

INJURIES FROM THE PEPCON EXPLOSION (1988) AND OTHER INCIDENTS.

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ABSTRACT

An explosion at the PEPCON ammonium-perchlorate plant on May 4, 1988, in Henderson, Nevada, broke more than 10,000 windows and caused over \$70 million damages to the Henderson-Las Vegas communities. A lawsuit by a conglomerate of insurers led to "discovery" of 77 claims for various injuries. Most of the 306 people treated at hospitals did not participate in this suit; their injury costs were apparently paid by medical insurance and not incorporated into the combined damage claim. Their records could not be obtained for analysis because of patient privacy considerations. Nevertheless, their number from the newspapers could be compared to window damage claims to show roughly one laceration victim per 100 broken window panes.

Damage analyses led to a determination that the equivalent TNT yield of the largest and most damaging explosion was about 250-tons, surface burst. Weather conditions and glass damage claims were combined to provide a plan map of overpressure isobars for comparison with injury claims from the lawsuit. A number of examples are compared to results from other incidents..

WINDOW DAMAGES AND HAZARDS FROM EXPLOSIONS

Previous reports on the accidental explosion at the PEPCON ammonium-perchlorate plant in Henderson, Nevada, May 4, 1988 [1], have shown that this was equivalent to about 250-tons (227 Mg) TNT (1.05 TJ), surface burst, and that window damage claims roughly agreed with an empirical glass damage model (GDM) derived from the 1963 Medina incident, near San Antonio, Texas [2]. An overpressure versus distance curve for this explosion yield is shown in Figure 1 [3], along with curves for some of the other explosions that occurred during this incident. An approximate adjustment for strong southerly winds at accident time provided an overpressure isobar pattern that only required minor modification to conform to the damage intensity pattern, shown in Figure 2.

This PEPCON accident generated about 17,000 damage claims against insurers, for about \$77 million. Of these, 7513 claims from single-family homes included glass damage; results are compared to the GDM in Figure 3. With several assumptions based on the GDM and overall claims interpretations, it appears that about 12,000 broken windows were included in these claims. In addition, there was a significant number of windows broken which were not shown by claims reports. Some repair contracts were lumped together without specifying glass repairs, many window damages did not exceed policy-holder's deductibles, some were uninsured damages, and some home-owners simply made repairs without troubling themselves with claims paper work. It is not unreasonable to conclude that roughly 20,000 windows were broken by the PEPCON explosion.

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE AUG 1994		2. REPORT TYPE		3. DATES COVERED 00-00-1994 to 00-00-1994	
4. TITLE AND SUBTITLE Injuries from the PEPCON Explosion (1988) and Other Incidents				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) JWR Inc,5301 Central Avenue Suite 220,Albuquerque,NM,87108				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES See also ADM000767. Proceedings of the Twenty-Sixth DoD Explosives Safety Seminar Held in Miami, FL on 16-18 August 1994.					
14. ABSTRACT see report					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	unclassified	unclassified	Same as Report (SAR)	14	

FIGURE 1. DNA-1981 STANDARD OVERPRESSURE VS DISTANCE CURVES, PEPCON EXPLOSIONS.

