

# **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<br>OMB No. 0704-0188                  |                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|-------------------------------------|------------------------------------------------------------------|-----------------------------------------------------|------------------------------------|
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| 1. REPORT DATE<br><b>AUG 1994</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                    | 2. REPORT TYPE                      |                                                                  | 3. DATES COVERED<br><b>00-00-1994 to 00-00-1994</b> |                                    |
| 4. TITLE AND SUBTITLE<br><b>Injuries from the PEPCON Explosion (1988) and Other Incidents</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                    |                                     |                                                                  | 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)<br><b>JWR Inc,5301 Central Avenue Suite 220,Albuquerque,NM,87108</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                    |                                     |                                                                  | 8. PERFORMING ORGANIZATION<br>REPORT NUMBER         |                                    |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                    |                                     |                                                                  | 10. SPONSOR/MONITOR'S ACRONYM(S)                    |                                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                                                  | 11. SPONSOR/MONITOR'S REPORT<br>NUMBER(S)           |                                    |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT<br><b>Approved for public release; distribution unlimited</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                    |                                     |                                                                  |                                                     |                                    |
| 13. SUPPLEMENTARY NOTES<br><b>See also ADM000767. Proceedings of the Twenty-Sixth DoD Explosives Safety Seminar Held in Miami, FL on 16-18 August 1994.</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                    |                                     |                                                                  |                                                     |                                    |
| 14. ABSTRACT<br><b>see report</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                    |                                     |                                                                  |                                                     |                                    |
| 15. SUBJECT TERMS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                    |                                     |                                                                  |                                                     |                                    |
| 16. SECURITY CLASSIFICATION OF:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     | 17. LIMITATION OF<br>ABSTRACT<br><b>Same as<br/>Report (SAR)</b> | 18. NUMBER<br>OF PAGES<br><b>14</b>                 | 19a. NAME OF<br>RESPONSIBLE PERSON |
| a. REPORT<br><b>unclassified</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | b. ABSTRACT<br><b>unclassified</b> | c. THIS PAGE<br><b>unclassified</b> |                                                                  |                                                     |                                    |

