Abel Test

This test on chemical stability was proposed by *Abel* in 1875. The test parameter determined is the time after which a moist potassium iodide starch paper turns violet or blue when exposed to gases evolved by one gram of the explosive at 180°F (82.2 °C).

In commercial nitroclycerine explosives, for example, this coloration only develops after 10 minutes or more. In a more sensitive variant of the method, Zinc iodide – starch paper is employed.

The *Abel* test is still used in quality control of commercial nitrocellulose, nitroclycerine and nitroglycol, but is currently no longer employed in stability testing of propellants.

Acceptor*)

Empfängerladung; charge réceptrice

A charge of explosives or blasting agent receiving an impulse from an exploding → *Donor* charge.

Acremite

This is the name given by the U.S. inventor *Acre* to his mixture of about 94 % ammonium nitrate with 6 % fuel oil. This mixture was at first prepared in a primitive manner by the users themselves to obtain a very cheap explosive for open pit mining under dry conditions. As → *ANFO* the material has widely displaced the conventional cartridged explosives.

Actuator

Mechanical device operated by a solid propellant.

Adiabatic

Processes or phenomena assumed to occur in a closed system without energy exchange with the surroundings.

adiabatic flame temperature

The temperature obtained by thermodynamics calculations for the products of combustion of energetic materials neglecting energy loss to the surroundings.

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* Text quoted from glossary.

isobaric adiabatic flame temperature

Adiabatic flame temperature attained under constant pressure conditions.

isochoric adiabatic flame temperature

Adiabatic flame temperature attained under constant volume conditions

adiabatic temperature

The temperature attained by a system undergoing a volume or pressure change in which no heat enters or leaves the system.

Adobe Charge

Auflegerladung; pétardage

Synonymous with → *Mud Cap*

ADR

Abbreviation for "Accord Européen Relatif au Transport des Marchandises Dangereuses par Route" (European Agreement Concerning the international Carriage of Dangerous Goods by Road). It is based on the Recommendations on the Transport of Dangerous Goods Model Regulations (United Nations).

Aerozin

A liquid fuel for rocket engines, which is composed of 50 % anhydrous hydrazine and 50 % *asym*-dimethylhydrazine.

AGARD

Abbreviation for the NATO Advisory Group for Aeronautical Research and Development.

Airbag

Gasgenerator

The basic idea of the airbag as a passive restraint system in a motor vehicle was already patented fort he first time in 1951 in Germany. However, it takes nearly 20 years for start of development on two basic types of generators. Both types are manufactured nearly exclusively in series production and were built in cars starting 1975. Mainstream applications of restraint systems in almost every car started in 1990.

The first type is based on pure *pyrotechnic* for gas generation to fill the bag with hot gas. The second type is also known as *hybrid* design, where a gas is stored under high pressure. It acts as cold gas source since there is no need for this gas to be generated pyrotechnically. Most types of *hybrid* generators have a pyrotechnic heating charge to prevent excess cooling to undesired low temperatures. Both basic types of gas generator for airbags are used for driver, passenger, side and head airbags. Their diagrammatic construction is shown in Fig. 1 and Fig. 2.

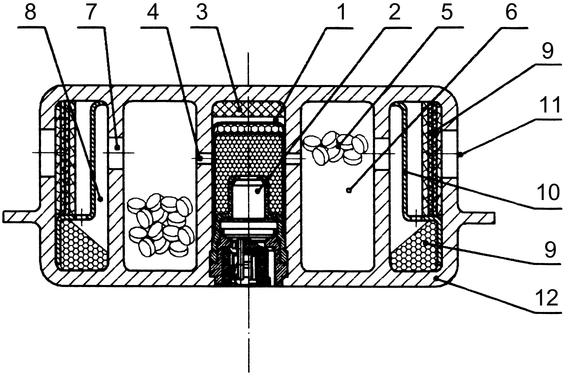
In the *hybrid* system the pre-pressurized gas (nitrogen, argon/helium or pure helium) is stored in high pressure containers fitted with a bursting membrane. Opening this membrane by pyrotechnic means allows the gas to flow out into the airbag. The cooling of the expanding gas is compensated or even over-compensated by a pyrotechnic charge. Since the total amount of pyrotechnic mixture is small in quantitative terms, the prescribed threshold values of the toxic impurities contained in the working gas can be adhered to relatively easily. This fact in addition to the ideal temperature of the working gas is the main advantage of *hybrid* gas generators. The disadvantages are the large weight, the subjection to the Pressure Vessel Regulation and the high noise level that occurs when the sealing disk opens, because initially the full gas pressure is present.