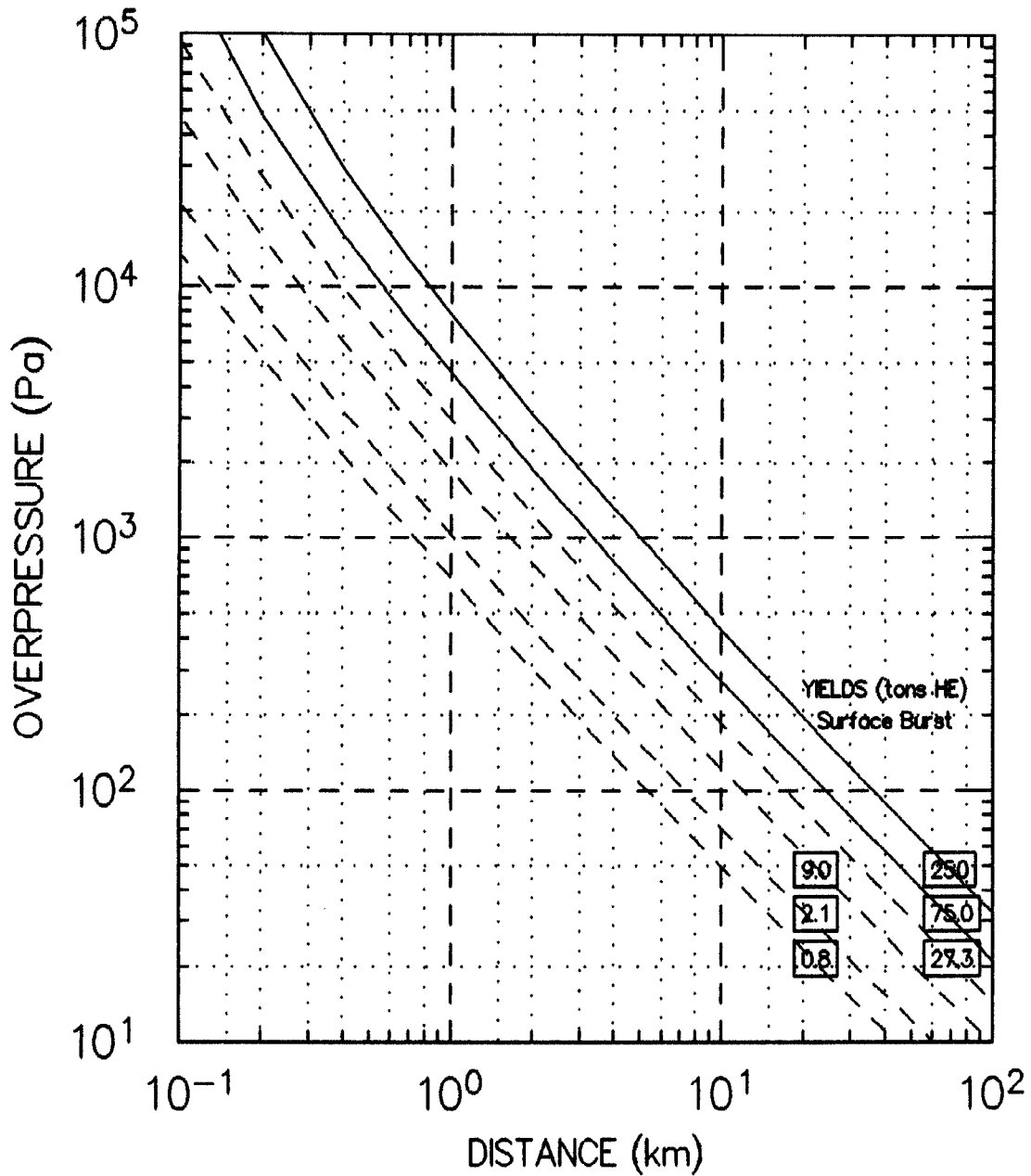


Figure 1. DNA-1981 Standard Overpressure vs Distance Curves, PEPCON Explosions.

FIGURE 2. AIRBLAST ISOBARS(Pa), PEPCON 250-TON TNT EQUIVALENT EXPLOSION.

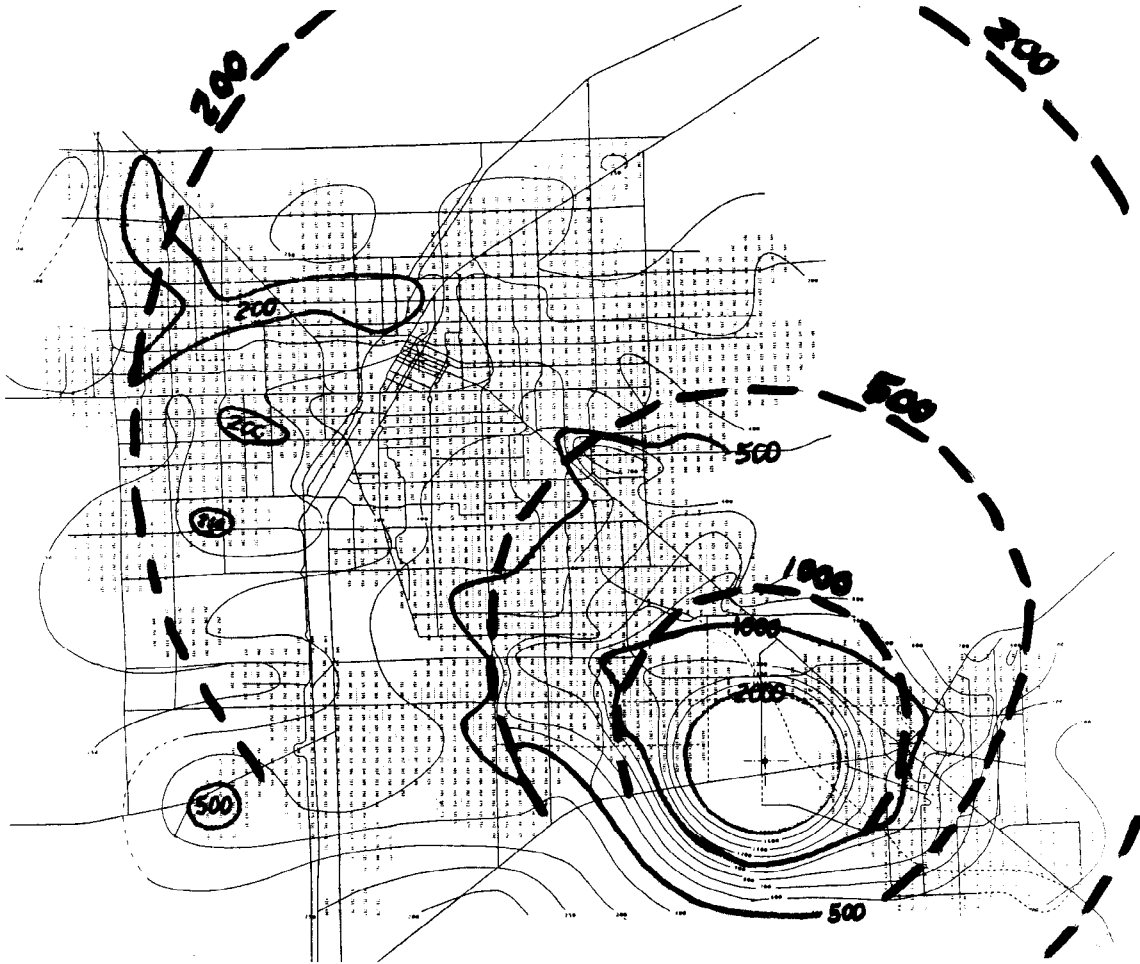


Figure 2. Airblast Isobars (Pa), PEPCON 250-ton TNT Equivalent Explosion.

