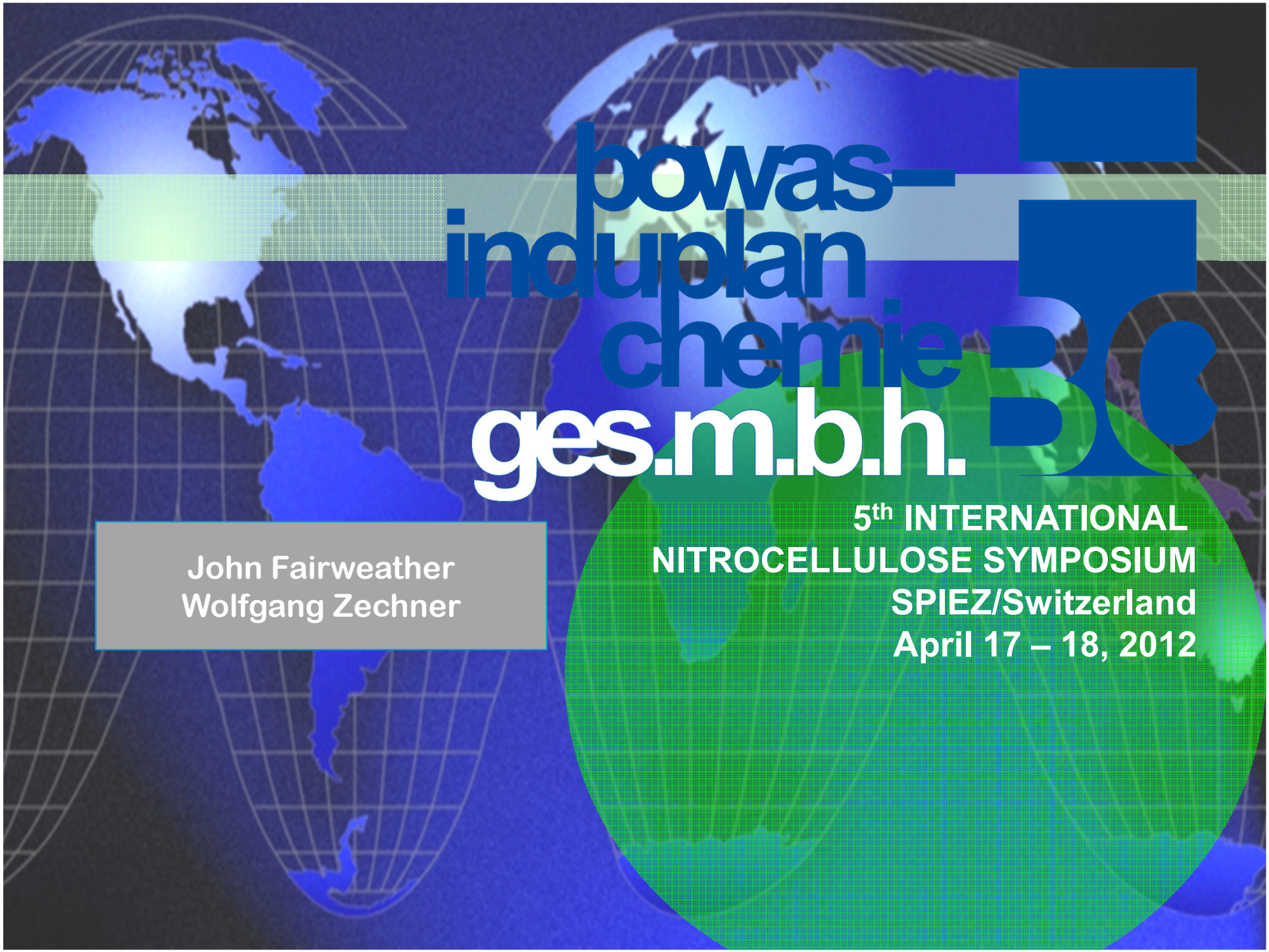

John Fairweather
Wolfgang Zechner

5th INTERNATIONAL NITROCELLULOSE SYMPOSIUM

SPIEZ/Switzerland
April 17 – 18, 2012

BOWAS is an engineering company specialised in design, planning and construction of plants for the explosives industry as well as in plants for production of raw materials for explosives industry, e.g. linters, acids, solvents, etc.

