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QUALIFICATION AND CHARACTERISATION OF NITROCELLULOSE.

- Nitrocellulose (NC) more strictly cellulose nitrate is arguably the most important explosive in military use.
- It is used in single base, double base and triple base propellants.
- Small arms ammunition uses mainly single base and some double base propellant while medium calibre and large calibre ammunition uses double or triple base propellant. It is also used in rocket motors and gas generators and in some high explosive compositions.
- Without NC propellants munition payloads could not be placed on their targets.



QUALIFICATION AND CHARACTERISATION OF NITROCELLULOSE.

- Qualification - What is it?
- Nitrocellulose Qualification and characterisation
- Specifications for nitrocellulose



Qualification Definition

- Qualification is the assessment of the energetic material (EM) by the National Authority according to STANAG 4170 and AOP-7 to determine whether it possesses properties which make it safe and suitable for consideration for use in its intended role
 - Main Charge, booster, gun propellant etc.



Qualification STANAG 4170

- NATO nations agree to a standardised Qualification process
- Each nation has developed their own database of test results
 - AOP-7
 - National annexes giving the test methods used



Qualification UK Policy

- OB Pillar Procs
 - P42700 - Qualification and Type Qualification
 - P104 - Change of Manufacture
 - P111 - Pyrotechnics
 - P119 - HE and Booster Compositions
 - P127 - Solid Propellants
 - N445 - IHE for NW
- Has been combined into DOSG Guidance Note to be issued shortly



What is Qualification?

- Characterisation of the explosive material in the “as produced” condition and after ageing
 - Chemical Stability
 - Mechanical Properties
 - Explosive Properties
- Normally during the development of the explosive



Type Qualification

- Type Qualification is given when the explosive has been assessed as part of the design of the specific munition, and predicted to be safe and suitable for military operational or training use in that system.



Qualification

Chemical Stability

- The explosive must be capable of having an acceptable service life
- Slow reaction rates at normal temperatures
- Increase in rate with temperature within acceptable limits
- No “Runaway” reaction, e.g. Propellant stabiliser consumption



Mechanical Properties

- Structural integrity
- material will not crack
- material will not crumble
- Exposure to service vibration and shock environments
- Mechanical stresses imposed by ignition



Hazard Properties

- A major part of the material qualification process is to assess the explosiveness of the energetic material in addition to the assessment of its sensitiveness
- Low explosiveness and low sensitiveness are desirable.
- EMTAP Manual of tests - currently under review



Hazard Testing

- Small scale tests (powder sensitiveness)
 - Rotter Dropweight impact (F of I; grit; SS explosiveness)
 - Friction (mallet; F of F)
 - Temperature of ignition (and behaviour)
 - ESD
- Charge Scale Tests
 - Tube tests
 - Fragment attack
 - Gap test



Qualification Conclusions

- Material Qualification is a risk reduction exercise
- Increases confidence in the successful completion of type qualification
- Baseline data for in service surveillance



Nitrocellulose Qualification

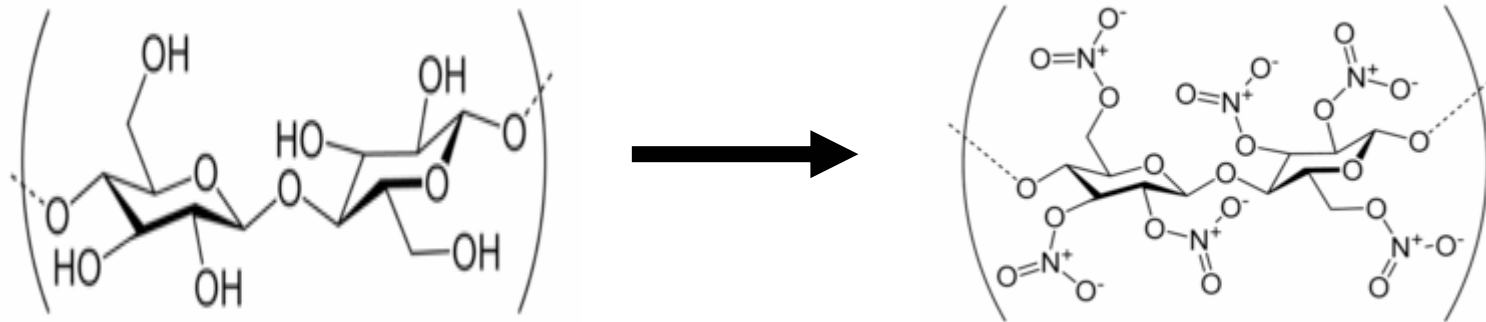
- So what qualification testing do we expect to be done on NC?
- Well as NC is not now used in the UK military as a demolition explosive or other uses in its “raw” state we do no qualification on the NC.
- We qualify the propellant or explosive made from the NC and hope the NC properties are sufficiently controlled by the manufacturing process and the relevant specifications.



Nitrocellulose Qualification

Manufacture and characterisation of Nitrocellulose

- NC is the nitric acid ester formed from the reaction of cellulose with nitric acid.