Dashed - Weather-Dependent Predictions

Solid - GDM Interpretation of damage claims

FIGURE 3. WINDOWS DAMAGE CLAIMS VERSUS INCIDENT OVERPRESSURE, PEPCON 250-T TNT EQUIVALENT EXPLOSION

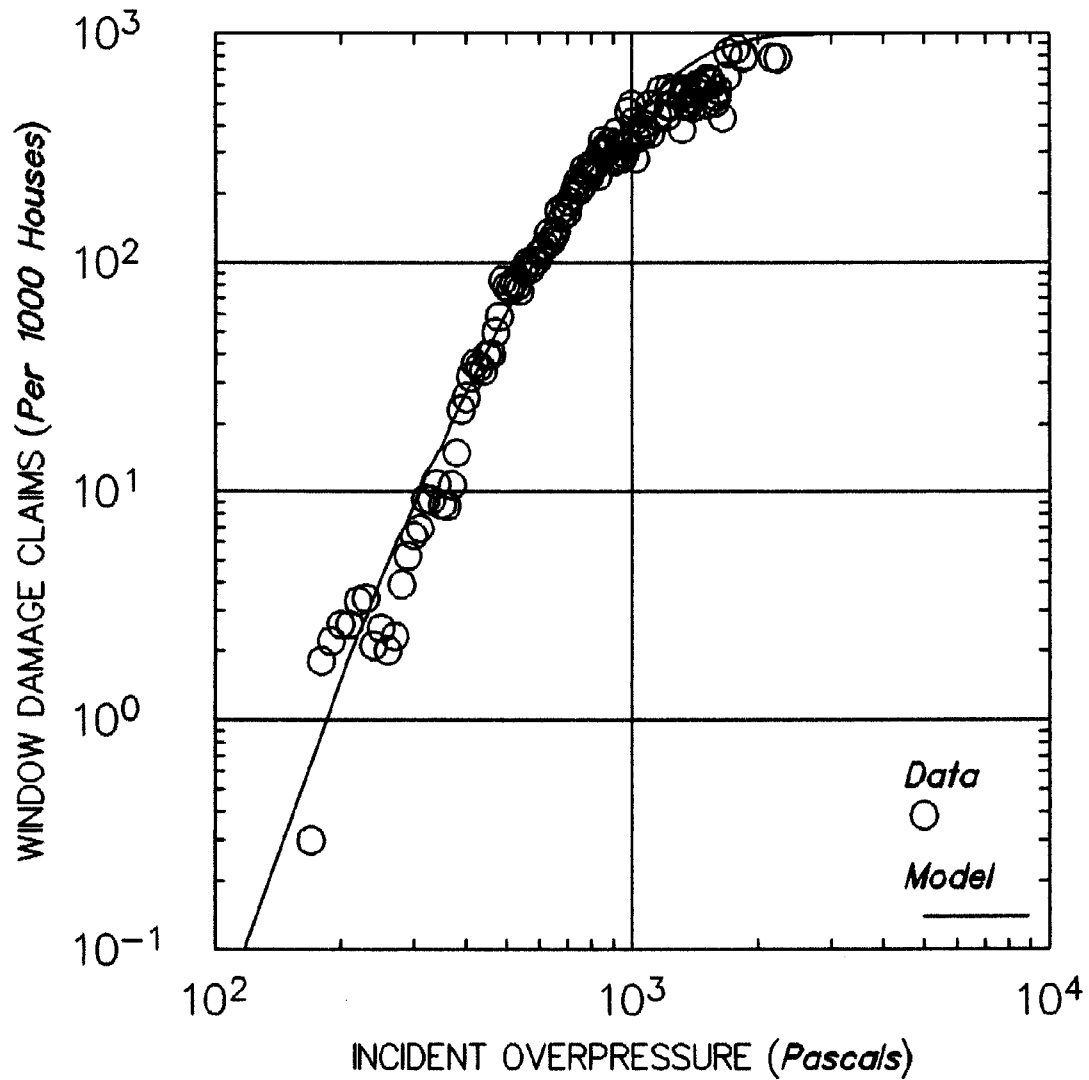


Figure 3. Window Damage Claims Versus Incident Overpressure, PEPCON 250-t TNT Equivalent Explosion.

Many concerns about hazards to people from airblast-broken windows have not been adequately resolved. From Medina, with 3544 claimed broken windows, there was no report of injury by glass. A number of other airblast incidents generated no glass injury claims or reports. Yet, in 1968, when a sonic boom salute at the Air Force Academy broke roughly 300 windows, fifteen people were hospitalized by flying glass, one with a very serious injury. It appears that overpressure from that sonic boom was possibly 1800 Pa, where most Medina window damage came from only a few hundred pascals. ESB files contain some undetailed reports of glass injuries from accidental explosions at Port Chicago, California (1944), Savannah, Illinois (1948), and Clark AFB, Philippines (1949), where overpressures ranged from about 600 Pa to possibly 4500 Pa. Thus it appears that near 1 kPa or larger airblast causes lacerations. Such strong blasts break glass into smaller shards and carries them on longer, faster trajectories. On the other hand, large panes, most susceptible to low overpressure damage, produce large shards that are hazardous in gravity fall, particularly from multi-story structures.