The unique feature of almost all *pyrotechnical gas generators* is the concentric assembly of three different chambers with different designs corresponding to their pressure conditions and functions. The innermost chamber with the highest pressure resistance contains the igniter unit consisting of a plug, squib and booster charge. Depending on the generator construction a pre-ignition unit may also be installed, whose task is to ignite the pyrotechnic mixture without electric current in case of high temperatures, which could occur in case of a fire. During normal electrical ignition the thin resistance wire of the igniter is heated and the ignition train started. The booster charge normally used is boron / potassium nitrate. The hot gases and particles generated by this charge enter the concentrically arranged combustion chamber and ignite the pyrotechnic main charge. Both chambers are designed for pressures up to 40 MPa. The pyrotechnic main charge consists generally of compressed pellets which generate the working gas and slag residues by a combustion process. The products leave the combustion chamber through nozzles and enter the low pressure region of the filter compartment, where the slag is removed from the gas flow. The filter compartment is equipped with various steel filters and deflector plates. The resulting gas flows through the filter compartment apertures into the bag.

The basic task of a gas generator is to provide sufficient non-toxic gas within approximately 25 ms to inflate the airbag to the specification pressure. The first pyrotechnic mixture used in airbag gas generators was based on sodium azide. Sodium azide reacts with oxidising agents, which bond chemically the remaining sodium as the nitrogen is liberated. Established oxidisers are the alkali and alkaline earth nitrates, metal oxides (e. g. CuO, Fe2O3), metal sulfides (MoS2) and sulphur. If necessary slag forming agents (e. g. SiO_2, aluminosilicates) were also added.

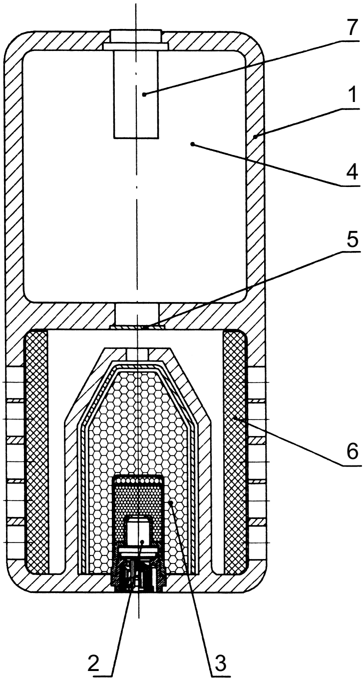
The consequence of advance in environmental awareness was that the toxic sodium azide has to be replaced despite pure nitrogen generation, lower reaction temperatures and greater long-term stability. Another factor against sodium azide was the relative low specific gas yield and the unsolved disposal procedure for this type of pyrotechnic mixture.

The unique feature of almost all *pyrotechnical* gas generators (specifically on the driver side) is the concentric assembly of three different chambers with different designs corresponding to their pressure conditions and functions. The innermost chamber with the highest pressure resistance contains the igniter unit consisting of a plug, electrical igniter matchhead and the igniter mixture. Depending on the generator construction, a pre-ignition unit may also be installed, whose task is to ignite the gas mixture without an electric current in the event of exposure to elevated external temperature – for example during a fire. During normal electrical ignition, the thin resistance wire of the igniter matchhead is heated to melting point and the ignition train started. As the ignition mixture burns away – usually a boron/potassium nitrate mixture – the resulting hot gases and particles flow through the peripheral holes and into the combustion chamber filled with the gas mixture, which is arranged concentrically around the igniter chamber and is designed for an operating pressure of 100–180 bar. The gas mixture consists of compressed tablets which, after ignition, burn to form the working gas and slag. The combustion products leave the combustion chamber through the nozzle holes. The low pressure region of the filter compartment is arranged around the combustion chamber. The filter compartment is fitted with various steel filters and deflector plates. In the filter compartment the hot gases are cooled down and freed from liquid/solid slag. The resulting working gas flows through the filter compartment apertures towards the gas bag. The liquid slag constituents must be cooled down to solidification in the filter compartment so that they can also be filtered out there. It is clear that the nature of the gas mixture – formerly called the propellant or propellant mixture – is exceptionally important with regard to providing the gas (fume) cloud during burn-up. The basic task of a gas generator is, when necessary, to supply sufficient non-toxic gas within approx.



