Quantity-Distance Assessment Session

WHAT DO QUANTITY-DISTANCES MEAN?

by Jean Gabriel GOLIGER

ABSTRACT

Quantity-Distances ensure the minimum practicable risk to life and property, including ammunition. Several kinds of QD are traditionally provided by safety manuals towards internal facilities (explosive magazines and workshops, other workshops and office buildings) and external facilities (public traffic routes, inhabited buildings, other categories of meeting places and buildings). Levels of protection against instantaneous propagation of explosion for 1.1. products, and against propagation of combustion for 1.3 products are well described. Levels of damage to persons and properties are well described from 1.1. products. They have to be precised from 1.2 and 1.3 products. This implies to define consistent levels of acceptable damage towards each category of possible exposed item.

French regulation defines six potential damage zones, separated by five (red, orange, yellow, green, blue) lines with defined decreasing potential damage. It provides a list of accepted exposed items, to be tolerated in these damage zones.

* SNPE - GTS - 91710 - VERT LE PETIT - FRANCE.
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Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18
WHAT DO "QUANTITY-DISTANCES" MEAN?

SUMMARY

- INTRODUCTION
- THE NEED
- THE FRENCH REGULATION APPROACH
- SUGGESTIONS
- CONCLUSIONS
INTRODUCTION

- QUANTITY-DISTANCE = QD

\[ QD = \text{THE MINIMUM PERMISSIBLE DISTANCE BETWEEN A POTENTIAL EXPLOSION SITE CONTAINING A GIVEN QUANTITY OF EXPLOSIVES AND AN EXPOSED SITE. IT IS BASED ON AN ACCEPTABLE RISK TO LIFE AND PROPERTY (INCLUDING AMMUNITION)} \]

THERE ARE 4 KINDS OF QD

INTER-MAGAZINE DISTANCES. EXPLOSIVES WORKSHOP DISTANCES. PUBLIC TRAFFIC ROUTE DISTANCES. INHABITED BUILDING DISTANCES.
- PES = POTENTIEL EXPLOSIVE SITE
- ES = EXPOSED SITE
- MANUALS PROVIDE QD

WHAT LEVELS OF ACCEPTABLE DAMAGES DO THESE QD IMPLY?
THE NEED

- LEVELS OF PROTECTION AGAINST INSTANTANEOUS PROPAGATION OF EXPLOSION FOR 1.1 PRODUCTS, PROPAGATION OF COMBUSTION FOR 1.3 PRODUCTS ARE WELL DESCRIBED IN MANUALS IN FUNCTION OF QUANTITIES AND DISTANCES FROM THE PES.

- LEVELS OF DAMAGE TOWARDS PERSONS AND PROPERTIES, FROM 1.1 PRODUCTS ARE WELL DESCRIBED, AS WELL.

- LEVELS OF DAMAGE FROM 1.2, 1.3 AND 1.4 PRODUCTS IN FUNCTION OF QUANTITIES AND DISTANCES ARE POORLY DESCRIBED, IN GENERAL.
EXAMPLE OF LEVELS OF DAMAGES TOWARDS PERSONS DESCRIBED BY NATO MANUAL D/258 FROM 1.1 PRODUCTS