PEPCON INJURIES

Las Vegas newspapers reported that 306 victims were treated at hospitals from this explosion. They also noted that 75% of these were injured by flying glass. Since many PEPCON workers, as well as employees of the adjacent Kidd Marshmallow Factory, totalling 104 people, were somewhat injured and probably not by glass, this leaves possibly 150-250 glass injuries from the 12- or 20-thousand broken windows in the neighboring communities. Thus, there were 50-150 broken window panes per glass injury, for comparison with 30 panes per injury at the Air force Academy. A very rough guess is that the median window-breaking overpressure from PEPCON was 1000 Pa. Thus a tentative rule-of-thumb conclusion may be reached, that 1-kPa overpressure can cause one glass injury per 100 broken panes, while 1.8-kPa overpressure might cause one glass injury per 30 broken panes.

In preparing the defense against a subrogated insurance carriers lawsuit, some claims for injury were obtained through the legal discovery process, along with 100+ boxes of property damage claims. There were 77 claimants for in-jury to 83 persons in this collection, shown in Table 1, but these records were of very little value for airblast injury analysis. Twenty-one were PEPCON or Kidd workers, including the two fatalities to PEPCON officials. Only 13 of 77 claimed glass injury, and 10 of these were in autos at or near the explosion site where they were hit by 10-30 kPa. Of the other three, two blamed window glass, one blamed door glass for their injury. Injury claims from other than glass, and from the community outside the PEPCON complex, numbered 53, of which 26 exhibited psychotic or possibly psychotic or larcenous symptoms during their deposition, as remarked by defense attorneys. Locations for a majority of these claimants, and their estimated overpressure exposures might be determined from the contemporary telephone directory, but this has not yet been done. The lawsuit was settled out of court, and there has been no forthcoming support for further analyses of either damage or injury data.

NEWSPAPER REPORTS OF PEPCON EXPLOSION EXPERIENCES

A review of newspaper stories provided locations which can be assigned overpressure exposures for correlation with reported experiences, as shown in Table 2. It is generally known now that there were two large explosions, of 75-t and 250-t TNT equivalences, separated by 4 minutes and 4 milliseconds in the seismic record. There were also an indefinite number of much smaller explosions, that did not trigger any seismic recorders. These were reported differently by various individuals, depending on their location. In hindsight, some of these news reports were obviously erroneous, either from transcription error or from the terrified confusion of close observers. Nevertheless, some of these reports are worthy of further analysis.

Table 1a. PEPCON Injury Claims in Lawsuit.

INAPPLICABLE OR INDETERMINATE CLAIMS

CLAIM NUMBER	NUMBER OF PERSONS	MALE OR FEMALE	CLAIM TYPE	PSYCHO?
9	2	MF	Property	
24	1	M	No Info	
40	1	M	No Info	Yes
41	1	F	No Info	Yes

WORKERS AT PEPCON OR KIDD MARSHMALLOW PLANT

CLAIM #	NO. OF PEOPLE	SEX M,F	IN CAR	GLASS INJURY	CUTS TO	INJURY NATURE	PSYCHO?	HEARING LOSS
27	1	M				Vice President, Fatal		
76	1	M				Comptroller, Fatal		
13	1	M	Y	Y	Hands	Spine injury		
53	1	M	Y	Y	Cuts	3 blasts, multiple injuries	?	Yes
2	1	M				Back, burns		Mild
4	1	M				Back, lungs		Mild
5	1	M				Burns		Permanent
15	1	M				Knee, back	Y	Temporary
17	1	M				Back, metal cuts		
22	1	M					Y	Permanent
28	1	M				Multiple		Permanent
54	1	M				Decked, strains		Permanent
57	1	F				Various, many		Permanent
60	1	M				Various		
65	1	F				Decked, back	?	
70	1	M						Permanent
78	1	M				Back, neck, etc.	Y	
79	1	M				Back, neck, ankle		
81	1	M				Multiple, trauma		

CLAIMS FROM OUTSIDE THE PEPCON COMPLEX FOR BLAST LACERATION INJURIES

CLAIM #	NO. OF PEOPLE	SEX M,F	IN CAR	INJURED BY DOOR GLASS	CUTS TO	INJURY NATURE	HEARING LOSS
7	1	M	Y		Y	Face, eye	
18	1	M		Y	Y	Nose	
19	1	M			Y	3" arm cut	
23	3	MFF	Y		Y	Lacerations to all	
42	2	FM	Y		Y	3 blasts	
62	1	M	Y		Y	Large cut	
66	2	M	Y		Y	Multiple	
69	1	F			Y	Eye, wrist	
						Hit by glass door, later died	
						2-3 windows broken	
						Multiple lacerations	Mild
						Artery, 40 stitched	

Table 1b. PEPCON Injury Claims in Lawsuit (Cont'd)