1. Ignition chamber
2. Igniter unit
3. Pre-ignition unit
4. Nozzle holes
5. Gas mixture
6. Combustion chamber
7. Nozzle holes
8. Filter chamber
9. Filter
10. Deflector plate
11. Filter chamber apertures
12. Gas generator housing

Fig. 1. Sectional diagram of a pyrotechnical gas generator for airbags



1. Hybrid generator housing
2. Igniter
3. Pyrotechnic mixture
4. High-pressure vessel
5. Sealing disk
6. Filter pack
7. Pressure measurement device

Fig. 2. Sectional diagram of a hybrid gas generator for airbags

40 ms to inflate the airbag to the specification pressure. From the mid-seventies to the mid-nineties the vast majority of gas mixtures in pyrotechnic gas generators were based on sodium azide. Sodium azide reacts with oxidising agents that bond chemically to the resulting sodium as the nitrogen is liberated. Established oxidisers include the alkali and alkaline earth nitrates, metal oxides (e. g. CuO, Fe2O3), metal sulphides (e. g. MoS2) and sulphur. If necessary, slag forming agents (e. g. SiO2, aluminosilicates) are also added.

The consequence of advances in environmental awareness is that gas mixtures containing azide are to be replaced because of the toxicity of their sodium azide, and this in spite of lower reaction temperature, purer nitrogen yield and greater long-term stability. However, one factor against sodium azide is that the correct disposal of unused gas mixtures throughout the world, which arise on a scale of thousands of tons per year, has not yet been guaranteed.

With regard to azide-free gas mixtures, there have been numerous patents and initial applications since the early nineties. These new gas mixtures generate more gas per gram (gas yields from gas mixtures containing NaN3: 0.30 – 0.35 l/g) and thus enable smaller and to some extent a more lightweight construction of the gas generators.

They can be classified into three categories:

1. High-nitrogen organic compounds (C, H, O, N) are combined with inorganic oxidisers:
   The fuels are, for example, 5-aminotetrazole, azodicarbonamide, → *Guanidine nitrate*, → *Nitroguanidine*, dicyandiamide, → *Triaminoguanidine nitrate* and similar compounds, as well as salts of, for example, 5-nitrobarbituric acid, urea derivatives and also nitramines and similar compounds. The oxidisers are, for example, alkali or alkaline earth nitrates, → *Ammonium*, alkali or alkaline earth perchlorates and metal oxides.
   Gas yield of these mixtures: 0.50 – 0.65 l/g.

2. Cellulose nitrate in combination (gelation) with nitrate esters of polyols (plus → *Stabilisers* and plasticizers), e. g. NC/NGL (→ *Nitroglycerine*) or NC/EDDN (→ *Ethylenediamine dinitrate*).
   Because of the unfavourable oxygen balance, it is necessary to secondary oxidise (e. g. with Hopcalite) to avoid excess CO formation. Despite favourable raw materials costs, the unfavourable storage stability, see below, must be noted here.
   Gas yield of the mixture: 0.8 – 0.9 g/l (not including the secondary oxidation).

3. High-oxygen, nitrogen-free organic compounds (C, H, O) are blended with inorganic oxidisers. The fuels used are, for example, tri or dicarboxylic acids (e. g. citric acid, tartaric acid, fumaric acid) or similar compounds. The oxidisers used are especially perchlor-

ates and chlorates with additional assistance from metal oxides. This enables any formation of NOx to be excluded.
Gas yield of the mixture: 0.5–0.6 l/g.

The gas mixtures are usually manufactured by grinding and blending the raw materials, which after a pre-compacting step are pressed into pellets or disks on (rotary table) presses, after which they are weighed out. Gas mixtures containing → *Nitrocellulose* are moulded after gelatinising in the usual way.

The fact that the transition from gas mixtures containing azide to ones free from azide is not simple is attributable to the following problems

(a) The considerably higher combustion temperatures impose higher demands on both the gas generator housing and on the airbag.
(b) The cooling curve of the combustion gases is steeper and must be taken into account.
(c) Condensation/filtration of the liquid/solid slag components is more difficult because of the temperature (fine dust problem).
(d) Gas mixtures containing nitrocellulose can cause difficulties in the long-term temperature test (400 hours at 107 °C, specification weight loss: < 3 %) and during temperature cycling storage (→ exudation).
(e) The long-term stability of the various azide-free gas mixtures is not yet sufficiently known.
(f) Despite an equilibrated oxygen balance, there is a tendency during the combustion of organic substances for toxic gases to be formed as by-products, although these are limited as follows:

Effluent Gas	Vehicle Level Limit	Driverside Limit
Chlorine (Cl_2)	5 ppm	1.7 ppm
Carbon monoxide (CO)	600 ppm	200 ppm
Carbon dioxide (CO_2)	20,000 ppm	6,700 ppm
Phosgene ($CoCl_2$)	1 ppm	0.33 ppm
Nitric Oxide (NO)	50 ppm	16.7 ppm
Nitrogen Dioxide (NO_2)	20 ppm	60.7 ppm
Ammonia (NH_3)	150 ppm	50 ppm
Hydrogen Chloride (HCl)	25 ppm	8.3 ppm
Sulphur Dioxide (SO_2)	50 ppm	16.7 ppm
Hydrogen Sulphide (H_2S)	50 ppm	16.7 ppm
Benzene (C_6H_6)	250 ppm	83.3 ppm
Hydrogen Cyanide (HCN)	25 ppm	8.3 ppm
Formaldehyde (HCHO)	10 ppm	3.3 ppm

In the case of the azide-free gas mixtures, there is currently no recognisable trend towards any particular fuel, since the size of the market entails a large range of variants with different requirements.

For example liquid gas generators are described in which carbon-free compounds are used and which can also be reacted to form working gases without any slag, e.g. systems consisting of hydrazine/hydrazine nitrate.

Air Blast

Druckwelle; onde de choc

The airborne acoustic or shock wave generated by an explosion → *Detonation*, → Fuel Air Explosives, → Thermobaric Explosives.

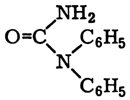
Air Loaders

Blasgeräte; chargeurs pneumatiques

Air loaders serve to charge prilled → *ANFO* blasting agents into boreholes. If the free-running prills cannot be charged by pouring, e.g. horizontal boreholes, boreholes with neglectable slope or boreholes with small diameters, they can be introduced by air loaders. This is done by loading the charge into a pressurized vessel and applying an air pressure of about 0,4 MPa (4 atm); a valve at the lowest point of the machine, which can be controlled from the borehole to be filled, leads to a long hose; when the valve is opened, a stream of air containing the explosive charge in suspension, is sent through it into the borehole. Other, portable machines work on the injector principle.

Akardite I

diphenylurea; Diphenylharnstoff; diphénylurée



colorless crystals
empirical formula: $C_{13}H_{12}N_2O$
energy of formation: –117.3 kcal/kg –490.6 kJ/kg
enthalpy of formation: –138.2 kcal/kg –578.2 kJ/kg
oxygen balance: –233.7
nitrogen content: 13.21 %
density: 1.276 g/cm^3

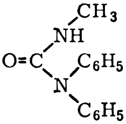
Akardite I serves as → *Stabilizer* for gunpowders, in particular for → *Double Base Propellants.*

Specifications

melting point: at least	183 °C = 361°F
moisture: not more than	0.2 %
ashes: not more than	0.1 %
chlorides: not more than	0.02 %
pH value: at least	5.0
acid, n/10 NaOH/100 g: not more than	2.0 cm^3

Akardite II

methyldiphenylurea; Methyldiphenylharnstoff; N-méthyl-N’, N’diphénylurée



colorless crystals
empirical formula: $C_{14}H_{14}N_2O$
molecular weight: 226.3
energy of formation: −90.5 kcal/kg = −378.5 kJ/kg
enthalpy of formation: −112.7 kcal/kg = −471.5 kJ/kg
oxygen balance: −240.4 %
nitrogen content: 12.38 %

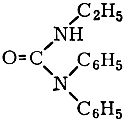
Akardite II is an effective → *Stabilizer* for double base gunpowders

Specifications

same as for Akardite I, except
melting point: at least 170−172 °C = 338−342°F

Akardite III

ethyldiphenylurea; Ethyldiphenylharnstoff; N-éthyl-N’, N’-diphénylurée



colorless crystals
empirical formula: $C_{15}H_{16}N_2O$
molecular weight: 240.3
energy of formation: −128.5 kcal/kg = −537.7 kJ/kg

enhalpy of formation: –151.9 kcal/kg = –635.5 kJ/kg
oxygen balance: –246.3 %
nitrogen content: 11.65 %

Akardite III is an effective → *Stabilizer* for double base propellants. Both Akardite II and Akardite III are gelatinizers as well as → *Stabilizers*.

Specifications

same as for Akardite I, exept	
melting point: at least	89 °C = 192°F

Alginates

Salts of alginic acid which are capable of binding 200–300 times their own volume of water. They are added as swelling or gelling agents to explosive mixtures in order to improve their resistance to moisture, and to → *Slurries* to increase viscosity.

Alex

Alex is an → aluminum powder formed by explosion of electrically heated aluminum wires in inert atmospheres with particle sizes between 50 and 200 nm. Due to a passivation layer of a thickness between 2 to 4 nm a substantial amount of the particles is already converted to alumina the formation of which should be avoided by in-situ coating. In addition to the diffusion controlled oxidation at lower temperatures, a partial oxidation of the particles can occur by a fast chemically controlled reaction. Alex can increase the burning rate of solid composite rocket propellants up to a factor of 2. An increase of detonation velocity is not confirmed but Alex might improve → *air blast* or fragment velocities of some high explosives.

All Fire

Mindestzündstrom; ampèrage minime d’amorcage

Minimum current that must be applied to an igniter circuit for reliable ignition of the primer-charge without regard to time of operation.

Aluminum Powder

Aluminiumpulver; poudre d'aluminum

Aluminum powder is frequently added to explosives and propellants to improve their performance. The addition of aluminium results in considerable gain in heat of explosion because of the high heat of formation of aluminia (1658 kJ/mole, 16260 kJ/kg) leading to higher temperatures of the fumes. Aluminium not reacted in the detonation front might be oxidized atmospheric oxygen to induce "post-heating" in the fume zone and to increase the → *air blast* or even to initiate a delayed secondary explosion.

Widely used mixtures of explosives with aluminum powder include → *Ammonals,* → DBX, → HBX-1, → Hexal, → Minex, → Minol, → Torpex, → Trialenes, → Tritonal and *Hexotonal*. In addition underwater explosives often contain aluminium powders.

The performance effect produced by aluminum powder is frequently utilized in → *Slurries*, also in → *Composite Propellants*.

Important characteristics of aluminum powders are shape and grain size of the powder granules. Waxed and unwaxed qualities are marketed. Propellant formulations often prescribe systematically varied grain sizes for obtaining optimal densities.

Amatex

A pourable mixture of trinitrotoluene, ammonium nitrate and RDX

Amatols

Pourable mixtures of ammonium nitrate and trinitrotoluene of widely varying compositions (40:60, 50:50, 80:20). The composition 80:20 may be loaded e.g. into grenades using a screw press (extruder).

Ammonals

Compressible or pourable mixtures containing ammonium nitrate and aluminum powder; the pourable mixtures contain → *TNT*

Ammongelit 2; 3

Trade names of ammonium nitrate – nitroglycol-based gelatinous explosives distributed in Germany and exported by ORICA and WASAGCHEMIE.

Ammongelit	Density g/cm^3	Weight Strength %
2	1.45	88

Ammon-Gelit TDF

Trade names of ammonium nitrate – nitroglycol-based gelatinous explosives distributed in Germany and exported by WASAGCHEMIE.

Ammon-Gelit TDF, a safehandling, gelatinous ammonium nitrate explosive, is, due to its similar properties, an alternative to → Wasag-Gelit 2 and it is manufactured without any nitrous aromatic components (→ DNT, → TNT).

Ammonium Azide

Ammoniumazid; azoture d'ammonium

$(NH_4)N_3$

colorless crystals
molecular weight: 60.1
energy of formation: +499.0 kcal/kg = +2087.9 kJ/kg
enthalpy of formation: +459.6 kcal/kg = +1922.8 kJ/kg
oxygen balance: –53.28
nitrogen content: 93.23 %
density: 1.346 g/cm^3

Ammonium azide is prepared by introducing a solution of ammonium chloride and sodium azide into dimethylformamide at 100 °C.

The solvent is then drawn off in vacuum.

Owing to its high vapor pressure, this compound has not yet found any practical application.