Our considerable knowledge and engineering experience enlarged in 1983 by integration of the activities of the WASAG engineering group. This is available to our clients world-wide.

BOWAS is an independent company and member of an internationally orientated group of companies controlled by the families of von Bohlen and Halbach. We also maintain close working conditions with a considerable number of cooperation partner companies and individuals to supplement our own capabilities. This enables BOWAS to make use of the resources of a wide range of production plants, the practical manufacturing expertise of the associated companies and international ties.

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DENSE TYPE NITROCELLULOSE

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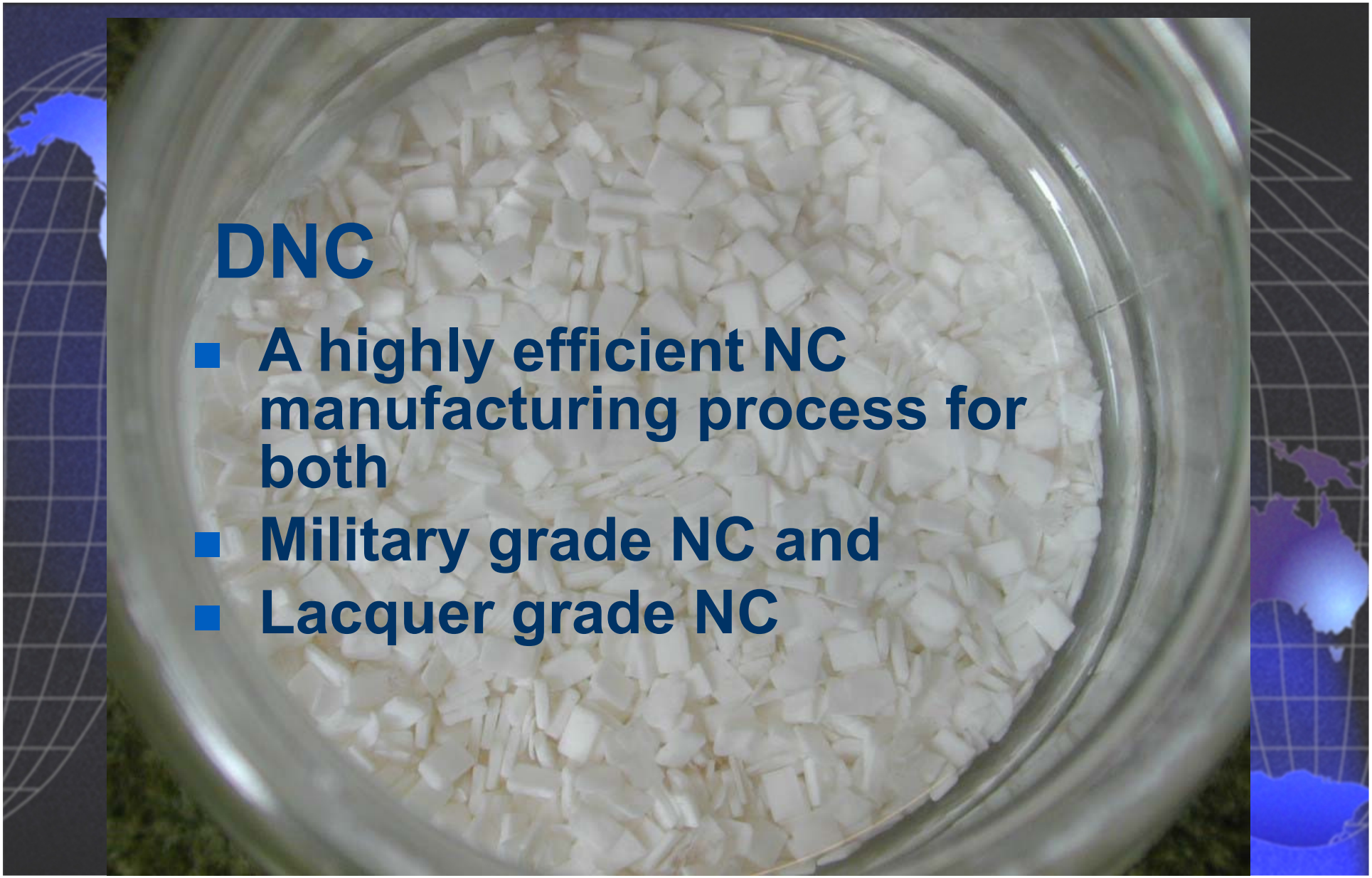