CLAIMS FROM OUTSIDE THE PEPCON COMPLEX FOR OTHER TYPES OF INJURIES

CLAIM #	NO. OF PEOPLE	SEX M,F	IN CAR	INJURED BY DOOR GLASS	CUTS TO	INJURY NATURE	PSYCHO?	HEARING LOSS
1	1	M				Invalid fell , died later	Y	
3	1	M				Head		
6	1	F				Fell, trampled	Y	
8	1	F				Fall on stairs, back injury		
10	1	M		Y		Cut chin, forehead		
11	1	M				Fall; back, neck		
12	1	F		Y		Knocked out, sprains		
14	1	M				Contusions, sprains		
16	1	M				Neck sprain		
20	1	F				Sinus troubles	Y	
21	1	M				Decked twice		Yes
25	1	M				Blown 10 ft		
26	1	M				Pulmonary		
29	1	M				Chemical inhalation	?	
30	1	M						Mild
31	1	M				Decked		
32	1	F		Y				
33	1	F		Y		Re-injured back		
34	1	F	Y	Y		Door broke wrist		
35	1	M				Shoulder		
36	1	F				Bathtub fall		
37	1	F		Y		Arm injury, inhalation		
38	1	M	Y			Nosebleed		M
39	1	M				Hearing claim in 1990		Y
43	1	F				Broken foot		
44	1	F				Fall, hurt arm		
45	1	M				Trauma		
46	1	F		Y		Door hit shoulder		
47	1	M				Decked, knee injury		
48	1	M				Neck sprain		Y
49	1	M				Concussion, strains		
50	1	F	Y			Nervous		P
51	1	F		Y		Wrist, chest		
52	1	M				Knees, shingles		
55	1	F				Hip fractured		
56	1	F				Decked, multiple injuries		
58	1	M				Knocked from ladder		
59	1	M				Decked, head injury		
61	1	F				Decked, nose injury		
63	1	F				Fall, trampled, etc.,		
64	1	M				Fall from ladder		
67	1	F				Head banged		
68	1	F				Hit by falling decoration		
71	1	M				Hit wall		
72a	4	M				Family claim		M
72b	"	F				Asthma		
72c	"	F				Hearing check		N
72d	"	M				Ear tubes blown out ?		?
73	1	F				Knocked unconscious		
74	1	M				Respiratory		
75	1	F				Back		
77	1	M				Nausea		
80	1	F				Head; knee surgery,		

Table 2a. NEWSPAPER REPORTS [AND JWR INTERPRETATIONS]

SOURCES: Sn = Las Vegas Sun, May n, 1988
(SRC) Rn = Las Vegas Review-Journal, May n, 1988
 *n = JWR Notes, May n, 1988

NOTE: Distance minimum = m maximum = x
STORAGE AREA:
 C = 1st Explosion,
 A = 2nd Explosion, 75-t HE Equivalent at 11:53:35 PDT
 B = 3rd Explosion, 250-t HE Equivalent at 11:57:35 PDT

A
R
E DIST DIR DP SRC
A (m) (deg) (kPa)

PEPCON

				R5. A succession of smaller explosions followed three major explosions which were spaced just seconds apart. [Incorrect]
				S6. Evacuation alarm sounded 7-10 minutes before the #1 explosion, made it possible for all but 1 [later figure was 2] to escape.
				R6. Police dispatcher received call at 11:51 from R.Westerfield; at 11:52 a woman reported an explosion; a third call came seconds later reporting two explosions.
				S7. Comptroller Westerfield called fire department at 11:51; they suspected the fire started 15 to 30 minutes earlier.
C	150m	030	40	R6. PEPCON parking lot scene: [Cars overturned, all very bashed. worse than pictures at 5-psi (35 kPa) in <u>The Effects of Nuclear Weapons</u> [Ref.4]].
A	70m	030	500	
A	190x	360	50	
B	150m	360	200	
B	310x	340	25	
C	200	040	25	S4. Hedrick: Wife & daughter brought lunch to PEPCON parking lot; #1 hit and he said get out; as A they got into their van, #2 broke the van windshield, cutting the girl; van looked sideswiped. He then drove his truck thru desert to Gibson, a mile away when #3 broke windows, causing minor injuries. What was reported as #2 must have been from Area C; A would have been nearly lethal. Thus #3 was from Area A, but no mention of Area B blast. #1 must be much smaller than C, and the very first explosion which sent batch house workers fleeing.]
	138	360	100	
B	1609	020	4	R5. Hedrick: Escaped as in previous report, but was only reunited with his family at the hospital.
				S4. Simon: PEPCON employee hitchhiked to hospital, treated released. Was on Boulder Hiway for #2. [Meant Lake Mead Drive? At least 500 m in 3 minutes?]
C	130	030	50	S5. Scroggins: In lab at PEPCON for #1. While running away, #2 threw him in air and he landed on his head; he felt 4 explosions. [Estimates assume that he ran at 2 mph in spite of head impact. B Fourth explosion probably was the small one between A and C on seismic record.]
A	200	350	50	
	460	350	20	
C	300	030	15	R5. Bob Williams: In PEPCON batch house he fought fire, then gave up & ran. #1 blew off his hard hat, #2 threw him 10-15 ft. He was uninjured. [To escape from the batch house, 50 m from C, with only a hard hat loss from C, he must have run 300 m in 5.6 min, north to parking lot and stopped for three minutes (Why?), where A hit with at east 50 kPa. Yet he was uninjured? He must have driven off to escape B.]
A	200	340	50	
				R5. Paul Herbert: PEPCON welder ran, but blast knocked him off feet. [He must have been knocked down by A around the parking lot and then got away from B by car.]
				R5. Frank Quintana: PEPCON worker fought fire until #1; he took off. [No mention of being knocked down. Also, batch house in lethal range from C at 20-t yield.]
C	220	010	25	S6. Chuck Bainbridge & Rick Christensen: PEPCON workers outran wave of dirt to reach their truck; they headed down Gibson at 30 mph when #2 hit and stalled the truck; they were in a hot debris shower. [Dirt wave must have come from C since A was in lethality range. No mention of #3 B.]
A	700	040	7.5	
B	840	030	10	

Table 2b. NEWSPAPER REPORTS [AND JWR INTERPRETATIONS] (Cont'd)

A
R
E DIST DIR DP SRC
A (m) (deg) (kPa)

PEPCON (Cont'd)