Vapor pressure:

Pressure millibar	Temperature °C	°F
1.3	29.2	84.6
7	49.4	121.0
13	59.2	138.6
27	69.4	157.0
54	80.1	176.2
80	86.7	188.1
135	95.2	203.4
260	107.7	225.9
530	120.4	248.7
1010	133.8	272.8

Ammonium Chloride

Ammoniumchlorid; chlorure d'ammonium

NH_4Cl

colorless crystals
molecular weight: 53.49
energy of formation: –1371.6 kcal/kg = –5738.9 kJ/kg
enthalpy of formation: –1404.9 kcal/kg = –5878.1 kJ/kg
oxygen balance: –44.9 %
nitrogen content: 26.19 %
sublimation point: 335 °C = 635°F

Ammonium chloride serves as a partner component to alkali nitrates in the so-called inverse salt-pair (ion-exchanged) explosives (→ *Permitted Explosives*).

Specifications

net content: at least	99.5 %
moisture: not more than	0.04 %
glow residue: not more than	0.5 %
Ca; Fe; SO_4: NO_3: not more than	traces
pH value:	4.6–4.9

Ammonium Dichromate

Ammoniumdichromat; dichromate d'ammonium

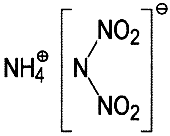
$(NH_4)_2Cr_2O_7$

orange red crystals
molecular weight: 252.1
energy of formation: –1693.1 kcal/kg = –7083.9 kJ/kg
enthalpy of formation: –1713.1 kcal/kg = –7167.4 kJ/kg
oxygen balance: ± 0 %
nitrogen content: 11.11 %
density: 2.15 g/cm^3

Ammonium dichromate decomposes on heating, but is not an explosive. It is a component of pyrotechnical charges, and is an effective additive which is introduced into ammonium nitrate-based propellants in order to catalyze the decomposition reaction.

Ammonium dinitramide

Ammoniumdinitramid; ADN



empirical formula: $H_4N_4O_4$
molecular weight: 124.06
energy of formation: –259.96 kcal/kg = –1086.6 kJ/kg
enthalpy of formation: –288.58 kcal/kg = –1207.4 kJ/kg
oxygen balance: +25.8 %
nitrogen content: 45.1 %
volume of explosion gases: 1084 l/kg
heat of explosion
  (H_2O liq.): 3337 kJ/kg
  (H_2O gas): 2668 kJ/kg
specific energy: 843 kJ/kg
density: 1.812 g/cm3 at 20 °C
melting point: 93.5 °C (decomposition at 135 °C and above)
impact sensitivity: 4 Nm
friction sensitivity: 64 N

Ammonium dinitramide is obtained by ammonolysis of dinitroamines, which are formed by the step-wise nitration of urethanes, β,β-iminodipropionitrile or nitramide. The last nitration step in each case requires the most powerful nitration reagents such as nitronium tetrafluoroborate or dinitrogen pentoxide. Other methods pass via the direct nitration of ammonia with dinitrogen pentoxide to a mixture of ADN and → *Ammonium Nitrate* or the nitration of ammonium sulfamate with nitric acid to a mixture of ADN and ammomium hydrogensulfate. On the basis of its good → *Oxygen Balance* and high → *Enthalpy of Formation*, ADN appears to be attractive as a halogen-free oxidising agent for solid rocket propellants and is currently the subject of intensive studies.

Ammonium Nitrate

Ammoniumnitrat; nitrate d'ammonium; AN

NH_4NO_3

colorless crystals
molecular weight: 80.0
energy of formation: –1058.3 kcal/kg = –4428.0 kJ/kg
enthalpy of formation: –1091.5 kcal/kg = –4567.0 kJ/kg
oxygen balance: +19.99 %
nitrogen content: 34.98 %
volume of explosion gases: 980 l/kg
heat of explosion
  (H_20 liq.): 593 kcal/kg = 2479 kJ/kg
  (H_20 gas): 345 kcal/kg = 1441 kJ/kg
melting point: 169.6 °C = 337.3°F
lead block test: 180 cm^3/10 g
deflagration point:
begins decomposition at melting point, complete at
  210 °C = 410°F
impact sensitivity: up to 5 kp m = 50 Nm no reaction
  friction sensitivity:
  up to 36 kp = 353 N pistil load no reaction
critical diameter of steel sleeve test: 1 mm

Ammonium nitrate is hygroscopic and readily soluble in water (the saturated solution contains about 65 % NH_4NO_3). Transitions from one polymorph to another take place at 125.2 °C, 84.2 °C, 32.3 °C and -16.9 °C. The product shows a great tendency to cake. The difficulties therefore involved are avoided by transformation into → *Prills*. Ammonium nitrate is marketed as dense prills and as porous prills. Both can be introduced in industrial explosives after milling except → *ANFO* blasting agents, which need unmilled porous prills.