PES = LIGHT STRUCTURE, UNBARRICADED

<table>
<thead>
<tr>
<th>CONFIGURATION</th>
<th>RECOMMENDED QD</th>
<th>EXPECTED INJURIES AT THESE QD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES/PES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QD = 8 Q 1/3</td>
<td></td>
<td>SERIOUS INJURIES WHICH MAY RESULT IN DEATH.</td>
</tr>
<tr>
<td>QD = 15 Q 1/3</td>
<td></td>
<td>NO SERIOUS INJURIES</td>
</tr>
<tr>
<td>QD = 22 Q 1/3</td>
<td></td>
<td>CAUSED BY GLASS BREAKAGE OR</td>
</tr>
<tr>
<td>QD = 22 Q 1/3</td>
<td>(Busy roads)</td>
<td>DEBRIS AND FRAG.</td>
</tr>
<tr>
<td>QD = 22 Q 1/3</td>
<td></td>
<td>POSSIBLE INJURIES CAUSED BY</td>
</tr>
<tr>
<td>QD = 44 Q 1/3</td>
<td></td>
<td>GLASS BREAKAGE OR FLYING/FALLING</td>
</tr>
<tr>
<td>QD = 44 Q 1/3</td>
<td></td>
<td>DEBRIS. POSSIBLE INJURIES</td>
</tr>
<tr>
<td>QD = 44 Q 1/3</td>
<td></td>
<td>ONLY BY GLASS BREAKAGE.</td>
</tr>
</tbody>
</table>
EXAMPLES OF LEVELS OF DAMAGE TOWARDS PERSONS DESCRIBED BY MANUALS (1.3 PRODUCTS, COMPATIBILITY GROUP C)

PES = LIGHT STRUCTURE, UNBARRICADED

<table>
<thead>
<tr>
<th>CONFIGURATION ES/PES</th>
<th>RECOMMENDED QD</th>
<th>EXPECTED INJURIES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.2 Q 1/3</td>
<td>IMMUNITY FOR PERSONNEL WITHIN THE EXPLOSIVES WORKSHOP</td>
</tr>
<tr>
<td></td>
<td>6.4 Q 1/3</td>
<td>NO DEATH, NOR SERIOUS INJURIES TO THEIR OCCUPANTS</td>
</tr>
</tbody>
</table>
USING A SNPE COMPUTER CODE "THAFT" WE HAVE TRIED TO DESCRIBE ACTUAL DAMAGES AT RECOMMENDED QD. THE COMPUTER CODE THAFT PROVIDES TWO DISTANCES:

DSR = DISTANCE WITH STATIC RECEPTOR: THE MAXIMAL DISTANCE AT WHICH A STATIC PERSON IS BURNT AT THE 2nd DEGREE, BARE SKIN.

DDR = DISTANCE WITH DYNAMIC RECEPTOR: THE MAXIMAL DISTANCE AT WHICH A DYNAMIC PERSON IS BURNT AT THE 2nd DEGREE, BARE SKIN. DYNAMIC, MEANS THAT THE PERSON IS SUPPOSED TO RUNAWAY AT 5 m/s IN THE GOOD DIRECTION AFTER A TIME OF REACTION EQUAL TO TWO SECONDS.
a) 10,000 Kg of gunpropellant in plastic bags supposed to burn in 15 s,

b) 70,000 Kg of gunpropellant in plastic bags supposed to burn in 30 s.

<table>
<thead>
<tr>
<th></th>
<th>10,000 Kg</th>
<th>70,000 Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>QD for explosives workshop</td>
<td>70 m</td>
<td>140 m</td>
</tr>
<tr>
<td>QD for inhabited buildings</td>
<td>135 m</td>
<td>265 m</td>
</tr>
<tr>
<td>ES</td>
<td>10,000 Kg</td>
<td>70,000 Kg</td>
</tr>
<tr>
<td>----</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>EXPLOSIVES WORKSHOP</td>
<td>EVEN IF THEY RUNAWAY, PEOPLE IN THE OPEN ARE BURNT AT THE 2nd DEGREE BARE SKIN</td>
<td></td>
</tr>
<tr>
<td>INHABITED BUILDING</td>
<td>EVEN IF THEY DON'T MOVE PEOPLE ARE NOT BURNT</td>
<td>IN THE OPEN, IF THEY RUNAWAY PEOPLE ARE NOT BURNT. IF THEY ARE STATIC, THEY ARE BURNT AT 2nd DEGREE, BARE SKIN</td>
</tr>
</tbody>
</table>

ACTUAL EXPECTED INJURIES AT RECOMMENDED QD FOR PEOPLE IN THE OPEN
WHAT DOES IT MEAN?