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

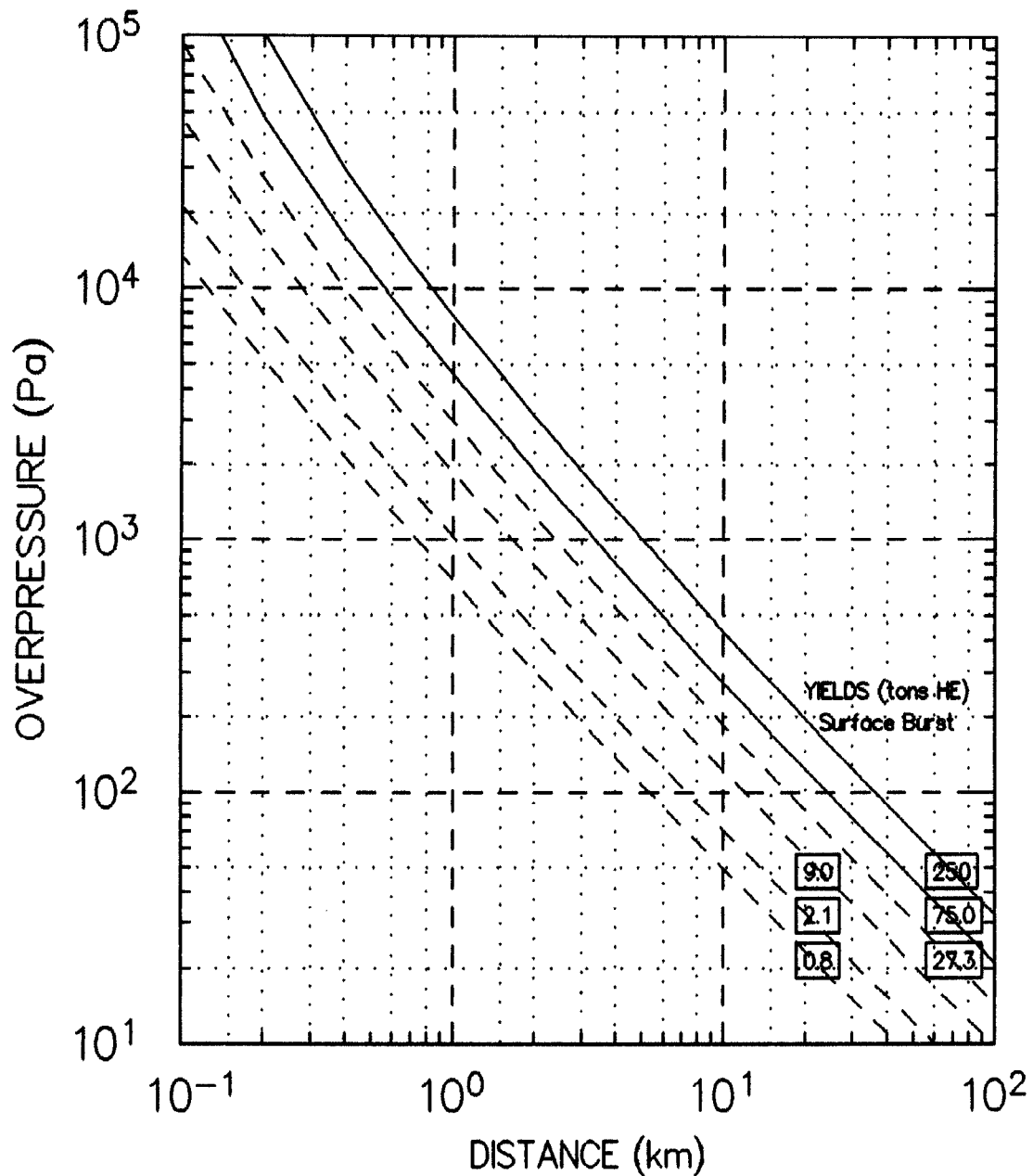


Figure 1. DNA-1981 Standard Overpressure vs Distance Curves, PEPCON Explosions.

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

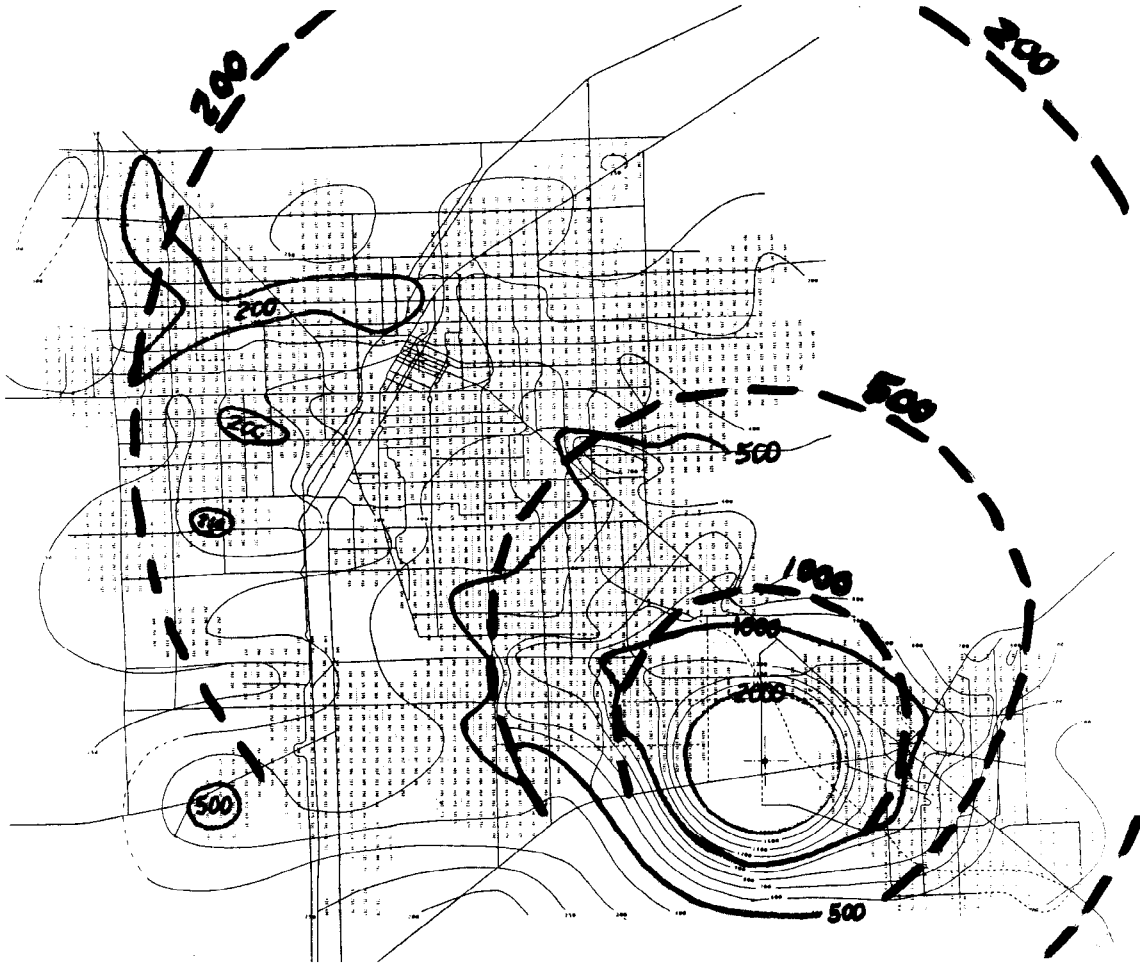


Figure 2. Airblast Isobars (Pa), PEPCON 250-ton TNT Equivalent Explosion.

Dashed - Weather-Dependent Predictions

Solid - GDM Interpretation of damage claims

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

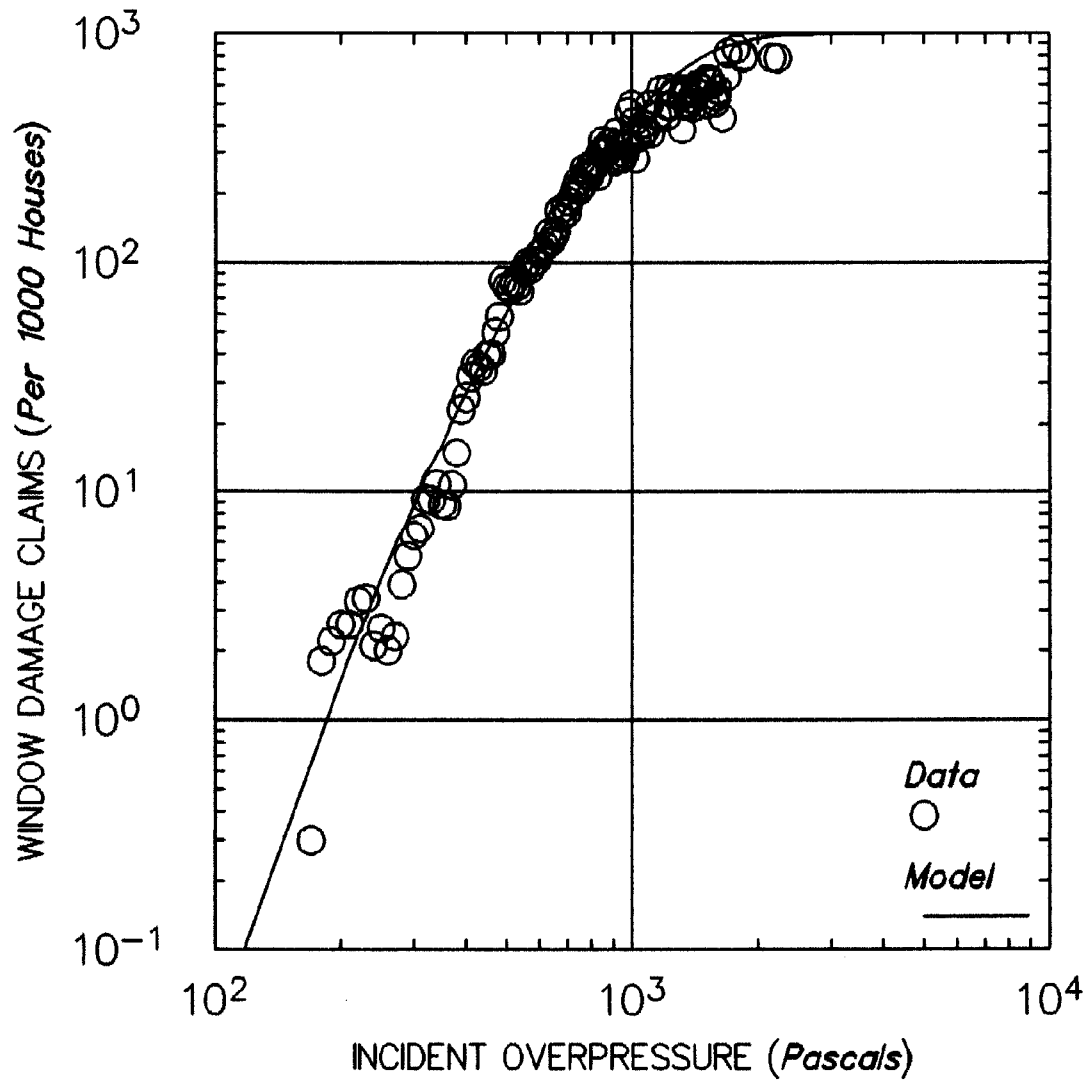


Figure 3. Window Damage Claims Versus Incident Overpressure, PEPCON 250-t TNT Equivalent Explosion.

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 injury 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<br>NUMBER | NUMBER OF<br>PERSONS | MALE OR<br>FEMALE | CLAIM<br>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<br># | NO. OF<br>PEOPLE | SEX<br>M,F | IN<br>CAR | GLASS<br>INJURY | CUTS<br>TO | INJURY<br>NATURE            | PSYCHO? | HEARING<br>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<br># | NO. OF<br>PEOPLE | SEX<br>M,F | IN<br>CAR | INJURED BY<br>DOOR GLASS | CUTS TO | INJURY<br>NATURE              | HEARING<br>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.]                                                                                                                                                                                                                                                                                                                                                                                              |
| A | 300  | 030 | 25  | 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<sup>2</sup> of 230 kft<sup>2</sup> 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 ft<sup>2</sup> 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, considering that it was not widely heard as was the second blast, which was loud and clear to 12 miles (19 km) with about 140-Pa overpressure. A 20-t blast would have given about 70 PL. That may, however, have been masked by wind noise from a storm which was moving with gusts to 13 m/s<sup>4</sup> throughout the event. For a small yield result, 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 close 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 be analyzed along a time line, in hope of determining 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.

## REFERENCES

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2. Reed, J.W., B.J. Pape, J.E. Minor, & L.C. DeHart, "Evaluation of Window Pane Damage Intensity in San Antonio Resulting from Medina Facility Explosion on November 13, 1963," Ann. N.Y. Acad. Sc., 152, 5650584, 1968.
3. ANSI (American National Standards Institute) Air blast Characteristics for Single Point Explosions in Air with a Guide to Evaluation of Atmospheric Propagation and Effects, ANSI S2.20-1983, Acoustical Society of America, New York NY, 1983.
4. Glasstone, S. and P.J. Dolan, The Effects of Nuclear Weapons Rev. Ed., U.S. Depts. of Defense and Energy, Washington DC, 1977.

**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<br>(mph) | X <sub>a</sub><br>(m) | X <sub>b</sub><br>(m) | t <sub>a</sub> - t <sub>b</sub> |       | W <sub>c</sub><br>(t HE) | Δp<br>(kPa) |
|------------------------|-----------------------|-----------------------|---------------------------------|-------|--------------------------|-------------|
|                        |                       |                       | (sec)                           | (min) |                          |             |
| 1                      | 0.447                 | 52.6                  | 117.6                           | 2.0   | 27.3                     | 12.0        |
| 2                      | 0.894                 | 269.9                 | 301.8                           | 5.0   | 9.0                      | 7.5         |
| 4                      | 1.788                 | 704.4                 | 393.9                           | 6.6   | 2.1                      | 3.8         |
| 6                      | 2.682                 | 1138.9                | 424.6                           | 7.1   | 0.8                      | 2.5         |

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

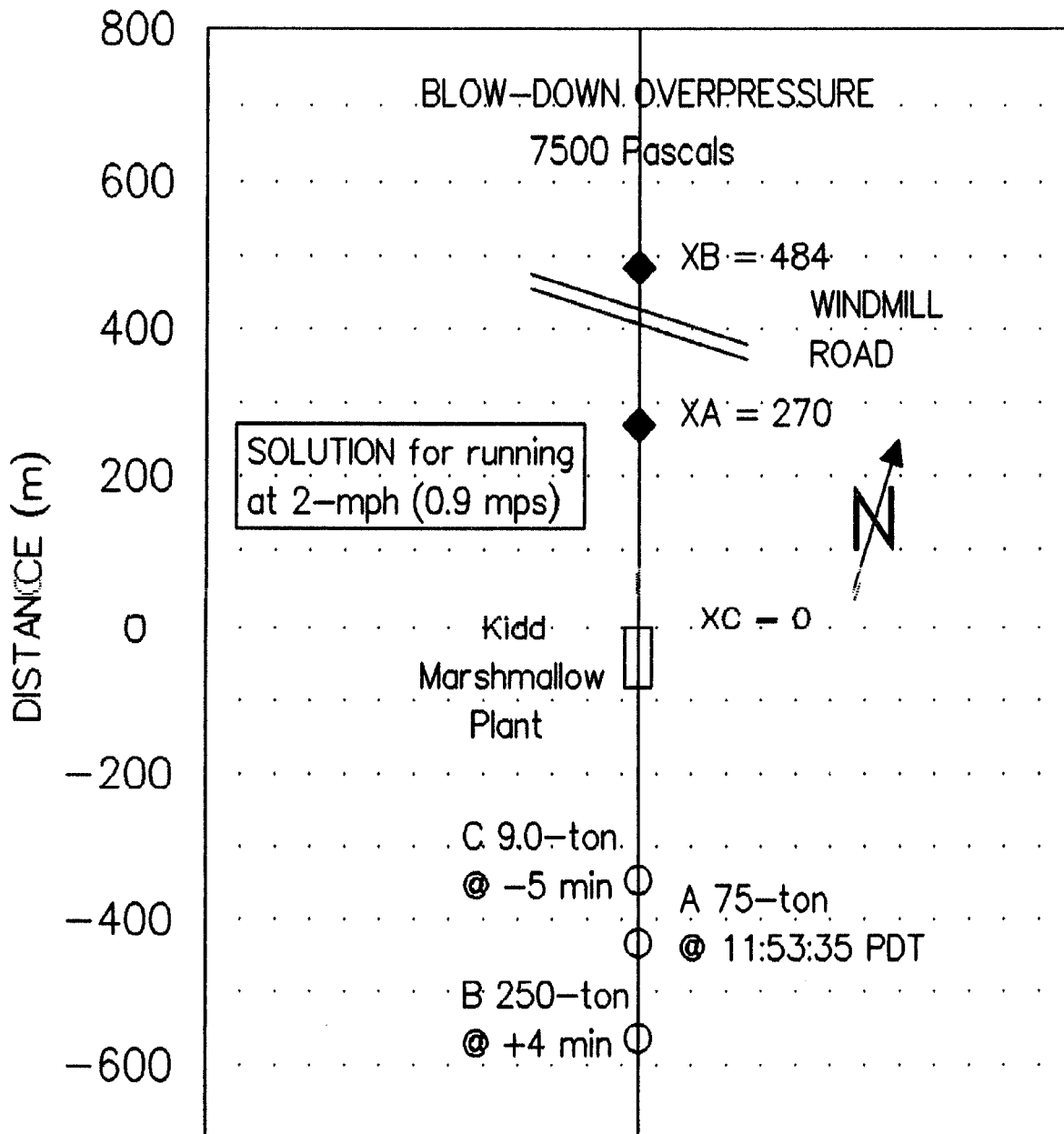


Figure 4. Analysis of Kidd Marshmallows Asst.Manager  
Wally Cox's Experience: Blown Down Three Times