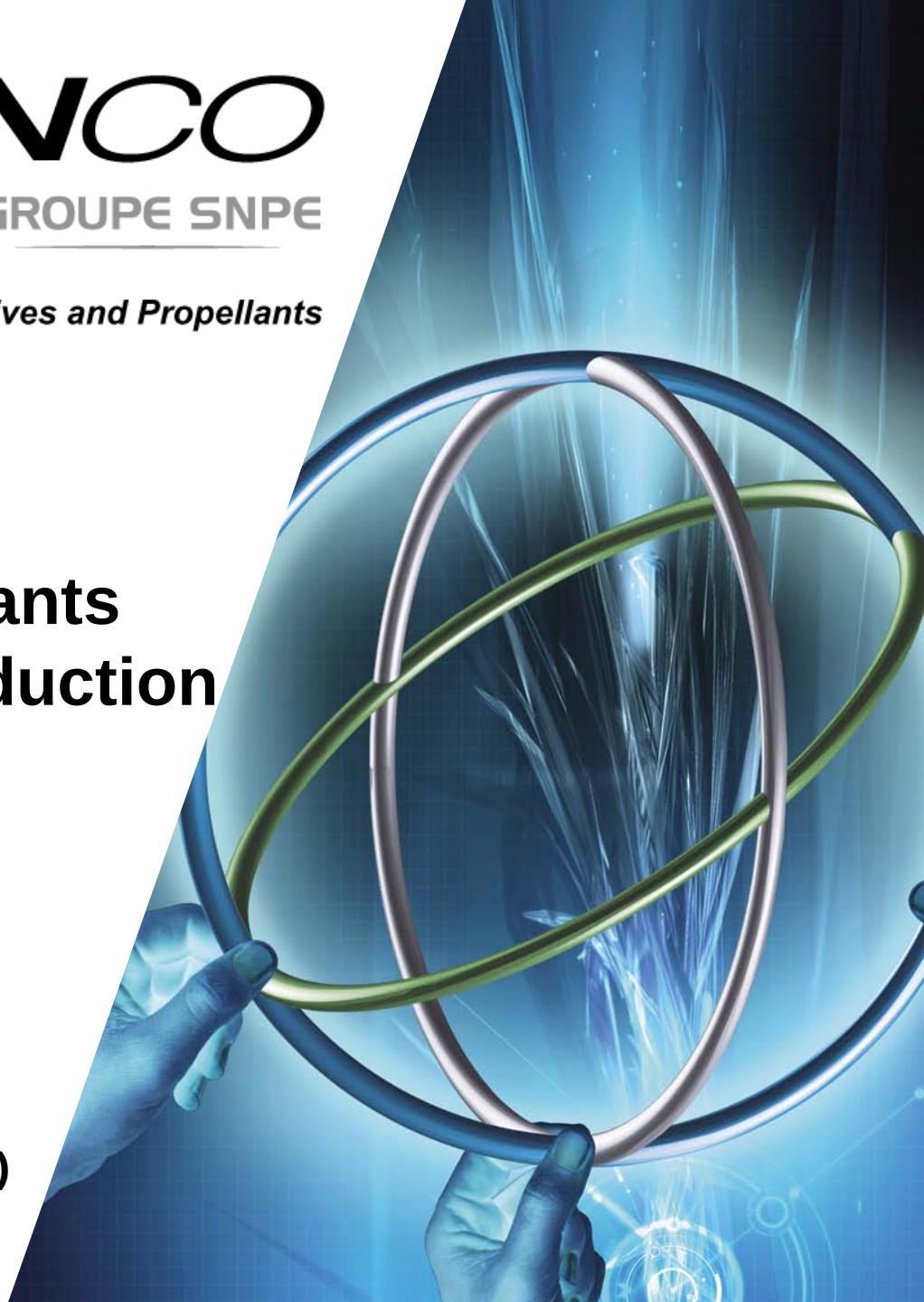
EURENCO

GROUPE SNPE

The leading international partner for Explosives and Propellants

Multibase gun propellants continuous process production in KARLSKOGA

Authors:
Anders HAFSTRAND (EURENCO Bofors)
Jean Louis PAULIN (EURENCO France)



Most of existing gun propellants production lines use batch processes:

- For mixing: by kneader (solvent way) or rolling mill (solventless way)
- For extrusion: by press

Many attempts were made to develop new processes aimed at reducing capacity and saving money (labor cost and investments) “safe, agile and low cost facility”.

The continuous process using automatic feeding and single or twin screw is one response and it is advisable to select this way for the new investments.

In this paper we plan to show, for continuous processes, NEXPLO and SME background, the existing industrial lines with additional features and the investment in the new company EURENCO.

EURENCO
GROUPE SNPE

SUMMARY

- Karlskoga industrial line for the continuous manufacture of:
  - solventless double base (DB) gun propellants
  - composite (LOVA) gun propellants
- SNPE experience with continuous process
- Main products and production lines in the field of gun propellants
- New production line for solvent multibase continuous process
- Small scale validation achieved for new production process phase
- Conclusions and perspectives

EURENCO
GROUPE SNPE

KARLSKOGA industrial line for the continuous manufacture of solventless DB gun propellant

- Concept: → continuous water process from wet NC up to propellant grains with pelletazing phase and two single screw stages, in-line cutting and automatic blending of either grains or sticks.

- Innovation in process: → fully under water process with mixing of intermediate products for a very even product.

- Innovation in equipment: → conical single barrel/screw extruders for auto feeding and high sheering work. Ignition led to the separation of the barrel and max. two days repair.

EURENCO
GROUPE SNPE

KARLSKOGA industrial line for the continuous manufacture of solventless DB gun propellant

NITROGLYCERINE
NITROCELLULOSE
ADDITIVES

↓

MIXING OF RAW MATERIALS IN WATER
PELLETAZING WITH SOLVENT → SOLVENT RECOVERY

↓

SINGLE-SCREW EXTRUSION
TO GRANULATE → TANK STORAGE

↓

DRYING OF GRANULATE ← TANK STORAGE

↓

SINGLE-SCREW EXTRUSION
TO PROPELLANT

↓

CUTTING

↓

DRYING

↓

GLAZING
BLENDING

↓

SIEVING
PACKING → STORAGE

EURENCO
GROUPE SNPE

KARLSKOGA industrial line for the continuous manufacture of solventless DB gun propellant

- Production has been running since 1977
- Advantages: Safe, continuous, low production cost, small lot to lot variation
- Disadvantages: Limited composition possibilities due to the under water process
- Main equipment designed in-house: tanks, extruders, dryers, cutters
- Over 10.000 tons produced for howitzer (105 & 155) and tank gun (105 & 120)
- DB propellants with 50-60% NC and 50-40% NG/inert plasticizer

EURENCO
GROUPE SNPE

KARLSKOGA industrial line for the continuous manufacture of composite gun propellants

- Concept:→ continuous process with automatic feeders for solid filler and liquids solvents and one twin screw.

  → for higher safety level, filler is first coated with part of binder for sensitivity decreasing,

- Innovation in process: → feedstock is only 1.3 or 1.4 class raw materials,

- Innovation in equipment: → twin screw machine with fully computerized control.

EURENCO
GROUPE SNPE

KARLSKOGA industrial line for the continuous manufacture of composite gun propellants

SOLVENT
FILLER (RDX)
BINDER (CAB, NC)
PLASTICIZER (INERT / ENERG.)

↓

DISSOLVING AND PRECIPITATION, DRYING OF POWDER → SOLVENT RECOVERY

↓

SOLVENT → TWIN-SCREW EXTRUSION TO PROPELLANT

↓

CUTTING → SOLVENT → SOLVENT TREATMENT

↓

DRYING → SOLVENT → SOLVENT TREATMENT

↓

GLAZING BLENDING

↓

SIEVING PACKING → STORAGE

EURENCO
GROUPE SNPE

Nexplo KARLSKOGA industrial line for the continuous manufacture of composite gun propellants

- Production has been running since 1996
- Advantages: Safe, continuous, low production cost, small lot to lot variation
- Computer process control system designed in house
- Over 200 tons produced for 40 & 57 mm IM, automotive safety
- M39 / M43 type propellants with 50-80% RDX and 20-50% binder / plasticizer
- The innovative and patented precipitation process is licensed to NSWC IH

EURENCO
GROUPE SNPE

EURENCO experience with continuous process

At first, feasibility tests were performed using twin screw between 1990 and 1993 for single base propellants:

- Validation step was reached with successful firing tests in 105 mm gun,
- This experience was used in designing in 1997 the new hunting single base propellant line: one machine D = 120 mm operates at 120 kg/h in three shifts.

Additional feasibility tests between 1992 and 2003:

- