**Explosion of the Grenelle gunpowder factory**

**August 31, 1794**

**Paris - [Seine]**

**France**

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**THE INSTALLATIONS IN QUESTION**

**Geographic location**

In 1860, the City of Paris annexed two communities, thus creating the XV district [7]:

- **Grenelle**
  Grenelle, an essentially industrial city roughly 30-year olds old, had a population of 20,000, most of whom had come from the Greater Paris area.

- **Vaugirard**
  A small labourer village for six centuries, Vaugirard had witnessed wars, famines and epidemics, followed by a relatively prosperous period during which country homes of Parisians and market gardens flourished.

**History of the site** [8]

Today, the "Château de Grenelle", as it is designated on XVII and XVIII century plans, would be located in Paris' XV district, between place Dupleix and rue Desaix. The manor house included a farm and nearly 115 hectares of land. During the reign of Louis XIII, it became the country home of the Count of Tréville, Captain of the King's musketeers, while the neighbouring farm of equal size belonged to the Canons of Sainte-Geneviève du Mont. In 1751, the French government purchased the property to generate income for the Military Training School. For more than ten years, the castle was used as the engineering offices of the architect Jacques-Ange Gabriel, then the Convention installed a gunpowder factory there. The gunpowder storage facility continued to operate until 1820, when the military gymnasium of Colonel Amoros took over the grounds. The last vestiges of the castle disappeared in 1860 with the construction of cavalry barracks that has just recently been demolished.

![Figure 1 – Grenelle Castle](http://www.paris15histoire.com/chateau.html)

*Drawing by Sébastien Leclerc in practical geometry by Alain-Manneson-Malet, 1702, Volume III*
On February 26, 1794, Lazare Carnot, the head of military affairs for the Comité de Salut Public (Committee of Public Safety), and Pierre-Louis Prieur, Member of the Convention and the Comité de Salut Public, designated Jean-Antoine Chaptal to oversee the manufacture of gunpowder at the Grenelle site. Jean-Antoine Chaptal was also Professor of Chemistry at the Medical School. The new production methods that he recommended increased daily production of potassium nitrate from 8 to 35,000 pounds\(^1\) (~3.7 to 16.3 t) [5].

**THE ACCIDENT, ITS BEHAVIOUR, EFFECTS AND CONSEQUENCES**

**The accident** [2, 5, 6, 11]

On August 31, 1794, at 7.15 am, **65,000 pounds (~30.2 t)** [5] or **150 t** [10] of powder, depending on the sources, exploded in the powder store of Château de Grenelle, located near the Military Training School. Based on the direction that the severed trees had fallen and the demolished buildings, the explosion appears to have been initiated in the Liberté graining machine.

The day before, 50,000 pounds (~23.3 t) of powder was sent to the outlying areas. Two days earlier, 100,000 lbs. (~46.5 t) was shipped from the powder store. Over the last 3 months, there had not been such a small quantity of power stocked at the gunpowder factor as at the time of the explosion.

The blast created by the explosion was heard all the way to Fontainebleau.

The rescue personnel attended to the injured and removed hundreds of victims from the rubble. The Charité and Gros-Caillou hospitals were overwhelmed by the massive arrival of the injured. At 11 am, all those injured in the blast had received first aid.

The police administration was in charge of monitoring public establishments, in particular. The Committee of Public Safety, responsible for monitoring the arsenal and prisons, secured Meudon and the stocks of powder, potassium nitrate and sulphur that had been spared in the explosion.

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\(^1\) A unit of mass which varies, depending on the region, between 380 and 550 grams (Le Petit Robert, version 1.2, 1996)
The consequences [2, 5, 6, 11]

The explosion caused considerable property damage. The blast shook homes in the surrounding area, cracked bridges and broke the seals on the underground doors of the Observatory.

The catastrophe resulted in the death of more than 1,000 people. The health officers ordered hospices to open their doors to the impoverished victims.

**Figure 3** – Engravings illustrating the explosion
European scale of industrial accidents

Even though the European scale of industrial accidents was created two centuries after the explosion of the Grenelle gunpowder factory, it is used here to characterise the accident.

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the "SEVESO" directive, the accident can be characterised by the following 4 indices, based on the information available.