DNC

- A highly efficient NC manufacturing process for both
- Military grade NC and
- Lacquer grade NC

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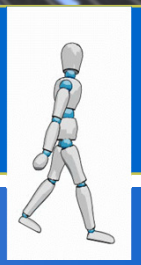
What are the reasons of producing NC in densified form?



- Cost saving
  - Densified raw material is becoming more readily available
  - Cotton Linters can be replaced by cheaper Wood Pulp
  - Shipping costs

- Handling of NC in the subsequent processes, higher bulk loading in processing equipment

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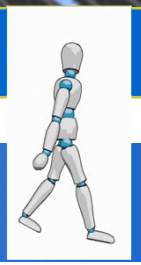
HOW TO PRODUCE DNC



- There are two ways to achieve densified NC
- Use densified raw material, cut it to chips and process in this form
- Use fluffy raw material and densify it before packing

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RANGE OF NC PROPERTIES

Nitrogen Content	10,4 – 13,5%
Viscosity	1000” – 1/16”
Solubility in various solvents & solvent mixes	Insoluble – 100%
Fibre Length	No requirements to 70 – 110 ml
Stability	Max. 2,5 ml NO/g NC

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NC GRADES

	INDUSTRIAL GRADES				MILITARY GRADES	
	Celluloid	Alcohol Soluble	Ester Soluble	Dynamite	Pyrocotton	Guncotton
Raw Material	Linters	Linters Wood Pulp	Linters Wood Pulp	Linters	Linters Wood Pulp	Linters Wood Pulp
N%	10,4 -10,8	10,8 – 11,2	11,8 – 12,2	12,0 – 12,3	12,5 – 12,7	> 13,35%
Viscosity	1000” – 1/16”, 40 – 50 different grades			800 – 1000”	30 – 1”	
Solubility	100% +				3 – 100%	
Fibre length		No requirements		> 100 ml	70 – 90 ml	
FNC/DNC	FNC	FNC/DNC	FNC/DNC	FNC	FNC/DNC	
Number of different grades	40 - 50			~ 5	40 – 50	
Application	Celluloid	Varnishes, Inks, Lacquer		Blasting Ex.		
World Market	Small	250.000 – 300.000 to/a				

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REQUIREMENTS / PRIORITIES

MILITARY GRADE

- **Quality acc. to propellant requirements**
  - Fibrous final product
- **Universality regarding grades**
- **Safe plant**
- **Highest availability, independence from sub-suppliers and from abroad**

LACQUER GRADE

- **Best solution quality**
  - No restriction to physical form
- **Universality regarding grades**
- **Best cost efficiency**
  - Cheapest raw materials
  - Highest yield
  - Lowest consumption
  - Lowest transport cost

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Military grade and Lacquer grade manufacturers have totally different priorities on their requirement

• Military Grade

- Quality is defined as N%, Viscosity, Stability, Fiber length, Solubility; for evaluation of all properties quantitative methods, specifications and tolerances exist
- Physical form has to be fibers
- Capacities typically 500 to 5000 to/a
- Total market volume ~ 50.000 to/a?

• Lacquer Grade

- Only quality attribute is solution quality, evaluation is by a qualitative method
- Physical form depends on client, chip form is preferred from large lacquer manufacturers
- Capacity of lacquer grade plants are typically much higher than for military grades (Luzhou 40.000 to/a
- Wolff 25.000 to/a, ICI 3 x 11.000 to/a, SNPE/TNC 50.000 to/a)
- Total market volume ~ 250.000 to/a

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Consequently raw material choice and process technology applicable differ

• Military Grade

- Low Density pulp
- Perfect chip cut not required
- Delamination welcome
- Continuous & batch process
- Deflaking/Refining required
- Mild thermal treatment
- No restrictions for mechanical stress

• Lacquer Grade

- High density pulp
- Perfect chip cut required
- No delamination tolerable
- (Continuous) & batch processes
- No Deflaking/Refining
- Aggressive thermal treatment
- Avoid mechanical stress

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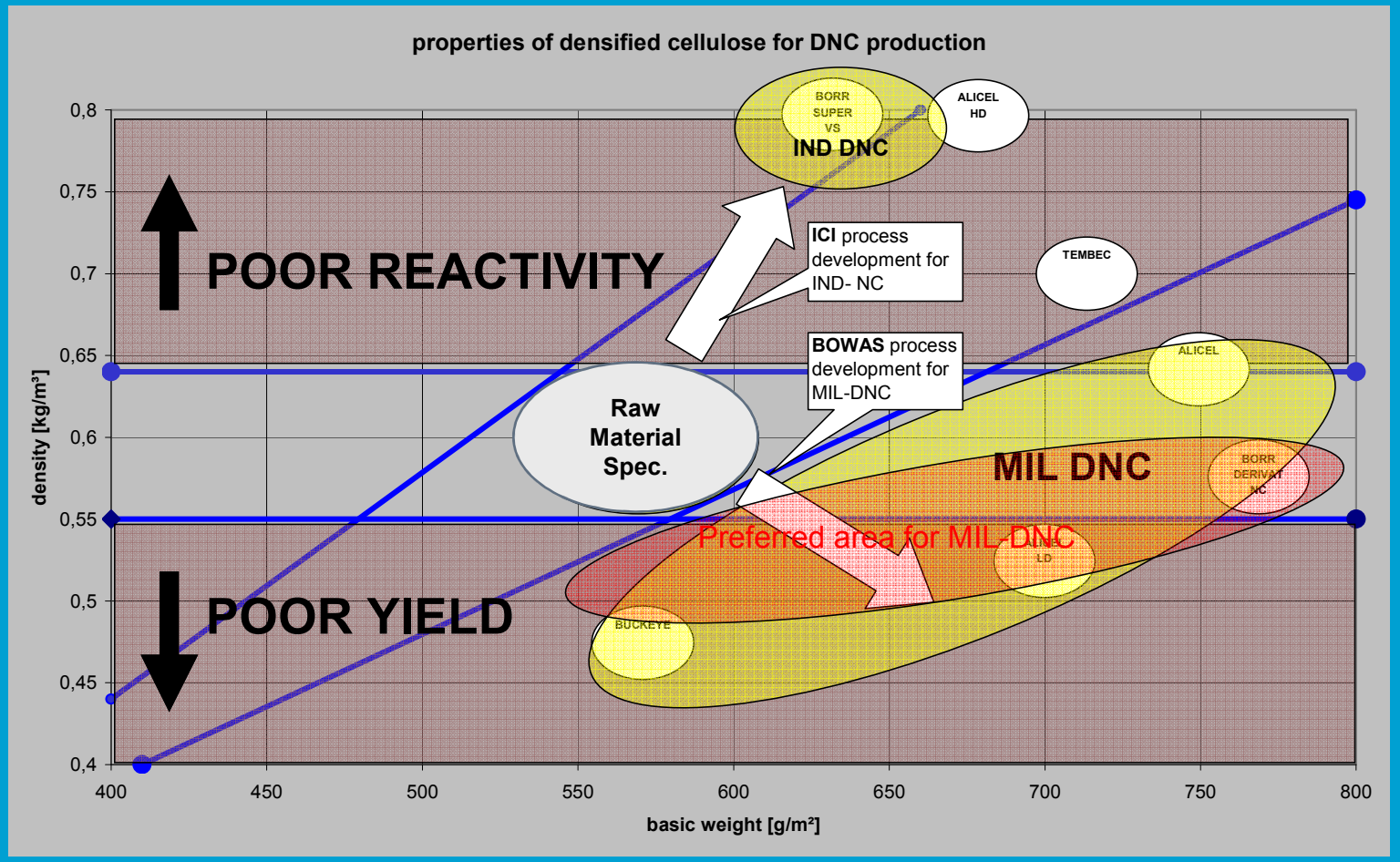
RAW MATERIAL PROPERTIES



