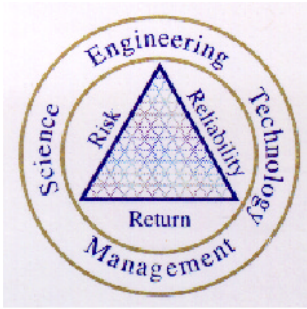
UNWIN
Integrated Risk Management



AN APPLICATION OF RISK-BASED DESIGN CRITERIA

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OUTLINE

- Background/Objectives
- Methods
- Results
- Conclusions

BACKGROUND

- HF Alkylation Unit operated by Ultramar Refining in Wilmington, CA
- Decision to install an (acid) Automatic Isolation and Evacuation System (AIES)
- Proposed local regulation in place specifying AIES design (based on API RP-751)
- Several design/operational options available

RISK-BASED DESIGN SELECTION

- Operational risk/reliability identified by Ultramar as key design selection criterion
  - Study commissioned
- Study objectives:
  - Quantify accident risks associated with each of three AIES design options
  - Identify and understand design features that *drive* risk profiles
  - Develop robust basis for selection among designs

OPTIONAL DESIGN CONCEPTS

- Option 1:
  - Emergency acid receiving vessel located outside battery limits
  - Given acid release, leak location diagnosed and acid transferred to receiving vessel
- Option 2:
  - Unit reconfigured from Series Recycle (SRC) to Series Acid Configuration (SAC)

OPTIONAL DESIGN CONCEPTS - Contd.

- Option 2 (Contd.):
  - Given acid release, all major acid holding vessels isolated. If release persists, leak location diagnosed and acid transferred to intact settler
- Option 3:
  - Combination of previous options:
    - Unit converted to SAC design
    - Given release, acid evacuated to remote receiving vessel

RISK METHODS

- Integrated Risk Model:
  - Front End: Model potential causes, locations, sizes, and likelihoods of acid releases from system
  - Analysis of system capabilities: identify those releases that are mitigatable by each AIES design option
    - Successful mitigation: release less than 1,500 gallons
    - Consideration of diagnosis and response times

RISK METHODS - Contd.

- Back End: Model potential failure modes of each AIES system design, and estimate failure likelihoods
- Analysis of system reliabilities
  - reliability block diagram analysis
  - systematic identification of failure modes: human errors, equipment failures, support system failures
- Analysis of consequences of unmitigatable or unmitigated releases:
  - Release size used as surrogate consequence measure

UNDERLYING RISK FORMULA

- $R = \Sigma (I_m \times A_{mn} \times C_m) + \Sigma (J_i \times D_i)$
- R = Risk metric
- I_m = Annual probability of mitigatable leak at location/size m
- J_i = Annual probability of unmitigatable leak at location/size i
- A_{mn} = Probability of AIES failure via mode n given leak m
- C_m/D_i = Consequence severity of leak m/i

AIES FAILURE MODES: EXAMPLE CUT-SETS

AIES OPTION: 3
RESPONSE MODE FOR: RELEASE IN ACID STORAGE SECTION
TOTAL FAILURE PROBABILITY = 1.21E-01

CUT-SET		DESCRIPTION	BE PROB[a]	CS PROB[b]
1	PEVAC-STFL	Evac Pump PEVAC Fails to Start from Cold and Evac Acid from Storage Section	6.46E-02	6.46E-02
2	H-DET-HFOK-OP1/3	Operators Fails to Detect Release Given HF Detector Alarm	3.67E-02	3.67E-02
3	HF-DET-FL	HF Detectors Fail to Respond to Release	1.98E-01	9.41E-03
	H-DET-HFFL-OP1/3	Operators Fail to Detect Release Given HF Detector Failure	4.75E-02	
4	MOV-J-FC	MOV J Fails Closed	5.09E-03	5.09E-03
5	MOV-K-FC	MOV K Fails Closed	5.09E-03	5.09E-03
6	H-MOV-DIS	Failure to Reconnect MOV Power After PLC Logic Test	3.00E-03	3.00E-03
7	H-XFER-OP1/3	Operator Fails to Diagnose Release Location and Initiate Evacuation	2.67E-03	2.67E-03

a Probability of basic event given demand on AIES
b Probability of cut-set (= product of constituent basic event probabilities) given demand on AIES

AIES RELIABILITY

AIES RESPONSE MODES			
AIES OPTION	**MODE**	**RELEASE SITE**	**UNAVAILABILITY[a]**
OPTION 1	1	Acid Storage Section	1.21E-1
	2	Reactor No. 1 Section	7.09E-2
	3	Reactor No. 2 Section	7.09E-2
	4	Acid Settler No. 1 Section	7.56E-2
	5	Acid Settler No. 2 Section	7.56E-2
OPTION 2	1	Line or Reactor Vessel	2.85E-2
	2	Acid Circulation Pump	9.54E-3
	3	Acid Storage Vessel	1.03E-1
	4	An Acid Settler Vessel	6.66E-2
OPTION 3	1	Acid Storage Section	1.21E-1
	2	Reactor No. 1 Section	7.09E-2
	3	Reactor No. 2 Section	7.09E-2
	4	Acid Settler No. 1 Section	6.62E-2
	5	Acid Settler No. 2 Section	6.62E-2

a Probability of AIES failure given the event of a mitigatable release

RISK ESTIMATES

AIES RISK COMPARISONS			
RISK PARAMETER (Annual)	**AIES OPTION**		
	Option 1	Option 2	Option 3
Release (IE) Frequency	**1.8E-1**	**9.2E-2**	**9.2E-2**
Unmitigatable Release Frequency	**6.6E-4**	**4.4E-4**	**4.8E-4**
Unmitigated Release Frequency	**1.4E-2**	**1.6E-3**	**6.6E-3**
AIES Unavailability	**7.6E-2**	**1.2E-2**	**6.7E-2**
Risk	**1.5**	**0.51**	**0.87**

RISK DRIVERS

- SAC (Options 2 and 3) have lower leak probability
  - Single active pump
  - Fewer potential leak sites
- Leak isolation (Option 2) more reliable than acid evaluation
  - Isolation less reliant on leak location diagnosis
  - Greater hardware reliability for isolation
  - Need to transfer acid is unlikely

CONCLUSIONS

- Acid isolation/transfer design selected in preference to acid evacuation design
- Risk-based case for AIES design selection accepted by regulatory agency
- Unit now operational with AIES in place