorine. The MF for hydrogen would be correct for this evaluation, as the MF for hydrogen is the higher.

6. **"Burner-Type" Reactor** – When feeding two reactants continuously, such as in burners, consider the "burner-type" reactor. An example is an HCl (hydrogen chloride) synthesis reactor, which, as a Process Unit reacts hydrogen with chlorine but normally contains only HCl, a completely non-reactive and non-combustible gas (MF = 1). However, the slightest upset can result in flameouts and reaction ceases, resulting in the Process Unit filling with reactants. The explosion hazards of HCl synthesis reactors are so well known that they are always provided with explosion relief. MF should be based on the higher MF of the two reactants, hydrogen (MF = 21) and chlorine (MF = 1); that is, the MF should be 21.

   Fired boilers and furnaces are subject to flameout and explosive re-ignition of the reactants, fuel and air. They should be treated similarly to the example in the previous paragraph.

7. **Mixtures with Mostly Water Composition** – If a mixture is mostly water, consider carefully the condition of the water in determining the "material factor" to avoid an unrealistically low value. For example, water saturated with butadiene will have a true flash point equal to that of butadiene but will not have a DTA/DSC exotherm. The vapor above such water is mostly butadiene. Thus $N_F = 4$ and $N_R = O$ for the vapor space and therefore MF = 21.

In summary, the **Process Unit** should be examined over its cycle of operation for the most hazardous state. This most hazardous state is when the worst possible materials may escape from or exist in the process equipment during normal starting up, operating or shutting down.

APPENDIX C

BASIC PREVENTIVE AND PROTECTIVE FEATURES

Many of the features below should be provided regardless of the type of operation or the magnitude of the Fire and Explosion Index. When they are not provided, the existing hazard exposure may be greater than the F&EI indicates. This list is not all-inclusive as other features may be needed, depending upon the specific installation.

A. Adequate water supply for fire protection. This is determined by multiplying its water demand by the length of time that the worst possible fire can be expected to last. The supply deemed adequate will vary with different authorities and may range from enough for a two-hour fire to enough for one lasting eight hours. (See Loss Prevention Principle (LPP) 4.5.)
B. Structural design of vessels, piping, structural steel, etc.
C. Overpressure relief devices. (See LPP 14.3)
D. Corrosion resistance and/or allowances.
E. Segregation of reactive materials in process lines and equipment.
F. Electrical equipment grounding.
G. Safe location of auxiliary electrical gear (transformers, breakers, etc.) (See LPP 3.5)
H. Normal protection against utility loss (alternate electrical feeder, spare instrument air compressor, etc.)
I. Compliance with various applicable codes (ASME, ASTM, ANSI, Building Codes, Fire Codes, etc.)
J. Fail-safe instrumentation. (See LPP 15.2)
K. Access to area for emergency vehicles and exits for personal evacuation. (See LPP 2.3)
L. Drainage to handle probable spills safely plus fire fighting water from hose nozzles and sprinkler heads and/or chemicals. (See LPP 2.4)
M. Insulation of hot surfaces that heat to within 80% of the autoignition temperature of any flammable in the area.
N. Adherence to the National Electrical Code. The Code should be followed except where variances have been requested/approved. (See LPP 3.1)
O. Limitation of glass devices and expansion joints in flammable or hazardous service. Such devices are not permitted unless absolutely essential. Where used, they must be registered and approved by the production manager and installed in accordance with Dow standards and specifications. (See LPP 6.9)
P. Building and equipment layout. Separation of high-hazard area must be recognized especially as it relates to both property damage and interruption of business. Separation of tanks must be at least in accordance with NFPA 30. (See LPP 2.2)
Q. Protection of pipe racks and instrument cable trays as well as their supports from exposure to fire. (See LPP 3.2)
R. Provision of accessible battery limit block valves.
S. Cooling tower loss prevention and protection. (See LPP 6.1)
T. Protection of fired equipment against accidental explosion and resultant fire. (See LPP 13.1 – 13.4)
U. Electrical classification. Division 2 electrical equipment will be required for outside flammable liquid handling where congestion is minimal and natural ventilation is unobstructed. Division 1 equipment is required only for special chemicals and/or special building or process handling conditions or where ventilation is inadequate. (See LPP 3.1)
V. Process control rooms shall be isolated by one hour fire walls from process control laboratories and/or electrical switch-gear and transformers. (See LPP 12.2)
W. A process review shall determine a need for reactive chemicals testing. (See *Guidelines For A Reactive Chemicals Program*.)
X. A HAZOP review is recommended in high hazard areas.

LOSS PREVENTION CHECKLIST

1. **Scope**

This checklist outlines most engineering topics needing consideration for possible loss prevention requirements. Such topics include: Location, Buildings, Fire Protection, Electrical, Sewers, Storage, Inert Gas Blanketing, Materials Handling, Machinery. Process, Process Computers, and General Safety Equipment.

2. **Introduction**

This checklist is intended as a guide for use when assessing the fire hazards and reviewing the loss prevention requirements of a chemical plant. It may also be of particular advantage in planning new facilities. No such checklist can ever be entirely complete or meet the needs of every situation. Care should be taken in using such a list to make sure that other pertinent items not included here are not overlooked.

3. **Location**

A. Plant layout; separation of units per hazard evaluation
B. Accessibility
C. Traffic – vehicular and pedestrian
D. Parking areas – entrances, exits, drainage, lighting, enclosures
E. Clearances – buildings for railroad traffic and vehicles (overhead turnarounds)
F. Drainage, impounding areas
G. Road locations, markings
H. Entrances, exits – pedestrian, vehicular, and railroad
I. Ignition sources – furnace location, flare stacks, boilers, burner management
J. Prevailing wind
K. Underground utility conduits
L. Flood control or protection
M. Loading/unloading facilities, avoid using main traffic area for this activity

4. **Buildings**

A. Basic non-combustible construction
B. Wind pressure, snow loads, floor loads, earthquake design
C. Roof material, anchorage
D. Roof vents and drains, smoke dispersal
E. Stairwells, ramps, lighting
F. Elevators and dumbwaiters
G. Fire walls, openings, fire doors
H. Explosion relief, blast design
I. Exits – fire escapes, identification, safety treads
J. Record storage
K. Ventilation – fans, blowers, air conditioning, scrubbing of toxic vapors, location of exhaust inlets, smoke and heat ventilation dampers, fire curtains
L. Lightning protection, structural and equipment grounding for electrical discharges
M. Building heaters (Division 1 or 2 or standard areas), vents
N. Locker rooms including need for separate lockers for work and street clothes, required number of each and air changes
O. Building drainage – inside and out, properly trapped

APPENDIX D

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P. Structural steel and equipment fireproofing
Q. Access ladders to roofs and outside level, escape ladders, fire escapes
R. Bearing capacity of subsoil
S. Heat and smoke detection
T. Elevation – flood plain restrictions
U. Wheel load on overhead crane

5. **Fire Protection**
   A. Water supply including secondary supplies, pumps, reservoirs and tanks
   B. Mains – adequate looping, cathodic protection, coated and wrapped when needed, sectional valves
   C. Hydrants – location, spacing, monitors
   D. Automatic sprinklers – occupancy classification, wet systems, dry systems, deluge systems
   E. Standpipes and tanks
   F. Type, size, location and number of fire extinguishers needed
   G. Fixed automatic extinguishing systems, CO_2, foam, dry powder
   H. Special fire protection systems – rise in temperature alarms, sprinkler system flow alarms, photoelectric smoke and flame alarms, snuffing steam
   I. Piping system – materials of construction, no cast iron if explosion is possible

6. **Electrical**
   A. Electrical hazard area classifications, intrinsically safe equipment
   B. Accessibility of critical circuit breakers and switchgear
   C. Polarized outlets and grounded systems
   D. Switches and breakers for critical equipment and machinery
   E. Lighting – Division 1 or 2 or standard areas, light intensity, approved equipment, emergency lights
   F. Telephones and intercoms – Division 1 or 2 or standard areas
   G. Type of electrical distribution system – voltage, grounded or ungrounded, overhead, underground
   H. Conduit, raceways, enclosures, corrosion considerations
   I. Motor and circuit protection
   J. Transformer location and types
   K. Fail safe control devices protection against automatic restarting
   L. Backup busses for critical loads
   M. Key interlocks for safety and proper sequencing, duplicate feeders
   N. Lightning protection
   O. Exposure of cable trays to fire damage
   P. Uninterruptible Power Supply (UPS) and emergency power system
   Q. Requirements for equipment grounding, methods and frequency of testing

7. **Sewers**
   A. Chemical sewers – trapped, accessible cleanouts, vents, locations, disposal, explosion possibilities, trap tanks, forced ventilation, flammable vapor detectors and alarms, freezing or ice blocks
   B. Sanitary sewers – treatment, disposal, traps, plugs, cleanouts, vents
   C. Storm sewers
   D. Waste treatment, possible dangers from steam contamination including fire hazard from spills into streams and lakes
   E. Drain trenches – open, buried, accessible cleanouts, presence of required baffles, exposure to process equipment
   F. Ground water impairment prevention, air and surface water safeguards and proper disposal of waste
   G. Sewer drains connected to process drains

8. **Storage**

A. General

1. Accessibility – entrances and exits, sizes
2. Sprinklered
3. Aisle space
4. Floor loading
5. Racks and spacing
6. Height of piles
7. Roof venting
8. Spill containment
9. Adequate tank venting for both pressure and vacuum

B. Flammable liquids – gases, dusts and powders, fumes and mists

1. Closed systems
2. Safe atmospheres throughout system
3. Areas to be sprinklered or provided with water spray
4. Emergency vents, flame arresters, relief valves, safe venting location including flares
5. Floor drains to chemical sewers properly trapped
6. Ventilation – pressurized controls, etc., and/or equipment
7. Tanks, bins, silos – safe distance separation, fireproofing supports or local deluge protection, dikes and drainage, inerting atmospheres, underground (not recommended)
8. Special extinguishing systems, explosion suppression – foam, dry chemicals, carbon dioxide
9. Dependable refrigeration systems for critical chemicals
10. Location of pumps, compressors, etc., away from spill potential
11. Weak roof seam construction on API tanks
12. Cross venting of source tanks and storage tanks

C. Raw Materials

1. Danger of risk classification of material including shock sensitivity
2. Facilities for receiving and storing
3. Identification and purity tests
4. Provisions to prevent materials being placed in wrong tanks, tank overflow, etc.

D. Finished Products

1. Identification and labeling to protect the customer
2. Conformance with shipping regulations
3. Segregation of dangerous materials
4. Protection from contamination, especially in the filling of tank cars and tank trucks
5. Placarding of shipping vehicles
6. Routing of dangerous shipments
7. Material Safety Data Sheets (MSDS) for safety information for customers
8. NFPA Hazard Ratings
9. Heat detection
10. Conveyers and their location in production areas
11. Flammable liquid storage – paints, oils, solvents
12. Reactive or explosive storage – quantities, distance separation, limited access
13. Disposal of wastes – incinerators, air and water pollution safeguards
14. Spill control
15. Safe shipping containers

9. **Inert Gas Blanketing of All Flammable Products**
   A. Consider raw material, intermediates and products
   B. Consider storage, materials handling and processes

10. **Materials Handling**
   A. Truck loading and unloading facilities
   B. Railroad loading and unloading facilities
   C. Industrial trucks and tractors – gasoline, diesel, liquefied petroleum gas, and battery powered
   D. Loading and unloading docks for rail, tank trucks, and truck trailer grounding systems for flammable liquids
   E. Cranes – mobile, capacity marking, overload protection, limit switches, inspection schedules
   F. Warehouse area – floor loading and arrangement, sprinklers, height of piles, ventilation, smoke and heat detection
   G. Conveyors and their location in production areas
   H. Flammable liquid storage – paints, oils, solvents
   I. Reactive or Explosive storage – quantities, distance separation, limited access
   J. Disposal of wastes – incinerators, air and ground water safeguards
   K. Spill control

11. **Machinery**
   A. Accessibility, maintenance and operations
   B. Remote emergency stop switches
   C. Vibration monitoring/shutdown
   D. Lubrication monitoring
   E. Overspeed protection
   F. Noise evaluation
   G. Do not use cast iron or other brittle construction materials on:
      1. Hazardous materials
      2. Equipment load bearing parts (e.g., pump casing frames)

12. **Process**
   A. Chemicals – fire and health hazards (skin and respiratory), instrumentation, operating rules, maintenance, compatibility of chemicals, stability, labeling of pipelines and equipment, etc.
   B. Critical pressures and temperatures
   C. Relief devices and flame arresters, properly registered
   D. Coded vessels made of suitable materials of construction
   E. Piping made to suitable specifications and codes and materials of construction
   F. Methods for handling runaway reactions
   G. Fixed fire protection systems – CO_2, foam, sprinkler deluge
   H. Vessels properly vented, safe location, deadhead pump protection
   I. Permanent vacuum cleaning systems
   J. Explosion barricades and isolation
   K. Inert gas blanketing systems – listing of equipment requiring blanketing
   L. Emergency shutdown valves and switches, location from critical area, action time for relays, emergency block valves
   M. Fireproofing of structural steel beams and columns (or area deluge protection)
   N. Safety devices for heat exchange equipment – vents, valves and drains
   O. Expansion loops for steam lines
   P. Do not use expansion joints unless not alternative – register and maintain
   Q. Do not use sight glasses – if absolutely necessary register and maintain

R. Steam and electrical tracing – provision for relief of thermal expansion in heated lines

S. Insulation for personnel protection – hot process, steam lines and tracing – overheating protection of material in pipe

T. Static grounding for vessels, piping and production equipment

U. Cleaning and maintenance of vessels and tanks – adequate manholes, platforms, ladders, clean-out openings and safe entry permit procedures

V. Provisions for corrosion monitoring and control

W. Pipeline identification

X. Radiation problems including personal protection for firefighters – processes and measuring instruments containing radioisotopes, X-rays, etc.

Y. Redundant critical instruments with alarms, fail safe operation

Z. Critical instrument designation and maintenance

AA. Fixed flammable gas detection and alarm systems

13. Process Computers

A. Control Room

1. Air handling – temperature, humidity, dust, positive pressure, etc.
2. Location – ground floor preferred, non-combustible construction
3. Floor covering – vinyl or laminated plastic to prevent static
4. Space requirements for accessibility
5. No paper or combustibles storage
6. Lighting and power receptacles
7. Fire protection – use CO_2, smoke detectors, heat detectors
8. Purged control room

B. Power Wiring and Grounding

1. Adequate power supply from special panel
2. Dual sources of power
3. Computer control system grounded at source, i.e., at step down transformer
4. Control room junction boxes connected to building ground

C. Signal Wiring

1. Field wiring terminated in a control junction box or other interface device
2. Wiring protected by cable tray, metal wireway, conduit or run below raised floor
3. Ribbon cables or similar type fragile cables run in separate enclosure from field cables

D. Control Systems

1. Fail safe conventions
2. Policies on parameter changes and manual control of outputs or input
3. Policies on control strategy changes and backup of current strategy
4. Documentation – inputs and outputs, operating discipline and control logic diagrams
5. Shutdown procedures for loss of utilities
6. Training
7. Alarm system
8. Regular audits
9. Control room integrity and location
10. Source of power for process controllers
11. Backup control systems

14. **Safety Equipment, General**
   A. Dispensary and equipment
   B. Ambulance
   C. Fire truck
   D. Emergency alarm system – alert, gas release, evacuate, etc.
   E. Fire whistle and siren – departments, inside and outside
   F. Snow removal and ice control equipment
   G. Safety showers and eye wash fountains – operational alarms, indication of location
   H. Safety ladders and cages
   I. Emergency equipment locations – gas masks, protective clothing, inside hose streams, stretchers, flash suits, self-contained breathing apparatus, etc.
   J. Laboratory safety shields
   K. Instruments – continuous, portable analyzers for flammable vapors and gases, oxygen, toxic vapors, etc.
   L. Communications – emergency telephones, radio, public address systems, paging systems, safe location and continuous manning of communication center
   M. Guards on rotating equipment
   N. Combustion safeguards on furnaces, burner management system (see LPP 13.1)
   O. Fuel gas shutoff valves
   P. Spill/vapor release alarms
   Q. Flange protectors on acid lines

APPENDIX E

EQUATIONS FOR DAMAGE FACTOR DATA

The Damage Factor is to be determined using Figure 8, page 53. This data is different from the data in the other figures in this report inasmuch as the data was fit to equations giving the damage factors at Process Unit Hazards Factors from 1.0 to 8.0 for each of the discrete Material Factors. Since there are nine Material Factors - 1, 4, 10, 14, 16, 21, 24, 29, and 40 - there are nine equations.

It is important to note that there really is no meaning for the intermediate Material Factors other than the nine defined cases. The data points were joined by lines solely for the purpose of allowing it to be easier to follow along the lines of constant Process Unit Hazards Factors. The main value of this figure is to allow for the interpolation of the Damage Factors between different values of the Process Unit Hazards Factors.

The nine equations derived for the nine Material Factors are as follows:

For the **Material Factor of 1** the equation for the Damage Factors (Y axis) based on the Process Unit Hazards Factors from 1 through 8 is as follows:

$$Y = 0.003907 + 0.002957(X) + 0.004031(X^2) - 0.00029(X^3)$$

or

Y = 0.003907 + 0.002957*X + 0.004031*X^2 - 0.00029*X^3

For the **Material Factor of 4** the equation for the Damage Factors (Y axis) based on the Process Unit Hazards Factors from 1 through 8 is as follows:

$$Y = 0.025817 + 0.019071(X) - 0.00081(X^2) + 0.000108(X^3)$$

or

Y = 0.025817 + 0.019071*X - 0.00081*X^2 + 0.000108*X^3

For the **Material Factor of 10** the equation for the Damage Factors (Y axis) based on the Process Unit Hazards Factors from 1 through 8 is as follows:

$$Y = 0.098582 + 0.017596(X) + 0.000809(X^2) - 0.000013(X^3)$$

or

Y = 0.098582 + 0.017596*X + 0.000809*X^2 - 0.000013*X^3

For the **Material Factor of 14** the equation for the Damage Factors (Y axis) based on the Process Unit Hazards Factors from 1 through 8 is as follows:

$$Y = 0.20592 + 0.018938(X) + 0.007628(X^2) - 0.00057(X^3)$$

or

Y = 0.20592 + 0.018938*X + 0.007628*X^2 - 0.00057*X^3

For the **Material Factor of 16** the equation for the Damage Factors (Y axis) based on the Process Unit Hazards Factors from 1 through 8 is as follows:

$$Y = 0.256741 + 0.019886(X) + 0.011055(X^2) - 0.00088(X^3)$$

or

Y = 0.256741 + 0.019886*X + 0.011055*X^2 - 0.00088*X^3

For the **Material Factor of 21** the equation for the Damage Factors (Y axis) based on the Process Unit Hazards Factors from 1 through 8 is as follows:

$$Y = 0.340314 + 0.076531(X) + 0.003912(X^2) - 0.00073(X^3)$$

or

Y = 0.340314 + 0.076531*X + 0.003912*X^2 - 0.00073*X^3

For the **Material Factor of 24** the equation for the Damage Factors (Y axis) based on the Process Unit Hazards Factors from 1 through 8 is as follows:

$$Y = 0.395755 + 0.096443(X) - 0.00135(X^2) - 0.00038(X^3)$$

or

Y = 0.395755 + 0.096443*X - 0.00135*X^2 - 0.00038*X^3

For the **Material Factor of 29** the equation for the Damage Factors (Y axis) based on the Process Unit Hazards Factors from 1 through 8 is as follows:

$$Y = 0.484766 + 0.094288(X) - 0.00216(X^2) - 0.00031(X^3)$$

or

Y = 0.484766 + 0.094288*X - 0.00216*X^2 - 0.00031*X^3

For the **Material Factor of 40** the equation for the Damage Factors (Y axis) based on the Process Unit Hazards Factors from 1 through 8 is as follows:

$$Y = 0.554175 + 0.080772(X) + 0.000332(X^2) - 0.00044(X^3)$$

or

Y = 0.554175 + 0.080772*X + 0.000332*X^2 - 0.00044*X^3

The equations are given in both word processing format and text format. For reading this guide in text format only, the figures and the word processing format equations will not appear. However, the equation in text format will allow determination of the Damage Factor.

APPENDIX F

ACRONYMS AND ABBREVIATIONS

ACV	Actual Cash Value
AIChE	American Institute of Chemical Engineers
ANSI	American National Standards Institute
API	American Petroleum Institute
ARC	Accelerating Rate Calorimeter
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BI	Business Interruption
BTU	British Thermal Unit
CEI	Chemical Exposure Index
DRI	Distribution Ranking Index
DSC	Differential Scanning Calorimeter
DTA	Differential Thermal Analysis
EBV	Emergency Block Valve
F&EI	Fire and Explosion Index
FMEA	Failure Mode and Effect Analysis
HAZOP	HAZard and OPerability Study
LPG	Liquefied Petroleum Gas
LPP	Loss Prevention Principle
MF	Material Factor
MPDO	Maximum Probable Days Outage
MPPD	Maximum Probable Property Damage
MSDS	Material Safety Data Sheet
NFPA	National Fire Protection Association
QRA	Quantitative Risk Assessment
SI	International System of Units (Le Systeme International d'Unites)
S/LP/S	Safety/Loss Prevention/Security
STP	Standard Temperature and Pressure
UPS	Uninterruptible Power Supply
US/British Units	United States/British Units
VPM	Value of Production for the Month

APPENDIX F

CORPORATE SAFETY, LOSS PREVENTION, AND SECURITY PUBLICATIONS

Minimum Requirements	
Minimum Requirements for S/LP/S	June 1989
Guidelines	
Guidelines for A Contractor Safety, Loss Prev., & Security Program, 2nd Edition	January 1992
Guidelines for Safety, Loss Prevention and Security Audits, 3rd Edition	November 1989
Guidelines for Office Safety, Loss Prevention and Security, 2nd Edition	April 1988
Guidelines for Emergency Planning	September 1985
Guidelines for A Motor Vehicle Accident Prevention Program, 3rd Edition	May 1992
Guidelines for Safety on Non-Dow Premises (Reprinted Oct. 1988)	December 1980
Guidelines for S/LP/S Reporting, 5th Edition	June 1990
Guidelines for Root Cause Incident Investigation	February 1993
Fire and Explosion Index Hazard Classification Guide, 7th Edition	January 1994
Guidelines for Public Warehouse Rating & Risk Analysis	January 1990
Distribution Emergency Response Process[2]	1991
Air Travel - Policy and Guidelines (Reprinted Jan. 1989)	April 1980
Guidelines for Safe Sample Shipping, 3rd Edition	June 1992
Guidelines for A Reactive Chemicals Program, 2nd Edition	January 1987
Guidelines for Handling Dow Proprietary Information, 2nd Edition	March 1991
Guidelines for Personal Safety & Security at Hotels/Motels and Other Off-Premises Facilities (Reprinted Nov. 1988)	July 1981
Guidelines for Determining Dust Hazard Potential	October 1989
Guidelines For Assessing Potential Acquisitions, 2nd Edition	July 1992
Program Requirements For Hearing Conservation[1]	July 1992
Basic Requirements for an Industrial Hygiene Program[3]	August 1987
Chemical Exposure Index Guide, 2nd Edition	September 1993
Chemical Hazard Engineering Guidelines	1993
Environmental Protection Guidelines for Operations	1990
Loss Prevention Self-Inspection Guideline	February 1991
Program Requirements for Respiratory Equipment[1]	October 1990
Program Requirements and Guidelines for Research and Development Facilities or Support Laboratories[3]	May 1991
Guidelines for Burner Management Systems for Boilers and Process Furnaces	June 1993
Global Hazardous Materials Distribution Guidelines[4]	March 1991
Guidelines for Management of Change	February 1992
Program Requirements for Personal Protective Equipment[1]	March 1992
Program Guidelines for Ergonomics and Ergonomic Program Guideline Resource Document[1]	September 1992
Guidelines for Chemical Labeling (for the U.S. Area)[5]	May 1992
Guidelines for Confined Space Entry	June 1993
Process Risk Management Guidelines for Facilities and Distribution	January 1994
Practices	
Loss Prevention Principles	Biannually
Loss Prevention Principles - Abstracts	Biannually
Operations Practices	April 1990
Others	
Dow Safety Improvement System (DSIS)	October 1991
Dow Safety Improvement System User's Guide	April 1992
Fundamentals of Fire and Explosion - By Daniel R. Stull	
Topical Index of S&LP Standards & Specifications	October 1986
S&LP Audio/Visual Listing	September 1990
The Office Safety Handbook	1977
Security...In The Office & Data Handling Areas	1983

Publications Available from:
Corporate Safety, Loss Prevention, and Security
2030 Dow Center - Midland, MI (517) 636-3358 or -6821

DO A 044696
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[1]Occupational Health Guide
[2]US Area Distribution Guide
[3]Industrial Hygiene Guide
[4]Corp. Product Dept. Guide
[5]Health and Environmental Sciences - CHEC

01/94

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a) Emergency Power	.98	f) Inert Gas	.94 to .96
b) Cooling	.97 to .99	g) Operating Instructions/ Procedures	.91 to .99
c) Explosion Control	.84 to .98	h) Reactive Chemical Review	.91 to .98
d) Emergency Shutdown	.96 to .99		
e) Computer Control	.93 to .99		

C_1 Total ____________*

2. Material Isolation (C_2)

a) Remote Control Valves	.96 to .98	c) Drainage	.91 to .97
b) Dump/Blowdown	.96 to .98	d) Interlock	.98

C_2 Total ____________*

3. Fire Protection (C_3)

a) Leak Detection	.94 to .98	f) Sprinkler Systems	.74 to .97
b) Structural Steel	.95 to .98	g) Water Curtains	.97 to .98
c) Buried Tanks	.84 to .91	h) Foam	.92 to .97
d) Water Supply	.94 to .97	i) Hand Extinguishers/Monitors	.95 to .98
e) Special Systems	.91	j) Cable Protection	.94 to .98

C_3 Value ____________*

Credit Factor = $C_1 \times C_2 \times C_3$ = ____________ Enter on Line D Below

UNIT ANALYSIS SUMMARY

A-1. F & EI ____________
A-2. Radius of Exposure ____________ ft.
A-3. Value of Area of Exposure $MM ____________
B. Damage Factor ____________
C. Base MMPD (A-3 X B) $MM ____________
D. Credit Factor ____________
E. Actual MMPD (C X D) $MM ____________
F. Days Outage (MPDO) ____________ days.
G. Business Interruption Loss (BI) $MM ____________

*Product of all factors used.

BACK OF FORM C-22380 R-4-87 (471-036) W462

DO A 044697
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LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a) Emergency Power	.98	f) Inert Gas	.94 to .96
b) Cooling	.97 to .99	g) Operating Instructions/ Procedures	.91 to .99
c) Explosion Control	.84 to .98	h) Reactive Chemical Review	.91 to .98
d) Emergency Shutdown	.96 to .99		
e) Computer Control	.93 to .99		

C_1 Total ____________*

2. Material Isolation (C_2)

a) Remote Control Valves	.96 to .98	c) Drainage	.91 to .97
b) Dump/Blowdown	.96 to .98	d) Interlock	.98

C_2 Total ____________*

3. Fire Protection (C_3)

a) Leak Detection	.94 to .98	f) Sprinkler Systems	.74 to .97
b) Structural Steel	.95 to .98	g) Water Curtains	.97 to .98
c) Buried Tanks	.84 to .91	h) Foam	.92 to .97
d) Water Supply	.94 to .97	i) Hand Extinguishers/Monitors	.95 to .98
e) Special Systems	.91	j) Cable Protection	.94 to .98

C_3 Value ____________*

Credit Factor = $C_1 \times C_2 \times C_3$ = ____________ Enter on Line D Below

UNIT ANALYSIS SUMMARY

A-1. F & EI	____________		
A-2. Radius of Exposure	____________ ft.		
A-3. Value of Area of Exposure		$MM	____________
B. Damage Factor	____________		
C. Base MMPD (A-3 X B)		$MM	____________
D. Credit Factor	____________		
E. Actual MMPD (C X D)		$MM	____________
F. Days Outage (MPDO)			____________ days.
G. Business Interruption Loss (BI)		$MM	____________

*Product of all factors used.