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Compromises in raw material choise may lead to compromises in quality, universality or efficiency and cannot be fully compensated in the process

- **Military Grade**
  - Unfavorable raw material can lead to off spec product, independent of the grade

- **Lacquer Grade**
  - Unfavorable raw material can lead to severe quality & capacity losses, loss of yield, loss of efficiency, dependant on grade

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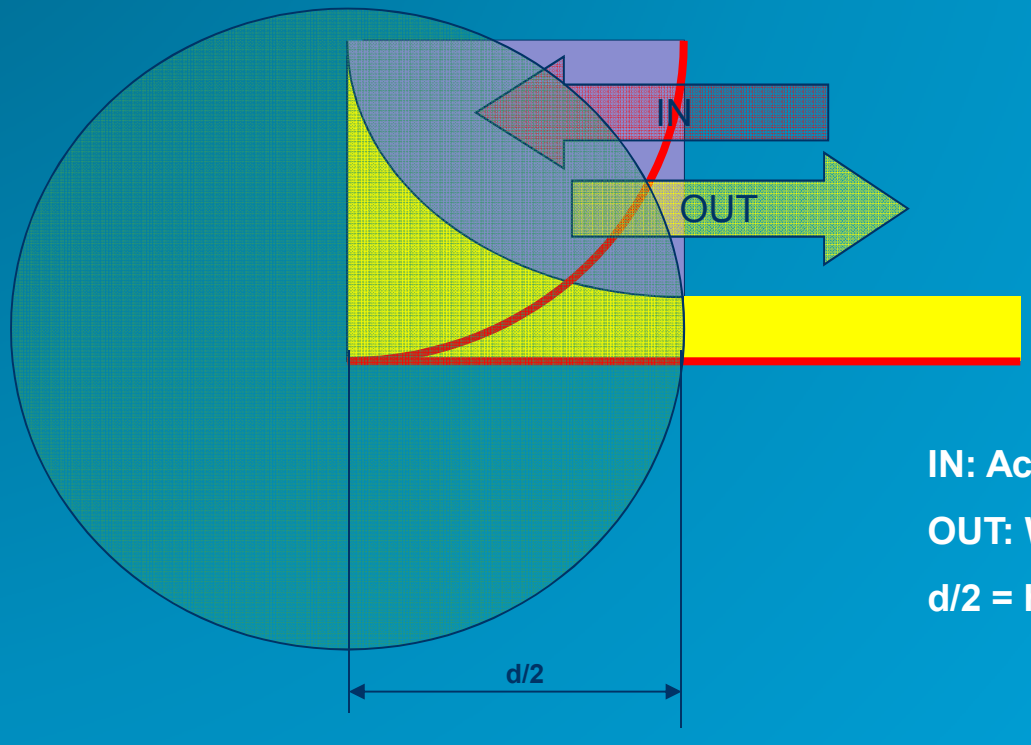
PROCESS BACKGROUND

Diffusion plays an important role in the esterification of fibrous cellulose

$Ni = \pm Dij \times \Delta ci \times 1/L$
Diffusion

+

$C_6H_7O_2(OH)_3 + 3\ HNO_3 \leftrightarrow C_6H_7O_2(O.NO_2)_3 + 3\ H_2O$
Reaction



IN: Acid, Water, Alcohol

OUT: Water, By-products

d/2 = half fiber diameter

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BACKGROUND OF THE DNC PROCESS