The parameters that comprise these indices and the corresponding rating method are indicated in the appendix hereto and are available at the following address: [http://www.aria.ecologie.gouv.fr](http://www.aria.ecologie.gouv.fr)

![indices](image)

The 30.2 t or 150 t of black powder that exploded represents 60.4 to 300% of the corresponding Seveso threshold (50 t – explosive substances classified in a division other than 1.4 as per the European Agreement Concerning the International Carriage of Dangerous Goods (ADR) (United Nations)), which equals level 5 of the "quantities of dangerous substances" rating per parameter Q1 (Q1 between 1 and 10 times the threshold).

As the effects of the explosion had not been characterised and windows were broken at distances less than 300 m, parameter Q2 was given a rating of 1.

The overall "dangerous materials released" rating is thus 5.

Three parameters are involved in determining the level of the "Human and social consequences" rating: H3, H4 and H6.
- Level 6 of parameter H3 characterises the thousands of deaths (H3 > 50).
- Parameter H4 reaches level 1 by default: the number of seriously injured is unknown.
- Parameter H6 is 2 by default: the number of third parties without shelter or unable to work is unknown.

As a result, the overall "Human and social consequences" rating is 6.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

New working methods enabled daily production capacity to be increased. The Director of the Grenelle powder manufacturing operation, Jean-Antoine Chaptal, had continuously warned the Committee of Public Safety that the rapid increase in production was not without major risk. The 2,000 labourers, crowded into the workshop, manufactured black powder in an overheated atmosphere without any protective measures whatsoever. The catastrophe on the morning of August 31, 1794 was thus foreseeable. [5, 6]

DEVELOPMENT OF THE BLACK POWDER MANUFACTURING OPERATION

While the composition of black powder has changed very little over the centuries, its production techniques have undergone constant development. As a precaution, the sulphur and charcoal were ground separately until a homogenous powder was obtained. The potassium nitrate (saltpetre) was added only at the end, in the presence of water (1.5 l of water for 10 kg of powder). Additional water was added regularly to compensate for losses due to evaporation. The grinding and mixing were performed using pestles, very similar to tools used in metallurgy, which are placed into movement by hydraulic wheels equipped with cams. These powder making facilities were called "powder mills".

In France, during the revolutionary period and the First Empire, the need for powder was such that more expeditious albeit more dangerous means were favoured: the workers ground the ingredients by hand in rotating casks partly filled with bronze balls (marbles). The manufacturing techniques continued to improve and evolve over the centuries. [4]
ACTIONS TAKEN

Jean-Antoine Chaptal was not held responsible for this deadly explosion [5].

The report compiled by Treilhard on behalf of the Committees of Public Health and Safety on the Grenelle gunpowder factory explosion (meeting of the 15th Fructidor of Year II of the Republic) stipulates that certain measures be implemented [2]:

- fabrication of powder in several locations (powder mill) and in locations far from all habitation, thus reducing quantities and thus the risk at the source,
- replacement of labourers by new, recently developed "mechanisms",
- improvement of the quality of the substance produced.

LESSONS LEARNED

This industrial catastrophe appears to have helped to define the foundations of our legislation concerning Classified Installations and Environmental Protection based on the principle of using techniques that are economically acceptable and respect of the sensitivity of the environment and surrounding region. In this case, the lessons learned from the explosion at the Grenelle powder works were:

- the use of procedures requiring little human interaction,
- and installations far from areas of housing.

Issued by the Committee of State, the Imperial Decree of October 15, 1810, relative to “manufacturing facilities and workshops that produce offensive or objectionable odours” [3], stipulates that these establishments cannot "be created without the permission of the administrative authority" and shall be divided into three classes [9, 10]:

- The first class concerns "facilities which must be located far from private housing". Permission for establishments of this class is granted in certain conditions by decree issued by the Committee of State.
- The second applies to "facilities whose location away from housing is not strictly necessary, although is subject to confirmation that the operations conducted do not discomfort the landowners of the surrounding area, or cause them damage". The implementation of these establishments requires prefectural approval, by the advice of the sub-prefects.
- The third corresponds to establishments "that can be located near housing areas without problem, although are subject to monitoring by the police". Permission to create these establishments is granted by the sub-prefect, by the advice of the mayors.