Ammonium nitrate is the most important raw material in the manufacture of industrial explosives. It also serves as a totally gasifiable oxygen carrier in rocket propellants.

Phase Stabilized Ammonium Nitrate PSAN and Spray Crystallized Ammonium Nitrate SCAN are special qualities provided by ICT.

Specifications

net content (e.g. by N-determination): at least	98.5 %
glow residue: not sandy, and not more than	0.3 %
chlorides, as NH_4Cl: not more than	0.02 %
nitrites:	none
moisture: not more than	0.15 %
Ca; Fe; Mg: not more than	traces
reaction:	neutral
Abel test at 82.2 °C = 180°F: at least	30 min.
pH:	5.9+0.2
solubles in ether: not more than	0.05 %
unsolubles in water: not more than	0.01 %
acidity, as HNO_3: not more than	0.02 %

Specifications for prills

boric acid	0.14+0.03 %
density of grain: at least	1.50 g/cm^3
bulk density: at least	0.8 g/cm^3

Ammonium Nitrate Explosives

Ammonsalpeter-Sprengstoffe; explosifs au nitrate d'ammonium

Ammonium nitrate explosives are mixtures of ammonium nitrate with carbon carriers such as wood meal, oils or coal and sensitizers such as → *Nitroglycol* or → *TNT* and → *Dinitrotoluene*. They also may contain → *Aluminum Powder to* improve the → *Strength*. Such mixtures can be cap-sensitive. The non-cap-sensitive ones are classed as → *Blasting agents*.

Mixtures of porous ammonium nitrate prills with liquid hydrocarbons, loaded uncartridged by free pouring or by means of → *Air Loaders* are extensively used under the name → ANFO blasting agents.

The resistance to moisture of powder-form ammonium nitrate explosives and blasting agents is low, but can be improved by addition of hydrophobic agents (e.g. calcium stearate). The densities of the powders are about 0.9–1.05 g/cm^3.

Higher density and better water resistance are obtained using gelatinous ammonium nitrate explosives. They are based on ammonium nitrate and 20–40 % gelatinized nitroglycol or a nitroclycerine-nitroglycol mixture. The German Ammongelites also contain low-melting TNT-dinitrololuene mixtures. Ammonium nitrate gelatins have widely replaced the elder sodium nitratenitroclycerine gelignites. The density of the gelatinous explosives is about 1.5–1.6 g/cm^3.

Water-containing ammonium nitrate mixtures with fuels are known as → *Slurries* and → *Emulsion Slurries*

Many permitted explosives are ammonium nitrate in powder form or gelatinous explosives with added inert salts such as sodium chloride or potassium chloride which reduce their explosion temperature.

Ammonium Nitrate Emulsion

ANE

Intermediate for → Emulsion (blasting) explosives. These emulsions are non sensitized and are intended to produce an emulsion (a blasting) explosive only after further processing prior to use. Emulsions typicallyconsist of ammonium nitrate (partly replaced by other inorganic nitrate salts), water, fuel and emulsifier agents.

Ammonium Perchlorate

Ammoniumperchlorat; perchlorate d'ammonium; APC

NH_4ClO_4

colorless crystals
molecular weight: 117.5
energy of formation: –576.5 kcal/kg = –2412.0 kJ/kg
enthalpy of formation: –601.7 kcal/kg = –2517.4 kJ/kg
oxygen balance: +34.04 %
nitrogen content: 11.04 %
volume of explosion gases: 799 l/kg
heat of explosion (H_2O liq.): 471 kcal/kg = 1972 kJ/kg
density: 1.95 g/cm^3
melting point: decomposition on heating
lead block test: 195 cm^3/10 g
deflagration point: 350 °C = 662°F
impact sensitivity: 1.5 kp m = 15 N m

Ammonium perchlorate is prepared by neutralizing ammonia by perchloric acid. It is purified by crystallization.

Ammonium perchlorate is the most important oxygen carrier for → *Composite Propellants*. Unlike alkali metal perchlorates, it has the advantage of being completely convertible to gaseous reaction products.