50 C

DOW

FIRE & EXPLOSION INDEX

AREA / COUNTRY	DIVISION	LOCATION	DATE
North America	LAD		4/17/96
SITE	MANUFACTURING UNIT	PROCESS UNIT	
	Glycol I	PDC - T-1200	

PREPARED BY:	APPROVED BY: (Superintendent)	BUILDING
		1501
REVIEWED BY: (Management)	REVIEWED BY: (Technology Center)	REVIEWED BY: (Safety & Loss Prevention)

MATERIALS IN PROCESS UNIT
PDC

STATE OF OPERATION
__ DESIGN __ START UP ✓ NORMAL OPERATION __ SHUTDOWN

BASIC MATERIAL(S) FOR MATERIAL FACTOR
PDC

MATERIAL FACTOR (See Table 1 or Appendices A or B) Note requirements when unit temperature over 140 °F (60 °C)		16
1. General Process Hazards	**Penalty Factor Range**	**Penalty Factor Used(1)**
Base Factor	1.00	1.00
A. Exothermic Chemical Reactions	0.30 to 1.25	—
B. Endothermic Processes	0.20 to 0.40	—
C. Material Handling and Transfer	0.25 to 1.05	—
D. Enclosed or Indoor Process Units	0.25 to 0.90	—
E. Access	0.20 to 0.35	—
F. Drainage and Spill Control - Flat Area ______ gal or cu.m.	0.25 to 0.50	0.50
General Process Hazards Factor (F_1)		1.50
2. Special Process Hazards		
Base Factor	1.00	1.00
A. Toxic Material(s) Nh = 2	0.20 to 0.80	0.40
B. Sub-Atmospheric Pressure (< 500 mm Hg)	0.50	0.50
C. Operation In or Near Flammable Range ✓ Inerted __ Not Inerted		
1. Tank Farms Storage Flammable Liquids	0.50	—
2. Process Upset or Purge Failure	0.30	—
3. Always in Flammable Range	0.80	—
D. Dust Explosion (See Table 3)	0.25 to 2.00	—
E. Pressure (See Figure 2) Operating Pressure -7 psig or kPa gauge / Relief Setting 50 psig or kPa gauge	0.18 / 0.25	.18/.2[illegible] .13
F. Low Temperature	0.20 to 0.30	—
G. Quantity of Flammable/Unstable Material: Quantity 6700 lb or kg; H_C = 6.3×10³ BTU/lb or kcal/kg		
1. Liquids or Gases in Process (See Figure 3)		0.15
2. Liquids or Gases in Storage (See Figure 4)		—
3. Combustible Solids in Storage, Dust in Process (See Figure 5)		—
H. Corrosion and Erosion	0.10 to 0.75	—
I. Leakage – Joints and Packing	0.10 to 1.50	—
J. Use of Fired Equipment (See Figure 6)		—
K. Hot Oil Heat Exchange System (See Table 5)	0.15 to 1.15	—
L. Rotating Equipment	0.50	—
Special Process Hazards Factor (F_2)		2.18
Process Unit Hazards Factor (F_1 x F_2) = F_3 5x		3.27
Fire and Expl si n Index (F_3 x MF = F&EI)		52

(1) For no penalty use 0.00.

FORM C-22360 Rev/01-94 (471-00036)

DO A 044699
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LOSS CONTROL CREDIT FACTORS

1. Process Contr l Credit Factor (C_1)

Feature	Credit Factor Range	Credit Factor Used(2)	Feature	Credit Fact r Rang	Credit Factor Used(2)
a. Emergency Power	0.98	1	f. Inert Gas	0.94 to 0.96	1
b. Cooling	0.97 to 0.99	1	g. Operating Instructions/Procedures	0.91 to 0.99	0.91
c. Explosion Control	0.84 to 0.98	1	h. Reactive Chemical Review	0.91 to 0.98	0.91
d. Emergency Shutdown	0.96 to 0.99	1	i. Other Process Hazard Analysis	0.91 to 0.98	0.98
e. Computer Control	0.93 to 0.99	0.97			

C_1 Value(3) $\boxed{0.787}$

2. Material Isolation Credit Factor (C_2)

Feature	Credit Factor Range	Credit Factor Used(2)	Feature	Credit Factor Range	Credit Factor Used(2)
a. Remote Control Valves	0.96 to 0.98	0.96	c. Drainage	0.91 to 0.97	1
b. Dump/Blowdown	0.96 to 0.98	1	d. Interlock	0.98	1

C_2 Value(3) $\boxed{0.96}$

3. Fire Protection Credit Factor (C_3)

Feature	Credit Factor Range	Credit Factor Used(2)	Feature	Credit Factor Range	Credit Factor Used(2)
a. Leak Detection	0.94 to 0.98	1	f. Water Curtains	0.97 to 0.98	1
b. Structural Steel	0.95 to 0.98	1	g. Foam	0.92 to 0.97	1
c. Fire Water Supply	0.94 to 0.97	0.94	h. Hand Extinguishers/Monitors	0.93 to 0.98	1
d. Special Systems	0.91	1	i. Cable Protection	0.94 to 0.98	1
e. Sprinkler Systems	0.74 to 0.97	0.97			

C_3 Value(3) $\boxed{0.91}$

Loss Control Credit Factor = $C_1 \times C_2 \times C_{3(3)}$ = $\boxed{0.687}$ (Enter on line 7 below)

PROCESS UNIT RISK ANALYSIS SUMMARY

1. Fire & Explosion Index (F&EI)........................(See Front)		
2. Radius of Exposure.......................................(Figure 7)	ft or m	
3. Area of Exposure...	ft² or m²	
4. Value of Area of Exposure..		$MM
5. Damage Factor..(Figure 8)		
6. Base Maximum Probable Property Damage – (Base MPPD) [4 x 5]................................		$MM
7. Loss Control Credit Factor............................(See Above)	0.69	
8. Actual Maximum Probable Property Damage – (Actual MPPD) [6 x 7]............................		$MM
9. Maximum Probable Days Outage – (MPDO)......(Figure 9)	days	
10. Business Interruption – (BI)...		$MM

(2) For no credit factor enter 1.00. (3) Product of all factors used.

Refer to *Fire & Explosion Index Hazard Classification Guide* (Form #471-00001) for details.

BACK OF FORM C-22380 Rev01-94 (471-00036)

DO A 044700
CONFIDENTIAL

89°C

Dow

FIRE & EXPLOSION INDEX

AREA / COUNTRY	DIVISION	LOCATION	DATE
North America	LAD		4/17/96
SITE	MANUFACTURING UNIT	PROCESS UNIT	
	Glycol I	PDC - T-1000	

PREPARED BY:	APPROVED BY: (Superintendent)	BUILDING
Tonya Tyler		1501
REVIEWED BY: (Management)	REVIEWED BY: (Technology Center)	REVIEWED BY: (Safety & Loss Prevention)

MATERIALS IN PROCESS UNIT
PDC - EPI, DCIPE

STATE OF OPERATION
✓ DESIGN ___ START UP ___ NORMAL OPERATION ___ SHUTDOWN

BASIC MATERIAL(S) FOR MATERIAL FACTOR
PDC

MATERIAL FACTOR (See Table 1 or Appendices A or B) Note requirements when unit temperature over 140 °F (60 °C): 16

1. General Process Hazards	Penalty Factor Range	Penalty Factor Used(1)
Base Factor	1.00	1.00
A. Exothermic Chemical Reactions	0.30 to 1.25	—
B. Endothermic Processes	0.20 to 0.40	—
C. Material Handling and Transfer	0.25 to 1.05	—
D. Enclosed or Indoor Process Units	0.25 to 0.90	—
E. Access	0.20 to 0.35	—
F. Drainage and Spill Control Flat Area ______ gal or cu.m.	0.25 to 0.50	0.50
General Process Hazards Factor (F_1)		1.50
2. Special Process Hazards		
Base Factor	1.00	1.00
A. Toxic Material(s) Nh=2	0.20 to 0.80	0.4
B. Sub-Atmospheric Pressure (< 500 mm Hg)	0.50	0.50
C. Operation In or Near Flammable Range ✓ Inerted ___ Not Inerted		
1. Tank Farms Storage Flammable Liquids	0.50	—
2. Process Upset or Purge Failure	0.30	—
3. Always in Flammable Range	0.80	—
D. Dust Explosion (See Table 3)	0.25 to 2.00	—
E. Pressure (See Figure 2) Operating Pressure -7 psig or kPa gauge	.18	.18 ($\frac{.18}{.25}$)
Relief Setting 50 psig or kPa gauge	.25	.13
F. Low Temperature	0.20 to 0.30	—
G. Quantity of Flammable/Unstable Material: Quantity 1790 lb or kg; H_C = 6.3 x103 BTU/lb or kcal/kg		
1. Liquids or Gases in Process (See Figure 3)		0.15
2. Liquids or Gases in Storage (See Figure 4)		—
3. Combustible Solids in Storage, Dust in Process (See Figure 5)		—
H. Corrosion and Erosion	0.10 to 0.75	—
I. Leakage – Joints and Packing	0.10 to 1.50	—
J. Use of Fired Equipment (See Figure 6)		—
K. Hot Oil Heat Exchange System (See Table 5)	0.15 to 1.15	—
L. Rotating Equipment	0.50	—
Special Process Hazards Factor (F_2)		2.18
Process Unit Hazards Factor (F_1 x F_2) = F_3		3.27
Fire and Explosi n Index (F_3 x MF = F&EI)		52

(1) For no penalty use 0.00.

DO A 044701
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FORM C-22380 Rev/01-94 (471-00036)

LOSS CONTROL CREDIT FACTORS

1. Process Contr l Credit Factor (C_1)

Feature	Credit Fact r Range	Credit Fact r Used(2)	Feature	Credit Factor Range	Credit Factor Used(2)
a. Emergency Power	0.98	1	f. Inert Gas	0.94 to 0.96	1
b. Cooling	0.97 to 0.99	1	g. Operating Instructions/Procedures	0.91 to 0.99	0.91
c. Explosion Control	0.84 to 0.98	1	h. Reactive Chemical Review	0.91 to 0.98	0.91
d. Emergency Shutdown	0.96 to 0.99	1	i. Other Process Hazard Analysis	0.91 to 0.98	0.98
e. Computer Control	0.93 to 0.99	0.97			

C_1 Value(3) 0.787

2. Material Isolation Credit Factor (C_2)

Feature	Credit Factor Range	Credit Factor Used(2)	Feature	Credit Factor Range	Credit Factor Used(2)
a. Remote Control Valves	0.96 to 0.98	0.96	c. Drainage	0.91 to 0.97	1
b. Dump/Blowdown	0.96 to 0.98	1	d. Interlock	0.98	1

C_2 Value(3) 0.96

3. Fire Protection Credit Factor (C_3)

Feature	Credit Factor Range	Credit Factor Used(2)	Feature	Credit Factor Range	Credit Factor Used(2)
a. Leak Detection	0.94 to 0.98	0.98	f. Water Curtains	0.97 to 0.98	1
b. Structural Steel	0.95 to 0.98	1	g. Foam	0.92 to 0.97	1
c. Fire Water Supply	0.94 to 0.97	0.94	h. Hand Extinguishers/Monitors	0.93 to 0.98	1
d. Special Systems	0.91	1	i. Cable Protection	0.94 to 0.98	1
e. Sprinkler Systems	0.74 to 0.97	0.97			

C_3 Value(3) 0.89

Loss Control Credit Factor = $C_1 \times C_2 \times C_{3(3)}$ = 0.67 (Enter on line 7 below)

PROCESS UNIT RISK ANALYSIS SUMMARY

1. Fire & Explosion Index (F&EI)........................ (See Front)		
2. Radius of Exposure ....(Figure 7)	ft or m	
3. Area of Exposure..	ft^2 or m^2	
4. Value of Area of Exposure		$MM
5. Damage Factor ....(Figure 8)		
6. Base Maximum Probable Property Damage – (Base MPPD) [4 x 5]		$MM
7. Loss Control Credit Factor............................(See Above)	0.67	
8. Actual Maximum Probable Property Damage – (Actual MPPD) [6 x 7]		$MM
9. Maximum Probable Days Outage – (MPDO)......(Figure 9)	days	
10. Business Interruption – (BI)		$MM

(2) For no credit factor enter 1.00. (3) Product of all factors used.

Refer to *Fire & Explosion Index Hazard Classification Guide* (Form #471-00001) for details.

BACK OF FORM C-22380 Rev01-94 (471-00036)

DO A 044702
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Volume of Product | TMT 4/17/96

T-1200

From tray rating program from vendor

2.5" per tray (70) = 175"

Full level in bottom = 5' Total level = 19.6'

$V = \pi(2.5/2)^2\ 19.6' = 96\ ft^3\ (69\ lb/ft^3) = 6700\ lbs$

T-1000

0.

Typical volume in packing is 0.05 of total Packing volume ordered

[illegible] = [illegible] ft^3 (69) = 130,000 ft^3 (.05) = 6490 [illegible]

Liq level = $\pi(\frac{5}{2})^2$ [illegible] = [illegible]

Total = [illegible]

75

DO A 044703
CONFIDENTIAL

Update table

PLANT RISK ANALYSIS SUMMARY

AREA: U.S. / N. Am.   DIV./LOCATION: Louisiana Division   DATE: 3/10/92

PLANT: Glycol I   REPLACEMENT VALUE: PO $54.5 / PG $20.2   PREPARED BY: Dean / Tyler

Process Units	Material Factor MF	F&EI (F3XMF)	Value Area of Exposure $MM	Base MPPD $MM	Actual MMPD $MM	Days Outage MPDO	B.I. Loss $MM	
PO Storage Area #1	24	70.8	4.0	2.6	1.30	23	2.0	
PO Storage Area #2	24	70.8	4.0	2.6	1.30	23	2.0	
PG Hydrogenator Area #3	21	71.6	10.2	5.7	3.70	50	2.0	
Reactors Area #4	21	65.1	4.5	2.5	1.20	22	1.9	
Reactors Area #5	21	65.1	4.5	2.5	1.20	22	1.9	
Distillation (T-102C) Area #6	24	96.0	3.4	2.5	1.40	26	2.2	
Distillation (T-102B) Area #7	24	117.0	6.8	5.3	2.90	70	3.5	
Distillation (T-300) (8/95) 2nd Area #8	24	140.0 1 · 2nd	4.0	2.5	1.60	28	2.4	
Thr x - Area #9	16	99.2	5.0	3.0	1.15	22	1.9	
AD-6201A (9-30-92)	24	63.6						
DV-900 - Area #10 (3/95)	16	105	3.0	1.83	1.37	25	11.7	B. Lehigh

DO A 044704
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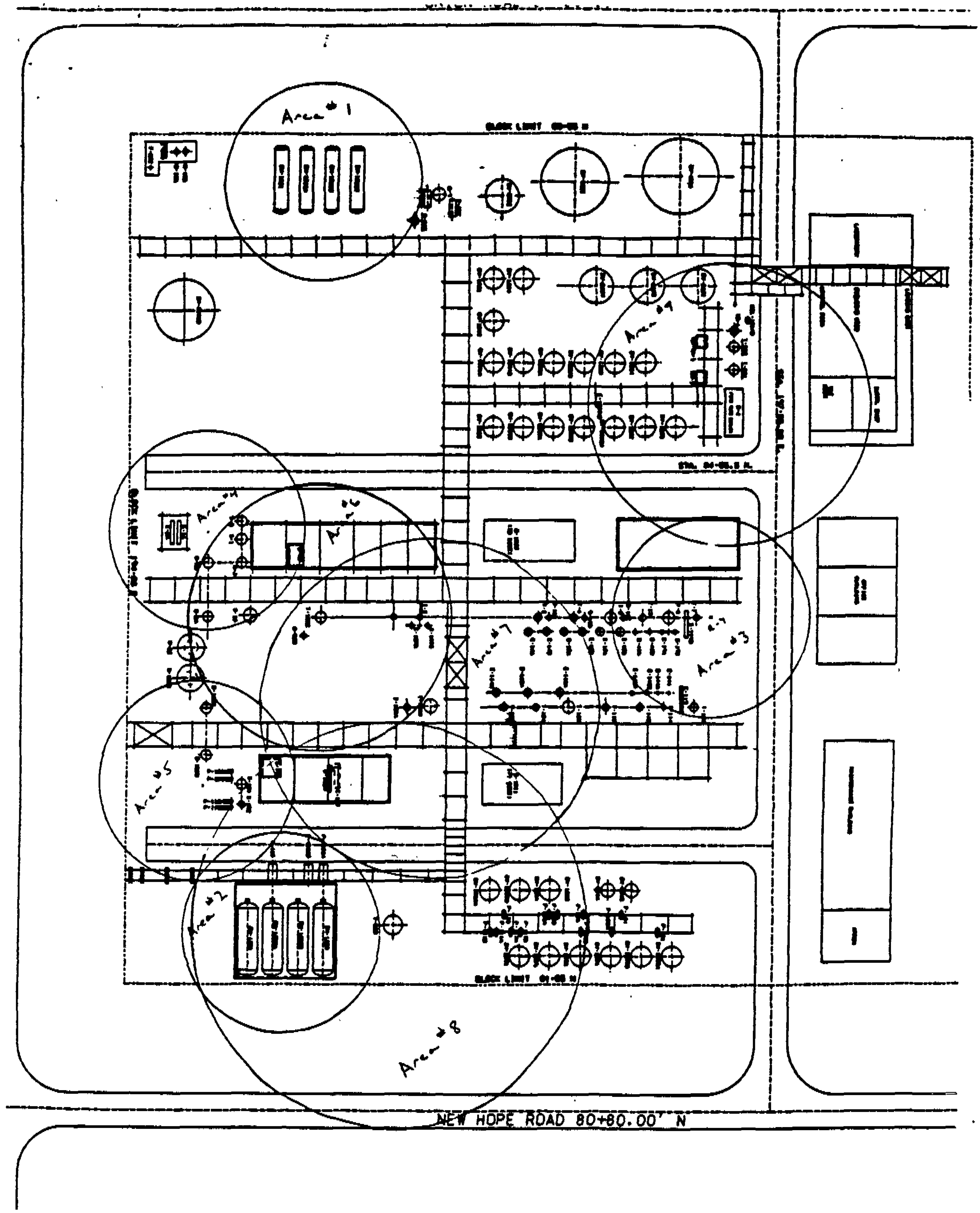

DO A 044705
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REVISION

FIRE AND EXPLOSION INDEX DOW

LOCATION	DATE

PLANT	PROCESS UNIT	EVALUATED BY	REVIEWED BY
Glycol 1	70 Storage PO		

MATERIALS AND PROCESS

MATERIALS IN PROCESS UNIT
Propylene Oxide

STATE OF OPERATION
START-UP . . SHUT-DOWN : : NORMAL OPERATION

BASIC MATERIAL(S) FOR MATERIAL FACTOR
Propylene Oxide

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I OR APPENDICES A OR B) Note requirements when unit temperature over 140°F)			24
1. GENERAL PROCESS HAZARDS	PENALTY	PENALTY USED	
BASE FACTOR	1.00	1.00	
A EXOTHERMIC CHEMICAL REACTIONS (FACTOR .30 to 1.25)		—	
B ENDOTHERMIC PROCESSES (FACTOR .20 to .40)		—	
C MATERIAL HANDLING & TRANSFER (FACTOR .25 to 1.05)		—	
D. ENCLOSED OR INDOOR PROCESS UNITS (FACTOR .25 to .90)		—	
E. ACCESS	.35	—	
F DRAINAGE AND SPILL CONTROL (FACTOR .25 to .50) ____ Gals.		—	
GENERAL PROCESS HAZARDS FACTOR (F_1)		1.0	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR	1.00	1.00	
A TOXIC MATERIAL(S) (FACTOR 0.20 to 0.80)		0.4	
B SUB-ATMOSPHERIC PRESSURE (500 mm Hg)	.50	—	
C OPERATION IN OR NEAR FLAMMABLE RANGE INERTED : : NOT INERTED			
1 TANK FARMS STORAGE FLAMMABLE LIQUIDS	.50	0.5	
2 PROCESS UPSET OR PURGE FAILURE	.30	—	
3 ALWAYS IN FLAMMABLE RANGE	.80	—	
D DUST EXPLOSION (FACTOR .25 to 2.00) (SEE TABLE II)		—	
E PRESSURE (SEE FIGURE 2) OPERATING PRESSURE ____ psig RELIEF SETTING 50 psig		0.25	
F LOW TEMPERATURE (FACTOR .20 to .30)		—	
G QUANTITY OF FLAMMABLE/UNSTABLE MATERIAL: QUANTITY 260,000 lbs., H_c = 13.2×10^3 BTU/lb		0.60	
1. LIQUIDS, GASES AND REACTIVE MATERIALS IN PROCESS (SEE FIG. 3)		—	
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)			
3. COMBUSTIBLE SOLIDS IN STORAGE, DUST IN PROCESS (SEE FIG. 5)		—	
H CORROSION AND EROSION (FACTOR .10 to .75)		0.10	
I. LEAKAGE — JOINTS AND PACKING (FACTOR .10 to 1.50)		0.10	
J. USE OF FIRED HEATERS (SEE FIG. 6)		—	
K. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15) (SEE TABLE III)		—	
L. ROTATING EQUIPMENT	.50	—	
SPECIAL PROCESS HAZARDS FACTOR (F_2)		2.95	
UNIT HAZARD FACTOR ($F_1 \times F_2$ = F_3)		2.95	
FIRE AND EXPLOSION INDEX ($F_3 \times MF$ = F & EI)			70.8

DO A 044706
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To PO.AREA

EXHIBIT B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a) Emergency Power	.98	f) Inert Gas - N_2	.94 to .96
b) Cooling	.97 to .99	g) Operating Instructions/ Procedures	.91 to .99
c) Explosion Control	.84 to .98	h) Reactive Chemical Review Every 2 yrs	.91 to .98
d) Emergency Shutdown	.96 to .99		
e) Computer Control	.93 to .99		

C_1 Total 0.813 *

2. Material Isolation (C_2)

a) Remote Control Valves	.96 to .98	c) Drainage	.91 to .97
b) Dump/Blowdown	.96 to .98	d) Interlock	.98

C_2 Total 0.921 *

3. Fire Protection (C_3)

- Combustible Gas detection — Yes - Automated

a) Leak Detection	.94 to .98	f) Sprinkler Systems	.74 to .97
b) Structural Steel deluge gun	.95 to .98	g) Water Curtains	.97 to .98
c) Buried Tanks	.84 to .91	h) Foam	.92 to .97
d) Water Supply	.94 to .97	i) Hand Extinguishers/Monitors	.95 to .98 0.96
e) Special Systems	.91	j) Cable Protection	.94 to .98

C_3 Value 0.662 *

Credit Factor = $C_1 \times C_2 \times C_3$ = 0.496 Enter on Line D Below

UNIT ANALYSIS SUMMARY

A-1. F & EI	70.8		
A-2. Radius of Exposure	60 ft.		
A-3. Value of Area of Exposure		$MM	1.7
B. Damage Factor	0.66		
C. Base MMPD (A-3 X B)		$MM	1.12
D. Credit Factor	0.496		
E. Actual MMPD (C X D)		$MM	0.56
F. Days Outage (MPDO)			16 days.
G. Business Interruption Loss (BI)		$MM	1.4

* Product of all factors used.

BACK OF FORM C-22380 R-4-87 (471-036)

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FIRE AND EXPLOSION INDEX DOW

LOCATION	DATE
	11/13/89

PLANT	PROCESS UNIT	EVALUATED BY	REVIEWED BY
Glycol I	71 Storage PO	T. Tyler	

MATERIALS AND PROCESS

MATERIALS IN PROCESS UNIT

PO

STATE OF OPERATION

START-UP SHUT-DOWN ✓ NORMAL OPERATION

BASIC MATERIAL(S) FOR MATERIAL FACTOR

PO

MATERIAL FACTOR (SEE TABLE I OR APPENDICES A OR B) Note requirements when unit temperature over 140°F)			24
1. GENERAL PROCESS HAZARDS	PENALTY	PENALTY USED	
BASE FACTOR	1.00	1.00	
A. EXOTHERMIC CHEMICAL REACTIONS (FACTOR .30 to 1.25)			
B. ENDOTHERMIC PROCESSES (FACTOR .20 to .40)			
C. MATERIAL HANDLING & TRANSFER (FACTOR .25 to 1.05)			
D. ENCLOSED OR INDOOR PROCESS UNITS (FACTOR .25 to .90)	-		
E. ACCESS	.35		
F. DRAINAGE AND SPILL CONTROL (FACTOR .25 to .50) ____ Gals.			
GENERAL PROCESS HAZARDS FACTOR (F_1)		1.0	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR	1.00	1.00	
A. TOXIC MATERIAL(S) (FACTOR 0.20 to 0.80)		0.4	
B. SUB-ATMOSPHERIC PRESSURE (< 500 mm Hg)	.50		
C. OPERATION IN OR NEAR FLAMMABLE RANGE ☐ INERTED ☐ NOT INERTED			
1. TANK FARMS STORAGE FLAMMABLE LIQUIDS	.50	0.5	
2. PROCESS UPSET OR PURGE FAILURE	.30		
3. ALWAYS IN FLAMMABLE RANGE	.80		
D. DUST EXPLOSION (FACTOR .25 to 2.00) (SEE TABLE II)			
E. PRESSURE (SEE FIGURE 2) OPERATING PRESSURE ____ psig RELIEF SETTING 50 psig		0.25	
F. LOW TEMPERATURE (FACTOR .20 to .30)			
G. QUANTITY OF FLAMMABLE/UNSTABLE MATERIAL: QUANTITY 260,000 lbs., H_c = 13.2×10^3 BTU/lb		0.60	
1. LIQUIDS, GASES AND REACTIVE MATERIALS IN PROCESS (SEE FIG. 3)			
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)			
3. COMBUSTIBLE SOLIDS IN STORAGE, DUST IN PROCESS (SEE FIG. 5)			
H. CORROSION AND EROSION (FACTOR .10 to .75)			
I. LEAKAGE – JOINTS AND PACKING (FACTOR .10 to 1.50)		0.10	
J. USE OF FIRED HEATERS (SEE FIG. 6)		0.10	
K. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15) (SEE TABLE III)			
L. ROTATING EQUIPMENT	.50		
SPECIAL PROCESS HAZARDS FACTOR (F_2)		2.95	
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$)		2.95	
FIRE AND EXPLOSION INDEX ($F_3 \times MF = F\&EI$)			70.8

FORM C-22380 R-4-87 (471-036)

DO A 044708
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71 Storage

EXHIBIT B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a) Emergency Power	.98	f) Inert Gas N_2	.94 to .96
b) Cooling	.97 to .99	g) Operating Instructions/ Procedures	.91 to .99
c) Explosion Control	.84 to .98	h) Reactive Chemical Review 2 yrs	.91 to .98
d) Emergency Shutdown	.96 to .99		
e) Computer Control	.93 to .99		

C_1 Total 0.813 *

2. Material Isolation (C_2)

a) Remote Control Valves	.96 to .98	c) Drainage	.91 to .97
b) Dump/Blowdown	.96 to .98	d) Interlock	.98

C_2 Total 0.921 *

3. Fire Protection (C_3)

- Comb. Gas Detec.

- Yes Automated

a) Leak Detection	.94 to .98	f) Sprinkler Systems	.74 to .97
b) Structural Steel deluge gun	.95 to .98	g) Water Curtains	.97 to .98
c) Buried Tanks	.84 to .91	h) Foam	.92 to .97
d) Water Supply	.94 to .97	i) Hand Extinguishers/Monitors	.95 to .98 0.96
e) Special Systems	.91	j) Cable Protection	.94 to .98

C_3 Value 0.662 *

Credit Factor = $C_1 \times C_2 \times C_3$ = 0.496 Enter on Line D Below

UNIT ANALYSIS SUMMARY

A-1. F & EI	70.8		
A-2. Radius of Exposure	60 ft.		
A-3. Value of Area of Exposure		$MM	1.7
B. Damage Factor	0.66		
C. Base MMPD (A-3 X B)		$MM	1.12
D. Credit Factor	0.496		
E. Actual MMPD (C X D)		$MM	0.56
F. Days Outage (MPDO)			16 days.
G. Business Interruption Loss (BI)		$MM	1.4

* Product of all factors used.

BACK OF FORM C-22380 R-4-87 (471-036)

DO A 044709
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EXHIBIT A

FIRE AND EXPLOSION INDEX

LOCATION	DATE
	Nov. 13, 19[illegible]

PLANT	PROCESS UNIT	EVALUATED BY	REVIEWED BY
Glycol 1	R-7 Hydrogenator(3)	T. Tyler	

MATERIALS AND PROCESS

MATERIALS IN PROCESS UNIT: Propylene Glycol - Hydrogen

STATE OF OPERATION: START UP ✓SHUT DOWN NORMAL OPERATION

BASIC MATERIAL(S) FOR MATERIAL FACTOR: Hydrogen

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I OR APPENDICES A OR B) Note requirements when unit temperature over 140 F)			21
1. GENERAL PROCESS HAZARDS	PENALTY	PENALTY USED	
BASE FACTOR	1.00	1.00	
A EXOTHERMIC CHEMICAL REACTIONS (FACTOR .30 to 1.25)		0.30	
B ENDOTHERMIC PROCESSES (FACTOR .20 to .40)		—	
C MATERIAL HANDLING & TRANSFER (FACTOR .25 to 1.05)		—	
D ENCLOSED OR INDOOR PROCESS UNITS (FACTOR .25 to .90)		—	
E. ACCESS	.35	—	
F DRAINAGE AND SPILL CONTROL (FACTOR 25 to 50) ______ Gals.		0.25	
GENERAL PROCESS HAZARDS FACTOR (F_1)		1.55	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR	1.00	1.00	
A TOXIC MATERIAL(S) (FACTOR 0.20 to 0.80)		—	
B SUB-ATMOSPHERIC PRESSURE (500 mm Hg)	.50	—	
C OPERATION IN OR NEAR FLAMMABLE RANGE . INERTED ☐ NOT INERTED			
1 TANK FARMS STORAGE FLAMMABLE LIQUIDS	.50	0.50	
2 PROCESS UPSET OR PURGE FAILURE	.30	—	
3. ALWAYS IN FLAMMABLE RANGE	.80	—	
D. DUST EXPLOSION (FACTOR 25 to 2.00) (SEE TABLE II)		—	
E PRESSURE (SEE FIGURE 2) OPERATING PRESSURE ... psig RELIEF SETTING 175 psig		0.4	
F LOW TEMPERATURE (FACTOR .20 to .30)		—	
G QUANTITY OF FLAMMABLE/UNSTABLE MATERIAL. QUANTITY Sm-ll lbs.. H_c= 51.6x10^3 BTU/lb			
1 LIQUIDS, GASES AND REACTIVE MATERIALS IN PROCESS (SEE FIG. 3)		0.10	
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)		—	
3 COMBUSTIBLE SOLIDS IN STORAGE, DUST IN PROCESS (SEE FIG. 5)		—	
H CORROSION AND EROSION (FACTOR .10 to 75)		0.10	
I. LEAKAGE - JOINTS AND PACKING (FACTOR .10 to 1.50)		0.10	
J. USE OF FIRED HEATERS (SEE FIG. 6)		—	
K. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15) (SEE TABLE III)		—	
L. ROTATING EQUIPMENT	.50	—	
SPECIAL PROCESS HAZARDS FACTOR (F_2)		2.20	
UNIT HAZARD FACTOR (F_1 x F_2 F_3)		3.41	
FIRE AND EXPLOSION INDEX (F_3 x MF F & EI)			71.6

FORM C-22380 R-4-87 (471-036)

DO A 044710
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EXHIBIT B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a) Emergency Power	.98	f) Inert Gas N2	.94 to .96
b) Cooling	.97 to .99	g) Operating Instructions/ Procedures	.91 to .99
relief device – c) Explosion Control	.84 to .98	h) Reactive Chemical Review	.91 to .98
d) Emergency Shutdown	.96 to .99	2 yr.	
e) Computer Control	.93 to .99		

C_1 Total 0.839 *

2. Material Isolation (C_2)

a) Remote Control Valves yes	.96 to .98	c) Drainage	.91 to .97
b) Dump/Blowdown	.96 to .98	d) Interlock	.98

C_2 Total 0.856 *

3. Fire Protection (C_3)

a) Leak Detection	.94 to .98	f) Sprinkler Systems deluge	.74 to .97 0.96
b) Structural Steel	.95 to .98	g) Water Curtains	.97 to .98
c) Buried Tanks	.84 to .91	h) Foam	.92 to .97
d) Water Supply	.94 to .97	i) Hand Extinguishers/Monitors	.95 to .98
e) Special Systems	.91	j) Cable Protection	.94 to .98

C_3 Value 0.912 *

Credit Factor = $C_1 \times C_2 \times C_3$ = 0.655 Enter on Line D Below

UNIT ANALYSIS SUMMARY

A-1. F & EI	71.6		
A-2. Radius of Exposure	60 ft.		
A-3. Value of Area of Exposure		$MM	12.5
B. Damage Factor	0.56		
C. Base MMPD (A-3 X B)		$MM	7.0
D. Credit Factor	0.655		
E. Actual MMPD (C X D)		$MM	4.59
F. Days Outage (MPDO)			53 days.
G. Business Interruption Loss (BI)		$MM	4.6

* Product of all factors used.