Figure 4 - Example of a powder mill located in the northern part of the island, near what is now the Chaussée de Banlève – Toulouse.

Plan Jouvin de Rochefort, vers 1678, détail. Musée Paul Dupuy
http://www.culture.gouv.fr/culture/inventai/itiinv/ramier/Htm/edifices/poudre/poudr1.htm

Figure 5 – Ancient statutory instruments
http://fondation-calvet.org/habillages/images/livres.jpg

This imperial decree, which forms the initial foundations of a specific nomenclature, is completed by the order of January 14, 1815 which outlines the regulations governing manufacturing facilities, establishments and workshops that produce offensive or objectionable odours, and extends the information memorandum of the commodo incommodo procedure to 2nd class establishments [9].
Nowadays in France, the storage of explosive or pyrotechnic products, including fireworks, is governed by specific regulations which establish the technical specifications that an operator must respect to prevent accidents and ensure the protection of employees, the general public and the environment [1].

In France, large explosive product storage facilities are subject to legislation relative to texts governing installations classified for environmental protection [1].

More recently, section 1311 of the nomenclature of installations classified for environmental protection specifies the declaration procedures to which the establishment is subject, according to the quantities of powders, explosives and other explosive products stored on site.

**Table 1 – Section No. 1311 – Storage of powders and explosives / Section modified by decree No. 99-1220 of December 28, 1999 [3]**

<table>
<thead>
<tr>
<th>Powders, explosive and other explosive products (storage of):</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The total quantity of active material likely to be present in the installation:</td>
<td></td>
</tr>
<tr>
<td>1. Greater than 10 t</td>
<td>AS (1)</td>
</tr>
<tr>
<td>2. Greater than or equal to 2 t, but less than or equal to 10 t</td>
<td>A (1)</td>
</tr>
<tr>
<td>3. Greater than or equal to 500 kg, but less than 2 t</td>
<td>A (1)</td>
</tr>
</tbody>
</table>

(1) A: authorisation; D: declaration; S: authorisation with public easement. (2) Radius expressed in kilometres.

The authorisations with public easement enable a security perimeter to be established for urban development purposes within the commune(s) concerned by the risks, and foresees compensation to adjacent land owners aggrieved by the requirements. This compensation is borne by the warehouse operator [1].

Other texts are also applicable: notably, decree 90-153 establishing a prefectoral certification for explosive warehouses, decree 90-897 which classifies fireworks from K1 to K4 according to their dangerousness, decree 79-846 issued as per Labour Regulations, and the interministerial order of September 26, 1980 [1].
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APPENDIX

REPORT COMPILED ON BEHALF OF THE COMMITTEES ON PUBLIC HEATH AND SAFETY ON THE GRENELLE POWDER FACTORY

CONVENTION NATIONALE

RAPPORT

AU NOM DES COMITÉS DE SALUT PUBLIC ET DE SÉCURITÉ GÉNÉRALE,

Sur l'explosion de la pouderie de Grenelle,

par TAILLARD,

Dans le lointain du 15e arrondissement, un 2e de la République familier aux indépendants.

Lecture par ordre de la Connaissance Nationale.

U a le jour de devoir réitérer à tous les auditeurs d'abord, ce qui nous représente la fâcheuse déclaration d'un député de la République, qui a été dénoncé à la presse, après avoir été réprimandé par le président de la République.

La Convention d'abord le 18 septembre dernier, a été réunie pour discuter de la question de l'explosion, qui a eu lieu à Grenelle, le 8 septembre dernier.

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La Convention a été réunie pour discuter de la question de l'explosion, qui a eu lieu à Grenelle, le 8 septembre dernier.
IMPERIAL DECREE OF OCTOBER 15, 1810 RELATIVE TO MANUFACTURING FACILITIES AND WORKSHOPS WHICH PRODUCE OFFENSIVE OR OBJECTIONABLE ODOURS

NAPOLEON, Emperor of the French, King of Italy, Protector of the Confederation of the Rhine, Mediator of the Swiss Confederation;

On the report by our Minister of the Interior;

In view of the complaints filed by various individuals against the manufacturing facilities and workshops whose operations produce offensive or objectionable odours;

The report compiled on these establishments by the chemical section of the Institute’s physical sciences and mathematics department;

Recognised by our Committee of State;

We have DECREED AND DECREE as follows:

Article 1 of the decree of October 15, 1810

Effective upon publication of this decree, manufacturing facilities and workshops which produce offensive or objectionable odours require permission from the administrative authority to operate: these establishments shall be divided into three classes.

