Overpressure thresholds Based on TNT equivalent

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Table 1. Classification of Structural Damage Based on Blast Overpressure

Risk Damage Structures	Po (kPa)	Damage of Building Structure
RDS1 Insignificant (0.14 – ≤2 kPa)	0.14	Annoying noise (137 dB if low frequency, 10–15 Hz) [2].
	0.21	Breakage of large windows previously under stress [2].
	0.28	Loud noise (143 dB), sonic boom, glass failure [2].
	0.69	Small windows break due to pressure [2].
	1.03	Typical pressure to break glass [2].
	≤2	Accidental glass damage [1].
RDS2 Minor (>2 – ≤9 kPa)	2.07	Safe distance, 95% probability of no serious damage below this level, projectile limit, minor ceiling damage, 10% window breakage [2].
	2.76	Minor structural damage to houses [2].
	4.8	Minor structural damage to houses [2].
	6.9	Partial house collapse, uninhabitable [2].
	9	Slight distortion of coated steel frames [2].
	>2 - ≤9	Minor glass breakage and light architectural damage such as displacement of roof tiles and falling plaster [1].
RDS3 Moderate (>9 – ≤25 kPa)	13.8	Partial collapse of roof and walls [2].
	15.8	Lower limit of serious structural damage [2].

Risk Damage Structures	Po (kPa)	Damage of Building Structure
	17.2	50% of brick walls collapse [2].
	20.7	Heavy machinery (3,000 lb) slightly damaged in industrial buildings; steel frames distorted or detached from foundation [2].
	>9 - ≤25	Widespread glass shattering and significant damage to non-structural elements like doors, windows, and roofs [1].
	13.8 - 20.7	Collapse of unreinforced concrete walls or cement blocks [2].
	20.7 - ≤25	Frame-less steel panels destroyed; oil storage tanks ruptured (20.7 kPa - ≤25 kPa) [2].
RDS4 Serious (>25 – ≤40 kPa)	27.6	Light industrial structures collapse [2].
	34.5	Utility poles break; 40,000 lb hydraulic equipment slightly damaged [2].
	25 - 27.6	Frame-less steel panels destroyed; oil storage tanks ruptured (25 kPa - 27.6 kPa) [2].
	>25 - ≤40	Extensive damage to non-structural elements such as brick facades, roofs, and ceilings [1].
	34.5 - ≤40	Near-total destruction of residential houses (34.5 kPa - ≤40 kPa) [2].
RDS5 Severe (>40 – ≤55 kPa)	48.2	8–12 inch thick unreinforced brick panels fail from shear or bending [2].
	40 - 48.2	Near-total destruction of residential houses (40 kPa - 48.2 kPa) [2].
	>40 - ≤55	Heavy damage to non-structural elements leading to ceiling collapse [1].
	48.2 - ≤55	8–12 inch thick unreinforced brick panels fail from shear or bending (48.2 kPa - ≤55 kPa) [2].
RDS6 Major (>55 – ≤76 kPa)	62	Freight train cars completely destroyed [2].
	55 - 55.1	8–12 inch thick unreinforced brick panels fail from shear or bending (55 kPa - 55.1 kPa) [2].
	>55 - ≤76	Partial collapse of non-structural elements and significant damage to concrete columns [1].

Risk Damage Structures	Po (kPa)	Damage of Building Structure
RDS7 Catastrophic (>76 kPa)	68.9	Fully loaded train cars totally destroyed [2].
	2,068	Likely total damage to structures; 7,000 lb equipment displaced and severely damaged; 12,000 lb machinery still present [2].
	>76	Near-total collapse of all building elements, including heavy damage to load-bearing concrete columns [1].

Table 2. Classification of Injury Severity Based on Blast Overpressure

Risk Injury	Po (kPa)	Primary Effects	Secondary/Tertiary Effects	Conclusion
Minor Injury (<20 kPa)	<20	No serious injuries; eardrum rupture is not significant.	Glass cracking can begin around 1–1.5 kPa [4]; widespread breakage typically 2–9 kPa [1].	Primary injury is unlikely, but secondary injury risk from glass fragments remains.
Moderate Injury (20–30 kPa)	20–30	Minor contusion [1]; 1% eardrum rupture (20–30 kPa) [4].	Moderate structure damage may cause ceiling sections to fall and small objects to drop [2].	Combination of minor contusion and secondary injuries from fragments/debris.
Serious Injury (30–50 kPa)	30–50	Moderate contusion [1]; eardrum rupture probability 50% around 110 kPa [4].	Wider structural damage creates flying debris [2], which can cause fractures.	Injury severity rises due to the combined effects of the blast wave and flying debris.
Severe Injury (50–100 kPa)	50–100	Serious internal contusions and possibly fatal [1]; risk of blast-lung depends on positive-phase duration with overpressure 70 kPa at 50 ms or 140–200 kPa at 3 ms [4].	Many buildings heavily damaged; some may be totally destroyed [2], creating entrapment under rubble.	Concurrence of internal injuries and entrapment is potentially fatal.
Fatality (>100 kPa)	>100	High mortality for unprotected persons, but thresholds depend on positive-phase duration: 1% lethality 190 kPa at 50 ms or 400–500 kPa at 3 ms [4].	Total building collapse; large debris moving rapidly [2].	Fatality risk escalates where both overpressure and duration exceed thresholds.