- The basic idea behind the DNC process is the usage of densified raw material (wood pulp) which is cut into geometrical pellets (called chips) instead of fluff (baled linters).
- The high bulk density of the chips and the favourable rheologic properties of the bulk mixtures of pellets and liquid (mixed acid in the nitration, water in the stabilisation process) allow a much higher solids loading of vessels; for example :

	Nitration	Pressure boiling
FNC	1 : 65	1 : 20
DNC	1 : 10 to 1 : 15	1 : 10

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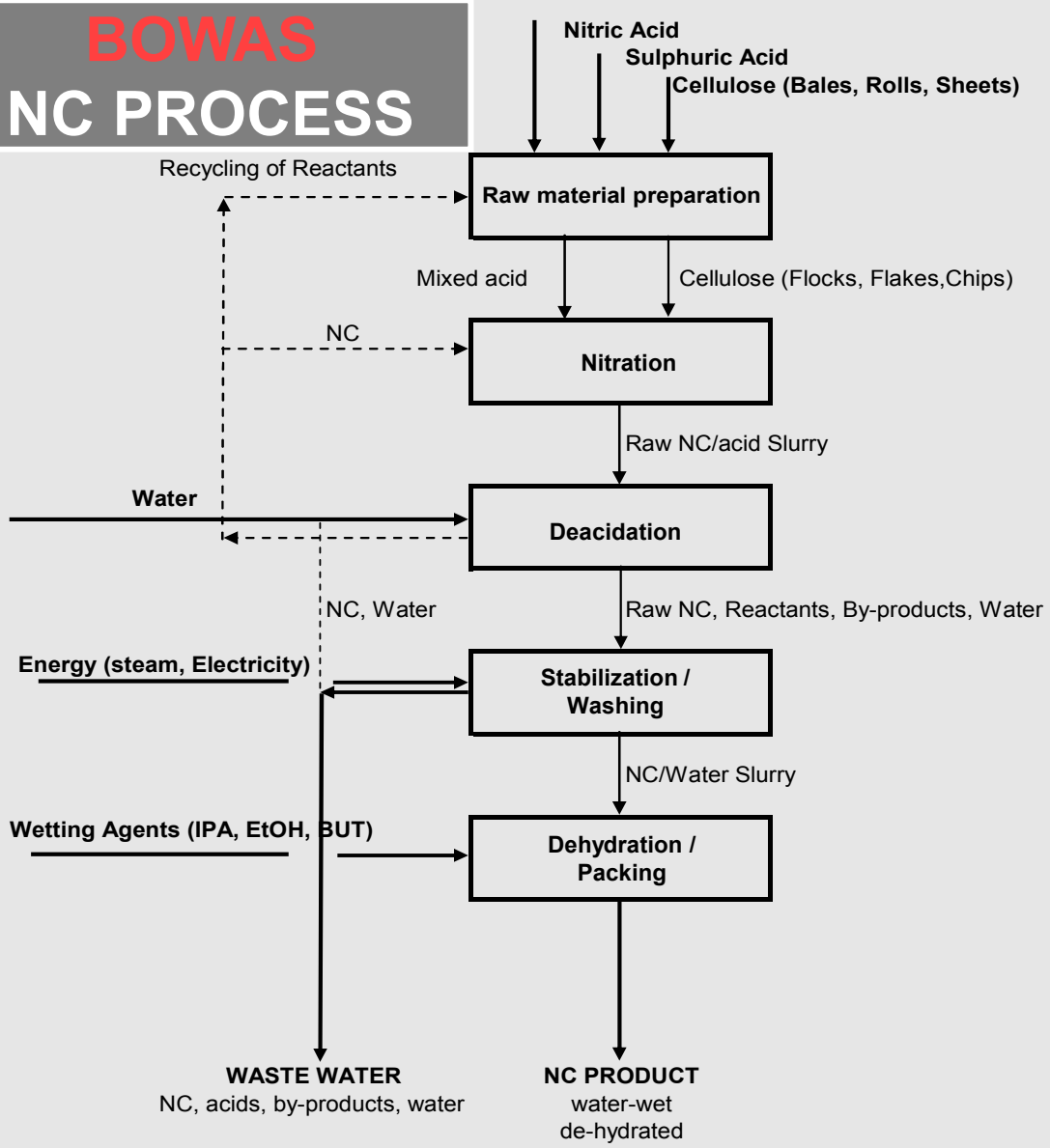
BOWAS NC PROCESS