The first shall concern those which must be located far from private housing.

The second applies to manufacturing facilities and workshops whose location away from housing is not strictly necessary, but subject to confirmation that the operations conducted do not discomfort the landowners of the surrounding area, or cause damage”.

The third corresponds to establishments that can be located near housing areas without problem, although are subject to monitoring by the police.
Article 2 of the decree of October 15, 1810
The permission required to establish manufacturing facilities or workshops of the first category shall be granted, with the formalities outlined hereinafter, by a decree established by our Committee of State. Permission regarding establishments of the second class shall be granted by the prefects, by the advice of the sub-prefects. Permissions for the operation of establishments located in the last class shall be granted by the sub-prefects, who will seek council with the mayors.

Article 3 of the decree of October 15, 1810
The permission for manufacturing facilities of the first class shall only be granted based on the following formalities:

The authorisation request shall be submitted to the prefect, and posted, by order, in all communities within a radius of five kilometres.

Within this period, any individual may oppose the decision. The mayors of the communes concerned shall have the same right.

Article 4 of the decree of October 15, 1810
If opposition is voiced, the prefectoral council shall give its notice, subject to the decision of the Committee of State.

Article 5 of the decree of October 15, 1810
If no opposition is voiced, permission shall be granted, if justified, based on the opinion of the prefect and the report of the Minister of the Interior.

Article 6 of the decree of October 15, 1810
Concerning soda fabrication facilities, or if the facility must be established in the jurisdiction of the customs authorities, our customs director shall be consulted.

Article 7 of the decree of October 15, 1810
Authorisation to operate manufacturing facilities and workshops of the second category shall be granted only after the following formalities have been fulfilled.

The entrepreneur shall first submit his request to the sub-prefect of his district, who will forward it to the mayor of the commune where the establishment is to operate, charging him to address questions relative to the commodo and incommodo decree. Once these procedures were complete, the sub-prefect drew up an order that was sent to the prefect. The prefect would then render a decision, subject to recourse to our Committee of State by all interested parties.

If opposition is voiced, it shall be ruled upon by the prefectoral council, subject to recourse to the Committee of State.

Article 8 of the decree of October 15, 1810
The manufacturing facilities or establishments placed in the third category may not operate without the permission of the Chief of Police, in Paris, and without the permission of the mayor in other cities.

If there are claims against the decision made by the Chief of Police or the mayors, relative to a request for operation by manufacturing facility or workshop, they shall be judged by the prefectoral council.

Article 9 of the decree of October 15, 1810
The local authority shall indicate the location where the manufacturing facilities or workshops of the first category may operate, and shall specify its distance from private dwellings. Any individual erecting
constructions in the immediate area of these manufacturing facilities and workshops once their implantation has been granted, shall no longer be able to request their removal.

**Article 10 of the decree of October 15, 1810**

The triple breakdown of facilities that produce offensive or objectionable odours shall be performed in accordance with the table in the appendix hereto. It shall be used as a guide when ruling on requests relative to the installation of these establishments.

**Article 11 of the decree of October 15, 1810**

The provisions of this decree shall not be applied retroactively: in consequence thereof, all establishments that are currently active shall continue to operate freely, excluding damages, for which the entrepreneurs may be liable, that prejudicially affect the property of their neighbours; damages shall be arbitrated by the courts.

**Article 12 of the decree of October 15, 1810**

However, in the event of serious consequences for public health, crops, or general interest, the manufacturing facilities and workshops of the first category which cause them may be removed, under the authority of a decree by the Committee of State, after having heard the local police, consulted the prefects, and heard the defence of the manufacturers.

**Article 13 of the decree of October 15, 1810**

The establishments mentioned in article 11 shall no longer benefit from this advantage upon transfer to another location, or they shall shut down their operations for a period of six months. In either case, they shall be considered as newly-created establishments and may resume activity after having once again obtained permission, if required.