C 220 080 22 R5. PEPCON workers driving from plant were blown from their cars. [Must have not reached Gibson
A 300 080 25 Blvd when hit by blast from A.]
B 840 060 10

KIDD MARSHMALLOW PLANT

C 170m 330 38 S6. Explosion #2 started Kidd workers to flee. [Why did they wait after #1 from C? 1 mph solution C
345x 305 12 assumed for these C estimates from 27-t HE.]
A 270m 290 30
A 430x 295 12
B 390m 305 32
B 565x 305 12
C 346 325 12 S6. Kidd Asst-Mgr Wally Cox: Was thrown three times, sustained a perforated eardrum. [See special A
485 320 12 analysis for him. Values also for 1 mph, 27-t HE.]
B 724 320 12

NEARBY ROADS

B 2700 090 2.2 S4. Lake Mead at Kerr-McGee: Reifsnnyder's Bronco was thrown onto median and he lost control,
crashing into the median.
B 410m 170 30 S4. HWY-146: George Tuttle and 3 passengers had windshield and drivers side windows blown out; all
had cuts to faces and arms - minor injuries. It almost destroyed our car, with large dents. [Cars left
along Lake Mead Blvd appeared generally to have less than expected damage for 35 kPa.]
A 500 040 12 R4. Approaching PEPCON: Fire Captain Lewis Banning saw concussion roll across desert, when #2
B 560 035 18 blew windshield from firetruck. His face was cut, and his engineer Blackford received a nose cut.
[Approximate location guessed.]
A 500 040 12 R5. Approaching PEPCON: Fire Chief Dale Starr had windshield blown out and was cut on the face; car
B 560 035 18 looked sledge hammered, with all windows broken. [Location guessed.]
B 410m 170 30 R7. Lake Mead or Boulder Highway?: Pat Rose was knocked out by a rock blown into their car window,
en route to fishing at Lake Mead. [He was reported to be still in a coma in July, 1988.]
B 6750m 360 0.7 S5. Tropicana Blvd: Harris driving when the big one moved his car like hitting a big pothole.
S6. Expressway: Panic in deadlocked traffic to several miles away, as toxic cloud passed overhead.
R4.
Seven police officers were injured.

NEARBY FACILITIES:

B 950m 100 9000 S4. Chemstar: Tyree Clark said blast propelled him off his feet to 15 ft, he was knocked unconscious
and
B 1250x 100 6000 sustained a broken wrist. Co-workers were similarly thrown around. 8000 Lake Mead Dr.?
B 1332 070 5400 S4. Sunset Ridge bridge: John Quick was blown from his work perch, fell 20 ft, and suffered a broken
ankle, at p mile.
B 8530 350 700 S4. Sanitation plant: all windows shattered, 300 employees sent home. 5857 E. Flamingo. [Sounds
extreme.]

Table 2c. NEWSPAPER REPORTS [AND JWR INTERPRETATIONS] (Cont'd)

A
R
E DIST DIR DP SRC
A (m) (deg) (kPa)

SCHOOLS:

B 3260 100 1800	S4. Burkholder: Ceiling beam fell on a girl's head, she was hospitalized. Several students received glass wounds. School bus window was shattered. Part of the roof came down.
	S5. Burkholder Jr High: April Harmer fell from stairs.
	S6. Burkholder Jr.High: Front entrance buckled and sunk several feet by the blast.
B 4200 320 1300	R6. McDoniel Elementary School: Front door was blown off and ceiling tiles dropped on students.
B 6715 090 700	S7. Basic High School: 3-4 kft ² of 230 kft ² of ceiling tiles were blown down.
B 6200 330 800	R4. Southern Nevada Voc-Tech Inst: Damaged nearly all of its windows.

ST.ROSE DE LIMA HOSPITAL:

B 4245 90 1300	R4. Over 100 were treated but none had been at the plant.
	R4. Part of the hospital roof caved in @ Lake Mead Drive & Boulder Hwy.
	R6. An infant cut on the eyelid. 80% of the windows were broken.

DOWNTOWN HENDERSON:

B 3670 060 1500	R4. Sperry was 1/4 mile away when explosions began; everything was blown off shelves; the owner of R&R Car Wash, 936 Boulder Hiway, he heard several ear-piercing explosions rock his building. [Dog Shot, BUSTER-JANGLE, knocked Desert Inn dishes from shelves at a likely lower overpressure.]
B 2940 090 2000	R4. OK Tires: #3 broke store & car windows @ 505 Lake Mead Drive.
B 4105 090 1300	S4. Barber Shop: Robert Helmke, Water St. barber, was cut on hands & neck, and had deep arm cut. Took out window and frame.
B 4105 090 1300	S5. Joe Bright's "Sassy Scissors", 1950 Water St. had door blown open but no window was broken.
B 4525 085 1100	S5. At Lake Mead & Boulder Highway, a two-story building front was collapsed.
B 4105 090 1300	R6. In a downtown furniture store, blast tossed tables and couches were cut by flying glass.
B 4105 090 1300	R6. "This Place" Bookstore had its ceiling buckled.