Table 3. Classification of Process Equipment Damage Based on Blast Overpressure

Risk Damage Equipment	Po (kPa)	Impact of Process Equipment
RDE1 Insignificant (<3.45 kPa)	<3.45	No significant damage to process equipment is recorded.
RDE2 Minor (3.45 – <10.34 kPa)	3.45	Windows and gauges in both steel- and concrete-roof control houses break, and louvers on the cooling tower fall off [3].
	6.89	The steel-roof control house roof collapses and damages the switchgear, instruments in the concrete-roof control house are damaged, and the cone-roof tank roof collapses [3].
RDE3 Moderate (10.34 – <27.58 kPa)	10.34	The steel-roof control house roof collapses, the frame of the concrete-roof control house deforms, and windows and gauges in the instrument cubicle break [3].
	13.79	The concrete-roof control house roof collapses, internal parts of the cooling tower are damaged, fire-heater bricks crack, windows and gauges of the chemical reactor break, and the filter suffers debris/missile damage [3].
	17.24	The fire heater is displaced and connected pipes break [3].
	20.68	Cone-roof and floating-roof tanks uplift and become tilted, power lines in the instrument cubicle are severed, controls are damaged, and the regenerator moves so that attached piping breaks [3].
	24.13	Block walls of both steel- and concrete-roof control houses fall, the cooling-tower frame collapses, the cracking reactor moves and attached piping breaks, and pine-support frames deform [3].
RDE4 Serious (27.58 – <41.37 kPa)	27.58	The chemical reactor moves and its connected piping breaks [3].
	31.03	Internal parts of the filter are damaged, the gas-meter case is damaged, and the utilities electronic transformer suffers debris/missile damage [3].
	34.47	The fire heater overturns or is destroyed, the regenerator moves and piping breaks, structural frames deform, debris from the electric motor causes missile damage, and the blower case is damaged [3].
	37.92	The fractionation-column frame develops cracks [3].
RDE5 Severe (41.37 – <55.16 kPa)	41.37	The instrument cubicle overturns or is destroyed, piping on pine supports breaks and the frame collapses, horizontal pressure-vessel frames deform, several units move with broken pipes, and the gas-regulator utilities unit moves and its piping breaks [3].

Risk Damage Equipment	Po (kPa)	Impact of Process Equipment
	44.82	Cone-roof and floating-roof tanks uplift with large tilt, the chemical-reactor frame deforms, and the extraction column moves so that connected piping breaks [3].
	48.26	The cracking reactor moves and piping breaks, and the fractionation column overturns or is destroyed [3].
	51.71	The regenerator overturns or is destroyed, the utilities electronic transformer moves and piping breaks, and both the steam turbine and heat exchanger move so that their connected piping breaks [3].
RDE6 Major (55.16 – <82.74 kPa)	55.16	The spherical tank moves and its connected pipes break [3].
	62.05	The chemical reactor overturns or is destroyed, the electric motor moves and piping breaks, and the horizontal pressure vessel and heat exchanger overturn or are destroyed [3].
	65.5	The filter uplifts and is heavily tilted [3].
	68.95	The utilities electronic transformer and the blower overturn or are destroyed, the gas regulator controls and case are damaged, and the extraction column shifts on its foundation [3].
RDE7 Catastrophic (≥82.74 kPa)	82.74	The filter, cracking reactor, and extraction column overturn or are destroyed, steam-turbine controls are damaged, and the vertical pressure vessel and pump move with broken pipes [3].
	96.53	Steam-turbine piping breaks, the spherical tank moves and piping breaks, and the vertical pressure vessel overturns or is destroyed [3].
	110.32	The spherical tank overturns or is destroyed and the pump shifts on its foundation [3].
	137.9	The floating-roof tank roof collapses, the electric motor moves on its foundation, and the steam turbine moves on its foundation [3].

References

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This work is part of my thesis research on evaluating the consequences of explosions relative to distance for various chemical materials (AN and H_2). The objective is purely academic, serving as an initial estimation for determining safe distances in process facilities. I sincerely appreciate any feedback or constructive criticism to enhance this study, whether from a chemical engineering perspective or in terms of digital and interactive data presentation.