**Article 14 of the decree of October 15, 1810**

Our Ministers of the Interior and the police, are responsible for the enforcement of this decree, within the scope of their duties, which shall be included in the collection of laws.

NAPOLEON

By the Emperor:

Minister Secretary of State,

H. B. DUC DE BASSANO
**APPENDIX:**

**NOMENCLATURE OF MANUFACTURING FACILITIES, ESTABLISHMENTS AND WORKSHOPS PRODUCING AN OFFENSIVE OR OBJECTIONABLE ODOR, THE INSTALLATION OF WHICH CANNOT TAKE PLAT WITHOUT AUTORIZATION FROM THE ADMINISTRATIVE AUTHORITY**

Establishments and Workshops that can no longer operate near private dwellings, and whose creation requires authorisation from the Minister of the Interior.

<table>
<thead>
<tr>
<th>Establishment Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starch manufacturers</td>
<td>Lime-burning kilns</td>
</tr>
<tr>
<td>Explosives manufacturers</td>
<td>Hog farms</td>
</tr>
<tr>
<td>Prussian blue</td>
<td>Sewage powder</td>
</tr>
<tr>
<td>Tripe houses</td>
<td>Hemp retting</td>
</tr>
<tr>
<td>Purified mineral coal</td>
<td>Ammonium chloride</td>
</tr>
<tr>
<td>Purified mineral coal</td>
<td>Artificial soda</td>
</tr>
<tr>
<td>Scavengers</td>
<td>Taffeta and varnished cloth</td>
</tr>
<tr>
<td>Glue</td>
<td>Slaughterhouses</td>
</tr>
<tr>
<td>Musical instrument string</td>
<td>Carbonised sod</td>
</tr>
<tr>
<td>Linen cloth manufacturers</td>
<td>Tripe processors</td>
</tr>
<tr>
<td>Rendering works</td>
<td>Scalding vats</td>
</tr>
<tr>
<td>Etching, sulphuric acid, etc.</td>
<td>Patent leathers</td>
</tr>
<tr>
<td>Brown tallow</td>
<td>Paperboard makers</td>
</tr>
<tr>
<td>Menagerie</td>
<td>Varnish manufacturers</td>
</tr>
<tr>
<td>Minium</td>
<td>Neat's foot or horn oil</td>
</tr>
<tr>
<td>Gypsum kilns</td>
<td></td>
</tr>
</tbody>
</table>

Establishments and workshops whose location away from housing is not strictly necessary, but subject to confirmation that the operations conducted do not discomfort the landowners of the surrounding area, or cause damage. Prefectoral authorisation is required for these establishments to operate.

<table>
<thead>
<tr>
<th>Establishment Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceruse</td>
<td>White tallow</td>
</tr>
<tr>
<td>Candlesticks</td>
<td>Ivory black</td>
</tr>
<tr>
<td>Curriers</td>
<td>Lamp black</td>
</tr>
<tr>
<td>Blanket manufacturers</td>
<td>Lead works</td>
</tr>
<tr>
<td>Green hide depots</td>
<td>Lead shot</td>
</tr>
<tr>
<td>Brandy distillery</td>
<td>Dissection halls</td>
</tr>
<tr>
<td>Metal foundries</td>
<td>Tobacco manufacturers</td>
</tr>
<tr>
<td>Refining of metals in a cupola furnace</td>
<td>Silk oilcloths</td>
</tr>
<tr>
<td></td>
<td>Cow barns</td>
</tr>
</tbody>
</table>
Establishments or workshops which can operate near private dwelling without problem, requiring only permission from the Sub-Prefect.

<table>
<thead>
<tr>
<th>Establishment</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alum</td>
<td>Printing characters</td>
</tr>
<tr>
<td>Buttons</td>
<td>Metal gilders</td>
</tr>
<tr>
<td>Breweries</td>
<td>Wallpapers</td>
</tr>
<tr>
<td>Wax producers</td>
<td>Soap manufacturers, etc.</td>
</tr>
<tr>
<td>Parchment and starch adhesive</td>
<td>Vitrails</td>
</tr>
<tr>
<td>Transparent horns</td>
<td></td>
</tr>
</tbody>
</table>

Certified correct:

Minister Secretary of State,

H. B. DUC DE BASSANO