

= Demon core =

The demon core was a 6 @. @ 2 @- @ kilogram ( 14 lb ) , 89 @- @ millimetre @- @ diameter ( 3 @. @ 5 in ) subcritical mass of plutonium that was involved in two criticality accidents . It briefly went supercritical in two separate accidents at the Los Alamos laboratory in 1945 and 1946 , and resulted in the acute radiation poisoning and subsequent deaths of scientists Harry Daghlia and Louis Slotin . After these incidents the spherical plutonium core was referred to as the " demon core " .

= Manufacturing and early history =

The demon core ( like the second core used in the bombing of Nagasaki ) was a solid 6 @. @ 2 @- @ kilogram ( 14 lb ) 3 @. @ 5 @- @ inch @- @ diameter ( 89 mm ) sphere . It consisted of three parts : two plutonium @- @ gallium hemispheres and a ring , designed to keep neutron flux from " jetting " out of the joined surface between the hemispheres during implosion . The core of the device used in the Trinity nuclear test at the Alamogordo Bombing and Gunnery Range in July did not have such a ring .

The refined plutonium was shipped from the Hanford Site in Washington state to the Los Alamos Laboratory ; an inventory document dated August 30 shows Los Alamos had expended " HS @- @ 1 , 2 , 3 , 4 ; R @- @ 1 " ( the components of the Trinity and Nagasaki bombs ) and had in its possession " HS @- @ 5 , 6 ; R @- @ 2 " , finished and in the hands of quality control . Material for " HS @- @ 7 , R @- @ 3 " was in the Los Alamos metallurgy section , and would also be ready by September 5 ( it is not certain whether this date allowed for the unmentioned " HS @- @ 8 " ' s fabrication to complete the fourth core ) . The metallurgists used a plutonium @- @ gallium alloy , which stabilized the  $\delta$  phase allotrope of plutonium so it could be hot pressed into the desired spherical shape . As plutonium was found to corrode readily , the sphere was then coated with nickel .

On August 10 , Major General Leslie R. Groves , Jr . , wrote to General of the Army George C. Marshall , the Chief of Staff of the United States Army , to inform him that :

The next bomb of the implosion type had been scheduled to be ready for delivery on the target on the first good weather after August 24th , 1945 . We have gained 4 days in manufacture and expect to ship the final components from New Mexico on August 12th or 13th . Providing there are no unforeseen difficulties in manufacture , in transportation to the theatre or after arrival in the theatre , the bomb should be ready for delivery on the first suitable weather after August 17th or 18th .

Marshall added an annotation , " It is not to be released on Japan without express authority from the President " , as President Harry S. Truman was waiting to see the effects of the first two attacks . On August 13 , the third bomb was scheduled . It was anticipated that it would be ready by August 16 to be dropped on August 19 . This was pre @- @ emptied by Japan 's surrender on August 15 , 1945 , while preparations were still being made for it to be couriered to Kirtland Field . The third core remained at Los Alamos .

= First incident =

The core , assembled , was designed to be at " -5 cents " , or 5 percent below critical mass . In this state it takes but a small amount of additional criticality @- @ enhancing factors to cause the core to become supercritical , and then prompt critical , " a transient @- @ state of extremely rapid power increase " . Fortunately these factors are not common in the environment ; they are circumstances like the compression of the solid metallic core  $\gamma$  which would eventually be the method used to explode the bomb , the addition of more nuclear material or provision of an external reflector which would reflect outbound neutrons back into the core . The experiments conducted at Los Alamos leading to the two fatal accidents were designed to guarantee that the core was indeed close to the critical point by arranging such reflectors and seeing how much ( or little ) neutron reflection was required to approach supercriticality .

On August 21 , 1945 , the plutonium core produced a burst of neutron radiation that led to Harry

Daghlian 's death . Daghljan , a physicist , made a mistake while performing neutron reflector experiments on the core . He was working alone ; a security guard , Private Robert J. Hemmerly , was seated at a desk 10 to 12 feet ( 3 to 4 m ) away . The core was placed within a stack of neutron @-@ reflective tungsten carbide bricks and the addition of each brick moved the assembly closer to criticality . While attempting to stack another brick around the assembly , Daghljan accidentally dropped it onto the core and thereby caused the core to go well into supercriticality , a self @-@ sustaining critical chain reaction . Despite quick action in moving the brick off the assembly , Daghljan received a fatal dose of radiation . He died 25 days later from acute radiation poisoning .

= = Second incident = =

On May 21 , 1946 , physicist Louis Slotin and seven other Los Alamos personnel were in a Los Alamos laboratory conducting another experiment to verify the exact point at which a subcritical mass ( core ) of fissile material could be made critical by the positioning of neutron reflectors . Slotin , who was leaving Los Alamos , was showing the technique to Alvin C. Graves , who would use it in a final test before the Operation Crossroads nuclear tests scheduled a month later at Bikini Atoll . It required the operator to place two half @-@ spheres of beryllium ( a neutron reflector ) around the core to be tested and manually lower the top reflector over the core via a thumb hole on the top . As the reflectors were manually moved closer and farther away from each other , scintillation counters measured the relative activity from the core . Allowing them to close completely could result in the instantaneous formation of a critical mass and a lethal power excursion . Under Slotin 's unapproved protocol , the only thing preventing this was the blade of a standard straight screwdriver , manipulated by the scientist 's other hand . Slotin , who was given to bravado , became the local expert , performing the test on almost a dozen occasions , often in his trademark blue jeans and cowboy boots , in front of a roomful of observers . Enrico Fermi reportedly told Slotin and others they would be " dead within a year " if they continued performing it .

On the day of the accident , Slotin 's screwdriver slipped outward a fraction of an inch while he was lowering the top reflector , allowing the reflector to fall into place around the core . Instantly there was a flash of blue light and a wave of heat across Slotin 's skin ; the core had become supercritical , releasing an intense burst of neutron radiation estimated to have lasted about a half second . Slotin quickly twisted his wrist , flipping the top shell to the floor . The heating of the core and shells stopped the criticality within seconds of its initiation , while Slotin 's reaction prevented a recurrence and ended the accident . The position of Slotin 's body over the apparatus also shielded the others from much of the neutron radiation , but he received a lethal dose of 1 @,@ 000 rad ( 10 Gy ) neutron / 114 rad ( 1 @.@ 14 Gy ) gamma in under a second and died nine days later from acute radiation poisoning . The nearest person to Slotin , Graves , who was watching over Slotin 's shoulder and was thus partially shielded by him , received a high but non @-@ lethal radiation dose . Graves was hospitalized for several weeks with severe radiation poisoning and developed chronic neurological and vision problems as a result of the exposure . He died 20 years later of a heart attack . This heart attack may have been caused by hidden complications from radiation exposure , but its cause could also have been genetic , as his father had died from the same cause .

There have been five studies done of the amount of radiation each person involved received in the accident ; these are the latest , dated 1978 , from a table in this reference :

Two machinists in another part of the building were not treated : Paul Long and another , unidentified .

After these incidents the core , originally known as " Rufus " , was referred to as the " demon core " . Hands @-@ on criticality experiments were stopped , and remote @-@ control machines were designed by Schreiber , one of the survivors , to perform such experiments with all personnel at a quarter @-@ mile distance .

= = Operation Crossroads = =

The core was intended to be used in the Operation Crossroads nuclear tests , but after the criticality

accident , time was needed for its radioactivity to decline . It was therefore scheduled for the third test of the series , provisionally named Charlie , but this was cancelled due to the unexpected level of radioactivity after the underwater Baker test and the inability to decontaminate the target warships . It was later melted down and the material reused in another core .