EXHIBIT A

FIRE AND EXPLOSION INDEX DOW

LOCATION	DATE
	11/13/89

PLANT	PROCESS UNIT	EVALUATED BY	REVIEWED BY
Glycol 1	7D Reactors	T. Tylee	

MATERIALS AND PROCESS

MATERIALS IN PROCESS UNIT

Propylene ..., H_2O, Cl_2, PDC, PCH

STATE OF OPERATION

START-UP ☐ SHUT-DOWN ✓NORMAL OPERATION

BASIC MATERIAL(S) FOR MATERIAL FACTOR

Propylene

	PENALTY	PENALTY USED
MATERIAL FACTOR (SEE TABLE I OR APPENDICES A OR B) Note requirements when unit temperature over 140°F) →		21
1. GENERAL PROCESS HAZARDS	PENALTY	PENALTY USED
BASE FACTOR →	1.00	1.00
A. EXOTHERMIC CHEMICAL REACTIONS (FACTOR .30 to 1.25)		0.30
B ENDOTHERMIC PROCESSES (FACTOR .20 to .40)		—
C MATERIAL HANDLING & TRANSFER (FACTOR .25 to 1.05)		—
D ENCLOSED OR INDOOR PROCESS UNITS (FACTOR .25 to .90)		—
E ACCESS	.35	—
F DRAINAGE AND SPILL CONTROL (FACTOR .25 to .50) ______ Gals.		0.25
GENERAL PROCESS HAZARDS FACTOR (F_1) →		1.55
2. SPECIAL PROCESS HAZARDS		
BASE FACTOR →	1.00	1.00
A TOXIC MATERIAL(S) (FACTOR 0.20 to 0.80)		0.2
B SUB-ATMOSPHERIC PRESSURE (< 500 mm Hg)	.50	—
C OPERATION IN OR NEAR FLAMMABLE RANGE ☐ INERTED ☐ NOT INERTED		
1. TANK FARMS STORAGE FLAMMABLE LIQUIDS	.50	—
2 PROCESS UPSET OR PURGE FAILURE	.30	0.3
3 ALWAYS IN FLAMMABLE RANGE	.80	—
D DUST EXPLOSION (FACTOR .25 to 2.00) (SEE TABLE II)		—
E PRESSURE (SEE FIGURE 2) OPERATING PRESSURE ____ psig RELIEF SETTING 8 psig		0.15
F LOW TEMPERATURE (FACTOR .20 to .30)		—
G. QUANTITY OF FLAMMABLE/UNSTABLE MATERIAL: QUANTITY Small lbs., H_c = 19.7×10^3 BTU/lb		
1. LIQUIDS, GASES AND REACTIVE MATERIALS IN PROCESS (SEE FIG. 3)		0.15
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)		—
3 COMBUSTIBLE SOLIDS IN STORAGE, DUST IN PROCESS (SEE FIG. 5)		—
H CORROSION AND EROSION (FACTOR .10 to .75)		0.10
I. LEAKAGE – JOINTS AND PACKING (FACTOR .10 to 1.50)		0.10
J. USE OF FIRED HEATERS (SEE FIG. 6)		—
K. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15) (SEE TABLE III)		—
L ROTATING EQUIPMENT	.50	—
SPECIAL PROCESS HAZARDS FACTOR (F_2) →		2.0
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$) →		3.1
FIRE AND EXPLOSION INDEX ($F_3 \times MF = F\&EI$) →		65.1

FORM C-22380 R-4-87 (471-036)

DO A 044712
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Reactors

EXHIBIT B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a) Emergency Power	.98	f) Inert Gas N_2	.94 to .96
b) Cooling	.97 to .99	g) Operating Instructions/ Procedures	.91 to .99
c) Explosion Control	.84 to .98	h) Reactive Chemical Review	.91 to .98
Yes - d) Emergency Shutdown	.96 to .99		
e) Computer Control TOC	.93 to .99		

C_1 Total 0.71 *

2. Material Isolation (C_2)

Yes - EBV's a) Remote Control Valves	.96 to .98	c) Drainage - well sloped	.91 to .97
b) Dump/Blowdown	.96 to .98	d) Interlock	.98

C_2 Total 0.856 *

3. Fire Protection (C_3)

a) Leak Detection	.94 to .98	f) Sprinkler Systems	.74 to .97 .92
Fireproofing b) Structural Steel	.95 to .98	g) Water Curtains	.97 to .98
c) Buried Tanks	.84 to .91	h) Foam	.92 to .97
d) Water Supply	.94 to .97	i) Hand Extinguishers/Monitors	.95 to .98
e) Special Systems	.91	j) Cable Protection	.94 to .98

C_3 Value 0.78 *

Credit Factor = $C_1 \times C_2 \times C_3$ = 0.474 Enter on Line D Below

UNIT ANALYSIS SUMMARY

A-1. F & EI	45.1		
A-2. Radius of Exposure	56 ft.		
A-3. Value of Area of Exposure		$MM	5.5
B. Damage Factor	0.55		
C. Base MMPD (A-3 X B)		$MM	3.0
D. Credit Factor	0.474		
E. Actual MMPD (C X D)		$MM	1.43
F. Days Outage (MPDO)			15 days.
G. Business Interruption Loss (BI)		$MM	1.3

* Product of all factors used.

BACK OF FORM C-22380 R-4-87 (471-036)

DO A 044713
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EXHIBIT A

FIRE AND EXPLOSION INDEX

DOW

LOCATION	DATE
	11/13/5

PLANT	PROCESS UNIT	EVALUATED BY	REVIEWED BY
Glycol I	71 Reactors	T. Tyler	

MATERIALS AND PROCESS

MATERIALS IN PROCESS UNIT

Propylene, H_2O, Cl_2, PDC, PCH

STATE OF OPERATION

START-UP ☐ SHUT-DOWN ☑ NORMAL OPERATION

BASIC MATERIAL(S) FOR MATERIAL FACTOR

Propylene

MATERIAL FACTOR (SEE TABLE I OR APPENDICES A OR B) Note requirements when unit temperature over 140°F) → 21

1. GENERAL PROCESS HAZARDS	PENALTY	PENALTY USED
BASE FACTOR →	1.00	1.00
A. EXOTHERMIC CHEMICAL REACTIONS (FACTOR .30 to 1.25)		0.30
B ENDOTHERMIC PROCESSES (FACTOR .20 to .40)		
C MATERIAL HANDLING & TRANSFER (FACTOR .25 to 1.05)		
D ENCLOSED OR INDOOR PROCESS UNITS (FACTOR .25 to .90)		
E ACCESS	.35	
F DRAINAGE AND SPILL CONTROL (FACTOR .25 to .50) ______ Gals.		0.25
GENERAL PROCESS HAZARDS FACTOR (F_1) →		1.55

2. SPECIAL PROCESS HAZARDS	PENALTY	PENALTY USED
BASE FACTOR →	1.00	1.00
A TOXIC MATERIAL(S) (FACTOR 0.20 to 0.80)		0.2
B SUB-ATMOSPHERIC PRESSURE (500 mm Hg)	.50	
C OPERATION IN OR NEAR FLAMMABLE RANGE ☐ INERTED ☐ NOT INERTED		
1 TANK FARMS STORAGE FLAMMABLE LIQUIDS	.50	
2 PROCESS UPSET OR PURGE FAILURE	.30	0.3
3 ALWAYS IN FLAMMABLE RANGE	.80	
D. DUST EXPLOSION (FACTOR .25 to 2.00) (SEE TABLE II)		
E PRESSURE (SEE FIGURE 2) OPERATING PRESSURE ______ psig RELIEF SETTING 8 psig		0.15
F LOW TEMPERATURE (FACTOR .20 to .30)		
G. QUANTITY OF FLAMMABLE/UNSTABLE MATERIAL: QUANTITY Small lbs., H_c = 19.7x10^3 BTU/lb		
1. LIQUIDS, GASES AND REACTIVE MATERIALS IN PROCESS (SEE FIG. 3)		0.15
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)		
3 COMBUSTIBLE SOLIDS IN STORAGE, DUST IN PROCESS (SEE FIG. 5)		
H CORROSION AND EROSION (FACTOR .10 to .75)		0.10
I. LEAKAGE – JOINTS AND PACKING (FACTOR .10 to 1.50)		0.10
J. USE OF FIRED HEATERS (SEE FIG. 6)		
K HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15) (SEE TABLE III)		
L. ROTATING EQUIPMENT	.50	
SPECIAL PROCESS HAZARDS FACTOR (F_2) →		2.0
UNIT HAZARD FACTOR ($F_1 \times F_2$ = F_3) →		3.1

FIRE AND EXPLOSION INDEX (F_3 x MF = F & EI) → 65.1

FORM C-22380 R-4-87 (471-036)

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EXHIBIT B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a) Emergency Power	.98	f) Inert Gas N2	.94 to .96
b) Cooling	.97 to .99	g) Operating Instructions/ Procedures Yearly	.91 to .99
c) Explosion Control	.84 to .98		
Yes — d) Emergency Shutdown	.96 to .99	h) Reactive Chemical Review	.91 to .98
e) Computer Control TDC	.93 to .99	2 yr, Extensive when changes	

C_1 Total 0.71 *

2. Material Isolation (C_2)

EBV's a) Remote Control Valves	.96 to .98	c) Drainage - well Drained Area	.91 to .97
b) Dump/Blowdown	.96 to .98	d) Interlock	.98

C_2 Total 0.856 *

3. Fire Protection (C_3)

a) Leak Detection	.94 to .98	f) Sprinkler Systems	.74 to .97 0.92
b) Structural Steel	.95 to .98	g) Water Curtains	.97 to .98
c) Buried Tanks	.84 to .91	h) Foam	.92 to .97
d) Water Supply	.94 to .97	i) Hand Extinguishers/Monitors	.95 to .98
e) Special Systems	.91	j) Cable Protection	.94 to .98

C_3 Value 0.78 *

Credit Factor = $C_1 \times C_2 \times C_3$ = 0.474 Enter on Line D Below

UNIT ANALYSIS SUMMARY

A-1. F & EI	65.1		
A-2. Radius of Exposure	56 ft.		
A-3. Value of Area of Exposure		$MM	5.5
B. Damage Factor	0.55		
C. Base MMPD (A-3 X B)		$MM	3.0
D. Credit Factor	0.474		
E. Actual MMPD (C X D)		$MM	1.43
F. Days Outage (MPDO)			15 days.
G. Business Interruption Loss (BI)		$MM	1.3

* Product of all factors used.

BACK OF FORM C-22380 R-4-87 (471-036)

DO A 044715
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FIRE AND EXPLOSION INDEX DOW

LOCATION	DATE
	11/13/89

PLANT	PROCESS UNIT	EVALUATED BY	REVIEWED BY
Glycol I	T-102 C (8)	T. Tyler	

MATERIALS AND PROCESS

MATERIALS IN PROCESS UNIT

PO - PDC - DCIPE

STATE OF OPERATION: START-UP . SHUT-DOWN ✓ NORMAL OPERATION

BASIC MATERIAL(S) FOR MATERIAL FACTOR: PO

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I OR APPENDICES A OR B) Note requirements when unit temperature over 140 F)			24
1. GENERAL PROCESS HAZARDS	PENALTY	PENALTY USED	
BASE FACTOR	1.00	1.00	
A EXOTHERMIC CHEMICAL REACTIONS (FACTOR .30 to 1.25)			
B ENDOTHERMIC PROCESSES (FACTOR .20 to .40)			
C MATERIAL HANDLING & TRANSFER (FACTOR .25 to 1.05)			
D ENCLOSED OR INDOOR PROCESS UNITS (FACTOR .25 to .90)			
E. ACCESS	.35		
F DRAINAGE AND SPILL CONTROL (FACTOR .25 to .50) Gals.		.25	
GENERAL PROCESS HAZARDS FACTOR (F_1)		1.25	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR	1.00	1.00	
A TOXIC MATERIAL(S) (FACTOR 0.20 to 0.80)		0.4	
B SUB-ATMOSPHERIC PRESSURE (500 mm Hg)	.50	0.5	
C OPERATION IN OR NEAR FLAMMABLE RANGE .. INERTED ☐ NOT INERTED			
1 TANK FARMS STORAGE FLAMMABLE LIQUIDS	.50		
2 PROCESS UPSET OR PURGE FAILURE	.30		
3 ALWAYS IN FLAMMABLE RANGE	.80		
D DUST EXPLOSION (FACTOR .25 to 2.00) (SEE TABLE II)			
E PRESSURE (SEE FIGURE 2) OPERATING PRESSURE ____ psig RELIEF SETTING 50 psig		.25	
F LOW TEMPERATURE (FACTOR .20 to .30)			
G QUANTITY OF FLAMMABLE/UNSTABLE MATERIAL: QUANTITY 34200 lbs.. H_c = 13.2x10³ BTU/lb			
1. LIQUIDS, GASES AND REACTIVE MATERIALS IN PROCESS (SEE FIG. 3)		0.85	
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)			
3 COMBUSTIBLE SOLIDS IN STORAGE, DUST IN PROCESS (SEE FIG. 5)			
H CORROSION AND EROSION (FACTOR .10 to .75)		0.10	
I. LEAKAGE - JOINTS AND PACKING (FACTOR .10 to 1.50)		0.10	
J. USE OF FIRED HEATERS (SEE FIG. 6)			
K. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15) (SEE TABLE III)			
L. ROTATING EQUIPMENT	.50		
SPECIAL PROCESS HAZARDS FACTOR (F_2)		3.2	
UNIT HAZARD FACTOR ($F_1 \times F_2$ F_3)		4.0	
FIRE AND EXPLOSION INDEX ($F_3 \times$ MF F & EI)			96

FORM C-22380 R-4-87 (471-036)

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T-102C

EXHIBIT B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a) Emergency Power	.98	f) Inert Gas	.94 to .96
b) Cooling	.97 to .99	g) Operating Instructions/ Procedures	.91 to .99 .93
c) Explosion Control	.84 to .98	h) Reactive Chemical Review	.91 to .98
d) Emergency Shutdown	.96 to .99		
e) Computer Control	.93 to .99		

Extensive with process change

C_1 Total 0.821 *

2. Material Isolation (C_2)

- well drained

Yes - a) Remote Control Valves	.96 to .98	c) Drainage	.91 to .97
b) Dump/Blowdown	.96 to .98	d) Interlock	.98

C_2 Total 0.874 *

3. Fire Protection (C_3)

- Comb. Gas Det.

Bottom of column

a) Leak Detection	.94 to .98	f) Sprinkler Systems	.74 to .97 0.92
b) Structural Steel	.95 to .98	g) Water Curtains	.97 to .98
c) Buried Tanks	.84 to .91	h) Foam	.92 to .97
d) Water Supply	.94 to .97	i) Hand Extinguishers/Monitors	.95 to .98
e) Special Systems	.91	j) Cable Protection	.94 to .98

C_3 Value 0.773 *

Credit Factor = $C_1 \times C_2 \times C_3$ = 0.554 Enter on Line D Below

UNIT ANALYSIS SUMMARY

A-1. F & EI	96		
A-2. Radius of Exposure	81 ft.		
A-3. Value of Area of Exposure		$MM	15.0
B. Damage Factor	0.74		
C. Base MMPD (A-3 X B)		$MM	11.1
D. Credit Factor	0.554		
E. Actual MMPD (C X D)		$MM	6.1
F. Days Outage (MPDO)			62 days.
G. Business Interruption Loss (BI)		$MM	5.4

* Product of all factors used.

BACK OF FORM C-22380 R-4-87 (471-036)

DO A 044717
CONFIDENTIAL

FIRE AND EXPLOSION INDEX DOW

LOCATION	DATE
	Nov. 11, 1980

PLANT	PROCESS UNIT	EVALUATED BY	REVIEWED BY
Glycol I	T-102B (a)	T. Tyler	

MATERIALS AND PROCESS

MATERIALS IN PROCESS UNIT
Propylene oxide, PDC, DCIPE

STATE OF OPERATION: START-UP / SHUT-DOWN / ☒ NORMAL OPERATION

BASIC MATERIAL(S) FOR MATERIAL FACTOR: PO

MATERIAL FACTOR (SEE TABLE I OR APPENDICES A OR B) Note requirements when unit temperature over 140°F) → 24

1. GENERAL PROCESS HAZARDS	PENALTY	PENALTY USED
BASE FACTOR →	1.00	1.00
A. EXOTHERMIC CHEMICAL REACTIONS (FACTOR .30 to 1.25)		
B. ENDOTHERMIC PROCESSES (FACTOR .20 to .40)		
C. MATERIAL HANDLING & TRANSFER (FACTOR .25 to 1.05)		
D. ENCLOSED OR INDOOR PROCESS UNITS (FACTOR .25 to .90)		
E. ACCESS	.35	
F. DRAINAGE AND SPILL CONTROL (FACTOR .25 to .50) ______ Gals.		0.25
GENERAL PROCESS HAZARDS FACTOR (F_1) →		1.25

2. SPECIAL PROCESS HAZARDS	PENALTY	PENALTY USED
BASE FACTOR →	1.00	1.00
A. TOXIC MATERIAL(S) (FACTOR 0.20 to 0.80)		0.40
B. SUB-ATMOSPHERIC PRESSURE (< 500 mm Hg)	.50	0.50
C. OPERATION IN OR NEAR FLAMMABLE RANGE ☐ INERTED ☐ NOT INERTED		
1. TANK FARMS STORAGE FLAMMABLE LIQUIDS	.50	
2. PROCESS UPSET OR PURGE FAILURE	.30	.3
3. ALWAYS IN FLAMMABLE RANGE	.80	
D. DUST EXPLOSION (FACTOR .25 to 2.00) (SEE TABLE II)		
E. PRESSURE (SEE FIGURE 2) OPERATING PRESSURE ______ psig RELIEF SETTING 50 psig		.25
F. LOW TEMPERATURE (FACTOR .20 to .30)		
G. QUANTITY OF FLAMMABLE/UNSTABLE MATERIAL: QUANTITY 50,000 lbs.. H_c= 13.2 BTU/lb		
1. LIQUIDS, GASES AND REACTIVE MATERIALS IN PROCESS (SEE FIG. 3)		1.25
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)		
3. COMBUSTIBLE SOLIDS IN STORAGE, DUST IN PROCESS (SEE FIG. 5)		
H. CORROSION AND EROSION (FACTOR .10 to .75)		0.10
I. LEAKAGE – JOINTS AND PACKING (FACTOR .10 to 1.50)		0.10
J. USE OF FIRED HEATERS (SEE FIG. 6)		
K. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15) (SEE TABLE III)		
L. ROTATING EQUIPMENT	.50	
SPECIAL PROCESS HAZARDS FACTOR (F_2) →		3.90
UNIT HAZARD FACTOR ($F_1 \times F_2$ = F_3) →		4.875

FIRE AND EXPLOSION INDEX (F_3 x MF = F & EI) → 117

DO A 044718
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T-102B

EXHIBIT B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a) Emergency Power	.98	f) Inert Gas	.94 to .96
b) Cooling	.97 to .99	g) Operating Instructions/ Procedures	.91 to .99 0.93
c) Explosion Control	.84 to .98	h) Reactive Chemical Review	.91 to .98
d) Emergency Shutdown	.96 to .99		
e) Computer Control	.93 to .99		

TDC

C_1 Total 0.821 *

2. Material Isolation (C_2)

- well drained

Yes - a) Remote Control Valves	.96 to .98	c) Drainage	.91 to .97
b) Dump/Blowdown	.96 to .98	d) Interlock	.98

C_2 Total 0.874 *

3. Fire Protection (C_3)

Comb. gas det.

B. Hm of Column

a) Leak Detection	.94 to .98	f) Sprinkler Systems	.74 to .97 0.92
b) Structural Steel	.95 to .98	g) Water Curtains	.97 to .98
c) Buried Tanks	.84 to .91	h) Foam	.92 to .97
d) Water Supply	.94 to .97	i) Hand Extinguishers/Monitors	.95 to .98
e) Special Systems	.91	j) Cable Protection	.94 to .98

C_3 Value 0.773 *

Credit Factor = $C_1 \times C_2 \times C_3$ = 0.555 Enter on Line D Below

UNIT ANALYSIS SUMMARY

A-1. F & EI	117		
A-2. Radius of Exposure	100 ft.		
A-3. Value of Area of Exposure		$MM	26.5
B. Damage Factor	0.78		
C. Base MMPD (A-3 X B)		$MM	20.7
D. Credit Factor	0.555		
E. Actual MMPD (C X D)		$MM	11.5
F. Days Outage (MPDO)			85 days.
G. Business Interruption Loss (BI)		$MM	7.3

* Product of all factors used.

BACK OF FORM C-22380 R-4-87 (471-036)

DO A 044719
CONFIDENTIAL

FIRE AND EXPLOSION INDEX DOW

LOCATION	DATE
	11/13/89

PLANT	PROCESS UNIT	EVALUATED BY	REVIEWED BY
Glycol I	T-300	T. Tyler	Rev. 3/9

MATERIALS AND PROCESS

MATERIALS IN PROCESS UNIT
PO - PDC - DCIPE

STATE OF OPERATION
START-UP ☐ SHUT-DOWN ☑ NORMAL OPERATION

BASIC MATERIAL(S) FOR MATERIAL FACTOR
PO

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I OR APPENDICES A OR B) Note requirements when unit temperature over 140°F)			24
1. GENERAL PROCESS HAZARDS			
BASE FACTOR	1.00	1.00	
A. EXOTHERMIC CHEMICAL REACTIONS (FACTOR .30 to 1.25)		—	
B. ENDOTHERMIC PROCESSES (FACTOR .20 to .40)		—	
C. MATERIAL HANDLING & TRANSFER (FACTOR .25 to 1.05)		—	
D. ENCLOSED OR INDOOR PROCESS UNITS (FACTOR .25 to .90)		—	
E. ACCESS	.35	—	
F. DRAINAGE AND SPILL CONTROL (FACTOR .25 to .50) ______ Gals.		0.25	
GENERAL PROCESS HAZARDS FACTOR (F_1)		1.25	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR	1.00	1.00	
A. TOXIC MATERIAL(S) (FACTOR 0.20 to 0.80)		0.40	
B. SUB-ATMOSPHERIC PRESSURE (< 500 mm Hg)	.50	0.50	
C. OPERATION IN OR NEAR FLAMMABLE RANGE ☐ INERTED ☐ NOT INERTED			
1. TANK FARMS STORAGE FLAMMABLE LIQUIDS	.50	—	
2. PROCESS UPSET OR PURGE FAILURE	.30	0.3	
3. ALWAYS IN FLAMMABLE RANGE	.80	—	
D. DUST EXPLOSION (FACTOR .25 to 2.00) (SEE TABLE II)		—	
E. PRESSURE (SEE FIGURE 2) OPERATING PRESSURE — psig RELIEF SETTING 50 psig		0.25	
F. LOW TEMPERATURE (FACTOR .20 to .30)		—	
G. QUANTITY OF FLAMMABLE/UNSTABLE MATERIAL: QUANTITY 187240 lbs., H_c = 13.3×10³ BTU/lb	*		
1. LIQUIDS, GASES AND REACTIVE MATERIALS IN PROCESS (SEE FIG. 3)		~~2~~	1.5 *
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)		—	
3. COMBUSTIBLE SOLIDS IN STORAGE, DUST IN PROCESS (SEE FIG. 5)		—	
H. CORROSION AND EROSION (FACTOR .10 to .75)		0.10	
I. LEAKAGE — JOINTS AND PACKING (FACTOR .10 to 1.50)		0.10	
J. USE OF FIRED HEATERS (SEE FIG. 6)		—	
K. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15) (SEE TABLE III)		—	
L. ROTATING EQUIPMENT	.50	—	
SPECIAL PROCESS HAZARDS FACTOR (F_2)		~~4.65~~	4.15
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$)		~~5.81~~	5.19
FIRE AND EXPLOSION INDEX (F_3 x MF = F & EI)			~~140~~ 125

FORM C-22380 R-4-87 (471-036)

DO A 044720
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EXHIBIT B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a) Emergency Power	.98	f) Inert Gas	.94 to .96
b) Cooling	.97 to .99	g) Operating Instructions/ Procedures	.91 to .99 0.92
c) Explosion Control	.84 to .98	h) Reactive Chemical Review	.91 to .98
d) Emergency Shutdown	.96 to .99		
e) Computer Control	.93 to .99		

TOC

C_1 Total 0.893 *

2. Material Isolation (C_2)

a) Remote Control Valves	.96 to .98	c) Drainage	.91 to .97
b) Dump/Blowdown	.96 to .98	d) Interlock	.98

C_2 Total 0.874 *

Comb Gas

3. Fire Protection (C_3)

Both of Column

a) Leak Detection	.94 to .98	f) Sprinkler Systems	.74 to .97 0.92
b) Structural Steel	.95 to .98	g) Water Curtains	.97 to .98
c) Buried Tanks	.84 to .91	h) Foam	.92 to .97
d) Water Supply	.94 to .97	i) Hand Extinguishers/Monitors	.95 to .98
e) Special Systems	.91	j) Cable Protection	.94 to .98

C_3 Value 0.814 *

Credit Factor = $C_1 \times C_2 \times C_3$ = 0.635 Enter on Line D Below

UNIT ANALYSIS SUMMARY

A-1. F & EI	140 125		
A-2. Radius of Exposure	118 ft.		
A-3. Value of Area of Exposure		$MM	22.4
B. Damage Factor	0.62		
C. Base MMPD (A-3 X B)		$MM	13.9
D. Credit Factor	0.635		
E. Actual MMPD (C X D)		$MM	8.8
F. Days Outage (MPDO)			75 days.
G. Business Interruption Loss (BI)		$MM	6.5

* Product of all factors used.