Nitrocellulose Qualification

Manufacture and characterisation of Nitrocellulose

- In the UK and most of Europe cellulose obtained from cotton is the main source though wood cellulose was used in the UK until about 12 years ago mainly for use in extruded double base propellant for rocket motors and even cellulose obtained from flax has been used.
- The properties of the cotton linters are important as they influence the properties of the NC made from them. Specifications for military grade NC require the linters manufacturer to meet certain manufacturing controls and the supplied linters to have specified chemical and physical properties
- The choice of linter grade depends on processability and NC properties required



Nitrocellulose Qualification

Manufacture and characterisation of Nitrocellulose

- Nitrocellulose is a nitrate ester of cellulose and with three hydroxyl groups on each glucose unit the trinitrate is the maximum level of nitration obtainable. The dinitrate and mononitrate are also possible.
- The level of nitration is usually determined and specified by the % nitrogen, the mononitrate having 6.76% N. the dinitrate 11.12% N and the trinitrate 14.15%.



Nitrocellulose Qualification

Manufacture and characterisation of Nitrocellulose

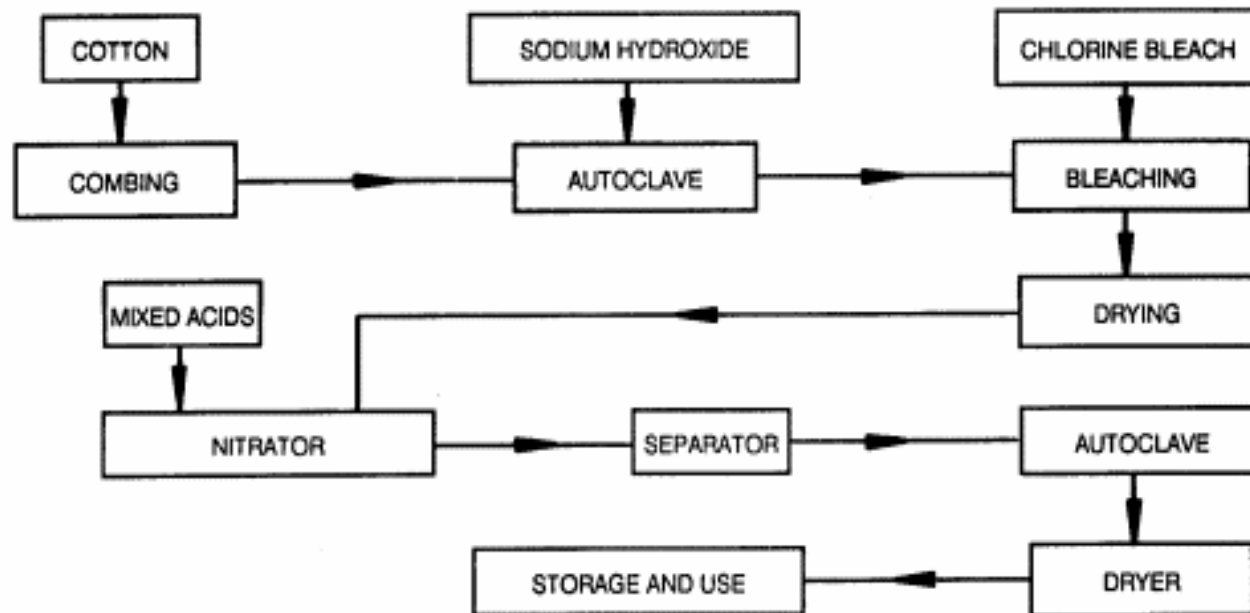
- In practice nitrogen levels between 12% and 13.4% are used in military grade propellants.
- As you can't partially nitrate a hydroxyl group the nitrogen level is obtained from a mixture of mono, di and trinitrate groups in a molecule and as the % N is a macro level determination i.e. averaged over a large number of molecules there may even be some un-nitrated molecules.



Nitrocellulose Qualification

Manufacture and characterisation of Nitrocellulose

- The manufacture of NC from cotton can be summed up in the diagram



Nitrocellulose Qualification

Manufacture and characterisation of Nitrocellulose

- The NC is characterised by the specifications for the Cellulose and the finished NC.
- The UK cellulose linters specification sets limits for moisture, oil, fluidity, woody matter, fibre length and solubility in sodium hydroxide solution.
- UK specification Def Stan 13-175 specifies Nitrogen content, Mineral content, Settling test, LBR test, Alkalinity as CaCO_3 , Ether/alcohol solubility, matter Insoluble in acetone, Sulphate as H_2SO_4 , Stability test at 132°C , Heat test at 77°C , Total calcium as Ca.
- The US Mil Standard and the NATO STANAG have similar requirements.



Nitrocellulose Qualification

Manufacture and characterisation of Nitrocellulose

- The LBR (lead β Resorcyate) requirement in the Def Stan is an NEC Ardeer test known to be able to identify those batches of NC that had good processability in casting powder manufacture.
- In a paper by Bullock, Cosgrove, Head and Lewis of PERME along with Marshall, Wason and Watson of NEC and ICI it was shown that the LBR value correlated with the number average molecular weight and the good processability was due to the presence of a low molecular weight fraction.



Nitrocellulose Qualification Specification

- The UK is the custodian of the NATO STANAG for NC and this year is embarking on an update of the standard. There is now an opportunity to ensure the most appropriate properties and parameters and test methods are included in the specification.
- What should be in it?
 - Present requirements?
 - Molecular weight distributions?
 - Others ? You tell us.



Nitrocellulose Qualification Specification

- Last year Dr Beat Vogelsanger and Marcel Wälchli prepared an excellent summary of the various specifications in use by NATO countries including comments from interested parties.
- Mr Dave Tucker from Dstl in the UK will lead the review.



QUALIFICATION AND CHARACTERISATION OF NITROCELLULOSE.

Questions