- **Raw Materials**
  - Linters bales/rolls, WP-rolls
- **Nitration**
  - Batch/Continuous process
- **Deacidation**
  - Batch/Continuous process
  - Acid washing
  - Recycling
- **Stabilization / Washing**
  - 75% Process time reduction
  - Hollanders/Refiners/Deflakers
  - Automation
  - Recycling
- **Dehydration / Packing**
  - Batch/Continuous process
  - Simultaneous dewatering & de-hydration
  - Automation
  - Recycling
  - Densification

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RESULTS

- ✓ Best product quality
- ✓ Highest Safety Standards
- ✓ Saving of Resources
  - ➢ Recycling
  - ➢ Energy saving
  - ➢ Highest yield
- ✓ Low Environmental impact
- ✓ Compact plant
  - ➢ Low investment cost
  - ➢ Low operation cost

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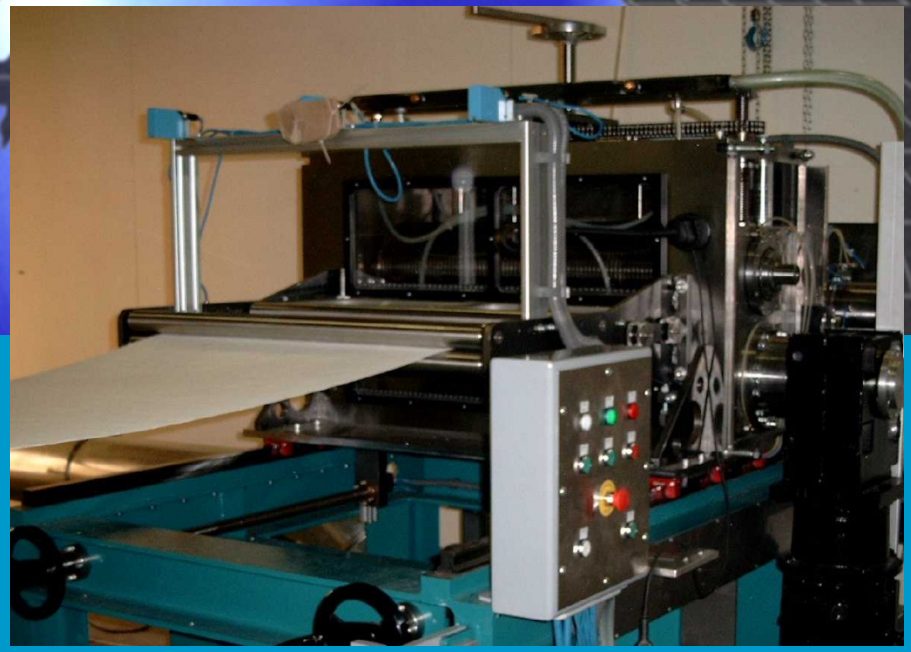