BACK OF FORM C-22380 R-4-87 (471-036)

DO A 044721
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TMT 6/95

T-300 quantity of liquid

7% of packing volume – from Glitschrep
6" on each distributor

$\pi(\frac{11}{2})^2 .5 (5) = 237\ ft^3 (52 \frac{lb}{ft^3}) = 12,427\ lbs$

11,400 ft^3 packing ordered
– Not all put in vessel. ?
$.07(11,400) = 798\ ft^3 (52 \frac{lb}{ft^3}) = 41,496\ lbs$

$Level = 7.5 (\pi)(\frac{11}{2})^2 = 712\ ft^3 (52) = 37044$ –

Total = 90,967 lbs

EXHIBIT A

FIRE AND EXPLOSION INDEX DOW

Temp=1082°C

LOCATION	DATE
	11/13/89

PLANT	PROCESS UNIT	EVALUATED BY	REVIEWED BY
Glycol I	Throx	T. Tyler	

MATERIALS AND PROCESS

MATERIALS IN PROCESS UNIT

DCIPE, EPI, PDC

STATE OF OPERATION

START-UP SHUT-DOWN ✓ NORMAL OPERATION

BASIC MATERIAL(S) FOR MATERIAL FACTOR

PDC

MATERIAL FACTOR (SEE TABLE I OR APPENDICES A OR B) Note requirements when unit temperature over 140 F)			16
1. GENERAL PROCESS HAZARDS	**PENALTY**	**PENALTY USED**	
BASE FACTOR	1.00	1.00	
A. EXOTHERMIC CHEMICAL REACTIONS (FACTOR .30 to 1.25)		0.50	
B. ENDOTHERMIC PROCESSES (FACTOR .20 to .40)		—	
C. MATERIAL HANDLING & TRANSFER (FACTOR .25 to 1.05)		—	
D. ENCLOSED OR INDOOR PROCESS UNITS (FACTOR .25 to .90)		—	
E. ACCESS	.35	—	
F. DRAINAGE AND SPILL CONTROL (FACTOR .25 to .50) ______ Gals.		0.50	
GENERAL PROCESS HAZARDS FACTOR (F_1)		2.0	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR	1.00	1.00	
A. TOXIC MATERIAL(S) (FACTOR 0.20 to 0.80)		0.4	
B. SUB-ATMOSPHERIC PRESSURE (< 500 mm Hg)	.50	0.5	
C. OPERATION IN OR NEAR FLAMMABLE RANGE ✓ INERTED ☐ NOT INERTED			
1. TANK FARMS STORAGE FLAMMABLE LIQUIDS	.50	—	
2. PROCESS UPSET OR PURGE FAILURE	.30	0.30	
3. ALWAYS IN FLAMMABLE RANGE	.80	—	
D. DUST EXPLOSION (FACTOR .25 to 2.00) (SEE TABLE II)		—	
E. PRESSURE (SEE FIGURE 2) OPERATING PRESSURE ______ psig RELIEF SETTING ______ psig		—	
F. LOW TEMPERATURE (FACTOR .20 to .30)		—	
G. QUANTITY OF FLAMMABLE/UNSTABLE MATERIAL: QUANTITY small lbs., H_c= ______ BTU/lb			
1. LIQUIDS, GASES AND REACTIVE MATERIALS IN PROCESS (SEE FIG. 3)		—	
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)		0.1	
3. COMBUSTIBLE SOLIDS IN STORAGE, DUST IN PROCESS (SEE FIG. 5)		—	
H. CORROSION AND EROSION (FACTOR .10 to .75)		0.1	
I. LEAKAGE – JOINTS AND PACKING (FACTOR .10 to 1.50)		0.1	
J. USE OF FIRED HEATERS (SEE FIG. 6)		0.1	
K. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15) (SEE TABLE III)		—	
L. ROTATING EQUIPMENT	.50	0.5	
SPECIAL PROCESS HAZARDS FACTOR (F_2)		3.1	
UNIT HAZARD FACTOR ($F_1 \times F_2$ = F_3)		6.2	
FIRE AND EXPLOSION INDEX ($F_3 \times$ MF = F & EI)			99.2

DO A 044723
CONFIDENTIAL

Throx Area

EXHIBIT B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a) Emergency Power	.98	f) Inert Gas - N_2	.94 to .96
b) Cooling	.97 to .99	g) Operating Instructions/ Procedures	.91 to .99
Burner Management c) Explosion Control	.84 to .98	h) Reactive Chemical Review	.91 to .98
d) Emergency Shutdown	.96 to .99	Extensive	
e) Computer Control	.93 to .99		

C_1 Total 0.583 *

2. Material Isolation (C_2)

Yes - a) Remote Control Valves	.96 to .98	c) Drainage	.91 to .97
Yes - b) Dump/Blowdown	.96 to .98	d) Interlock	.98

C_2 Total 0.903 *

3. Fire Protection (C_3)

- Fairly well drained

a) Leak Detection	.94 to .98 .96	f) Sprinkler Systems	.74 to .97 0.80
b) Structural Steel	.95 to .98	g) Water Curtains	.97 to .98
c) Buried Tanks	.84 to .91	h) Foam	.92 to .97
d) Water Supply	.94 to .97	i) Hand Extinguishers/Monitors	.95 to .98
e) Special Systems	.91	j) Cable Protection	.94 to .98

C_3 Value 0.730 *

Credit Factor = $C_1 \times C_2 \times C_3$ = 0.384 Enter on Line D Below

UNIT ANALYSIS SUMMARY

A-1. F & EI	99.2		
A-2. Radius of Exposure	86 ft.		
A-3. Value of Area of Exposure		$MM	11.0
B. Damage Factor	0.60		
C. Base MMPD (A-3 X B)		$MM	6.6
D. Credit Factor	0.384		
E. Actual MMPD (C X D)		$MM	2.5
F. Days Outage (MPDO)			36 days.
G. Business Interruption Loss (BI)		$MM	3.1

* Product of all factors used.

BACK OF FORM C-22380 R-4-87 (471-036)

DO A 044724
CONFIDENTIAL

8°C

EXHIBIT A

FIRE AND EXPLOSION INDEX DOW

LOCATION	DATE
LA Division	9/30/92

PLANT	PROCESS UNIT	EVALUATED BY	REVIEWED BY
Glycol I	AD-6201A	Vic Dean	

MATERIALS AND PROCESS

MATERIALS IN PROCESS UNIT

Propylene Oxide

STATE OF OPERATION

☐ START-UP ☐ SHUT-DOWN ☑ NORMAL OPERATION

BASIC MATERIAL(S) FOR MATERIAL FACTOR

Propylene Oxide

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I OR APPENDICES A OR B) Note requirements when unit temperature over 140°F) →			24
1. GENERAL PROCESS HAZARDS			
BASE FACTOR →	1.00	1.00	
A. EXOTHERMIC CHEMICAL REACTIONS (FACTOR .30 to 1.25)		—	
B. ENDOTHERMIC PROCESSES (FACTOR .20 to .40)		—	
C. MATERIAL HANDLING & TRANSFER (FACTOR .25 to 1.05)		—	
D. ENCLOSED OR INDOOR PROCESS UNITS (FACTOR .25 to .90)		—	
E. ACCESS	35	—	
F. DRAINAGE AND SPILL CONTROL (FACTOR .25 to .50) ______ Gals.		0.25	
GENERAL PROCESS HAZARDS FACTOR (F_1) →		1.25	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR →	1.00	1.00	
A. TOXIC MATERIAL(S) (FACTOR 0.20 to 0.80)	—	0.4	
B. SUB-ATMOSPHERIC PRESSURE (<500 mm Hg)	.50	—	
C. OPERATION IN OR NEAR FLAMMABLE RANGE ☑ INERTED ☐ NOT INERTED		—	
1. TANK FARMS STORAGE FLAMMABLE LIQUIDS	.50	—	
2. PROCESS UPSET OR PURGE FAILURE	30	0.3	
3. ALWAYS IN FLAMMABLE RANGE	80	—	
D. DUST EXPLOSION (FACTOR .25 to 2.00) (SEE TABLE II)		—	
E. PRESSURE (SEE FIGURE 2) OPERATING PRESSURE 80 psig RELIEF SETTING 150 psig		0.26	
F. LOW TEMPERATURE (FACTOR .20 to .30)		—	
G. QUANTITY OF FLAMMABLE UNSTABLE MATERIAL: QUANTITY 23700 lbs., H_c = 206 BTU/lb		—	
1. LIQUIDS, GASES AND REACTIVE MATERIALS IN PROCESS (SEE FIG. 3)		0.16	
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)		—	
3. COMBUSTIBLE SOLIDS IN STORAGE, DUST IN PROCESS (SEE FIG. 5)		—	
H. CORROSION AND EROSION (FACTOR .10 to .75)		—	
I. LEAKAGE — JOINTS AND PACKING (FACTOR .10 to 1.50)		—	
J. USE OF FIRED HEATERS (SEE FIG. 6)		—	
K. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15) (SEE TABLE III)		—	
L. ROTATING EQUIPMENT	.50	—	
SPECIAL PROCESS HAZARDS FACTOR (F_2) →		2.12	
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$) →		2.65	
FIRE AND EXPLOSION INDEX ($F_3 \times MF$ = F & EI) →			63.6

DO A 044725
CONFIDENTIAL

Radius of exposure → 52'

2/18/92
UWO

Value of Areas

Area #1

Modular Cost PO Storage - 3200

Assume 25% to Storage

(0.25)(3200) = 800 m$

Add 500 m$ for inst. and piping

Total = 1.3 mm$

Add $500 for glycol (R-500)

= $\boxed{1.7\ mm\$\checkmark}$

Area #2

Same cost + same T-300

— 1.7 mm$✓

Area #3

Finishing - 11.6 mm

Hydro. - 0.9 mm

Total = $12.5 mm

Area #4

Hypoclorination 8500/2 ≈ 4.3 mm

+ 25% Cond = 0.25 × 4.0/2 = 0.5 mm

+ 0.7 mm Steel = 5.5 mm

Area #5

Same as Area #4

UWO
2/18/92

Area #6

50% Hypochlorination (one side) = 2.2
100% Condensing (one side) = 2.0
30% Finishing = 8.0
100% PDC Finishing = 3.8
Total 15.0

Area #7

60% Finishing 16.5
100% Switch Gear 2.0
100% Condensing 71 Side 2.0
25% " 70 Side 0.5
100% 71, 70 Triples 5.5 mm
Total 26.5 mm$

Area #8

50% Finishing = 13.7
100% Switch Gear 2.0
100% 71 Side Condensing 2.0
100% 71 Storage 1.7
Glycol / PDC Storage 3.0

22.4

Throx - Area #9
Control Room / MOO 4.0
Throx 5.0
Glycol 2.0
11.0

DO A 044727
CONFIDENTIAL

23.7°C

EXHIBIT A

FIRE AND EXPLOSION INDEX

LOCATION	DATE
LAD	6/18/93

PLANT	PROCESS UNIT	EVALUATED BY	REVIEWED BY
Glycol 1	DV-900	BJL	

MATERIALS AND PROCESS

MATERIALS IN PROCESS UNIT
PDC

STATE OF OPERATION
☐ START-UP ☐ SHUT-DOWN ☒ NORMAL OPERATION

BASIC MATERIAL(S) FOR MATERIAL FACTOR
PDC

MATERIAL FACTOR (SEE TABLE I OR APPENDICES A OR B) Note requirements when unit temperature over 140° F) → 16

1. GENERAL PROCESS HAZARDS	PENALTY	PENALTY USED	
BASE FACTOR →	1.00	1.00	
A. EXOTHERMIC CHEMICAL REACTIONS (FACTOR .30 to 1.25)		—	
B. ENDOTHERMIC PROCESSES (FACTOR .20 to .40)		—	
C. MATERIAL HANDLING & TRANSFER (FACTOR .25 to 1.05)		—	
D. ENCLOSED OR INDOOR PROCESS UNITS (FACTOR .25 to .90)		—	
E. ACCESS	.35	0.35	
F. DRAINAGE AND SPILL CONTROL (FACTOR .25 to .50) 162500 Gals.		0.5	
GENERAL PROCESS HAZARDS FACTOR (F_1) →		1.85	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR →	1.00	1.00	
A. TOXIC MATERIAL(S) (FACTOR 0.20 to 0.80) $N_h = 2$		0.4	
B. SUB-ATMOSPHERIC PRESSURE (< 500 mm Hg)	.50	—	
C. OPERATION IN OR NEAR FLAMMABLE RANGE ☒ INERTED ☐ NOT INERTED		—	
1. TANK FARMS STORAGE FLAMMABLE LIQUIDS	.50	—	
2. PROCESS UPSET OR PURGE FAILURE	.30	—	
3. ALWAYS IN FLAMMABLE RANGE	.80	0.80	
D. DUST EXPLOSION (FACTOR .25 to 2.00) (SEE TABLE II)		—	
E. PRESSURE (SEE FIGURE 2) OPERATING PRESSURE 0 psig RELIEF SETTING 20 psig		0.21	
F. LOW TEMPERATURE (FACTOR .20 to .30)		—	
G. QUANTITY OF FLAMMABLE/UNSTABLE MATERIAL: QUANTITY 1.2MM lbs., H_c = ~~6463~~ 6300 BTU/lb		—	
1. LIQUIDS, GASES AND REACTIVE MATERIALS IN PROCESS (SEE FIG. 3)		—	
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)		0.75	
3. COMBUSTIBLE SOLIDS IN STORAGE, DUST IN PROCESS (SEE FIG. 5)		—	
H. CORROSION AND EROSION (FACTOR .10 to .75)		0.1	
I. LEAKAGE — JOINTS AND PACKING (FACTOR .10 to 1.50)		0.3	
J. USE OF FIRED HEATERS (SEE FIG. 6) N		—	
K. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15) (SEE TABLE III)		—	
L. ROTATING EQUIPMENT	.50	—	
SPECIAL PROCESS HAZARDS FACTOR (F_2) →		3.56	
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$) →			6.59
FIRE AND EXPLOSION INDEX ($F_3 \times MF$ = F & EI) →			105

DO A 044728
CONFIDENTIAL

FORM C-22380 R-4-87 (471-036)

EXHIBIT B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a) Emergency Power	.98	f) Inert Gas	0.95 .94 to .96 ✓
b) Cooling	.97 to .99	g) Operating Instructions/ Procedures	.91 to .99
c) Explosion Control	.84 to .98	h) Reactive Chemical Review	.91 to .98
d) Emergency Shutdown	.96 to .99		
e) Computer Control	.93 to .99		

C_1 Total 0.95 *

2. Material Isolation (C_2)

a) Remote Control Valves	.96 to .98	c) Drainage	.91 to .97
b) Dump/Blowdown	.96 to .98	d) Interlock	.98

C_2 Total 0.97 *

3. Fire Protection (C_3)

a) Leak Detection	.94 to .98	f) Sprinkler Systems	0.81 .74 to .97 ✓
b) Structural Steel	.95 to .98	g) Water Curtains	.97 to .98
c) Buried Tanks	.84 to .91	h) Foam	.92 to .97
d) Water Supply	.94 to .97	i) Hand Extinguishers/Monitors	.95 to .98
e) Special Systems	.91	j) Cable Protection	.94 to .98

C_3 Value 0.81 *

Credit Factor = $C_1 \times C_2 \times C_3$ = 0.746 Enter on Line D Below

UNIT ANALYSIS SUMMARY

A-1. F & EI	105		
A-2. Radius of Exposure	89 ft.		
A-3. Value of Area of Exposure		$MM	3 w/ product
B. Damage Factor	0.61		
C. *Base MMPD (A-3 X B)		$MM	1.83
D. Credit Factor	0.746		
E. Actual MMPD (C X D)		$MM	1.37
F. Days Outage (MPDO)			25 days.
G. Business Interruption Loss (BI)		$MM	11.7

* Product of all factors used.

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BACK OF FORM C-22380 R-4-87 (471-036)

VPM ≃ 20E6 /month

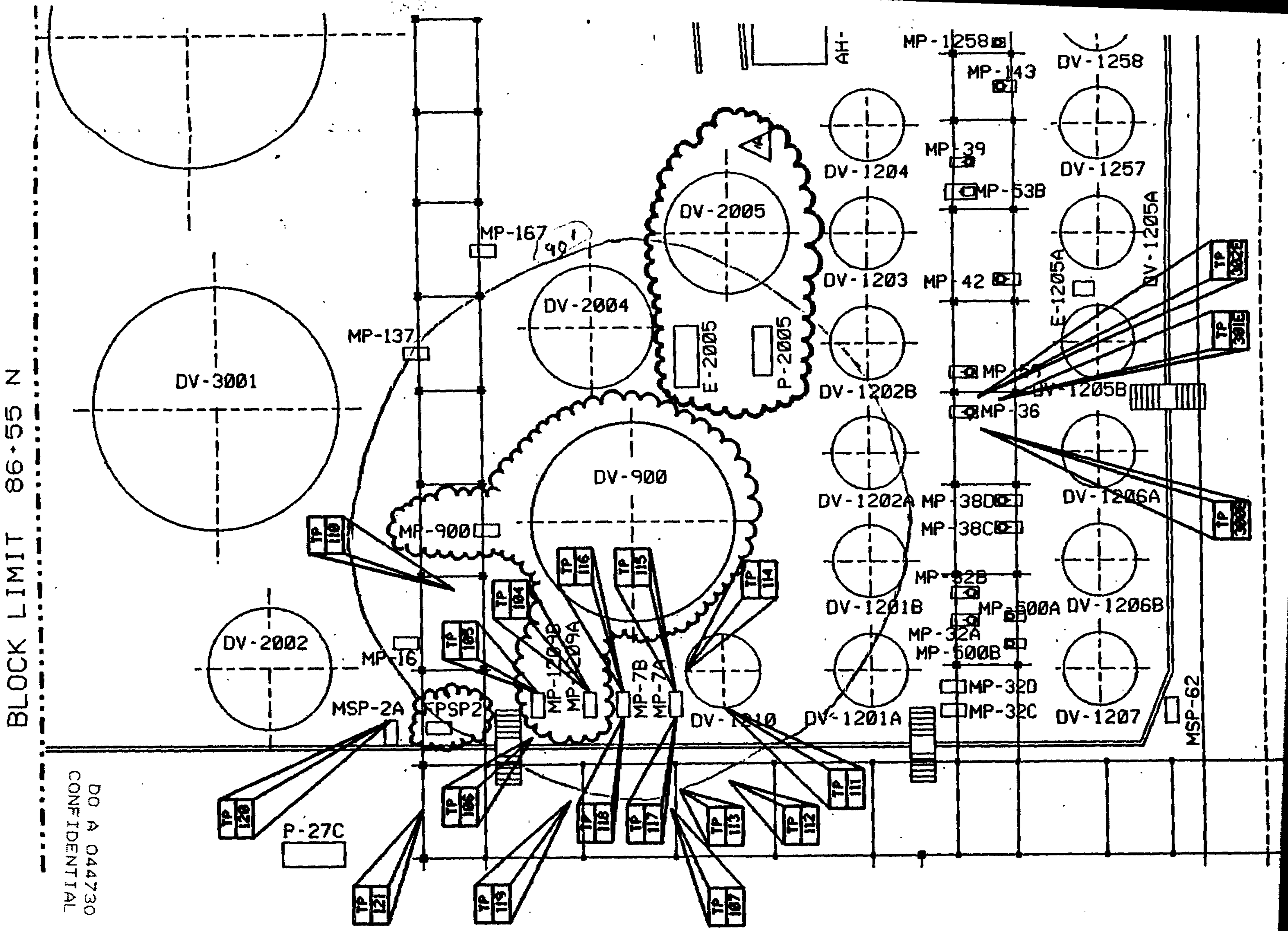

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EXHIBIT A

FIRE AND EXPLOSION INDEX Dow

LOCATION	DATE
LA Division	12/15/

PLANT	PROCESS UNIT	EVALUATED BY	REVIEWED BY
Glycol 1	AD-6201 A	Vic Dean	

MATERIALS AND PROCESS

MATERIALS IN PROCESS UNIT
Propylene Oxide

STATE OF OPERATION
☐ START-UP ☐ SHUT-DOWN ☑ NORMAL OPERATION

BASIC MATERIAL(S) FOR MATERIAL FACTOR
Propylene Oxide

MATERIAL FACTOR (SEE TABLE I OR APPENDICES A OR B) Note requirements when unit temperature over 140°F)			24
1. GENERAL PROCESS HAZARDS	PENALTY	PENALTY USED	
BASE FACTOR →	1.00	1.00	
A. EXOTHERMIC CHEMICAL REACTIONS (FACTOR .30 to 1.25)		—	
B. ENDOTHERMIC PROCESSES (FACTOR .20 to .40)		—	
C. MATERIAL HANDLING & TRANSFER (FACTOR .25 to 1.05)		—	
D. ENCLOSED OR INDOOR PROCESS UNITS (FACTOR .25 to .90)		—	
E. ACCESS	.35	—	
F. DRAINAGE AND SPILL CONTROL (FACTOR .25 to .50) ______ Gals.		0.25	
GENERAL PROCESS HAZARDS FACTOR (F_1) →		1.25	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR →	1.00	1.00	
A. TOXIC MATERIAL(S) (FACTOR 0.20 to 0.80)		0.4	
B. SUB-ATMOSPHERIC PRESSURE (< 500 mm Hg)	.50	—	
C. OPERATION IN OR NEAR FLAMMABLE RANGE ☑ INERTED ☐ NOT INERTED			
1. TANK FARMS STORAGE FLAMMABLE LIQUIDS	.50	—	
2. PROCESS UPSET OR PURGE FAILURE	.30	—	
3. ALWAYS IN FLAMMABLE RANGE	.80	—	
D. DUST EXPLOSION (FACTOR .25 to 2.00) (SEE TABLE II)		—	
E. PRESSURE (SEE FIGURE 2) OPERATING PRESSURE 80 psig RELIEF SETTING 150 psig		0.2	
F. LOW TEMPERATURE (FACTOR .20 to .30)		—	
G. QUANTITY OF FLAMMABLE/UNSTABLE MATERIAL: QUANTITY 100900 lbs., H_c = 13.2×10³ BTU/lb		—	
1. LIQUIDS, GASES AND REACTIVE MATERIALS IN PROCESS (SEE FIG. 3)		1.6	
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)		—	
3. COMBUSTIBLE SOLIDS IN STORAGE, DUST IN PROCESS (SEE FIG. 5)		—	
H. CORROSION AND EROSION (FACTOR .10 to .75)		—	
I. LEAKAGE – JOINTS AND PACKING (FACTOR .10 to 1.50)		—	
J. USE OF FIRED HEATERS (SEE FIG. 6)		—	
K. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15) (SEE TABLE III)		—	
L. ROTATING EQUIPMENT	.50	—	
SPECIAL PROCESS HAZARDS FACTOR (F_2) →		3.2	
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$) →		4	
FIRE AND EXPLOSION INDEX ($F_3 \times MF$ = F & EI) →			96

DO A 044731
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FORM C-22380 R-4-87 (471-036)

EXHIBIT B

LOSS CONTROL CREDIT FACTORS

1. Pr cess C ntrol (C_1)

a) Emergency Power	.98	f) Inert Gas	.94 to .96
b) Cooling	.97 to .99	g) Operating Instructions/ Procedures	.91 to .99 0.96 See over
c) Explosion Control	.84 to .98	h) Reactive Chemical Review	.91 to .98
MOOV d) Emergency Shutdown	.96 to .99		
e) Computer Control	.93 to .99 Fail-Safe - 0.97		

C_1 Total 0.876 *

2. Material Isolation (C_2)

a) Remote Control Valves	.96 to .98	c) Drainage	.91 to .97
b) Dump/Blowdown	.96 to .98	d) Interlock	.98

C_2 Total 0.892 *

3. Fire Protection (C_3)

a) Leak Detection	.94 to .98	f) Sprinkler Systems 0.81	.74 to .97
b) Structural Steel	.95 to .98	g) Water Curtains	.97 to .98
c) Buried Tanks	.84 to .91	h) Foam	.92 to .97
d) Water Supply	.94 to .97	i) Hand Extinguishers/Monitors	.95 to .98 0.97
e) Special Systems	.91	j) Cable Protection	.94 to .98

C_3 Value 0.747 *

Credit Factor = $C_1 \times C_2 \times C_3$ = 0.584 Enter on Line D Below

UNIT ANALYSIS SUMMARY

A-1. F & EI	96		
A-2. Radius of Exposure	80 ft.		
A-3. Value of Area of Exposure		$MM	3.0
B. Damage Factor	0.74		
C. Base MMPD (A-3 X B)		$MM	2.22
D. Credit Factor	0.584		
E. Actual MMPD (C X D)		$MM	1.30
F. Days Outage (MPDO)			25 days.
G. Business Interruption Loss (BI)		$MM	0.58

* Product of all factors used.

BACK OF FORM C-22380 R-4-87 (471-036)

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CHEMICAL EXPOSURE INDEX SUMMARY

Complete the following Table (See Note 1) by filling in and multiplying the appropriate Risk Factor Scale numbers for each of the major Risk areas as identified in the following formula (See "Definitions of Scale Numbers" CEI, page 6):

I.	x	II.	x	III.	x	IV.	x	V.	=	VI.
ACUTE HEALTH HAZARD SCALE NO.		VAPOR QUANTITY SCALE NO.		DISTANCE (RECIPROCAL) SCALE NO.		MOLECULAR WEIGHT SCALE NO.		PROCESS PENALTIES SCALE NO.		CHEMICAL EXPOSURE INDEX

Identification of Containment Vessels being evaluated:
Name or Number (See Notes 2 & 3)

	I.	II.	III.	IV.	V.	VI. (CEI)
Source #1 AD-6201 A						
To (1) Public	2	4	3	4	1	96
(2) Other in-company Facility	2	4	4	4	1	128
(3) Non-company Plant or Business	2	4	3	4	1	96
Source #2 (if needed) ______						
To (1) Public						
(2) Other in-company Facility						
(3) Non-company Plant or Business						

NOTE 1 — The distance scale number in column III is the only factor normally expected to change, so column III and the corresponding CEI (column VI) are all that would normally be expected to differ from the first calculation for each source.

NOTE 2 — Only different sources of the same chemical should be evaluated on this sheet. Use a separate Chemical Exposure Index for every different chemical.

NOTE 3 — Use additional sheets if additional sources with differing potential impact are present.

NOTE 4 — It is important to document the worst case scenarios for future reference. See "Review Procedure and Check List," page 7.

Back of Form C-91720
TT-3044

DO A 044733
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CHEMICAL EXPOSURE INDEX

PLANT Glycol 1 LOCATION LA Division

CHEMICAL (One per index) Propylene Oxide TOTAL QUANTITY IN PLANT ______

LARGEST SINGLE CONTAINMENT AD-6201A TEMPERATURE OF CONTAINMENT 25°C

PRESSURE OF CONTAINMENT 80 PSIG BOILING POINT 93 F

FLASH POINT, °C -37°C MOLECULAR WEIGHT 58

EMERGENCY EXPOSURE PLANNING GUIDELINE (EEPG) CONCENTRATION,
(Refer to CEI Pg. 6 & Tables I & II, Pgs. 10-11) ______

I. Complete the Chemical Exposure Index Summary (on page 5) and show highest CEI to the Public ______ 96

This CEI number determines the level of review needed:

0 to 100	Internal review — Superintendent and Major Manager review and sign every two years.
100 to 300	Site Review Committee, Superintendent and Major Manager review every two years.
300 to 400	Area Representative and the preceding group review every two years.
Above 400	Corporate Representative and the preceding group review every two years.

II. Complete Chemical Exposure Review Checklist (see page 7, CEI) prepare Review Package, and indicate date ready for further reviews.
(Will be scheduled with Loss Prevention Contact) ______

III. List any Sights, Odors, or Sounds which might come from your facility and cause public concern or inquiries (e.g., smoke, large relief valves, odors below hazardous levels such as mercaptans or amines, etc.)