OTHER REPORTS: (k = kilometers)

B 5.8k 130 850	R4. Klempnauer, 626 Greenway Road, windows blown out; at 7-11 on Pacific when #2 broke 3 windows.
B 6.1k 080 800	S5. Lauderdale, 1100 N.Center St, windows blown out; wife blown from bed and cut on arm.
B 3.1k 090 1700	R4. At home Henderson, it hit me and I was thrown on the floor. [Location assumed in western Henderson for this and other unaddressed reports.]
A 5.8k 315 500	S5. Bloomquist said #1 blew double glass doors open; #2 knocked him to floor at Green Valley Athletic Club.
B 6.0k 315 800	
B 12.0k 315 350	S4. Desert Springs Hospital, 2075 E. Flamingo, had 2 second-story windows broken.
B 3100 090 700	S5. Joe Bright, watching TV when it went off; he went to look, and was blown to the floor. [Exact location ?]
B 2425 ? 2500	S5. Ann Walk, Glen Halla Health Care Center, at 1.5 miles, saw glass flying.
A 12.3k 310 310	R5. Muriel Stevens was at Maryland Parkway & Flamingo, when #1 caused them to run outside.
B 12.2k 310 430	
B 21.3k 360 200	R5. Andrew Zubal at Nellis AFB, said blast shook windows in buildings on base.
B 8900 340 700	R5. Sam's Town gamblers would not leave their slot machines; Boulder Hwy at Nellis Blvd.
B 8315 345 500	R5. Nevada Palace, 5255 Boulder Hwy: 39 rooms with windows broken, no "serious" injuries, closed 2 hr.

Table 2d. NEWSPAPER REPORTS [AND JWR INTERPRETATIONS] (Cont'd)

A

R

E DIST DIR DP SRC

A (m) (deg) (kPa)

OTHER REPORTS (Cont'd) : (k = kilometers)

- B 8730 275 500 S6. Martha Yoon had arm broken by blown door, with cuts to head & back, as she was thrown to the floor. [1764 Yellowwood Dr, probable location.]
- B 3135 100 1300 S6. S. & T. Clark, 221 Carson Way, had about every window broken by #3.
- B 2900 300 1300 R6. Vallarte Drive, at 1 mile [?], had nearly every home damaged; insides looked as if house had been lifted from its foundation, shaken, and dropped back into place.

MISCELLANEOUS OBSERVATIONS:

- R6. Academy Glass Co. had 12,000 ft² in stock but it wouldn't last long.
- B 11.3k 290 420 *4. McCarran Field doors blown open, damaged.
- B 15.2k 310 330 *4. Hilton Hotel, man knocked down on 30th floor. [Startled? overpressure too low.]
- A 8800 340 420 *4. Arroyo Grande night security guard was blown from bed by A, went outside for B, at Sam's Town.
- B 8900 340 700
- B 2900 300 1300 *4. Santiago & Vallarta Aves. all garage doors bent or broken.
- B 3400 300 900 *5. Construction foreman said he was knocked 6 ft across porch by blast.
- B 3050 300 1300 *5. In home with east-facing kitchen, glass blown across room.
- B 3600 090 1200 *5. Ben Sweet, engineer, had west facing window broken in, scattering glass across his drawing board, on west Lake Mead Blvd @ Atlantic.
- B 600 120 16k *5. Car with all windows broken and roof caved in to top of seat.
- B 4750 160 650 R4. Black Mountain radio repeater was knocked off the air.
- B 610 up 16k S7. America West, at 2000 ft AGL, felt and heard the explosion. [Obviously not overhead.]

Several PEPCON workers reported significance to three, sometimes four explosions. The Kidd Assistant Manager, Wally Cox, reported that he was knocked down three times by blasts when fleeing the fire. Since he did not note any difference between them, it may be assumed that they each packed similar overpressures. Knowing the location, yield, and relative time of the last two explosions- and his approximate location at the firsts various assumptions about his running speed allow solutions for yield and time of the first explosion, as detailed in Table 3 and Figure 4. Considering this, as well as other observations, a most reasonable interpretation results that he averaged running over irregular ground at just over 1mph, including falls. He was hit three times by about 10 kPa, and the "first" explosion was of approximately 20-t TNT equivalence and occurred two minutes before the 75-t explosion This yield may seem large, consideringthatitwasnotwidelybeardaswasthesecondblast,wbichwasloudandclearto 12 miles (19 km)with about 140-Pa overpressure. A 20-t blast would have given about 70 PL That may, however, have been Asked by windnoisefromastormwhichwasMowingwithguststol3ms⁴throughoutthe&e~ Forasmalleryieldresult,Cox would have had to run faster and farther, and yet be knocked down by significantly lower overpressures.

Several occupied automobiles were hit by 10 - 30 kPa, smashing windows and causing lacerations to passengers. One driver was wrecked by only 2.2 kPa, which knocked his Bronco onto a median and out of control. And at greater distance, one driver likened the bump of 700 Pa to a large pothole. Very dose to the 75-t explosion, the PEPCON parking lot was the scene of auto destruction quite in excess of nuclear test experience at 35 kPa (5 psi) (4). Depending on exact location, the parking lot was hit by 50 - 500 kPa, and later by 25 - 200 kPa by the more distant 250-t explosion These and other observations in Table 2 should he analyzed along a time line, in hope of d&if~ring which explosions were responsible for each of the various reported effects.

Reports of being blown several feet by blast seem mostly attributable to up to 50-kPa overpressures, although one person was knocked out by at most 9 kPa, as he was slammed into a wall. A man working on a bridge was knocked from his perch by about 5.4 kPa. Several reported being knocked down by as little as 330 kPa, which strains credibility, unless startle is counted. At any rate, with such extensive blast damage, there are several potentials for injury beyond that from flying glass.

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Table 3. First Shot Parameter Solutions from W. Cox Experience, Knocked Down Three Times.