1 - FOR INHABITED BUILDINGS THE SAME QD DON'T PROVIDE CONSISTENT LEVELS OF PROTECTION FROM 1.3 PRODUCTS.

2 - WE REALIZE THAT FOR AN EXPLOSIVES WORKSHOP, PEOPLE IN THE OPEN CAN BE BURNT AT THE 2nd DEGREE, BARE SKIN, EVEN IF THEY RUNAWAY.

3 - WE REALIZE THAT FOR INHABITED BUILDINGS, PEOPLE IN THE OPEN HAVE TO RUNAWAY AND LOOK FOR A SHADOW.

FURTHER WORK MUST BE DONE ON LEVELS OF ACCEPTABLE DAMAGE FROM 1.3 PRODUCTS.
**FRENCH REGULATION APPROACH**

FRENCH REGULATION DEFINES 6 AREAS OF DECREASING LEVEL OF POTENTIAL DAMAGES TOWARDS PERSONS AND PROPERTIES DIVIDED BY 5 (RED, ORANGE, YELLOW, GREEN, BLUE) LINES.

<table>
<thead>
<tr>
<th>Z1 RED LINE</th>
<th>LETHAL INJURIES IN MORE THAN 50 % OF CASES, VERY SEVERE DAMAGES TO PROPERTIES</th>
</tr>
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<tbody>
<tr>
<td>Z2 ORANGE LINE</td>
<td>SERIOUS INJURIES WHICH MAY BE LETHAL, SEVERE DAMAGES</td>
</tr>
<tr>
<td>Z3 YELLOW LINE</td>
<td>INJURIES, MEDIUM AND SLIGHT DAMAGES</td>
</tr>
<tr>
<td>Z4 GREEN LINE</td>
<td>POSSIBILITIES OF INJURIES, SLIGHT DAMAGES</td>
</tr>
<tr>
<td>Z5 BLUE LINE</td>
<td>VERY LOW POSSIBILITY OF SLIGHT INJURY, VERY SLIGHT DAMAGE</td>
</tr>
<tr>
<td>NDZ</td>
<td>NO DANGER ZONE</td>
</tr>
</tbody>
</table>
IN FUNCTION OF THE PROBABILITY OF ACCIDENT, CLASSIFIED IN FIVE LEVELS P1 TO P5, AND OF THE NATURE OF THE POTENTIAL EXPOSED SITE, FRENCH REGULATION DESCRIBES IN A TABLE WHAT IS ACCEPTABLE OR NOT.

EXAMPLE : ES = INHABITED HOUSE

(Nota P1 = PROBABILITY FOR A STORAGE CONFIGURATION)
<table>
<thead>
<tr>
<th>Zi</th>
<th>Pi</th>
<th>INCREASING LEVEL OF PROBABILITIES OF ACCIDENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P1</td>
<td>P2</td>
</tr>
<tr>
<td>Z1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z2</td>
<td></td>
<td></td>
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<tr>
<td>Z3</td>
<td></td>
<td></td>
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<tr>
<td>Z4</td>
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<tr>
<td>Z5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NDZ</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Z1**: NOT ACCEPTABLE
- **Z2**: YELLOW LINE
- **Z3**: YELLOW LINE
- **Z4**: INHABITED ISOLATED HOUSES ONLY OR LINKED TO THE ESTABLISHMENT GREEN LINE
- **Z5**: INHABITED HOUSES EXCEPT (SEE UNDER) BLUE LINE
- **NDZ**: BUILDINGS OF GREAT HEIGHT, DENSELY INHABITED AREAS, GATHERING PLACES (CHURCHES, ....)

- **Pi** indicates the increasing level of probabilities of accidents.
- **Zi** refers to different zones with specific requirements.
- **P1** to **P5** denote varying degrees of acceptability or restrictions within each zone.
ASSOCIATED TECHNICAL CRITERIA CAN COMPLETE THE DEFINITION OF DAMAGE (EXAMPLE FROM SNPE)

- Z2 = "SERIOUS INJURIES WHICH MAY BE LETHAL"
  ----- FOR FRAGMENTS HAZARDS.