______

______

______

Reviewed by:	Date
Plant Superintendent or Manager: ______	______
Major or General Manager: ______	______
Site Review Representative: ______ (If Public CEI is above 100)	______
Area Review Representative: ______ (If Public CEI is above 300)	______
Corporate Review Representative: ______ (If Public CEI is above 400)	______

Form C-91720
TT-3848

DO A 044734
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AD-6201 A

12/15/92

$$L_{15} = 24.43\, \rho\, d^2 \left[h_{Lo} + \frac{144P}{\rho} - 7.77 \frac{d^2}{D^2} \right]$$

$\rho = 52.6$ lb/ft^3

$d^2 = (1.6)^2$ ← $A_{reh} = 2$ in^2 $r = 0.8$ in, $d = 1.6$

$h_{Lo} = 40'$

$P = 95$ psia

$D = 10'$

$$L_{15} = 24.43\,(52.6)(1.6)^2 \left[40 + \frac{(144)(95)}{(52.6)} - 7.77 \frac{(1.6)^2}{10^2} \right]$$

$L_{15} = 986489$

$$A = \frac{986489}{52.6} = 18755 \text{ ft}^2$$

$V = 8$ mph $P = 537.6$ (25°C)

$mw = 58$

$$W = 9.5 \times 10^{-6} (2.92 + 8)(18755)(537.6)(58)$$

$W_{15} = 60666$

DO A 044735
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RE-CAP WORK SHEET

PLANT: GLYCOL #1 PREPARED BY: GRANT - SAIA

DIVISION: LA. DIVISION DATE: 2/8/82

Process Units	Unit Hazard Factor F_3	Material Factor MF	F&EI (F_3XMF)	(A) Value Area of Exposure $MM	(B) Damage Factor from Figure 7	(C) Base MPPD $MM (AXB)	(D) Credit Factor $C_1 x C_2 x C_3$ from Figure 9	(E) Actual MPPD $MM (CXD)	(F) Days Outage MPDO from Figure 10
70 STORAGE P.O.	4.0	21	84	3.5 $\overline{M}$	.66	2.3 $\overline{M}$	.315	727 M	20
71 STORAGE P.O.	4.0	21	84	3.5 $\overline{M}$	.66	2.3 $\overline{M}$	.315	727 M	20
PROPYLENE GLYCOL	3.35	21	70.35	9.02 $\overline{M}$	.62	5.59 $\overline{M}$	.66	3.69 $\overline{M}$	50
70 REACTOR AREA 4	3.65	21	76.65	4.0 $\overline{M}$	.63	2.52 $\overline{M}$	.46	1.159 $\overline{M}$	22
71 REACTOR AREA 3	3.65	21	76.65	4.0 $\overline{M}$	.63	2.52 $\overline{M}$	.46	1 159 $\overline{M}$	22
AREA 8 - T-102C	4.73	21	99.27	3.0 $\overline{M}$	.72	2.16 $\overline{M}$	.48	1.04 $\overline{M}$	23
AREA 9 - T-102B	5.10	21	107.1	6.0 $\overline{M}$	.74	4.44 $\overline{M}$	.48	2.13 $\overline{M}$	33
AREA 10 - T-300	5.60	21	117.6	5.5 $\overline{M}$	.79	4.35 $\overline{M}$	.48	2.09 $\overline{M}$	33

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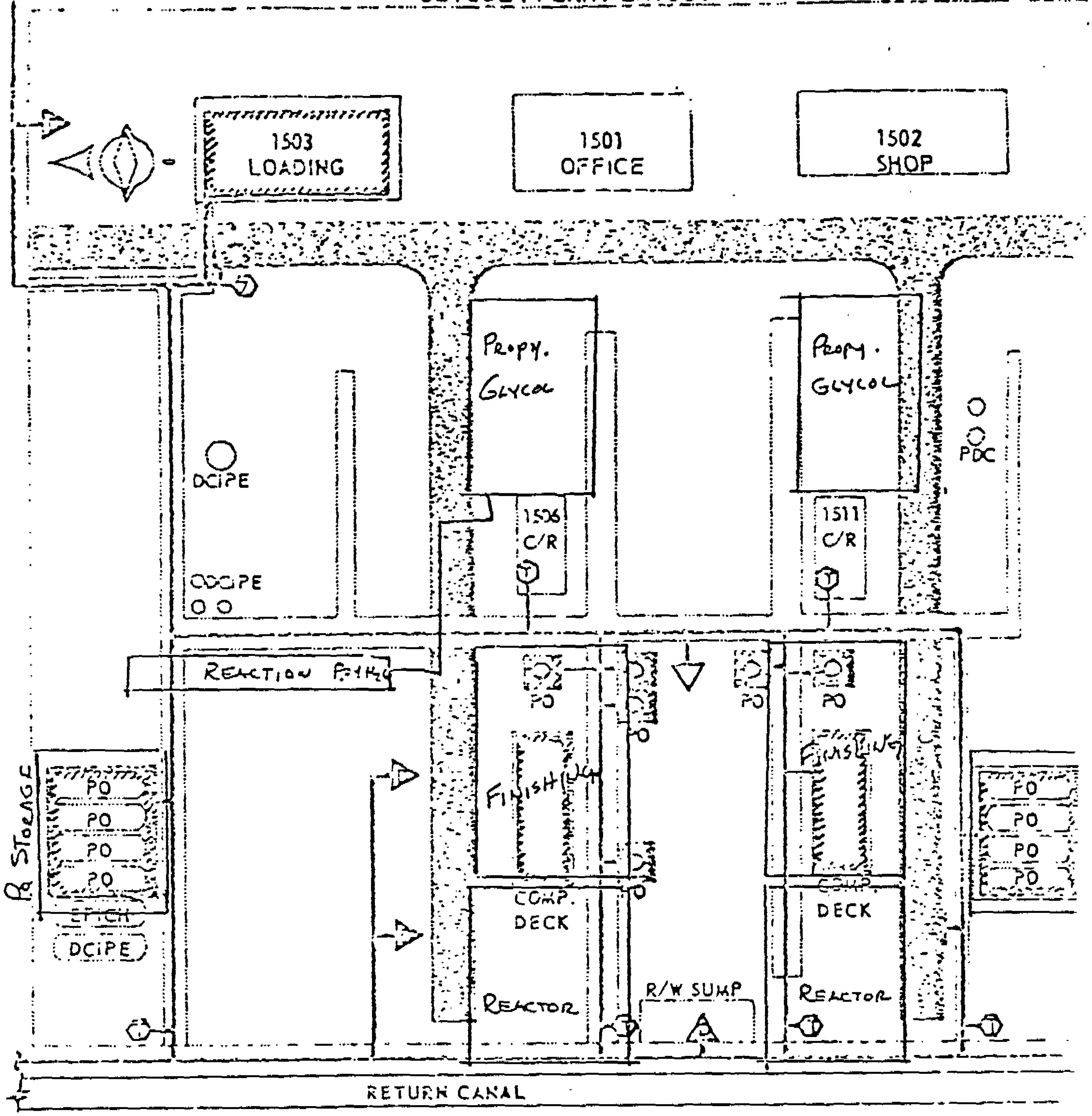
FORM C-50010 R-10-80 (471-037)

GLYCOL I PLANT LAYOUT



LEGEND:

PO – PROPYLENE OXIDE COLUMN OR STORAGE

PDC – PROPYLENE DI-CHLORIDE STORAGE

DCIPE – ETHER STORAGE

EPICH – EPICHOROHYDRIN STORAGE

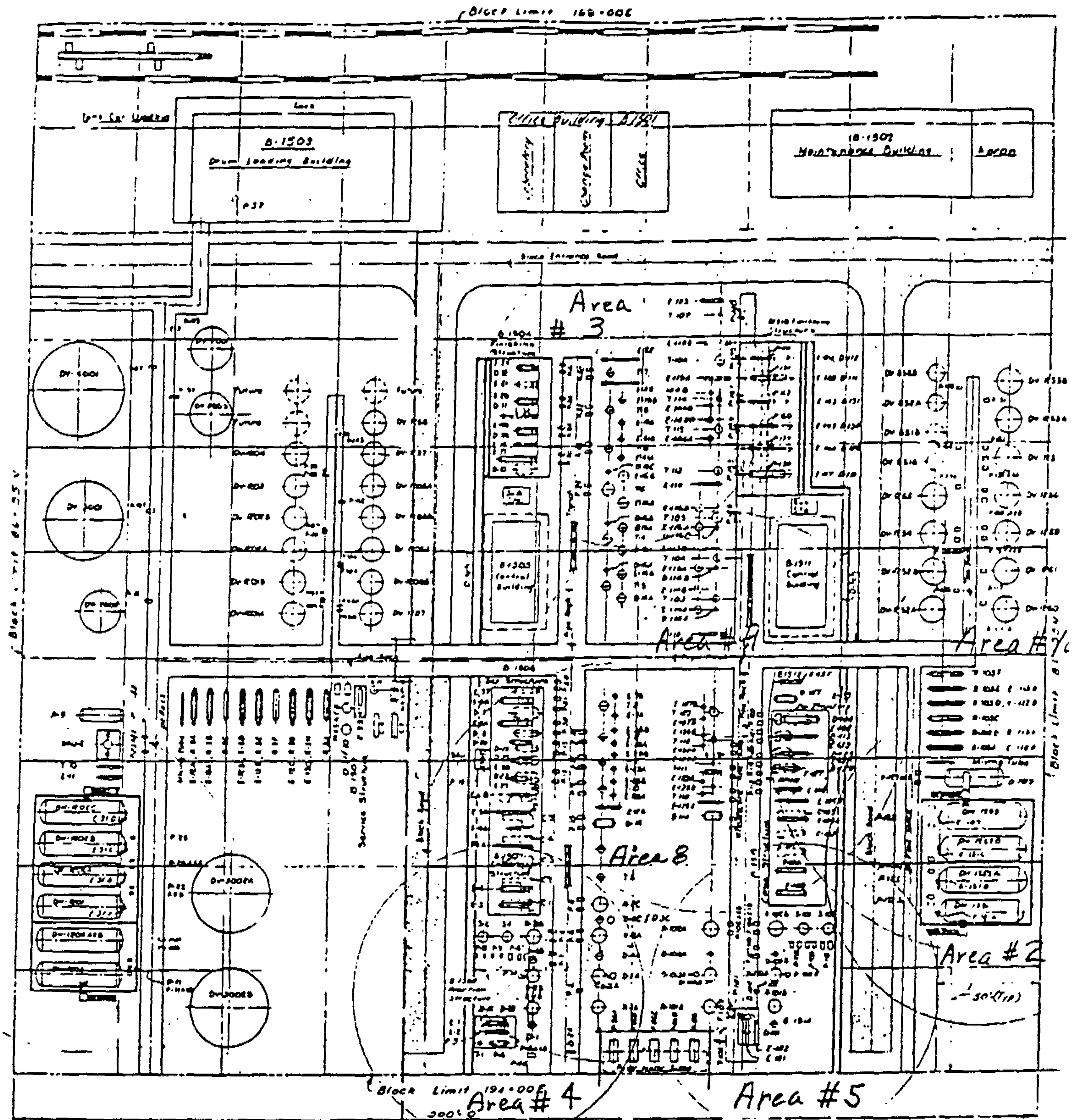
PROCESS WATER

SPRINKLER SYSTEM

SPRINKLER SYSTEM TRIP VALVE

DELUGE GUN

DO A 044738
CONFIDENTIAL



Subtract six (6) inches from all coordinates having a North designation and located in the area South & West of the heavy broken line (South Block Limit & River Water Pump excepted.)

DO A 044739
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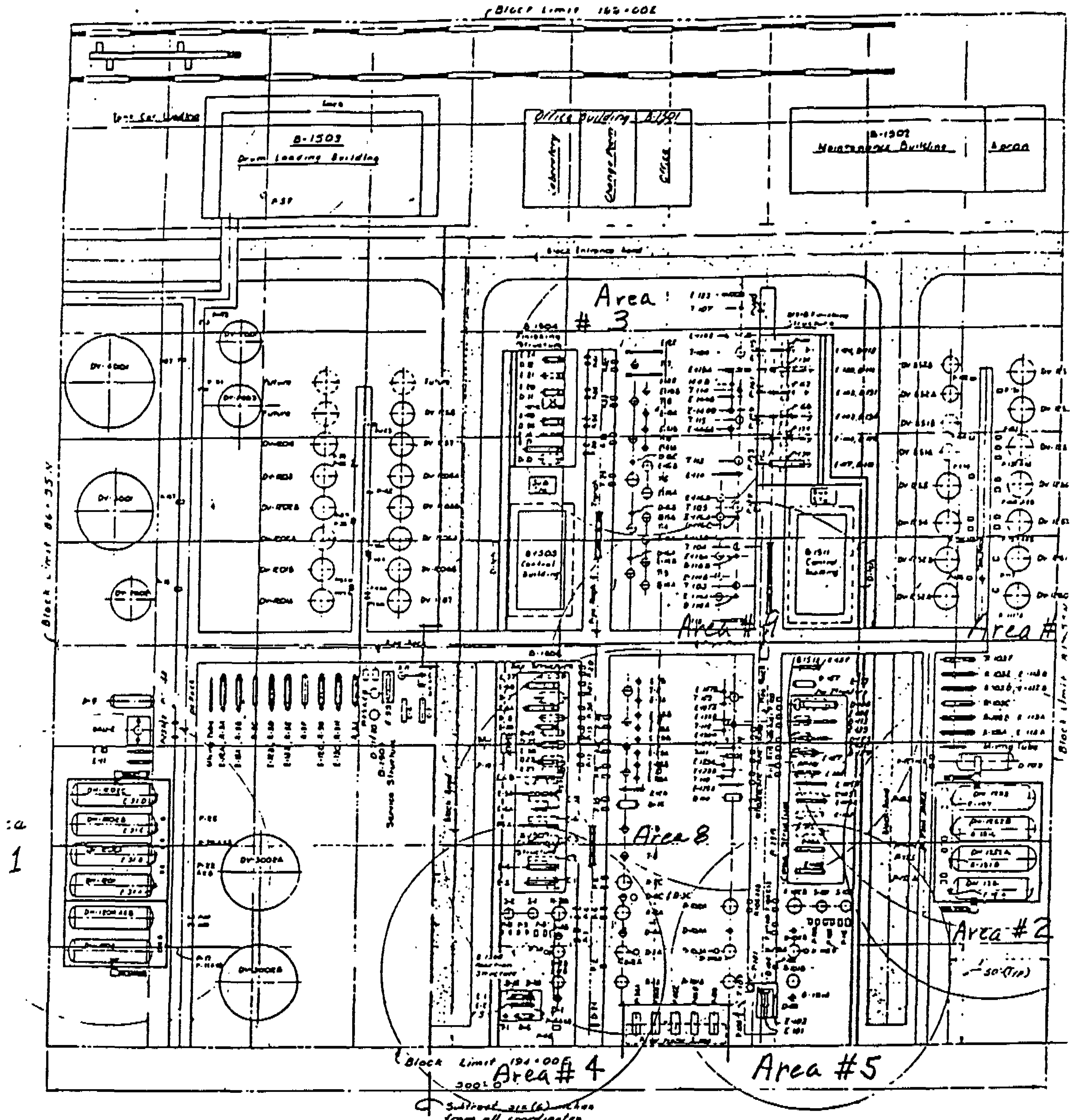
ORIGINAL B/N NO

CO. ORD	REVISION	BY	DATE	APP	MARK	CO. ORD	REVISION	BY	DATE	APP	MARK	CO. ORD
					△						△	C-1
					△						△	
					△						△	

B C D E F



DO A 044740
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ORIGINAL B/M NO
M 9002-GSC
M 9009 GSC

REVISION	BY	DATE	APP.	MARK	CO-ORD	REVISION	BY	DATE	APP.	MARK	CO-ORD
B/M				△		B/M				△	
B/M				△		B/M				△	
B/M				△		B/M				△	

FIRE AND EXPLOSION ...

Exhibit "A"

PLANT: Glyco1 #1 | UNIT: 70 F.O. Storage-Load | RECEIVED MAR 22 1982 SAFETY DEPT.

MATERIALS AND PROCESS

MATERIALS: F.O.

CATALYSTS: None | SOLVENTS: None

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I APPENDIX A)			21
1. GENERAL PROCESS HAZARDS (SEE TABLE II)			
BASE FACTOR	1.00	1.00	
A. EXOTHERMIC REACTIONS (FACTOR .30 to 1.25)			
B. ENDOTHERMIC REACTIONS (FACTOR .20 to .40)			
C. MATERIAL HANDLING & TRANSFER (FACTOR .25 to .85)			
D. ENCLOSED PROCESS UNITS (FACTOR .30 to .90)			
E. ACCESS	.35		
F. DRAINAGE (FACTOR .25 to .50)			
GENERAL PROCESS HAZARD FACTOR (F_1)		1.0	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR	1.00	1.00	
A. PROCESS TEMPERATURE (USE ONLY ONE)			
1. ABOVE FLASH POINT	.30	.30	
2. ABOVE BOILING POINT	.60		
3. ABOVE AUTOIGNITION	.75		
B. LOW PRESSURE (SUB ATOMOSPHERIC)	.50		
C. OPERATION IN OR NEAR FLAMMABLE RANGE			
1. TANK FARM STORAGE FLAMMABLE LIQUIDS	.50		
2. PROCESS UPSET OR PURGE FAILURE	.30	.30	
3. ALWAYS IN FLAMMABLE RANGE	.80		
D. DUST EXPLOSION (FACTOR .25 to 2.00) (SEE TABLE III)			
E. PRESSURE (SEE FIGURE 2)		.25	
F. LOW TEMPERATURE (FACTOR .20 to .30)			
G. QUANTITY OF FLAMMABLE MATERIAL			
1. LIQUIDS OR GASES IN PROCESS (SEE FIG. 3)			
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)		.95	
3. COMBUSTIBLE SOLIDS IN STORAGE (SEE FIG. 5)			
H. CORROSION AND EROSION (FACTOR .10 to .75)		.10	
J. LEAKAGE - JOINTS AND PACKING (FACTOR .10 to 1.50)		.10	
K. USE OF FIRED HEATERS (SEE FIG. 6)			
L. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15) (SEE TABLE IV)			
M. ROTATING EQUIPMENT, PUMPS, COMPRESSORS	.50		
SPECIAL PROCESS HAZARD FACTOR (F_2)		3.0	
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$)		4.0	
FIRE AND EXPLOSION INDEX ($F_3 \times MF = F \& EI$)			84

FORM C-22346 PRINTED 4-10-68 (431-016)

DO A 044741
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Exhibit B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a)	Emergency Power	.97	e)	Computer Control	.89 to .98
b)	Cooling	.95 to .98	f)	Inert Gas	.90 to .94
c)	Explosion Control	.75 to .96	g)	Operating Procedures	.86 to .99
d)	Emergency Shutdown	.94 to .98	h)	Reactive Chemical Review	.85 to .96

C_1 Total 0.699*

2. Material Isolation (C_2)

a)	Remote Control Valves	.94	c)	Drainage	.85 to .95
b)	Dump/Blowdown	.94 to .96	d)	Interlock	.96

dike = 1.0

C_2 Total 0.884*

3. Fire Protection (C_3)

a)	Leak Detection	.90 to .97	f)	Sprinkler Systems	.60 to .96
b)	Structural Steel	.92 to .97	g)	Water Curtains	.95 to .97
c)	Buried Tanks	.75 to .85	h)	Foam	.87 to .98
d)	Water Supply	.90 to .95	j)	Hand Extinguishers	.92 to .97 .95
e)	Special Systems	.85	k)	Cable Protection	.90 to .96

C_3 Total 0.51*

$C_1 \times C_2 \times C_3 =$ 0.315 See Figure 9 for conversion to Actual Credit Factor. (To Line D below).

RISK ANALYSIS SUMMARY

A-1.	F & EI	84	
A-2.	Radius of Exposure	72 ft.	
A-3.	Value of Area of Exposure		SMM \$3.5M
B.	Damage Factor	0.66	
C.	Base MPPD (A-3 X B)		SMM \$2.3M
D.	Credit Factor, Actual	0.315	
E.	Actual MPPD (C x D)		~~SMM~~ \$727,000
F.	Days Outage (MPDO)		20 days.

$BI = \frac{20}{30} \times 330{,}000 \times .7 =$ \$154,000

*Product of all factors used.

BACK OF FORM C-22380 R-10-80(471-836)

DO A 044742
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FIRE AND EXPLOSION DEX

Exhibit "A"

LOCATION	DATE

PLANT	UNIT	CHARGE
Glycol #1	71 P.O. Storage-Area 2	

MATERIALS AND PROCESS

MATERIALS: P.O.

CATALYSTS: None

SOLVENTS: None

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I APPENDIX A)			21
1. GENERAL PROCESS HAZARDS (SEE TABLE II)			
BASE FACTOR	1.00	1.00	
A EXOTHERMIC REACTIONS (FACTOR .30 to 1.25)			
B ENDOTHERMIC REACTIONS (FACTOR .20 to .40)			
C MATERIAL HANDLING & TRANSFER (FACTOR .25 to .85)			
D ENCLOSED PROCESS UNITS (FACTOR .30 to .90)			
E ACCESS	.35		
F DRAINAGE (FACTOR .25 to .50)			
GENERAL PROCESS HAZARD FACTOR (F_1)		1.0	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR	1.00	1.00	
A PROCESS TEMPERATURE (USE ONLY ONE)			
1 ABOVE FLASH POINT	.30	.30	
2 ABOVE BOILING POINT	.60		
3 ABOVE AUTOIGNITION	.75		
B LOW PRESSURE (SUB ATMOSPHERIC)	.50		
C OPERATION IN OR NEAR FLAMMABLE RANGE			
1 TANK FARM STORAGE FLAMMABLE LIQUIDS	.50		
2 PROCESS UPSET OR PURGE FAILURE	.30	.30	
3 ALWAYS IN FLAMMABLE RANGE	.80		
D DUST EXPLOSION (FACTOR .25 to 2.00) (SEE TABLE III)			
E PRESSURE (SEE FIGURE 2)		.25	
F LOW TEMPERATURE (FACTOR .20 to .50)			
G QUANTITY OF FLAMMABLE MATERIAL			
1 LIQUIDS OR GASES IN PROCESS (SEE FIG. 3)			
2 LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)		.95	
3 COMBUSTIBLE SOLIDS IN STORAGE (SEE FIG. 5)			
H CORROSION AND EROSION (FACTOR .10 to .75)		.10	
J LEAKAGE - JOINTS AND PACKING (FACTOR .10 to 1.50)		.10	
K. USE OF FIRED HEATERS (SEE FIG. 6)			
L. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15) (SEE TABLE IV)			
M. ROTATING EQUIPMENT, PUMPS, COMPRESSORS	.50		
SPECIAL PROCESS HAZARD FACTOR (F_2)		3.0	
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$)		4.0	
FIRE AND EXPLOSION INDEX ($F_3 \times MF = F\&EI$)			84

FORM C-22388 PRINTED 8-10-80 (471-036)

DO A 044743

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Exhibit B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a)	Emergency Power	.97	e)	Computer Control	.89 to .98
b)	Cooling	.95 to .98	f)	Inert Gas	.90 to .94
c)	Explosion Control	.75 to .96	g)	Operating Procedures	.86 to .99
d)	Emergency Shutdown	.94 to .98	h)	Reactive Chemical Review	.85 to .96

C_1 Total 0.699 *

2. Material Isolation (C_2)

a)	Remote Control Valves	.94	c)	Drainage	.85 to .95 dike = 1.0
b)	Dump/Blowdown	.94 to .96	d)	Interlock	.96

C_2 Total 0.884 *

3. Fire Protection (C_3)

a)	Leak Detection	.90 to .97	f)	Sprinkler Systems	.60 to .96
b)	Structural Steel	.92 to .97	g)	Water Curtains	.95 to .97
c)	Buried Tanks	.75 to .85	h)	Foam	.87 to .98
d)	Water Supply	.90 to .95	j)	Hand Extinguishers	.92 to .97 .95
e)	Special Systems	.85	k)	Cable Protection	.90 to .96

C_3 Total 0.51 *

$C_1 \times C_2 \times C_3 =$ 0.315 See Figure 9 for conversion to Actual Credit Factor. (To Line D below).

RISK ANALYSIS SUMMARY

A-1.	F & EI	84	
A-2.	Radius of Exposure	72 ft.	
A-3.	Value of Area of Exposure		SMM \$3.5M
B.	Damage Factor	0.66	
C.	Base MPPD (A-3 X B)		SMM \$2.3M
D.	Credit Factor, Actual	0.315	
E.	Actual MPPD (C x D)		~~SMM~~ \$727,000
F.	Days Outage (MPDO)		20 days.

$BI = \frac{20}{30} \times 330{,}000 \times .7 =$ \$154,000

*Product of all factors used.

BACK OF FORM C-22380 R-10-80(471-036)

DO A 044744
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FIRE AND EXPLOSION ...DEX

DOW

LOCATION

DATE

Exhibit "A"

PLANT: Glycol I

UNIT: Propylene Glycol

CHANGE

MATERIALS AND PROCESS

MATERIALS: Propylene Glycol – P.O. – H_2O – H_2 (Hydrogenation

CATALYSTS

SOLVENTS

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I APPENDIX A) P.O. →			21
1. GENERAL PROCESS HAZARDS (SEE TABLE II)			
BASE FACTOR →	1.00	1.00	
A. EXOTHERMIC REACTIONS (FACTOR .30 to 1.25) Hydrogenation	.30	.30	
B. ENDOTHERMIC REACTIONS (FACTOR .20 to .40)			
C. MATERIAL HANDLING & TRANSFER (FACTOR .25 to .85)			
D. ENCLOSED PROCESS UNITS (FACTOR .30 to .90)			
E. ACCESS	.35		
F. DRAINAGE (FACTOR .25 to .50)	.25	.25	
GENERAL PROCESS HAZARD FACTOR (F_1) →		1.55	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR →	1.00	1.00	
A. PROCESS TEMPERATURE (USE ONLY ONE)			
1. ABOVE FLASH POINT	.30		
2. ABOVE BOILING POINT	.60	.60	
3. ABOVE AUTOIGNITION	.75		
B. LOW PRESSURE (SUB ATOMOSPHERIC)	.50		
C. OPERATION IN OR NEAR FLAMMABLE RANGE			
1. TANK FARM STORAGE FLAMMABLE LIQUIDS	.50		
2. PROCESS UPSET OR PURGE FAILURE	.30		
3. ALWAYS IN FLAMMABLE RANGE	.80		
D. DUST EXPLOSION (FACTOR .25 to 2.00) (SEE TABLE III)			
E. PRESSURE (SEE FIGURE 2)			
F. LOW TEMPERATURE (FACTOR .20 to .30)			
G. QUANTITY OF FLAMMABLE MATERIAL			
1. LIQUIDS OR GASES IN PROCESS (SEE FIG. 3)			
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)			
3. COMBUSTIBLE SOLIDS IN STORAGE (SEE FIG. 5)			
H. CORROSION AND EROSION (FACTOR .10 to .75)	.10	.10	
J. LEAKAGE - JOINTS AND PACKING (FACTOR .10 to 1.50)	.10	.10	
K. USE OF FIRED HEATERS (SEE FIG. 6)			
L. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15) (SEE TABLE IV)			
M. ROTATING EQUIPMENT PUMPS, COMPRESSORS	.50		
SPECIAL PROCESS HAZARD FACTOR (F_2) →		1.80	
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$) →		3.35	
FIRE AND EXPLOSION INDEX ($F_3 \times MF = F\&EI$) →			70.35

[illegible]

DO A 044745
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Exhibit B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a)	Emergency Power	.97	e)	Computer Control	.89 to .98
b)	Cooling	.95 to .98	f)	Inert Gas	.90 to .94
c)	Explosion Control	.75 to .96	g)	Operating Procedures	.86 to .99
d)	Emergency Shutdown	.94 to .98	h)	Reactive Chemical Review	.85 to .96

C_1 Total 0.792 *

2. Material Isolation (C_2)

a)	Remote Control Valves	.94	c)	Drainage	.85 to .95
b)	Dump/Blowdown	.94 to .96	d)	Interlock	.96

C_2 Total 0.767 *

3. Fire Protection (C_3)

a)	Leak Detection	.90 to .97	f)	Sprinkler Systems	.60 to .96	.95
b)	Structural Steel	.92 to .97	g)	Water Curtains	.95 to .97	
c)	Buried Tanks	.75 to .85	h)	Foam	.87 to .98	
d)	Water Supply	.90 to .95	j)	Hand Extinguishers	.92 to .97	.95
e)	Special Systems	.85	k)	Cable Protection	.90 to .96	

C_3 Total 0.857 *

$C_1 \times C_2 \times C_3$ = 0.521 See Figure 9 for conversion to Actual Credit Factor. (To Line D below).

RISK ANALYSIS SUMMARY

A-1.	F & EI	70.35	
A-2.	Radius of Exposure	59 ft.	
A-3.	Value of Area of Exposure		\$MM (.82)(11 M) = \$9.02 M
B.	Damage Factor	.62	
C.	Base MPPD (A-3 X B)		\$MM \$5.59 M
D.	Credit Factor, Actual	.66	
E.	Actual MPPD (C x D)		\$MM \$3.69 M
F.	Days Outage (MPDO)		50 days.

$\left(\frac{50}{30}\right)(\$188{,}640)(.7) = BI$

BI = \$220,000

*Product of all factors used.

BACK OF FORM C-22380 R-10-80(471-036)

DO A 044746
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FIRE AND EXPLOSION INDEX

Exhibit "A"

	Plaq-emine	3/18/72
PLANT: Glycol #1	UNIT: 70 Reactor Area Area 4	CHARGE:

MATERIALS AND PROCESS

MATERIALS: Propylene, H_2O, Cl_2, PDC, PCH, Cell Effluent

CATALYSTS: None SOLVENTS: None

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I APPENDIX A) →			21
1. GENERAL PROCESS HAZARDS (SEE TABLE II)			
BASE FACTOR →	1.00	1.00	
A EXOTHERMIC REACTIONS (FACTOR .30 to 1.25)		1.30	
B ENDOTHERMIC REACTIONS (FACTOR .20 to .40)			
C MATERIAL HANDLING & TRANSFER (FACTOR .25 to .85)			
D ENCLOSED PROCESS UNITS (FACTOR .30 to .90)			
E ACCESS	.35		
F DRAINAGE (FACTOR .25 to .50)			
GENERAL PROCESS HAZARD FACTOR (F_1) →		1.30	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR →	1.00	1.00	
A PROCESS TEMPERATURE (USE ONLY ONE)			
1 ABOVE FLASH POINT	.30		
2 ABOVE BOILING POINT	.60	0.6	
3 ABOVE AUTOIGNITION	.75		
B LOW PRESSURE (SUB ATMOSPHERIC)	.50		
C OPERATION IN OR NEAR FLAMMABLE RANGE			
1 TANK FARM STORAGE FLAMMABLE LIQUIDS	.50		
2 PROCESS UPSET OR PURGE FAILURE	.30		
3 ALWAYS IN FLAMMABLE RANGE	.80		
D DUST EXPLOSION (FACTOR .25 to 2.00)(SEE TABLE III)			
E PRESSURE (SEE FIGURE 2)		0.2	
F LOW TEMPERATURE (FACTOR .20 to .50)			
G QUANTITY OF FLAMMABLE MATERIAL			
1 LIQUIDS OR GASES IN PROCESS (SEE FIG 3)		.15	
2 LIQUIDS OR GASES IN STORAGE (SEE FIG 4)			
3 COMBUSTIBLE SOLIDS IN STORAGE (SEE FIG 5)			
H CORROSION AND EROSION (FACTOR .10 to .75)		.1	
J LEAKAGE - JOINTS AND PACKING (FACTOR .10 to 1.50)		.3	
K USE OF FIRED HEATERS (SEE FIG 6)			
L HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15)(SEE TABLE IV)			
M ROTATING EQUIPMENT, PUMPS, COMPRESSORS	.50		
SPECIAL PROCESS HAZARD FACTOR (F_2) →		2.35	
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$) →		3.65	
FIRE AND EXPLOSION INDEX ($F_3 \times MF = F \& EI$) →			76.65

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FORM C-22300 PRINTED 8-10-68 (471-036)

Exhibit B

.OSS CONTROL CREDIT FACTOR

1. Process Control (C_1)

a) Emergency Power	.97		e) Computer Control	.89 to .98	.93
b) Cooling	.95 to .98		f) Inert Gas	.90 to .94	
c) Explosion Control	.75 to .96	.75	g) Operating Procedures	.86 to .99	
d) Emergency Shutdown	.94 to .98		h) Reactive Chemical Review	.85 to .96	

C_1 Total 0.500 *

2. Material Isolation (C_2)

a) Remote Control Valves	.94	c) Drainage	.85 to .95	.90
b) Dump/Blowdown	.94 to .96	d) Interlock	.96	

C_2 Total 0.795 *

3. Fire Protection (C_3)

a) Leak Detection	.90 to .97	.95	f) Sprinkler Systems	.60 to .96	
b) Structural Steel	.92 to .97	.95	g) Water Curtains	.95 to .97	
c) Buried Tanks	.75 to .85		h) Foam	.87 to .98	
d) Water Supply	.90 to .95		j) Hand Extinguishers	.92 to .97	.95
e) Special Systems	.85		k) Cable Protection	.90 to .96	

C_3 Total 0.772 *

$C_1 \times C_2 \times C_3 =$ 0.307 See Figure 9 for conversion to Actual Credit Factor. (To Line D below).