KNOWN VALUES

Shot Sequence	1	2	3
Storage Area	C	A	B
Kidd Exit Range D (m)	346	432	564
Explosion Yield (ton TNT)	?	75	250
Shot Time 11 hr + (PDT)	?	53:35.352	57:35.356

EQUATIONS

Symbols defined in Figure 4.

$$\begin{aligned}
 X_b - X_a &= (t_b - t_a) S(\text{peed}) \\
 X_b + D_b &= (X_a + D_a) (W_b / W_a)^{1/3} \\
 X_a &= 486.025 S - 164.686 \\
 X_b &= 726.025 S - 164.686 \\
 t_a - t_b &= X_a / S \\
 W_c &= W_b (D_c / (D_b + X_b))^3 \\
 &= 250 (0.00289 X_b + 1.630)^{-3}
 \end{aligned}$$

SOME SOLUTIONS

Running Speed (mph)	(m/s)	X _a (m)	X _b (m)	t _a - t _b (sec)	(min)	W _c (t HE)	Δp (kPa)
1	0.447	52.6	159.9	117.6	2.0	27.3	12.0
2	0.894	269.9	484.4	301.8	5.0	9.0	7.5
4	1.788	704.4	1133.6	393.9	6.6	2.1	3.8
6	2.682	1138.9	1782.7	424.6	7.1	0.8	2.5

FIGURE 4. ANALYSIS OF KIDD MARSHMALLOWS ASST. MANAGER WALLY COX'S EXPERIENCE: BLOWN DOWN THREE TIMES

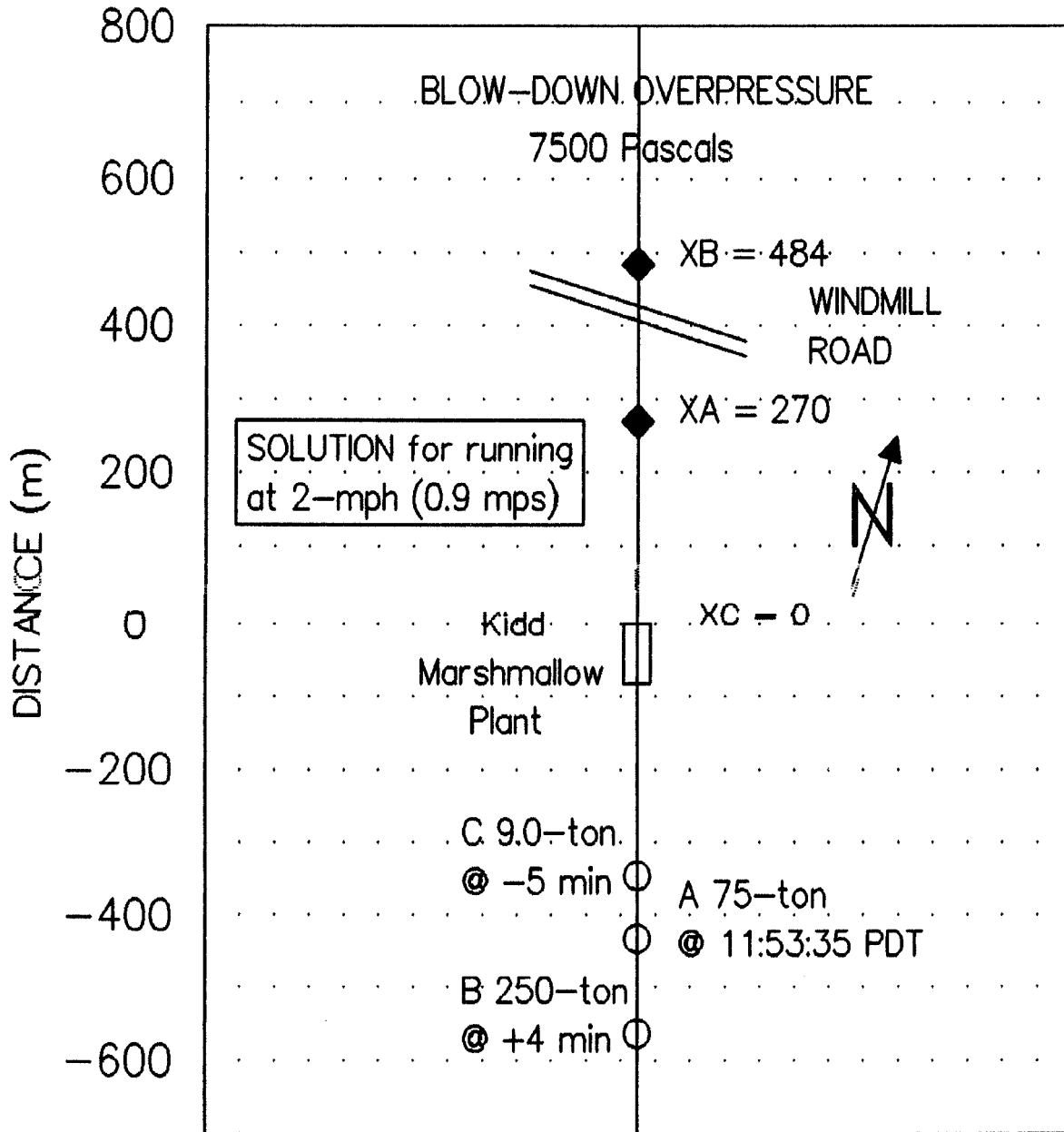


Figure 4. Analysis of Kidd Marshmallows Asst. Manager Wally Cox's Experience: Blown Down Three Times