Table 1. Specifications

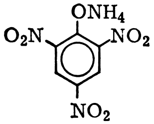
	Grade A	Grade B	Grade C
net content: at least	99.0 %	99.0 %	98.8 %
water-insolubles: not more than	0.03 %	0.01 %	0.25 %
bromates, as NH_4BrO_3: not more than	0.002 %	0.002 %	0.002 %
chlorides, as NH_4Cl: not more than	0.15 %	0.10 %	0.15 %
chromates, as K_2CrO_4: not more than	0.015 %	0.015 %	0.015 %
iron, as Fe: not more than	0.003 %	0.003 %	0.003 %
residue from sulfuric acid fuming: not more than	0.3 %	0.3 %	0.3 %
moisture: not more than	0.08 %	0.05 %	0.08 %
surface moisture: not more than	0.020 %	0.015 %	0.020 %
ash, sulfated: not more than	0.25 %	0.15 %	0.45 %
chlorate as NH_4ClO_3: not more than	0.02 %	0.02 %	0.02 %
Na and K: not more than	0.08 %	0.05 %	0.08 %
$Ca_3(PO_4)_2$:	none	none	0.15-0.22 %
pH:	4.3–5.3	4.3–5.3	5.5–6.5

Granulation classes

Class 1 – Through 420 and 297 micron sieve, retained on 74 micron sieve.
Class 2 – Through 297 micron sieve.
Class 3 – Through 149 micron sieve.
Class 4 – 50 to 70 % through 210 micron sieve.
Class 5 – Through 297 micron sieve, retained an 105 micron sieve.
Class 6 – 89 to 97 % through 297 micron sieve.
Class 7 – 45 to 65 % through 420 micron sieve.

Ammonium Picrate

ammonium-2,4,6-trinitrophenolate; Ammonpikrat; picrate d'ammonium; explosive D



yellow crystals
empirical formula: $C_6H_6N_4O_7$
molecular weight: 246.1
energy of formation: –355.0 kcal/kg = –1485.2 kJ/kg
enthalpy of formation: –375.4 kcal/kg = –1570.7 kJ/kg
oxygen balance: –52.0 %
nitrogen content: 22.77 %
volume of explosion gases: 909 l/kg
heat of explosion
  (H_2O liq.): 686 kcal/kg = 2871 kJ/kg
  (H_2O gas): 653 kcal/kg = 2732 kJ/kg
density: 1.72 g/cm^3
melting point: 280 °C = 536°F (decomposition)
lead block test: 280 cm^3/10 g
detonation velocity:
  7150 m/s = 23500 ft/s at $\rho = 1.6$ g/cm^3
deflagration point: 320 °C = 608°F
impact sensitivity: at 2 kp m = 19 N m no reaction

Ammonium picrate is soluble in water, alcohol and acetone, and is practically insoluble in ether. It is prepared by saturating an aqueous solution of picric acid with ammonia; a red form is formed first which passes into the stable yellow form in the presence of water vapor, on prolonged storage or by recrystallization from water. Ammonium picrate has been employed as an explosive in military charges.

Amorces

This term denotes very small priming plates utilized in children's toys. They contain an impact-sensitive mixture of potassium chlorate and red phosphorus.

The French word "amorce" means all of initiating or inflaming devices.

Andex 1, ML

Trade names of → *ANFO* explosives marketed in Germany by MSW-CHEMIE, and ORICA Germany GmbH (formerly DYNAMIT NOBEL) in 25-kg carton packs or in containers of about 900 kg capacity. Andex 2 contains a small percentage of rock salt.

Andex 1:
bulk density: 0.9 g/cm^3
weight strength: 75 %

ANFO

An abbreviation for ammonium nitrate fuel oil, a blasting agent composed of ammonium nitrate and liquid hydrocarbons. The application technique of these mixtures has now become very much easier owing to the fact that the material, which has a strong tendency to agglomeration, is commercially produced as porous prills. These are granules solidified from the liquid melt, sufficiently porous to take up about 6 % of the oil, which is the amount needed to produce oxygen balance. The nitrate, and the explosive produced from it retain their free flowing capacity. (see also → Acremite)

The explosive must be utilized in the form of a continuous column, and must be ignited by a powerful primer. This means that it must be poured loose (not as cartridges) into the borehole, or else blown into it with an → *Air Loader.*

Its manufacture is very cheap, and may even take place on continuous mixers an wheels. The material has now almost completely replaced conventional explosives in cartridge form in open-pit mining and in potash mining.

density: 0.9 g/cm^3
weight strength: 75 %

“Heavy Anfo” is a 50/50-mixture of Anfo and → *Emulsion Slurries* – which has higher loading densities than poured Anfo alone.

APU

(Auxiliary Power Unit) – Propellant-powered device used to generate electric or fluid power.