RAW MATERIAL PREPARATION

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NITRATION

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DEACIDATION

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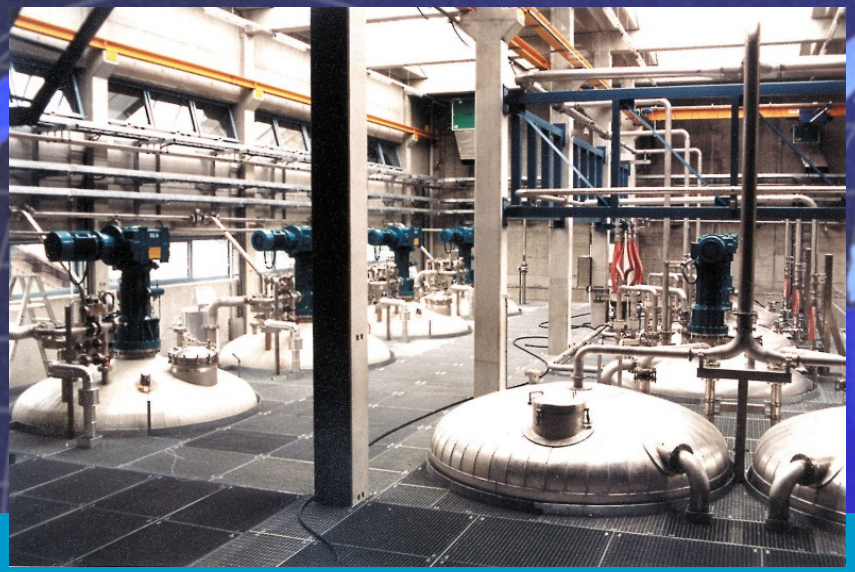
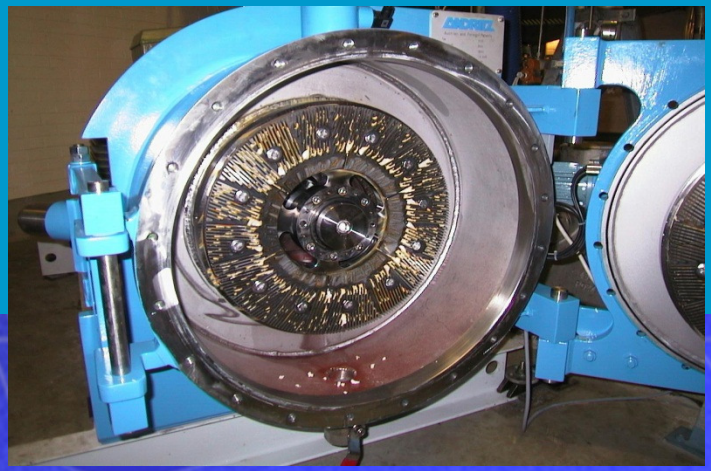


STABILIZATION



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DEHYDRATION

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INFLUENCE OF PROCESS ON PROPERTIES

	Nitrogen content	Viscosity	Fiber length	Stability	Solubility	Moisture	Total volatiles
Raw material / preparation		Low	Low		Low	High	High
Nitration	High	Low			High		
Pressure boiling		High		Medium			
Refining		Medium	High	High		High	High
Post boiling		Medium	Low	High			
Blending							
Dewatering/ Dehydration						High	High

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INFLUENCE OF PROCESS CONTROL ON PROPERTIES

	Nitrogen content	Viscosity	Fiber length	Stability	Solubility	Moisture	Total volatiles
Raw material / preparation		High		High		High	High
Nitration	High			High	High		
Pressure boiling		High		High			
Refining		High	High	High		High	High
Post boiling		High	Low	High		Low	Low
Blending	High	High			High		
Dewatering/ Dehydration						High	High

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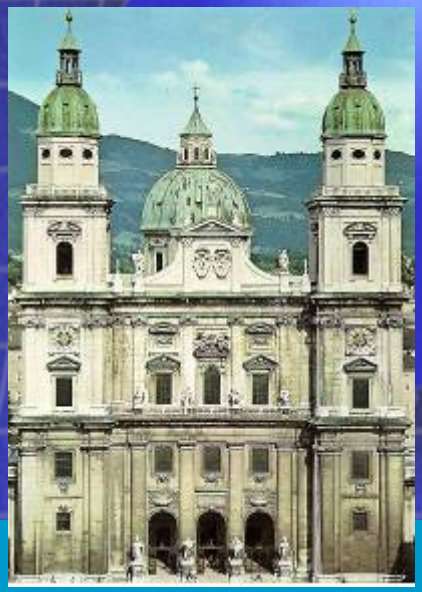

-THANK YOU FOR YOUR ATTENTION -