RISK ANALYSIS SUMMARY

A-1. F & EI	76.65		
A-2. Radius of Exposure	64 ft.		
A-3. Value of Area of Exposure		SMM	\$4.0M
B. Damage Factor	0.63		
C. Base MPPD (A-3 X B)		SMM	\$2.52M
D. Credit Factor, Actual	0.46		
E. Actual MPPD (C x D)		SMM	\$1.159M
F. Days Outage (MPDO)			22 days.

$BI = \frac{22}{30} \times 115{,}000 \times .70 =$
\$59,033

*Product of all factors used.

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BACK OF FORM C-22380 R-10-80(471-036)

FIRE AND EXPLOSION DEX DOW

Exhibit "A"

LOCATION	DATE
Plaquemine	2/8/82

PLANT	UNIT	CHARGE
Glycol #1	7/ Reactor Area Area 5	

MATERIALS AND PROCESS

MATERIALS: Propylene, H_2O, Cl_2, PDC, PCH, Cell Effluent

CATALYSTS: None

SOLVENTS: None

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I APPENDIX A) →			21
1. GENERAL PROCESS HAZARDS (SEE TABLE II)			
BASE FACTOR →	1.00	1.00	
A EXOTHERMIC REACTIONS (FACTOR .30 to 1.25)		.30	
B ENDOTHERMIC REACTIONS (FACTOR .20 to .40)			
C. MATERIAL HANDLING & TRANSFER (FACTOR .25 to .85)			
D ENCLOSED PROCESS UNITS (FACTOR .30 to .90)			
E ACCESS	.35		
F DRAINAGE (FACTOR .25 to .50)			
GENERAL PROCESS HAZARD FACTOR (F_1) →		1.30	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR →	1.00	1.00	
A PROCESS TEMPERATURE (USE ONLY ONE)			
1 ABOVE FLASH POINT	.30		
2. ABOVE BOILING POINT	.60	0.6	
3 ABOVE AUTOIGNITION	.75		
B LOW PRESSURE (SUB ATMOSPHERIC)	.50		
C OPERATION IN OR NEAR FLAMMABLE RANGE			
1 TANK FARM STORAGE FLAMMABLE LIQUIDS	.50		
2 PROCESS UPSET OR PURGE FAILURE	.30		
3. ALWAYS IN FLAMMABLE RANGE	.80		
D DUST EXPLOSION (FACTOR .25 to 2.00)(SEE TABLE III)			
E PRESSURE (SEE FIGURE 2)		0.2	
F. LOW TEMPERATURE (FACTOR .20 to .50)			
G QUANTITY OF FLAMMABLE MATERIAL			
1 LIQUIDS OR GASES IN PROCESS (SEE FIG. 3)		.15	
2 LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)			
3 COMBUSTIBLE SOLIDS IN STORAGE (SEE FIG. 5)			
H CORROSION AND EROSION (FACTOR .10 to .75)		.1	
J LEAKAGE - JOINTS AND PACKING (FACTOR .10 to 1.50)		.3	
K USE OF FIRED HEATERS (SEE FIG. 6)			
L. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15)(SEE TABLE IV)			
M ROTATING EQUIPMENT, PUMPS, COMPRESSORS	.50		
SPECIAL PROCESS HAZARD FACTOR (F_2) →		2.35	
UNIT HAZARD FACTOR ($F_1 \times F_2$ F_3) →		3.65	
FIRE AND EXPLOSION INDEX ($F_3 \times MF$) F & EI) →			76.65

FORM C-22380 PRINTED 8-10-80 (471-036)

DO A 044749

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Exhibit B

LOSS CONTROL CREDIT FACTOR

1. Process Control (C_1)

a) Emergency Power	.97		e) Computer Control	.89 to .98	.93
b) Cooling	.95 to .98		f) Inert Gas	.90 to .94	
c) Explosion Control	.75 to .96	.75	g) Operating Procedures	.86 to .99	
d) Emergency Shutdown	.94 to .98		h) Reactive Chemical Review	.85 to .96	

C_1 Total 0.500 *

2. Material Isolation (C_2)

a) Remote Control Valves	.94	c) Drainage	.85 to .95	.40
b) Dump/Blowdown	.94 to .96	d) Interlock	.96	

C_2 Total 0.795 *

3. Fire Protection (C_3)

a) Leak Detection	.90 to .97	.95	f) Sprinkler Systems	.60 to .96	
b) Structural Steel	.92 to .97	.95	g) Water Curtains	.95 to .97	
c) Buried Tanks	.75 to .85		h) Foam	.87 to .98	
d) Water Supply	.90 to .95		j) Hand Extinguishers	.92 to .97	.95
e) Special Systems	.85		k) Cable Protection	.90 to .96	

C_3 Total 0.772 *

$C_1 \times C_2 \times C_3 =$ 0.307 See Figure 9 for conversion to Actual Credit Factor. (To Line D below).

RISK ANALYSIS SUMMARY

A-1. F & EI	76.65		
A-2. Radius of Exposure	64 ft.		
A-3. Value of Area of Exposure		$MM	#4.0M
B. Damage Factor	0.63		
C. Base MPPD (A-3 X B)		$MM	#2.52M
D. Credit Factor, Actual	0.46		
E. Actual MPPD (C x D)		$MM	#1.159M
F. Days Outage (MPDO)			22 days.

BI = $\frac{22}{30}$ x 115,000 x .70 =
#59,033

*Product of all factors used.

BACK OF FORM C-22380 R-10-80 (471-036)

DO A 044750
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FIRE AND EXPLOSION IDEX DOW

Exhibit "A"

LOCATION Plaquemine, La.

DATE 2/8/8_

PLANT Glycol I

UNIT Area 8 T-102C

CHARGE

MATERIALS AND PROCESS

MATERIALS Propylene Oxide - PDC - DCIPE

CATALYSTS None

SOLVENTS None

MATERIAL FACTOR (SEE TABLE I APPENDIX A)			21
1. GENERAL PROCESS HAZARDS (SEE TABLE II)	PENALTY	PENALTY USED	
BASE FACTOR	1.00	1.00	
A EXOTHERMIC REACTIONS (FACTOR .30 to 1.25)	0.3	0.3	
B ENDOTHERMIC REACTIONS (FACTOR .20 to .40)			
C MATERIAL HANDLING & TRANSFER (FACTOR .25 to .85)			
D ENCLOSED PROCESS UNITS (FACTOR .30 to .90)			
E ACCESS	.35		
F DRAINAGE (FACTOR .25 to .50)		.25	
GENERAL PROCESS HAZARD FACTOR (F_1)		1.55	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR	1.00	1.00	
A PROCESS TEMPERATURE (USE ONLY ONE)			
1. ABOVE FLASH POINT	.30		
2 ABOVE BOILING POINT	.60	.60	
3 ABOVE AUTOIGNITION	.75		
B LOW PRESSURE (SUB-ATOMOSPHERIC)	.50		
C OPERATION IN OR NEAR FLAMMABLE RANGE			
1 TANK FARM STORAGE FLAMMABLE LIQUIDS	.50		
2. PROCESS UPSET OR PURGE FAILURE	.30	.30	
3. ALWAYS IN FLAMMABLE RANGE	.80		
D DUST EXPLOSION (FACTOR .25 to 2.00)(SEE TABLE III)			
E PRESSURE (SEE FIGURE 2)		.25	
F. LOW TEMPERATURE (FACTOR .20 to .50)			
G QUANTITY OF FLAMMABLE MATERIAL			
1 LIQUIDS OR GASES IN PROCESS (SEE FIG. 3)		.60	
2 LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)			
3. COMBUSTIBLE SOLIDS IN STORAGE (SEE FIG. 5)			
H CORROSION AND EROSION (FACTOR .10 to .75)		.10	
J LEAKAGE - JOINTS AND PACKING (FACTOR .10 to 1.50)		.10	
K. USE OF FIRED HEATERS (SEE FIG. 6)		.10	
L. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15)(SEE TABLE IV)			
M. ROTATING EQUIPMENT, PUMPS, COMPRESSORS	.50		
SPECIAL PROCESS HAZARD FACTOR (F_2)		3.05	
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$)		4.73	
FIRE AND EXPLOSION INDEX ($F_3 \times MF = F \& EI$)			99.27

FORM C-22380 PRINTED 8-10-80 (471-036)

DO A 044751
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Exhibit B

LOSS CONTROL CREDIT FACTOR

1. Process Control (C_1)

a)	Emergency Power	.97	e)	Computer Control	.89 to .98	.93
b)	Cooling	.95 to .98	f)	Inert Gas	.90 to .94	.92
c)	Explosion Control	.75 to 96	g)	Operating Procedures	.86 to .99	
d)	Emergency Shutdown	.94 to .98	h)	Reactive Chemical Review	.85 to .96	

C_1 Total .547 *

2. Material Isolation (C_2)

a)	Remote Control Valves	.94	c)	Drainage	.85 to .95
b)	Dump/Blowdown	.94 to .96	d)	Interlock	.96

C_2 Total .767 *

3. Fire Protection (C_3)

a)	Leak Detection	.90 to .97	f)	Sprinkler Systems	.60 to .96	.95
b)	Structural Steel	.92 to .97	g)	Water Curtains	.95 to .97	
c)	Buried Tanks	.75 to .85	h)	Foam	.87 to .98	
d)	Water Supply	.90 to .95	j)	Hand Extinguishers	.92 to .97	.95
e)	Special Systems	.85	k)	Cable Protection	.90 to .96	

C_3 Total .807 *

$C_1 \times C_2 \times C_3 =$ 0.339 See Figure 9 for conversion to Actual Credit Factor. (To Line D below).

RISK ANALYSIS SUMMARY

A-1.	F & EI	99.27	
A-2.	Radius of Exposure	86 ft.	
A-3.	Value of Area of Exposure		$MM \$3.0 M
B.	Damage Factor	0.72	
C.	Base MPPD (A-3 X B)		$MM \$2.16 M
D.	Credit Factor, Actual	0.48	
E.	Actual MPPD (C x D)		$MM \$1.04 M
F.	Days Outage (MPDO)		23 days.

BI = $177,099

*Product of all factors used.

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BACK OF FORM C-22389 R-10-80(471-036)

FIRE AND EXPLOSION ' DEX

Exhibit "A"

DOW

LOCATION: Plaquemine, La.

DATE: 2/8/8[illegible]

PLANT: Glycol I

UNIT: Arco 9 T-102B

CHARGE:

MATERIALS AND PROCESS

MATERIALS: Propylene Oxide - PDC - DCIPE

CATALYSTS:

SOLVENTS: None

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I APPENDIX A) →			21
1. GENERAL PROCESS HAZARDS (SEE TABLE II)			
BASE FACTOR →	1 00	1 00	
A EXOTHERMIC REACTIONS (FACTOR .30 to 1.25)	0.3	0.3	
B ENDOTHERMIC REACTIONS (FACTOR .20 to .40)			
C. MATERIAL HANDLING & TRANSFER (FACTOR .25 to .85)			
D ENCLOSED PROCESS UNITS (FACTOR .30 to .90)			
E ACCESS	.35		
F DRAINAGE (FACTOR .25 to .50)		0.25	
GENERAL PROCESS HAZARD FACTOR (F_1) →		1.55	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR →	1 00	1 00	
A PROCESS TEMPERATURE (USE ONLY ONE)			
1. ABOVE FLASH POINT	.30		
2 ABOVE BOILING POINT	.60	.60	
3 ABOVE AUTOIGNITION	.75		
B. LOW PRESSURE (SUB ATOMOSPHERIC)	.50		
C OPERATION IN OR NEAR FLAMMABLE RANGE			
1 TANK FARM STORAGE FLAMMABLE LIQUIDS	50		
2. PROCESS UPSET OR PURGE FAILURE	.30	.30	
3. ALWAYS IN FLAMMABLE RANGE	.80		
D DUST EXPLOSION (FACTOR .25 to 2.00)(SEE TABLE III)			
E PRESSURE (SEE FIGURE 2)		.25	
F. LOW TEMPERATURE (FACTOR .20 to .50)			
G QUANTITY OF FLAMMABLE MATERIAL			
1 LIQUIDS OR GASES IN PROCESS (SEE FIG. 3)		1.10	
2 LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)			
3 COMBUSTIBLE SOLIDS IN STORAGE (SEE FIG 5)			
H CORROSION AND EROSION (FACTOR .10 to .75)		.10	
J LEAKAGE - JOINTS AND PACKING (FACTOR .10 to 1.50)		.10	
K. USE OF FIRED HEATERS (SEE FIG. 6)		.10	
L. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15)(SEE TABLE IV)			
M. ROTATING EQUIPMENT, PUMPS, COMPRESSORS	.50		
SPECIAL PROCESS HAZARD FACTOR (F_2) →		3.55	
UNIT HAZARD FACTOR ($F_1 \times F_2$ F_3) →		5.10	
FIRE AND EXPLOSION INDEX ($F_3 \times MF$) F & EI) →			107.1

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FORM C-22380 PRINTED 8-18-80 (471-036)

3/7-[illegible]

Exhibit B

LOSS CONTROL CREDIT FACTOR

1. Process Control (C_1)

a) Emergency Power	.97		e) Computer Control	.89 to .98	.93
b) Cooling	.95 to .98		f) Inert Gas	.90 to .94	.92
c) Explosion Control	.75 to .96		g) Operating Procedures	.86 to .99	
d) Emergency Shutdown	.94 to .98		h) Reactive Chemical Review	.85 to .96	

C_1 Total 0.547 *

2. Material Isolation (C_2)

a) Remote Control Valves	.94	c) Drainage	.85 to .95
b) Dump/Blowdown	.94 to .96	d) Interlock	.96

C_2 Total 0.767 *

3. Fire Protection (C_3)

a) Leak Detection	.90 to .97	f) Sprinkler Systems	.60 to .96	.95
b) Structural Steel	.92 to .97	g) Water Curtains	.95 to .97	
c) Buried Tanks	.75 to .85	h) Foam	.87 to .98	
d) Water Supply	.90 to .95	j) Hand Extinguishers	.92 to .97	.95
e) Special Systems	.85	k) Cable Protection	.90 to .96	

C_3 Total 0.807 *

$C_1 \times C_2 \times C_3 =$ 0.339 See Figure 9 for conversion to Actual Credit Factor. (To Line D below).

RISK ANALYSIS SUMMARY

A-1. F & EI	107.1		
A-2. Radius of Exposure	90 ft.		
A-3. Value of Area of Exposure		$MM	6.0 m
B. Damage Factor	0.74		
C. Base MPPD (A-3 X B)		$MM	4.44 m
D. Credit Factor, Actual	0.48		
E. Actual MPPD (C x D)		$MM	2.13 m
F. Days Outage (MPDO)			33 days.

BI = $254, 100

*Product of all factors used.

DO A 044754
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BACK OF FORM C-22300 R-10-00(471-036)

FIRE AND EXPLOSION I DEX
Exhibit "A"

LOCATION	DATE
Plaquemine	2/8/72

PLANT	UNIT	CHARGE
Glycol I	Area 10, T-300	

MATERIALS AND PROCESS

MATERIALS: Propylene Oxide - PDC - DCIPE

CATALYSTS: None

SOLVENTS: None

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I APPENDIX A) →			21
1. GENERAL PROCESS HAZARDS (SEE TABLE II)			
BASE FACTOR →	1.00	1.00	
A. EXOTHERMIC REACTIONS (FACTOR .30 to 1.25)		0.3	
B. ENDOTHERMIC REACTIONS (FACTOR .20 to .40)			
C. MATERIAL HANDLING & TRANSFER (FACTOR .25 to .85)			
D. ENCLOSED PROCESS UNITS (FACTOR .30 to .90)			
E. ACCESS	.35		
F. DRAINAGE (FACTOR .25 to .50)		.25	
GENERAL PROCESS HAZARD FACTOR (F_1) →		1.55	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR →	1.00	1.00	
A. PROCESS TEMPERATURE (USE ONLY ONE)			
1. ABOVE FLASH POINT	.30		
2. ABOVE BOILING POINT	.60	.6	
3. ABOVE AUTOIGNITION	.75		
B. LOW PRESSURE (SUB ATOMOSPHERIC)	.50		
C. OPERATION IN OR NEAR FLAMMABLE RANGE			
1. TANK FARM STORAGE FLAMMABLE LIQUIDS	.50		
2. PROCESS UPSET OR PURGE FAILURE	.30	.30	
3. ALWAYS IN FLAMMABLE RANGE	.80		
D. DUST EXPLOSION (FACTOR .25 to 2.00)(SEE TABLE III)			
E. PRESSURE (SEE FIGURE 2)		.25	
F. LOW TEMPERATURE (FACTOR .20 to .50)			
G. QUANTITY OF FLAMMABLE MATERIAL			
1. LIQUIDS OR GASES IN PROCESS (SEE FIG. 3)		1.60	
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)			
3. COMBUSTIBLE SOLIDS IN STORAGE (SEE FIG. 5)			
H. CORROSION AND EROSION (FACTOR .10 to .75)		.10	
J. LEAKAGE - JOINTS AND PACKING (FACTOR .10 to 1.50)		.10	
K. USE OF FIRED HEATERS (SEE FIG. 6)		.10	
L. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15)(SEE TABLE IV)			
M. ROTATING EQUIPMENT, PUMPS, COMPRESSORS	.50		
SPECIAL PROCESS HAZARD FACTOR (F_2) →		4.05	
UNIT HAZARD FACTOR ($F_1 \times F_2 \times F_3$) →		5.60	
FIRE AND EXPLOSION INDEX ($F_3 \times MF$) (F & EI) →			117.6

FORM C-22380 PRINTED 8-10-60 (471-036)

DO A 044755
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Exhibit B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a)	Emergency Power	.97	e)	Computer Control	.89 to .98 .93
b)	Cooling	.95 to .98	f)	Inert Gas	.90 to .94 .92
c)	Explosion Control	.75 to .98	g)	Operating Procedures	.86 to .99
d)	Emergency Shutdown	.94 to .98	h)	Reactive Chemical Review	.85 to .96

C_1 Total 0.547 *

2. Material Isolation (C_2)

a)	Remote Control Valves	.94	c)	Drainage	.85 to .95
b)	Dump/Blowdown	.94 to .96	d)	Interlock	.96

C_2 Total 0.767 *

3. Fire Protection (C_3)

a)	Leak Detection	.90 to .97	f)	Sprinkler Systems	.60 to .96 .95
b)	Structural Steel	.92 to .97	g)	Water Curtains	.95 to .97
c)	Buried Tanks	.75 to .85	h)	Foam	.87 to .98
d)	Water Supply	.90 to .95	j)	Hand Extinguishers	.92 to .97 .95
e)	Special Systems	.85	k)	Cable Protection	.90 to .96

C_3 Total 0.807 *

$C_1 \times C_2 \times C_3$ = 0.339 See Figure 9 for conversion to Actual Credit Factor. (To Line D below).

RISK ANALYSIS SUMMARY

A-1.	F & EI	117.6	
A-2.	Radius of Exposure	97 ft.	
A-3.	Value of Area of Exposure		$MM $5.5 M
B.	Damage Factor	0.79	
C.	Base MPPD (A-3 X B)		$MM $4.35 M
D.	Credit Factor, Actual	0.48	
E.	Actual MPPD (C x D)		$MM $2.09
F.	Days Outage (MPDO)		33 days.

BI: $254,100

*Product of all factors used.

DO A 044756
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BACK OF FORM C-22300 R-10-80(471-036)

HIGH HAZARD PACKAGE - GLYCOL #1

PHASE II

4. a. Propylene raw material available by pipeline from ~~LHC #1~~ and LHC #2, and salt dome storage.

Chlorine raw material available by pipeline from division chlorine plants.

Caustic raw material available by pipeline from division Caustic Plant.

b. Propylene oxide by customers by tank car.

Propylene glycol to customers by tank car, barge.

PDC to division Solvents Plant for internal use.

c.,d. Division emergency fire water supplied by seven diesel driven deep wells and one diesel driven pump in Water Treating Plant. Deep wells and water treating rated at 5000 G.P.M. @ 125 psi each.

e. Spare parts are available in Louisiana Division and other Dow locations.

RE-CAP WORK SHEET

PLANT: GLYCOL #1 PREPARED BY: GRANT - SAIA

DIVISION: LA. DIVISION DATE: 2/8/82

Process Units	Unit Hazard Factor F_3	Material Factor MF	F&EI (F_3XMF)	(A) Value Area of Exposure $MM	(B) Damage Factor from Figure 7	(C) Base MPPD $MM (AXB)	(D) Credit Factor $C_1xC_2xC_3$ from Figure 9	(E) Actual MPPD $MM (CXD)	(F) Days Outage MPDO from Figure 10
✓ 70 STORAGE P.O.	4.0	21	84	3.5 $\overline{M}$	.66	2.3 $\overline{M}$	.315	727 M	20
71 STORAGE P.O.	4.0	21	84	3.5 $\overline{M}$	.66	2.3 $\overline{M}$	.315	727 M	20
PROPYLENE GLYCOL	3.35	21	70.35	9.02 $\overline{M}$	.62	5.59 $\overline{M}$	.66	3.69 $\overline{M}$	50
70 REACTOR AREA 4	3.65	21	76.65	4.0 $\overline{M}$	.63	2.52 $\overline{M}$	.46	1.159 $\overline{M}$	22
71 REACTOR AREA 5	3.65	21	76.65	4.0 $\overline{M}$	.63	2.52 $\overline{M}$	.46	1 159 $\overline{M}$	22
AREA 8 - T-102C	4.73	21	99.27	3.0 $\overline{M}$	.72	2.16 $\overline{M}$	.48	1.04 $\overline{M}$	23
AREA 9 - T-102B	5.10	21	107.1	6.0 $\overline{M}$	.74	4.44 $\overline{M}$	.48	2.13 $\overline{M}$	33
AREA 10 - T-300	5.60	21	117.6	5.5 $\overline{M}$	.79	4.35 $\overline{M}$	.48	2.09 $\overline{M}$	33

DO A 044758
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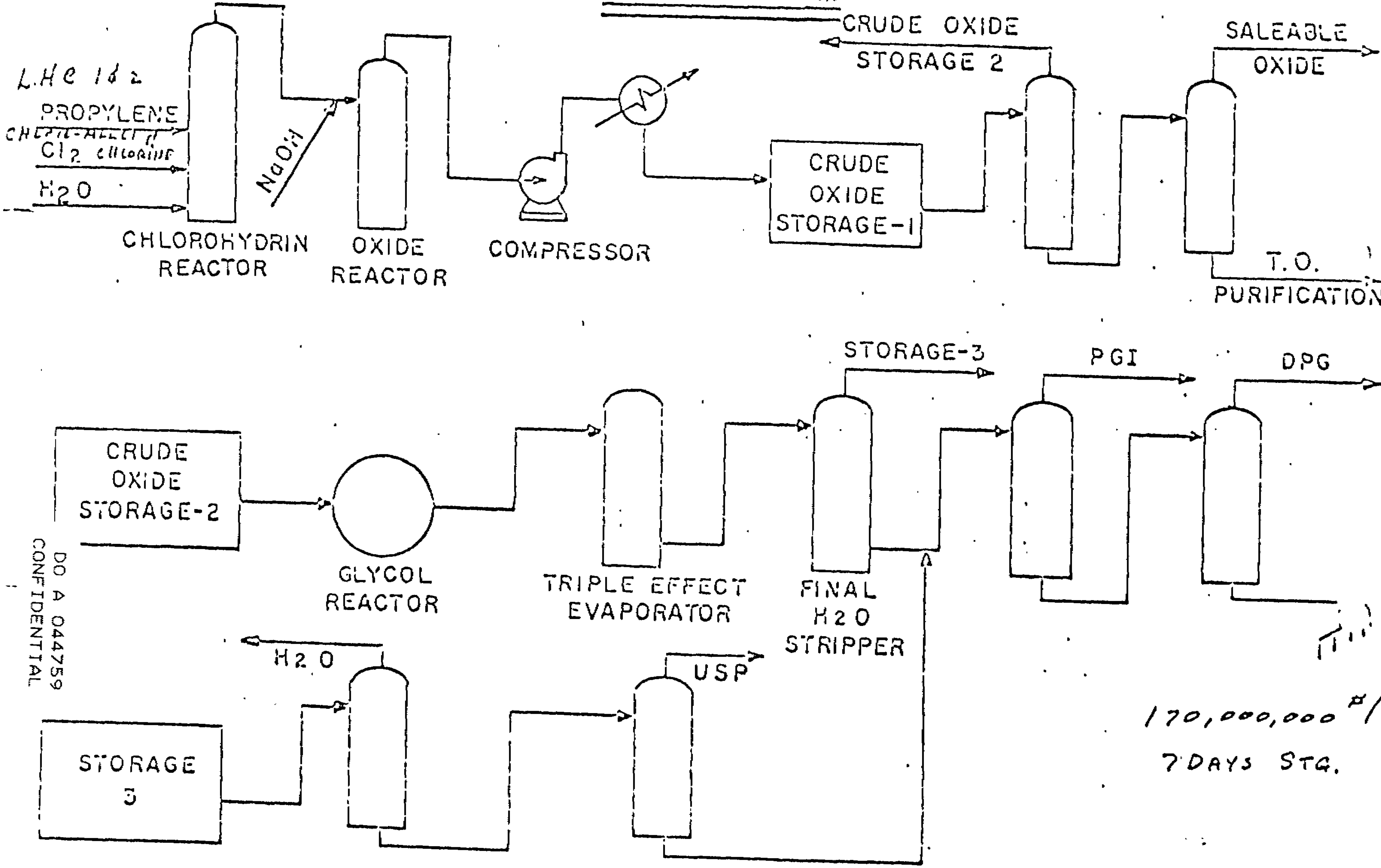
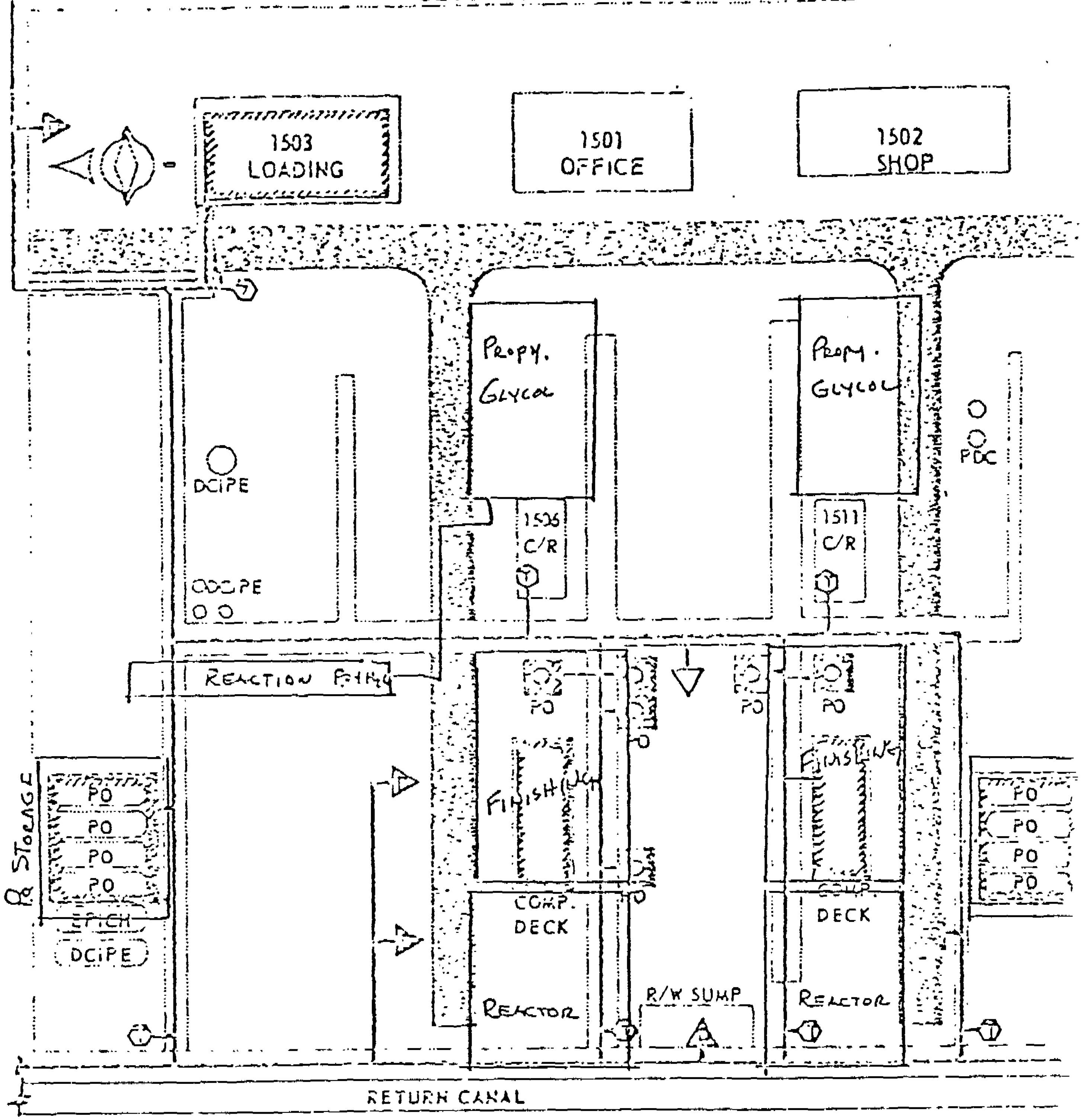
FORM C-50010 R-10-80 (471-037)

GLYCOL-I


PROPYLENE
Cl_2 CHLORINE
H_2O
NaOH
CHLOROHYDRIN REACTOR
OXIDE REACTOR
COMPRESSOR
CRUDE OXIDE STORAGE-1
CRUDE OXIDE STORAGE 2
SALEABLE OXIDE
T.O. PURIFICATION
CRUDE OXIDE STORAGE-2
GLYCOL REACTOR
TRIPLE EFFECT EVAPORATOR
FINAL H_2O STRIPPER
STORAGE-3
PGI
DPG
STORAGE 3
H_2O
USP
170,000,000 #/Y
7 DAYS STG.

