APPENDIX

The Nagasaki Atomic Bombing
The foremost characteristic of the physical damage caused by the Nagasaki atomic bomb was the tremendous, instantaneous destruction wreaked by the blast wind and the subsequent fires. These fires broke out simultaneously with the destruction of buildings over a wide area. The complete destruction and burning of buildings extended a distance of two kilometers beyond the hypocenter.
American naval officers look out over the Urakami valley from the grounds of Nagasaki Medical University (upper panel); The ruins of Nagasaki Medical University (lower panel). Taken on October 15, 1946 by a USS Bremerton crew member. (Courtesy of Brian Burke-Gaffney)
The ruins of Nagasaki Medical University (upper panel); Makeshift shacks in the Urakami valley (lower panel). Taken on October 15, 1946 by a USS Bremerton crew member. (Courtesy of Brian Burke-Gaffney)
The platform at Urakami Railroad Station and ruins of the Mitsubishi Nagasaki Steel Works (upper panel); The ruins of Urakami Cathedral (lower panel). Taken on October 15, 1946 by a USS Bremerton crew member. (Courtesy of Brian Burke-Gaffney)
The Nagasaki Atomic Bombing*

Circumstances of the bombing
At 11:02 a.m. August 9, 1945, two B29 bombers flew from Kumamoto north towards the west over the Shimabara peninsula and intruded from the northeast of Nagasaki city and dropped an atomic bomb at the north of the city, then flew out immediately. The atomic bomb was dropped at an altitude of 9,600 meters, and it exploded at a point approximately 500 meters above ground. On that day, it was a clear sky, also quite hot, but almost calm.

1. The energy of the atomic bomb
The energy of the plutonium bomb dropped on Nagasaki is estimated to be 21 kilotons of TNT. A huge fireball was created immediately after the explosion, an extremely powerful heat wave and radioactivity were emitted from the epicenter and the great expansion of air around the epicenter became the bomb blast. Those energy yields were estimated to be about 35% heat wave energy, nearly 50% blast energy, and the rest of about 15% radioactive energy.

2. The power of the heat wave
As explosion of the bomb occurred, the fireball reached millions of degrees Celsius at maximum and its volume rapidly expanded, then after 10 seconds, it lost brilliance. From the instant of explosion, the size and temperature of the fireball increased as follows: 0.1 milliseconds later, the diameter was about 28 m and the surface temperature was uniformly distributed at about 300,000°C; 10 milliseconds later, the diameter was about 180 m and the surface temperature was about 1,700°C; 0.3 seconds later, the surface temperature again increased to about 7,000°C; 1 second later, the diameter reached its maximum of about 280 m at 5,000°C surface temperature, and the temperature gradually diminished reaching 1,700°C by 3 seconds later. About 99% of the heat wave emitted from the fireball severely affected the ground only from 10 milliseconds to about 3 seconds after the explosion.

It was infrared rays emitted from 0.3 to 3 seconds after the explosion that caused burns on human bodies. The thermal burns on uncovered parts of the body were observed in people exposed to the bomb up to 4 km from the hypocenter. Furthermore, people who were exposed to the bomb without any shielding suffered lethal thermal burns and approximately 20 to 30% of deaths are estimated to be due to thermal burn injury.

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3. The power of the bomb blast

Hundreds of thousands of tons of impact pressure was instantly created by the explosion, and expanded air formed the bomb blast. The fringe of the blast developed as a shock wave which is a wall of high pressure air propagated at the speed of sound or faster. Ten seconds after the explosion, the shock wave reached approximately 3.7 km, and by 30 seconds, it reached about 11 km distance from the epicenter, eventually losing power.

The deaths and external injury cases caused by blast mainly came from collapsed structures and flying fragments. Within a 1.3 km radius distance from the hypocenter, casualties by blast were significant and 20% of the deaths there are considered due to the blast.

Furthermore, the damage was amplified by composite effects of heat wave, blast and secondary fires and many people burned to death under collapsed buildings.

4. The power of the radiation

In addition to the above-mentioned damages caused by heat wave, blast and secondary fires, the atomic bomb added a new type of scourge, never experienced by a conventional bomb, that of radiation exposure. Radiation itself could kill many of the people who were irradiated at greater than or equal to 4 Gy over their whole body. The atomic bomb survivors have persistently suffered mentally and physically due to composite interactions between radiation injury and thermal and external injuries.

State of damage

The damage reported by the Committee of Atomic Bomb Scientific Data Registry in July 1950 is as follows:

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>The dead</td>
<td>73,884 persons</td>
</tr>
<tr>
<td>The injured</td>
<td>74,909 persons</td>
</tr>
<tr>
<td>Number of victims</td>
<td>120,820 persons</td>
</tr>
<tr>
<td>Number of damaged houses</td>
<td>18,409 dwellings</td>
</tr>
<tr>
<td>Completely burned down houses</td>
<td>11,574 dwellings</td>
</tr>
<tr>
<td>Razed houses</td>
<td>1,326 dwellings</td>
</tr>
<tr>
<td>Partially razed houses</td>
<td>5,509 dwellings</td>
</tr>
</tbody>
</table>

\[\text{a}^{\text{The number of permanent residents whose dwellings were within 4 km radius of the hypocenter and were completely burned out or razed.}}\]
\[\text{b}^{\text{Number of dwellings within 4 km radius of the hypocenter and was about 36\% of total dwellings in the city.}}\]
\[\text{c}^{\text{Number of dwellings within 4 km radius from the hypocenter and was about 1/3 of the total dwellings in the city.}}\]
\[\text{d}^{\text{The dwellings within 1 km radius from the hypocenter were regarded as razed houses.}}\]
\[\text{e}^{\text{The dwellings between 1 to 4 km radius from the hypocenter were regarded as partially razed houses.}}\]
As of October 1, 1950, a total of 131,050 persons in Japan were noted as Nagasaki atomic bomb survivors by the supplementary survey of 1950 National Census, and the population of Nagasaki City just prior to the atomic bombing is estimated at around 210,000 persons.