ASSOCIATED CRITERION FOR Z2 is CPL < 0.1

WHERE CPL IS THE CONDITIONAL PROBABILITY OF LEHALITY DEFINED AS THE PROBABILITY OF KILLING SOMEBODY, SUPPOSING HE IS PRESENT IN A GIVEN AREA, SUPPOSING THE EXPLOSION HAS OCCURRED, TAKING INTO ACCOUNT THE DEGREE OF LEHTALITY (DEPENDING ON ITS KINETIC ENERGY) OF EACH PROJECTION.
<table>
<thead>
<tr>
<th>LIMIT</th>
<th>DAMAGE DUE TO PROJECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>RED LINE</td>
<td>CPL = 0.5</td>
</tr>
<tr>
<td>ORANGE LINE</td>
<td>CPL = 0.1</td>
</tr>
<tr>
<td>YELLOW LINE</td>
<td>CPR = (3 \times 10^{-2})</td>
</tr>
<tr>
<td>GREEN LINE</td>
<td>CPR = (10^{-2})</td>
</tr>
<tr>
<td>BLUE LINE</td>
<td>YFR = (10^{-7})</td>
</tr>
</tbody>
</table>

CPL = CONDITIONAL PROBABILITY OF LETHALITY OF SOMEBODY *
CPR = CONDITIONAL PROBABILITY OF REACHING OF SOMEBODY *
YFR = YEARLY FREQUENCY OF REACHING OF SOMEBODY *

* SUPPOSING HE IS PRESENT ON THE LINE, SUPPOSING THE EXPLOSION HAS OCCURRED.
SUGGESTIONS

1 - WE SUGGEST THAT THE DIFFERENT MANUALS INTRODUCE THE NOTION OF COLOURED LINES WHICH WOULD MATERIALIZE HAZARDOUS ZONE LIMITS.

EXPECTED ADVANTAGES
THREE MAIN ADVANTAGES ARE EXPECTED THROUGH THIS NEW PRESENTATION OF QD. THESE ARE:

- CONSISTENCY
THE LEVEL OF POTENTIAL DAMAGES IS SIMILAR BETWEEN TWO LINES, WHATEVER IS THE HAZARD DIVISION AND THE TYPE (ABOVEGROUND OR UNDERGROUND) OF THE STORAGE.
- ACCURACY
  QUANTITY-DISTANCES MAY BE CIRCULAR, BUT, FOR EXAMPLE IN UNDERGROUND MAGAZINES, THE EFFECTS ARE MAINLY ORIENTED. LINES TO DRAW SEEM MORE APPROPRIATE TO USE THAN CIRCLES.

- SIMPLICITY
  USING THE SAME COLOURED LINES BETWEEN THE DIFFERENT COUNTRIES WOULD MAKE TECHNICAL EXCHANGES BETWEEN EXPERTS EASIER.

EXAMPLE = "IN FRANCE, ISOLATED INHABITED BUILDINGS MUST BE LOCATED BEYOND THE YELLOW LINE". THIS SENTENCE SEEMS SIMPLE.
SUGGESTIONS

2 - DEFINITIONS AND DESCRIPTIONS GIVEN BY THE MANUALS FOR HAZARD DIVISION 1.1 COULD BE A GOOD START FOR THE REFLECTION ON ACCEPTABLE DAMAGES AND TECHNICAL CRITERIA FOR 1.2 AND 1.3 PRODUCTS.
CONCLUSIONS

EXISTING QD DON'T IMPLY ALWAYS CLEAR AND CONSISTENT ACCEPTED DAMAGES.

A PROGRESS COULD BE ACHIEVED THROUGH ADOPTION OF COLOURED LINES MATERIALIZING DEFINED DAMAGE ZONES.