GLYCOL I PLANT LAYOUT



LEGEND:

PO – PROPYLENE OXIDE COLUMN OR STORAGE

PDC – PROPYLENE DI-CHLORIDE STORAGE

DCIPE – ETHER STORAGE

EPICH – EPICHORОHYDRIN STORAGE

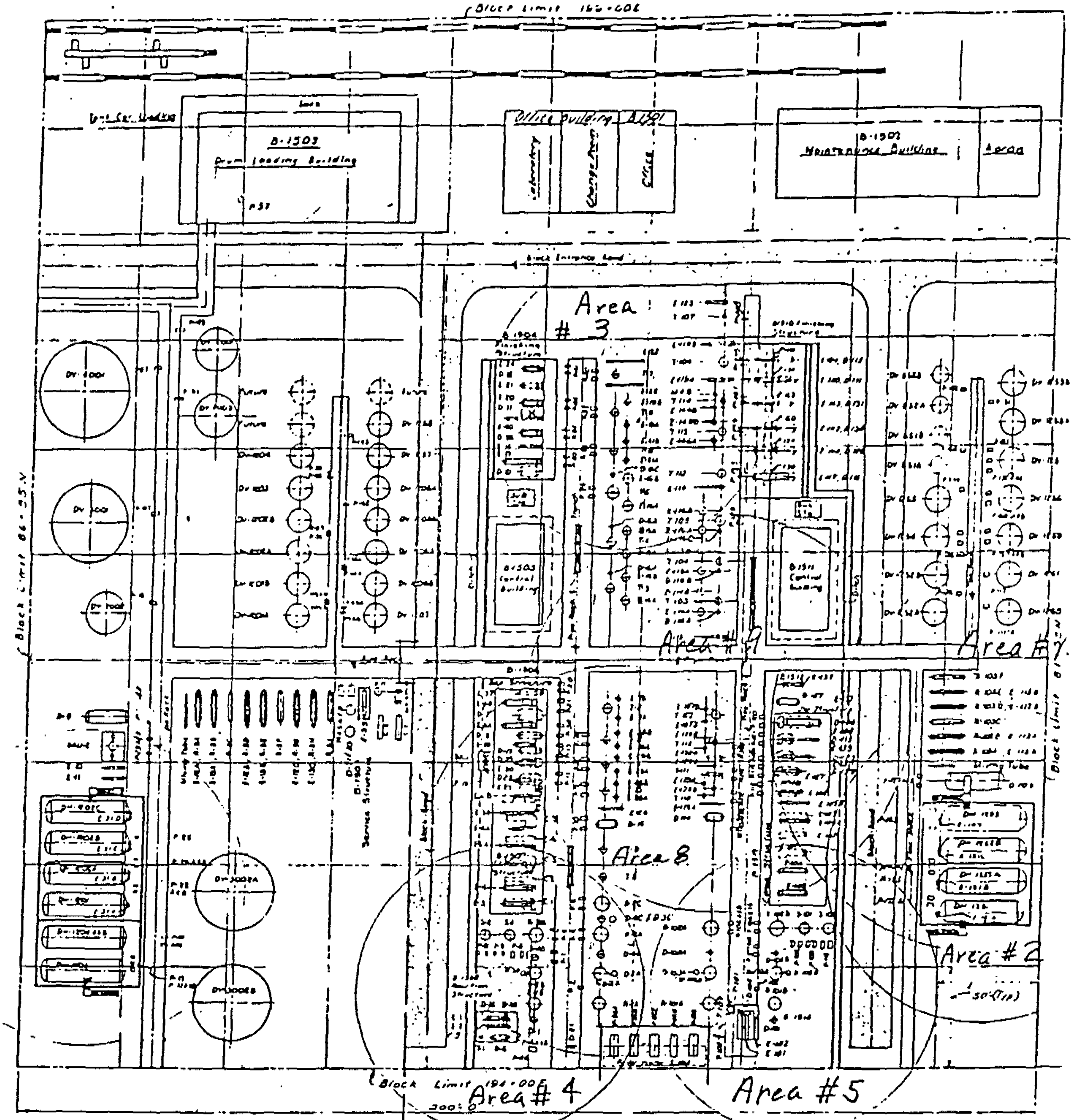
PROCESS WATER

SPRINKLER SYSTEM

SPRINKLER SYSTEM TRIP VALVE

DELUGE GUN

DO A 044760
CONFIDENTIAL



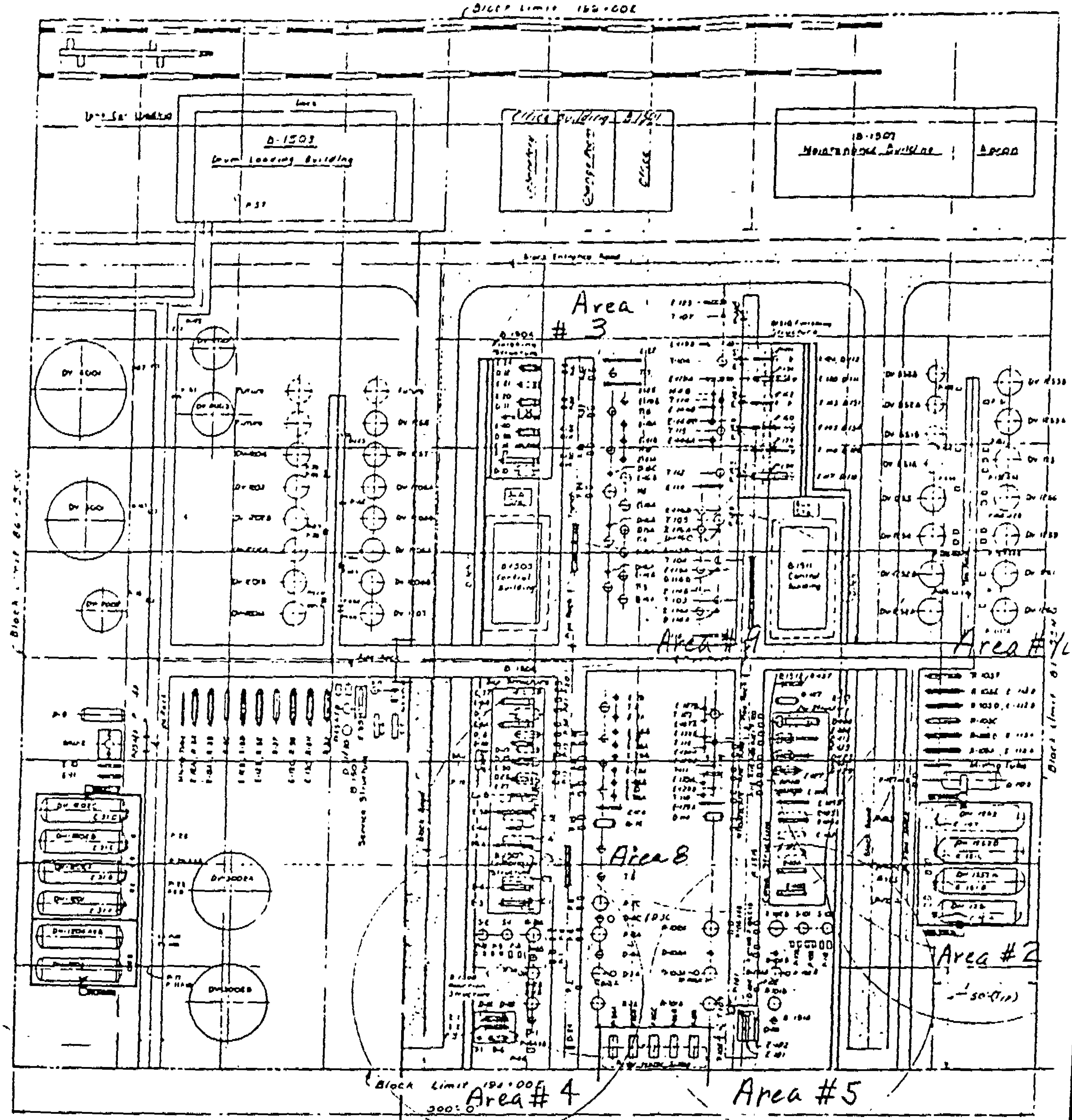
Subtract six (6) inches from all coordinates having a North designation and located in the area South & West of the heavy broken line (South Block Limit & River Water Sump excepted.)

DO A 044761
CONFIDENTIAL

ORIGINAL B/M NO

M9002-G50(
M9003-G5(

REVISION	BY	DATE	APP	MARK	CO. ORD	REVISION	BY	DATE	APP	MARK	CO. ORD



Subtract six (6) inches from all coordinates having a North designation and located in the area South & East of the heavy broken line (South Block Limit & River Water Supply included).

DO A 044762
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REVISION	BY	DATE	APP	MARK	CO-ORD	REVISION	BY	DATE	APP	MARK	CO-ORD

FIRE AND EXPLOSION INDEX

DOW

Exhibit "A"

RECEIVED

SAFETY DEPT.

PLANT	UNIT
Glycol #1	70 P.O. Storage-Load

MATERIALS AND PROCESS

MATERIALS: P.O.

CATALYSTS	SOLVENTS
None	None

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I APPENDIX A) →			21
1 GENERAL PROCESS HAZARDS (SEE TABLE II)			
BASE FACTOR →	1.00	1.00	
A EXOTHERMIC REACTIONS (FACTOR .30 to 1.25)			
B ENDOTHERMIC REACTIONS (FACTOR .20 to .40)			
C MATERIAL HANDLING & TRANSFER (FACTOR .25 to .85)			
D ENCLOSED PROCESS UNITS (FACTOR .30 to .90)			
E ACCESS	.35		
F DRAINAGE (FACTOR .25 to .50)			
GENERAL PROCESS HAZARD FACTOR (F_1) →		1.0	
2 SPECIAL PROCESS HAZARDS			
BASE FACTOR →	1.00	1.00	
A PROCESS TEMPERATURE (USE ONLY ONE)			
1 ABOVE FLASH POINT	.30	.30	
2 ABOVE BOILING POINT	.60		
3 ABOVE AUTOIGNITION	.75		
B LOW PRESSURE (SUB ATMOSPHERIC)	.50		
C OPERATION IN OR NEAR FLAMMABLE RANGE			
1 TANK FARM STORAGE FLAMMABLE LIQUIDS	.50		
2 PROCESS UPSET OR PURGE FAILURE	.30	.30	
3 ALWAYS IN FLAMMABLE RANGE	.80		
D DUST EXPLOSION (FACTOR .25 to 2.00) (SEE TABLE III)			
E PRESSURE (SEE FIGURE 2)		.25	
F LOW TEMPERATURE (FACTOR .20 to .30)			
G QUANTITY OF FLAMMABLE MATERIAL			
1 LIQUIDS OR GASES IN PROCESS (SEE FIG. 3)			
2 LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)		.95	
3 COMBUSTIBLE SOLIDS IN STORAGE (SEE FIG. 5)			
H CORROSION AND EROSION (FACTOR .10 to .75)		.10	
J LEAKAGE - JOINTS AND PACKING (FACTOR .10 to 1.50)		.10	
K USE OF FIRED HEATERS (SEE FIG. 6)			
L HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15) (SEE TABLE IV)			
M ROTATING EQUIPMENT PUMPS, COMPRESSORS	.50		
SPECIAL PROCESS HAZARD FACTOR (F_2) →		3.0	
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$) →		4.0	
FIRE AND EXPLOSION INDEX ($F_3 \times$ MF = F & EI) →			84

DO A 044763
CONFIDENTIAL

FORM C-22340 PRINTED 8-10-80 (471 016)

Exhibit B

)SS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a)	Emergency Power	97	e)	Computer Control	.89 to .98
b)	Cooling	.95 to .98	f)	Inert Gas	.90 to .94
c)	Explosion Control	.75 to .96	g)	Operating Procedures	.86 to .99
d)	Emergency Shutdown	.94 to .98	h)	Reactive Chemical Review	.85 to .96

C_1 Total 0.699 *

2. Material Isolation (C_2)

a)	Remote Control Valves	.94	c)	Drainage	.85 to .95 dike = 1.0
b)	Dump/Blowdown	.94 to .96	d)	Interlock	.96

C_2 Total 0.884 *

3. Fire Protection (C_3)

a)	Leak Detection	.90 to .97	f)	Sprinkler Systems	.60 to .96
b)	Structural Steel	.92 to .97	g)	Water Curtains	.95 to .97
c)	Buried Tanks	.75 to .85	h)	Foam	.87 to .98
d)	Water Supply	.90 to .95	j)	Hand Extinguishers	.92 to .97 .95
e)	Special Systems	.85	k)	Cable Protection	.90 to .96

C_3 Total 0.51 *

$C_1 \times C_2 \times C_3 =$ 0.315 See Figure 9 for conversion to Actual Credit Factor. (To Line D below).

RISK ANALYSIS SUMMARY

A-1.	F & EI	84	
A-2.	Radius of Exposure	72 ft.	
A-3.	Value of Area of Exposure		SMM \$3.5 m
B.	Damage Factor	0.66	
C.	Base MPPD (A-3 X B)		SMM \$2.3 m
D.	Credit Factor, Actual	0.315	
E.	Actual MPPD (C x D)		~~SMM~~ \$727,000
F.	Days Outage (MPDO)		20 days.

DO A 044764
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$BI = \frac{20}{30} \times 330{,}000 \times .7 =$
\$154,000

*Product of all factors used.

FIRE AND EXPLOSION DEX

Exhibit "A"

LOCATION	DATE

PLANT	UNIT	CHANGE
Glycol #1	71 P.O. Storage - Area 2	

MATERIALS AND PROCESS

MATERIALS: P.O.

CATALYSTS: None | SOLVENTS: None

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I APPENDIX A)			21
1. GENERAL PROCESS HAZARDS (SEE TABLE II)			
BASE FACTOR	1.00	1.00	
A. EXOTHERMIC REACTIONS (FACTOR .30 to 1.25)			
B. ENDOTHERMIC REACTIONS (FACTOR .20 to .40)			
C. MATERIAL HANDLING & TRANSFER (FACTOR .25 to .85)			
D. ENCLOSED PROCESS UNITS (FACTOR .30 to .90)			
E. ACCESS	.35		
F. DRAINAGE (FACTOR .25 to .50)			
GENERAL PROCESS HAZARD FACTOR (F_1)		1.0	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR	1.00	1.00	
A. PROCESS TEMPERATURE (USE ONLY ONE)			
1. ABOVE FLASH POINT	.30	.30	
2. ABOVE BOILING POINT	.60		
3. ABOVE AUTOIGNITION	.75		
B. LOW PRESSURE (SUB ATOMOSPHERIC)	.50		
C. OPERATION IN OR NEAR FLAMMABLE RANGE			
1. TANK FARM STORAGE FLAMMABLE LIQUIDS	.50		
2. PROCESS UPSET OR PURGE FAILURE	.30	.30	
3. ALWAYS IN FLAMMABLE RANGE	.80		
D. DUST EXPLOSION (FACTOR .25 to 2.00)(SEE TABLE III)			
E. PRESSURE (SEE FIGURE 2)		.25	
F. LOW TEMPERATURE (FACTOR .20 to .50)			
G. QUANTITY OF FLAMMABLE MATERIAL			
1. LIQUIDS OR GASES IN PROCESS (SEE FIG. 3)			
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)		.95	
3. COMBUSTIBLE SOLIDS IN STORAGE (SEE FIG. 5)			
H. CORROSION AND EROSION (FACTOR .10 to .75)		.10	
J. LEAKAGE - JOINTS AND PACKING (FACTOR .10 to 1.50)		.10	
K. USE OF FIRED HEATERS (SEE FIG. 6)			
L. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15)(SEE TABLE IV)			
M. ROTATING EQUIPMENT PUMPS COMPRESSORS	.50		
SPECIAL PROCESS HAZARD FACTOR (F_2)		3.0	
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$)		4.0	
FIRE AND EXPLOSION INDEX ($F_3 \times MF = F \& EI$)			84

DO A 044765
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FORM C-22390 PRINTED 8-10-80 (471-016)

Exhibit B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a)	Emergency Power	.97	e)	Computer Control	.89 to .98
b)	Cooling	.95 to .98	f)	Inert Gas	.90 to .94
c)	Explosion Control	.75 to .96	g)	Operating Procedures	.86 to .99
d)	Emergency Shutdown	.94 to .98	h)	Reactive Chemical Review	.85 to .98

C_1 Total 0.699*

2. Material Isolation (C_2)

a)	Remote Control Valves	.94	c)	Drainage	.85 to .95 dike = 1.0
b)	Dump/Blowdown	.94 to .96	d)	Interlock	.96

C_2 Total 0.884*

3. Fire Protection (C_3)

a)	Leak Detection	.90 to .97	f)	Sprinkler Systems	.60 to .96
b)	Structural Steel	.92 to .97	g)	Water Curtains	.95 to .97
c)	Buried Tanks	.75 to .85	h)	Foam	.87 to .98
d)	Water Supply	.90 to .95	j)	Hand Extinguishers	.92 to .97 .95
e)	Special Systems	.85	k)	Cable Protection	.90 to .96

C_3 Total 0.51*

$C_1 \times C_2 \times C_3 =$ 0.315 See Figure 9 for conversion to Actual Credit Factor. (To Line D below).

RISK ANALYSIS SUMMARY

A-1.	F & EI	84	
A-2.	Radius of Exposure	72 ft.	
A-3.	Value of Area of Exposure		SMM $3.5 M
B.	Damage Factor	0.66	
C.	Base MPPD (A-3 X B)		SMM $2.3 M
D.	Credit Factor, Actual	0.315	
E.	Actual MPPD (C x D)		~~SMM~~ $727,000
F.	Days Outage (MPDO)		20 days.

$$BI = \frac{20}{30} \times 330{,}000 \times .7 =$$

$154,000

*Product of all factors used.

DO A 044766
CONFIDENTIAL

BACK OF FORM C-22380 R-10-80 (471-036)

FIRE AND EXPLOSION ...DEX

Exhibit "A"

PLANT	UNIT	CHARGE
Glycol I	Propylene Glycol	

MATERIALS AND PROCESS

MATERIALS: Propylene Glycol – P. O. – H_2O – H_2 (Hydrogenation

CATALYSTS / SOLVENTS

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I APPENDIX A) P.O. →			21
1. GENERAL PROCESS HAZARDS (SEE TABLE II)			
BASE FACTOR →	1 00	1 00	
A EXOTHERMIC REACTIONS (FACTOR .30 to 1.25) Hydrogenation	.30	.30	
B ENDOTHERMIC REACTIONS (FACTOR .20 to .40)			
C MATERIAL HANDLING & TRANSFER (FACTOR .25 to .85)			
D ENCLOSED PROCESS UNITS (FACTOR .30 to .90)			
E ACCESS	.35		
F DRAINAGE (FACTOR .25 to .50)	.25	.25	
GENERAL PROCESS HAZARD FACTOR (F_1) →		1.55	
2 SPECIAL PROCESS HAZARDS			
BASE FACTOR →	1 00	1 00	
A PROCESS TEMPERATURE (USE ONLY ONE)			
1 ABOVE FLASH POINT	.30		
2 ABOVE BOILING POINT	.60	.60	
3 ABOVE AUTOIGNITION	.75		
B LOW PRESSURE (SUB ATOMOSPHERIC)	.50		
C OPERATION IN OR NEAR FLAMMABLE RANGE			
1 TANK FARM STORAGE FLAMMABLE LIQUIDS	.50		
2 PROCESS UPSET OR PURGE FAILURE	.30		
3 ALWAYS IN FLAMMABLE RANGE	.80		
D DUST EXPLOSION (FACTOR .25 to 2.00)(SEE TABLE III)			
E PRESSURE (SEE FIGURE 2)			
F LOW TEMPERATURE (FACTOR .20 to .50)			
G QUANTITY OF FLAMMABLE MATERIAL			
1 LIQUIDS OR GASES IN PROCESS (SEE FIG. 3)			
2 LIQUIDS OR GASES IN STORAGE (SEE FIG 4)			
3 COMBUSTIBLE SOLIDS IN STORAGE (SEE FIG 5)			
H CORROSION AND EROSION (FACTOR .10 to .75)	.10	.10	
J LEAKAGE JOINTS AND PACKING (FACTOR .10 to 1.50)	.10	.10	
K USE OF FIRED HEATERS (SEE FIG 6)			
L HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15)(SEE TABLE IV)			
M ROTATING EQUIPMENT PUMPS COMPRESSORS	.50		
SPECIAL PROCESS HAZARD FACTOR (F_2) →		1.80	
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$) →		3.35	
FIRE AND EXPLOSION INDEX ($F_3 \times MF$) →			70.35

DO A 044767
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Area - 3

Exhibit B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a)	Emergency Power	.97	e)	Computer Control	.89 to .98
b)	Cooling	.95 to .98	f)	Inert Gas	.90 to .94
c)	Explosion Control	.75 to .96	g)	Operating Procedures	.86 to .99
d)	Emergency Shutdown	.94 to .98	h)	Reactive Chemical Review	.85 to .96

C_1 Total 0.792 *

2. Material Isolation (C_2)

a)	Remote Control Valves	.94	c)	Drainage	.85 to .95
b)	Dump/Blowdown	.94 to .96	d)	Interlock	.96

C_2 Total 0.767 *

3. Fire Protection (C_3)

a)	Leak Detection	.90 to .97	f)	Sprinkler Systems	.60 to .96	.95
b)	Structural Steel	.92 to .97	g)	Water Curtains	.95 to .97	
c)	Buried Tanks	.75 to .85	h)	Foam	.87 to .98	
d)	Water Supply	.90 to .95	j)	Hand Extinguishers	.92 to .97	.95
e)	Special Systems	.85	k)	Cable Protection	.90 to .96	

C_3 Total 0.857 *

$C_1 \times C_2 \times C_3$ = 0.521 See Figure 9 for conversion to Actual Credit Factor. (To Line D below).

RISK ANALYSIS SUMMARY

A-1.	F & EI	70.35	
A-2.	Radius of Exposure	59 ft.	
A-3.	Value of Area of Exposure		SMM (.82)(11 M) = \$9.02 M
B.	Damage Factor	.62	
C.	Base MPPD (A-3 X B)		SMM \$5.59 M
D.	Credit Factor, Actual	.66	
E.	Actual MPPD (C x D)		SMM \$3.69 M
F.	Days Outage (MPDO)		50 days.

$\left(\frac{50}{30}\right)(\$188,640)(.7) = BI$

BI = \$220,000

*Product of all factors used.

DO A 044768
CONFIDENTIAL

BACK OF FORM C-2238D R-10-80 (471-036)

FIRE AND EXPLOSION INDEX

Exhibit "A"

LOCATION: Plaq. emine | 3/8/82

PLANT: Glycol #1 | UNIT: 70 Reactor Area Area 4 | CHANGE:

MATERIALS AND PROCESS

MATERIALS: Propylene, H_2O, Cl_2, PDC, PCH, Cell Effluent

CATALYSTS: None | SOLVENTS: None

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I APPENDIX A) →			21
1 GENERAL PROCESS HAZARDS (SEE TABLE II)	PENALTY	PENALTY USED	
BASE FACTOR →	1 00	1 00	
A EXOTHERMIC REACTIONS (FACTOR .30 to 1.25)		.30	
B ENDOTHERMIC REACTIONS (FACTOR .20 to .40)			
C MATERIAL HANDLING & TRANSFER (FACTOR .25 to .85)			
D ENCLOSED PROCESS UNITS (FACTOR .30 to .90)			
E ACCESS	.35		
F DRAINAGE (FACTOR .25 to .50)			
GENERAL PROCESS HAZARD FACTOR (F_1) →		1.30	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR →	1 00	1 00	
A PROCESS TEMPERATURE (USE ONLY ONE)			
1 ABOVE FLASH POINT	.30		
2 ABOVE BOILING POINT	.60	0.6	
3 ABOVE AUTOIGNITION	.75		
B LOW PRESSURE (SUB ATMOSPHERIC)	.50		
C OPERATION IN OR NEAR FLAMMABLE RANGE			
1 TANK FARM STORAGE FLAMMABLE LIQUIDS	.50		
2 PROCESS UPSET OR PURGE FAILURE	.30		
3 ALWAYS IN FLAMMABLE RANGE	.80		
D DUST EXPLOSION (FACTOR .25 to 2.00)(SEE TABLE III)			
E PRESSURE (SEE FIGURE 2)		0.2	
F LOW TEMPERATURE (FACTOR .20 to .50)			
G QUANTITY OF FLAMMABLE MATERIAL			
1 LIQUIDS OR GASES IN PROCESS (SEE FIG 3)		.15	
2 LIQUIDS OR GASES IN STORAGE (SEE FIG 4)			
3 COMBUSTIBLE SOLIDS IN STORAGE (SEE FIG 5)			
H CORROSION AND EROSION (FACTOR .10 to .75)		.1	
J LEAKAGE – JOINTS AND PACKING (FACTOR .10 to 1.50)		.3	
K USE OF FIRED HEATERS (SEE FIG 6)			
L HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15)(SEE TABLE IV)			
M ROTATING EQUIPMENT PUMPS COMPRESSORS	.50		
SPECIAL PROCESS HAZARD FACTOR (F_2) →		2.35	
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$) →		3.65	
FIRE AND EXPLOSION INDEX ($F_3 \times MF = F \& EI$) →			76.65

DO A 044769
CONFIDENTIAL

FORM C-22190 PRINTED 8-10-80 (421-016)

Exhibit B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a) Emergency Power	.97	e) Computer Control	.89 to .98 .93
b) Cooling	.95 to .98	f) Inert Gas	.90 to .94
c) Explosion Control	.75 to .96 .75	g) Operating Procedures	.86 to .99
d) Emergency Shutdown	.94 to .98	h) Reactive Chemical Review	.85 to .96

C_1 Total 0.500 *

2. Material Isolation (C_2)

a) Remote Control Valves	.94	c) Drainage	.85 to .95 .90
b) Dump/Blowdown	.94 to .96	d) Interlock	.96

C_2 Total 0.795 *

3. Fire Protection (C_3)

a) Leak Detection	.90 to .97 .95	f) Sprinkler Systems	.60 to .96
b) Structural Steel	.92 to .97 .95	g) Water Curtains	.95 to .97
c) Buried Tanks	.75 to .85	h) Foam	.87 to .98
d) Water Supply	.90 to .95	j) Hand Extinguishers	.92 to .97 .95
e) Special Systems	.85	k) Cable Protection	.90 to .96

C_3 Total 0.772 *

$C_1 \times C_2 \times C_3$ = 0.307 See Figure 9 for conversion to Actual Credit Factor. (To Line D below).

RISK ANALYSIS SUMMARY

A-1. F & EI	76.65		
A-2. Radius of Exposure	64 ft.		
A-3. Value of Area of Exposure		$MM	$4.0M
B. Damage Factor	0.63		
C. Base MPPD (A-3 X B)		$MM	$2.52M
D. Credit Factor, Actual	0.46		
E. Actual MPPD (C x D)		$MM	$1.159M
F. Days Outage (MPDO)			22 days.

$BI = \frac{22}{30} \times 115{,}000 \times .70 =$

$59,033

*Product of all factors used.

DO A 044770
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FIRE AND EXPLOSION DEX

Exhibit "A"

LOCATION	DATE
Plaquemine	2/8/82

PLANT	UNIT	CHARGE
Glycol #1	7/ Reactor Area Area 5	

MATERIALS AND PROCESS

MATERIALS: Propylene, H_2O, Cl_2, PDC, PCH, Cell Effluent

CATALYSTS	SOLVENTS
None	None

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I APPENDIX A)			21
1. GENERAL PROCESS HAZARDS (SEE TABLE II)	PENALTY	PENALTY USED	
BASE FACTOR	1.00	1.00	
A EXOTHERMIC REACTIONS (FACTOR .30 to 1.25)		.30	
B ENDOTHERMIC REACTIONS (FACTOR .20 to .40)			
C MATERIAL HANDLING & TRANSFER (FACTOR .25 to .85)			
D ENCLOSED PROCESS UNITS (FACTOR .30 to .90)			
E ACCESS	.35		
F DRAINAGE (FACTOR .25 to .50)			
GENERAL PROCESS HAZARD FACTOR (F_1)		1.30	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR	1.00	1.00	
A PROCESS TEMPERATURE (USE ONLY ONE)			
1 ABOVE FLASH POINT	.30		
2 ABOVE BOILING POINT	.60	0.6	
3 ABOVE AUTOIGNITION	.75		
B LOW PRESSURE (SUB ATOMOSPHERIC)	.50		
C OPERATION IN OR NEAR FLAMMABLE RANGE			
1 TANK FARM STORAGE FLAMMABLE LIQUIDS	.50		
2 PROCESS UPSET OR PURGE FAILURE	.30		
3 ALWAYS IN FLAMMABLE RANGE	.80		
D DUST EXPLOSION (FACTOR .25 to 2.00)(SEE TABLE III)			
E PRESSURE (SEE FIGURE 2)		0.2	
F. LOW TEMPERATURE (FACTOR .20 to .50)			
G QUANTITY OF FLAMMABLE MATERIAL			
1 LIQUIDS OR GASES IN PROCESS (SEE FIG. 3)		.15	
2 LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)			
3 COMBUSTIBLE SOLIDS IN STORAGE (SEE FIG. 5)			
H CORROSION AND EROSION (FACTOR .10 to .75)		.1	
J LEAKAGE - JOINTS AND PACKING (FACTOR .10 to 1.50)		.3	
K USE OF FIRED HEATERS (SEE FIG. 6)			
L. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15)(SEE TABLE IV)			
M ROTATING EQUIPMENT, PUMPS, COMPRESSORS	.50		
SPECIAL PROCESS HAZARD FACTOR (F_2)		2.35	
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$)		3.65	
FIRE AND EXPLOSION INDEX ($F_3 \times MF = F\&EI$)			76.65

FORM C 22380 PRINTED 8-10-80 (471-034)

DO A 044771
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Exhibit B

LOSS CONTROL CREDIT FACTOR.

1. Process Control (C_1)

a)	Emergency Power	.97	e)	Computer Control	.89 to .98 .93
b)	Cooling	.95 to .98	f)	Inert Gas	.90 to .94
c)	Explosion Control	.75 to .96 .85	g)	Operating Procedures	.86 to .99
d)	Emergency Shutdown	.94 to .98	h)	Reactive Chemical Review	.85 to .96

C_1 Total 0.500 *

2. Material Isolation (C_2)

a)	Remote Control Valves	.94	c)	Drainage	.85 to .95 .90
b)	Dump/Blowdown	.94 to .96	d)	Interlock	.96

C_2 Total 0.795 *

3. Fire Protection (C_3)

a)	Leak Detection	.90 to .97 .95	f)	Sprinkler Systems	.60 to .96
b)	Structural Steel	.92 to .97 .95	g)	Water Curtains	.95 to .97
c)	Buried Tanks	.75 to .85	h)	Foam	.87 to .98
d)	Water Supply	.90 to .95	j)	Hand Extinguishers	.92 to .97 .95
e)	Special Systems	.85	k)	Cable Protection	.90 to .96

C_3 Total 0.772 *

$C_1 \times C_2 \times C_3$ = 0.307 See Figure 9 for conversion to Actual Credit Factor. (To Line D below).

RISK ANALYSIS SUMMARY

A-1.	F & EI	76.65		
A-2.	Radius of Exposure	64 ft.		
A-3.	Value of Area of Exposure		$MM	#4.0M
B.	Damage Factor	0.63		
C.	Base MPPD (A-3 X B)		$MM	#2.52M
D.	Credit Factor, Actual	0.46		
E.	Actual MPPD (C x D)		$MM	#1.159M
F.	Days Outage (MPDO)			22 days.

BI = $\frac{22}{30}$ x 115,000 x .70 =
#59,033

*Product of all factors used.

BACK OF FORM C-22380 R-10-80(471-036)

DO A 044772
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FIRE AND EXPLOSION INDEX

Exhibit "A"

DOW

LOCATION: Plaquemine, La.

DATE: 2/8/8.

PLANT: Glycol I

UNIT: Area 8 T-102C

CHANGE:

MATERIALS AND PROCESS

MATERIALS: Propylene Oxide - PDC - DCIPE

CATALYSTS: None

SOLVENTS: None

MATERIAL FACTOR (SEE TABLE I APPENDIX A) → 21

1. GENERAL PROCESS HAZARDS (SEE TABLE II)	PENALTY	PENALTY USED
BASE FACTOR →	1.00	1.00
A. EXOTHERMIC REACTIONS (FACTOR .30 to 1.25)	0.3	0.3
B. ENDOTHERMIC REACTIONS (FACTOR .20 to .40)		
C. MATERIAL HANDLING & TRANSFER (FACTOR .25 to .85)		
D. ENCLOSED PROCESS UNITS (FACTOR .30 to .90)		
E. ACCESS	.35	
F. DRAINAGE (FACTOR .25 to .50)		.25
GENERAL PROCESS HAZARD FACTOR (F_1) →		1.55

2. SPECIAL PROCESS HAZARDS	PENALTY	PENALTY USED
BASE FACTOR →	1.00	1.00
A. PROCESS TEMPERATURE (USE ONLY ONE)		
1. ABOVE FLASH POINT	.30	
2. ABOVE BOILING POINT	.60	.60
3. ABOVE AUTOIGNITION	.75	
B. LOW PRESSURE (SUB ATOMOSPHERIC)	.50	
C. OPERATION IN OR NEAR FLAMMABLE RANGE		
1. TANK FARM STORAGE FLAMMABLE LIQUIDS	.50	
2. PROCESS UPSET OR PURGE FAILURE	.30	.30
3. ALWAYS IN FLAMMABLE RANGE	.80	
D. DUST EXPLOSION (FACTOR .25 to 2.00)(SEE TABLE III)		
E. PRESSURE (SEE FIGURE 2)		.25
F. LOW TEMPERATURE (FACTOR .20 to .50)		
G. QUANTITY OF FLAMMABLE MATERIAL		
1. LIQUIDS OR GASES IN PROCESS (SEE FIG. 3)		.60
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)		
3. COMBUSTIBLE SOLIDS IN STORAGE (SEE FIG. 5)		
H. CORROSION AND EROSION (FACTOR .10 to .75)		.10
J. LEAKAGE - JOINTS AND PACKING (FACTOR .10 to 1.50)		.10
K. USE OF FIRED HEATERS (SEE FIG. 6)		.10
L. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15)(SEE TABLE IV)		
M. ROTATING EQUIPMENT, PUMPS, COMPRESSORS	.50	
SPECIAL PROCESS HAZARD FACTOR (F_2) →		3.05
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$) →		4.73

FIRE AND EXPLOSION INDEX ($F_3 \times MF$) = F & EI → 99.27

DO A 044773
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FORM C-22380 PRINTED R-10-80 (471-034)

Exhibit B

LOSS CONTROL CREDIT FACTOR

1. Process Control (C_1)

a) Emergency Power	.97		e) Computer Control	.89 to .98	.93
b) Cooling	.95 to .98		f) Inert Gas	.90 to .94	.92
c) Explosion Control	.75 to .96		g) Operating Procedures	.86 to .99	
d) Emergency Shutdown	.94 to .98		h) Reactive Chemical Review	.85 to .96	

C_1 Total .547*

2. Material Isolation (C_2)

a) Remote Control Valves	.94	c) Drainage	.85 to .95
b) Dump/Blowdown	.94 to .96	d) Interlock	.96

C_2 Total .767*

3. Fire Protection (C_3)

a) Leak Detection	.90 to .97	f) Sprinkler Systems	.60 to .96	.95
b) Structural Steel	.92 to .97	g) Water Curtains	.95 to .97	
c) Buried Tanks	.75 to .85	h) Foam	.87 to .98	
d) Water Supply	.90 to .95	j) Hand Extinguishers	.92 to .97	.95
e) Special Systems	.85	k) Cable Protection	.90 to .96	

C_3 Total .807*

$C_1 \times C_2 \times C_3 =$ 0.339 See Figure 9 for conversion to Actual Credit Factor. (To Line D below).

RISK ANALYSIS SUMMARY

A-1. F & EI	99.27		
A-2. Radius of Exposure	86 ft.		
A-3. Value of Area of Exposure		$MM	$3.0M
B. Damage Factor	0.72		
C. Base MPPD (A-3 X B)		$MM	$2.16M
D. Credit Factor, Actual	0.48		
E. Actual MPPD (C x D)		$MM	$1.04M
F. Days Outage (MPDO)			23 days.

BI = $177,099

*Product of all factors used.

DO A 044774
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BACK OF FORM C-22380 R-10-80(471-036)

FIRE AND EXPLOSION ' DEX

Exhibit "A"

LOCATION: Plaquemine, La.

DATE: 2/8/82

PLANT: Glycol I

UNIT: Area 9 T-102B

CHANGE:

MATERIALS AND PROCESS

MATERIALS: Propylene Oxide - PDC - DCIPE

CATALYSTS:

SOLVENTS: None

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I APPENDIX A) →			21
1. GENERAL PROCESS HAZARDS (SEE TABLE II)			
BASE FACTOR →	1.00	1.00	
A EXOTHERMIC REACTIONS (FACTOR .30 to 1.25)	0.3	0.3	
B ENDOTHERMIC REACTIONS (FACTOR .20 to .40)			
C MATERIAL HANDLING & TRANSFER (FACTOR .25 to .85)			
D ENCLOSED PROCESS UNITS (FACTOR .30 to .90)			
E ACCESS	.35		
F DRAINAGE (FACTOR .25 to .50)		0.25	
GENERAL PROCESS HAZARD FACTOR (F_1) →		1.55	
2 SPECIAL PROCESS HAZARDS			
BASE FACTOR →	1.00	1.00	
A PROCESS TEMPERATURE (USE ONLY ONE)			
1 ABOVE FLASH POINT	.30		
2 ABOVE BOILING POINT	.60	.60	
3 ABOVE AUTOIGNITION	.75		
B LOW PRESSURE (SUB ATOMOSPHERIC)	.50		
C OPERATION IN OR NEAR FLAMMABLE RANGE			
1 TANK FARM STORAGE FLAMMABLE LIQUIDS	.50		
2 PROCESS UPSET OR PURGE FAILURE	.30	.30	
3 ALWAYS IN FLAMMABLE RANGE	.80		
D DUST EXPLOSION (FACTOR .25 to 2.00)(SEE TABLE III)			
E PRESSURE (SEE FIGURE 2)		.25	
F LOW TEMPERATURE (FACTOR .20 to .50)			
G QUANTITY OF FLAMMABLE MATERIAL			
1 LIQUIDS OR GASES IN PROCESS (SEE FIG 3)		1.10	
2 LIQUIDS OR GASES IN STORAGE (SEE FIG 4)			
3 COMBUSTIBLE SOLIDS IN STORAGE (SEE FIG 5)			
H CORROSION AND EROSION (FACTOR .10 to .75)		.10	
J LEAKAGE - JOINTS AND PACKING (FACTOR .10 to 1.50)		.10	
K. USE OF FIRED HEATERS (SEE FIG. 6)		.10	
L HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15)(SEE TABLE IV)			
M ROTATING EQUIPMENT, PUMPS, COMPRESSORS	.50		
SPECIAL PROCESS HAZARD FACTOR (F_2) →		3.55	
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$) →		5.10	
FIRE AND EXPLOSION INDEX ($F_3 \times MF = F\&EI$) →			107.1

FORM C-22380 PRINTED 9-10-80 (471-014)

DO A 044775

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Exhibit B

LOSS CONTROL CREDIT FACTOR

1. Process Control (C_1)

a)	Emergency Power	.97	e)	Computer Control	.89 to .98 .93
b)	Cooling	.95 to .98	f)	Inert Gas	.90 to .94 .92
c)	Explosion Control	.75 to .96	g)	Operating Procedures	.86 to .99
d)	Emergency Shutdown	.94 to .98	h)	Reactive Chemical Review	.85 to .96

C_1 Total 0.547 *

2. Material Isolation (C_2)

a)	Remote Control Valves	.94	c)	Drainage	.85 to .95
b)	Dump/Blowdown	.94 to .96	d)	Interlock	.96

C_2 Total 0.767 *

3. Fire Protection (C_3)

a)	Leak Detection	.90 to .97	f)	Sprinkler Systems	.60 to .96 .95
b)	Structural Steel	.92 to .97	g)	Water Curtains	.95 to .97
c)	Buried Tanks	.75 to .85	h)	Foam	.87 to .98
d)	Water Supply	.90 to .95	j)	Hand Extinguishers	.92 to .97 .95
e)	Special Systems	.85	k)	Cable Protection	.90 to .96

C_3 Total 0,807 *

$C_1 \times C_2 \times C_3 =$ 0.339 See Figure 9 for conversion to Actual Credit Factor. (To Line D below).

RISK ANALYSIS SUMMARY

A-1.	F & EI	107.1		
A-2.	Radius of Exposure	90 ft.		
A-3.	Value of Area of Exposure		$MM	6.0 M
B.	Damage Factor	0.74		
C.	Base MPPD (A-3 X B)		$MM	4.44 M
D.	Credit Factor, Actual	0.48		
E.	Actual MPPD (C x D)		$MM	2.13 M
F.	Days Outage (MPDO)			33 days.

BI = $254,100

*Product of all factors used.

DO A 044776
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BACK OF FORM C-22380 R-10-80(471-036)

FIRE AND EXPLOSION I DEX

Exhibit "A"

LOCATION	DATE
Plaquemine	2/8/92

PLANT	UNIT	CHARGE
Glycol I	Area 10, T-300	

MATERIALS AND PROCESS

MATERIALS	
Propylene Oxide - PDC - DCIPE	
CATALYSTS: None	SOLVENTS: None

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I APPENDIX A) →			21
1. GENERAL PROCESS HAZARDS (SEE TABLE II)	PENALTY	PENALTY USED	
BASE FACTOR →	1.00	1.00	
A. EXOTHERMIC REACTIONS (FACTOR .30 to 1.25)		0.3	
B. ENDOTHERMIC REACTIONS (FACTOR .20 to .40)			
C. MATERIAL HANDLING & TRANSFER (FACTOR .25 to .85)			
D. ENCLOSED PROCESS UNITS (FACTOR .30 to .90)			
E. ACCESS	.35		
F. DRAINAGE (FACTOR .25 to .50)		.25	
GENERAL PROCESS HAZARD FACTOR (F_1) →		1.55	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR →	1.00	1.00	
A. PROCESS TEMPERATURE (USE ONLY ONE)			
1. ABOVE FLASH POINT	.30		
2. ABOVE BOILING POINT	.60	.6	
3. ABOVE AUTOIGNITION	.75		
B. LOW PRESSURE (SUB ATOMOSPHERIC)	.50		
C. OPERATION IN OR NEAR FLAMMABLE RANGE			
1. TANK FARM STORAGE FLAMMABLE LIQUIDS	.50		
2. PROCESS UPSET OR PURGE FAILURE	.30	.30	
3. ALWAYS IN FLAMMABLE RANGE	.80		
D. DUST EXPLOSION (FACTOR .25 to 2.00)(SEE TABLE III)			
E. PRESSURE (SEE FIGURE 2)		.25	
F. LOW TEMPERATURE (FACTOR .20 to .50)			
G. QUANTITY OF FLAMMABLE MATERIAL			
1. LIQUIDS OR GASES IN PROCESS (SEE FIG. 3)		1.60	
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)			
3. COMBUSTIBLE SOLIDS IN STORAGE (SEE FIG. 5)			
H. CORROSION AND EROSION (FACTOR .10 to .75)		.10	
J. LEAKAGE - JOINTS AND PACKING (FACTOR .10 to 1.50)		.10	
K. USE OF FIRED HEATERS (SEE FIG. 6)		.10	
L. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15)(SEE TABLE IV)			
M. ROTATING EQUIPMENT, PUMPS, COMPRESSORS	.50		
SPECIAL PROCESS HAZARD FACTOR (F_2) →		4.05	
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$) →		5.60	
FIRE AND EXPLOSION INDEX ($F_3 \times MF$ = F & EI) →			117.6

DO A 044777
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FORM C-22380 PRINTED R-10-80 (471-016)

Exhibit B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a)	Emergency Power	.97	e)	Computer Control	.89 to .98 .93
b)	Cooling	.95 to .98	f)	Inert Gas	.90 to .94 .92
c)	Explosion Control	.75 to .96	g)	Operating Procedures	.86 to .99
d)	Emergency Shutdown	.94 to .98	h)	Reactive Chemical Review	.85 to .96

C_1 Total 0.547 •

2. Material Isolation (C_2)

a)	Remote Control Valves	.94	c)	Drainage	.85 to .95
b)	Dump/Blowdown	.94 to .96	d)	Interlock	.96

C_2 Total 0.767 •

3. Fire Protection (C_3)

a)	Leak Detection	.90 to .97	f)	Sprinkler Systems	.60 to .96 .95
b)	Structural Steel	.92 to .97	g)	Water Curtains	.95 to .97
c)	Buried Tanks	.75 to .85	h)	Foam	.87 to .98
d)	Water Supply	.90 to .95	j)	Hand Extinguishers	.92 to .97 .95
e)	Special Systems	.85	k)	Cable Protection	.90 to .96

C_3 Total 0.807 •

$C_1 \times C_2 \times C_3 =$ 0.339 See Figure 9 for conversion to Actual Credit Factor. (To Line D below).

RISK ANALYSIS SUMMARY

A-1.	F & EI	117.6	
A-2.	Radius of Exposure	97 ft.	
A-3.	Value of Area of Exposure		\$MM #5.5 M
B.	Damage Factor	0.79	
C.	Base MPPD (A-3 X B)		\$MM #4.35 M
D.	Credit Factor, Actual	0.48	
E.	Actual MPPD (C x D)		\$MM #2.09
F.	Days Outage (MPDO)		33 days.

BI: #254,100

•Product of all factors used.

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BACK OF FORM C-22380 R-10-80 (471-036)

Material Factors:

T2:

	Mole Frac.	FP (°F)	BP (°F)	AI (°F)	MF	
PO	.007	$N_F=3$		$N_R=1$	21	.147
PA (237)	.012	48.2	118	404.6	16	
Ace	.017				16	13.408
H_2O	.014				0	
PDC	.809				16	
EPI	.037	$N_F=2$			24	1.344
PCH	.017	125.6	272	0	10	.17
2MP	.019				24	
TCP	.006	$N_F=1$			14	.084
DCIPE	.062	170.6	363	0	4	.248
	1.00					$\boxed{15.4}$

T102A:

	Mole Frac	MF	
PO	.008	21	.168
PA	.014	16	15.872
ACE	.020	16	
H_2O	.017	0	
PDC	.941	16	
EPI	0		$\boxed{16.04}$
PCH	0		
2MP	0		
TCP	0		
DCIPE	0		
	1.00		

3.8 CM → 86 ft

T2 2.695 CM → 61 ft

T102A 3.05 CM → 69 ft

DO A 044779
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FIRE AND EXPLOSION INDEX

Exhibit "A"

PLANT	UNIT	CHARGE	LOCATION	DATE
Glycol I	TZ		LAD	3/3/87

MATERIALS AND PROCESS

MATERIALS: PO/PA/Ace/H_2O/PDC/EPI/PCH/2MP/TCP/DCIPE

CATALYSTS: ——

SOLVENTS: ——

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I APPENDIX A) →			15.4
1. GENERAL PROCESS HAZARDS (SEE TABLE II)			
BASE FACTOR →	1.00	1.00	
A. EXOTHERMIC REACTIONS (FACTOR .30 to 1.25)	0.3	0.3	
B. ENDOTHERMIC REACTIONS (FACTOR .20 to .40)			
C. MATERIAL HANDLING & TRANSFER (FACTOR .25 to .85)			
D. ENCLOSED PROCESS UNITS (FACTOR .30 to .90)			
E. ACCESS	.35		
F. DRAINAGE (FACTOR .25 to .50)		.25	
GENERAL PROCESS HAZARD FACTOR (F_1) →		1.55	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR →	1.00	1.00	
A. PROCESS TEMPERATURE (USE ONLY ONE)			
1. ABOVE FLASH POINT	.30		
2. ABOVE BOILING POINT	.60	.6	
3. ABOVE AUTOIGNITION	.75		
B. LOW PRESSURE (SUB ATMOSPHERIC)	.50		
C. OPERATION IN OR NEAR FLAMMABLE RANGE			
1. TANK FARM STORAGE FLAMMABLE LIQUIDS	.50		
2. PROCESS UPSET OR PURGE FAILURE	.30	.3	
3. ALWAYS IN FLAMMABLE RANGE	.80		
D. DUST EXPLOSION (FACTOR .25 to 2.00)(SEE TABLE III)			
* E. PRESSURE (SEE FIGURE 2)		.25	
F. LOW TEMPERATURE (FACTOR .20 to .50)			
G. QUANTITY OF FLAMMABLE MATERIAL			
* 1. LIQUIDS OR GASES IN PROCESS (SEE FIG 3)		.6	
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)			
3. COMBUSTIBLE SOLIDS IN STORAGE (SEE FIG. 5)			
H. CORROSION AND EROSION (FACTOR .10 to .75)		.1	
J. LEAKAGE – JOINTS AND PACKING (FACTOR .10 to 1.50)		.1	
K. USE OF FIRED HEATERS (SEE FIG. 6)		.1	
L. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15)(SEE TABLE IV)			
M. ROTATING EQUIPMENT PUMPS, COMPRESSORS	.50		
SPECIAL PROCESS HAZARD FACTOR (F_2) →		3.05	
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$) →		4.73	
FIRE AND EXPLOSION INDEX ($F_3 \times MF$ = F & EI) →			72.8

FORM C-22380 PRINTED R-10-80 (471-036)

DO A 044780
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Exhibit B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a)	Emergency Power	.97	e)	Computer Control	.89 to .98	.93
b)	Cooling	.95 to .98	f)	Inert Gas	.90 to .94	.92
c)	Explosion Control	.75 to .96	g)	Operating Procedures	.86 to .99	
d)	Emergency Shutdown	.94 to .98	h)	Reactive Chemical Review	.85 to .96	

C_1 Total .547 *

2. Material Isolation (C_2)

a)	Remote Control Valves	.94	c)	Drainage	.85 to .95
b)	Dump/Blowdown	.94 to .96	d)	Interlock	.96

C_2 Total .767 *

3. Fire Protection (C_3)

a)	Leak Detection	.90 to .97	f)	Sprinkler Systems	.60 to .96	.95
b)	Structural Steel	.92 to .97	g)	Water Curtains	.95 to .97	
c)	Buried Tanks	.75 to .85	h)	Foam	.87 to .98	
d)	Water Supply	.90 to .95	j)	Hand Extinguishers	.92 to .97	.95
e)	Special Systems	.85	k)	Cable Protection	.90 to .96	

C_3 Total .807 *

$C_1 \times C_2 \times C_3 =$ .339 See Figure 9 for conversion to Actual Credit Factor. (To Line D below).

RISK ANALYSIS SUMMARY

A-1.	F & EI	72.8	
A-2.	Radius of Exposure	61 ft.	
A-3.	Value of Area of Exposure		$MM ______
B.	Damage Factor	______	
C.	Base MPPD (A-3 X B)		$MM ______
D.	Credit Factor, Actual	______	
E.	Actual MPPD (C x D)		$MM ______
F.	Days Outage (MPDO)		______ days.

*Product of all factors used.

BACK OF FORM C-22380 R-10-80(471-036)

DO A 044781
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Exhibit C

RE-CAP WORK SHEET

PLANT: Z PREPARED: ____________

DIVISION: C DATE: ____________

Process Units	Unit Hazard Factor F_3	Material Factor MF	F&EI (F_3XMF)	(A) Value Area of Exposure $MM	(B) Damage Factor From Figure 7	(C) Base MPPD $MM (AXB)	(D) Credit Factor $C_1 \times C_2 \times C_3$ From Figure 9	(E) Actual MPPD $MM (CXD)	(F) Days Outage MPDO From Figure 10
1 Reactor	6.44	27	174	147' 15.0[illegible]	87	13.0	.49	6.4	40/110
2 Furnace	5.99	16	96	80' 12,00[illegible]	.58	7.0	57	4.0	28/90
3 Compressor	5.94	24	143	120' 15.0	83	12.5	46	5 7	35/110

Three Process Units in a hypothetical plant "Z" have been evaluated with results shown above. Assume a total Replacement Value of plant "Z" at $50.0MM. Then from the above re-cap the highest Base MPPD is $13.0MM and the highest Actual MPPD is $6.4MM with an MPDO range of 40 to 110 days for the Reactor (Process Unit 1).

FORM C 50010 (4?1-037)

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Exhibit B

LOSS CONTROL CREDIT FACTORS

1. Process Control (C_1)

a) Emergency Power	.97	e) Computer Control	.89 to .98	.93
b) Cooling	.95 to .98	f) Inert Gas	.90 to .94	.92
c) Explosion Control	.75 to .96	g) Operating Procedures	.86 to .99	
d) Emergency Shutdown	.94 to .98	h) Reactive Chemical Review	.85 to .96	

C_1 Total .547 *

2. Material Isolation (C_2)

a) Remote Control Valves	.94	c) Drainage	.85 to .95
b) Dump/Blowdown	.94 to .96	d) Interlock	.96

C_2 Total .767 *

3. Fire Protection (C_3)

a) Leak Detection	.90 to .97	f) Sprinkler Systems	.60 to .96	.95
b) Structural Steel	.92 to .97	g) Water Curtains	.95 to .97	
c) Buried Tanks	.75 to .85	h) Foam	.87 to .98	
d) Water Supply	.90 to .95	j) Hand Extinguishers	.92 to .97	.95
e) Special Systems	.85	k) Cable Protection	.90 to .96	

C_3 Total .807 *

$C_1 \times C_2 \times C_3$ = .339 See Figure 9 for conversion to Actual Credit Factor. (To Line D below).

RISK ANALYSIS SUMMARY

A-1. F & EI	81.8		
A-2. Radius of Exposure	69 ft.		
A-3. Value of Area of Exposure		$MM	
B. Damage Factor			
C. Base MPPD (A-3 X B)		$MM	
D. Credit Factor, Actual			
E. Actual MPPD (C x D)		$MM	
F. Days Outage (MPDO)			days.

*Product of all factors used.

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BACK OF FORM C-22380 R-10-80(471-036)

Exhibit C

RE-CAP WORK SHEET

PLANT: Z

DIVISION: C

PREPARED: ______

DATE: ______

Process Units	Unit Hazard Factor F_3	Material Factor MF	F&EI (F_3XMF)	(A) Value Area of Exposure $MM	(B) Damage Factor From Figure 7	(C) Base MPPD $MM (AXB)	(D) Credit Factor $C_1 \times C_2 \times C_3$ From Figure 9	(E) Actual MPPD $MM (CXD)	(F) Days Outage MPDO From Figure 10
(1) Reactor	6.44	27	174	147' 15.0:0	.87	13.0	.49	6.4	40/110
(2) Furnace	5.99	16	96	80' 12.0UC	58	7.0	57	4.0	28/90
(3) Compressor	5.94	24	143	120' 15 0	83	12.5	.46	5.7	35/110

Three Process Units in a hypothetical plant "Z" have been evaluated with results shown above. Assume a total Replacement Value of plant "Z" at $50.0MM. Then from the above re-cap the highest Base MPPD is $13.0MM and the highest Actual MPPD is $6.4MM with an MPDO range of 40 to 110 days for the Reactor (Process Unit 1).

FORM C [illegible]

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FIRE AND EXPLOSION INDEX

Exhibit "A"

LOCATION	DATE
LAD	3/~~3~~87

PLANT	UNIT	CHARGE
Glycol I	T102A	

MATERIALS AND PROCESS

MATERIALS: PO/PA/Ace/H_2O/PDC

CATALYSTS: ——— SOLVENTS: ———

	PENALTY	PENALTY USED	
MATERIAL FACTOR (SEE TABLE I APPENDIX A) →			16.04
1. GENERAL PROCESS HAZARDS (SEE TABLE II)	PENALTY	PENALTY USED	
BASE FACTOR →	1.00	1.00	
A. EXOTHERMIC REACTIONS (FACTOR .30 to 1.25)	0.3	0.3	
B. ENDOTHERMIC REACTIONS (FACTOR .20 to .40)			
C. MATERIAL HANDLING & TRANSFER (FACTOR .25 to .85)			
D. ENCLOSED PROCESS UNITS (FACTOR .30 to .90)			
E. ACCESS	.35		
F. DRAINAGE (FACTOR .25 to .50)		0.25	
GENERAL PROCESS HAZARD FACTOR (F_1) →		1.55	
2. SPECIAL PROCESS HAZARDS			
BASE FACTOR →	1.00	1.00	
A. PROCESS TEMPERATURE (USE ONLY ONE)			
1. ABOVE FLASH POINT	.30		
2. ABOVE BOILING POINT	.60	.6	
3. ABOVE AUTOIGNITION	.75		
B. LOW PRESSURE (SUB ATMOSPHERIC)	.50		
C. OPERATION IN OR NEAR FLAMMABLE RANGE			
1. TANK FARM STORAGE FLAMMABLE LIQUIDS	.50		
2. PROCESS UPSET OR PURGE FAILURE	.30	.3	
3. ALWAYS IN FLAMMABLE RANGE	.80		
D. DUST EXPLOSION (FACTOR .25 to 2.00)(SEE TABLE III)			
E. PRESSURE (SEE FIGURE 2)		.25	
F. LOW TEMPERATURE (FACTOR .20 to .50)			
G. QUANTITY OF FLAMMABLE MATERIAL			
1. LIQUIDS OR GASES IN PROCESS (SEE FIG. 3)		1.10	
2. LIQUIDS OR GASES IN STORAGE (SEE FIG. 4)			
3. COMBUSTIBLE SOLIDS IN STORAGE (SEE FIG. 5)			
H. CORROSION AND EROSION (FACTOR .10 to .75)		.1	
J. LEAKAGE – JOINTS AND PACKING (FACTOR .10 to 1.50)		.1	
K. USE OF FIRED HEATERS (SEE FIG. 6)		.1	
L. HOT OIL HEAT EXCHANGE SYSTEM (FACTOR .15 to 1.15)(SEE TABLE IV)			
M. ROTATING EQUIPMENT (PUMPS, COMPRESSORS)	.50		
SPECIAL PROCESS HAZARD FACTOR (F_2) →		3.55	
UNIT HAZARD FACTOR ($F_1 \times F_2 = F_3$) →		5.10	
FIRE AND EXPLOSION INDEX ($F_3 \times MF = F\&EI$) →			81.8

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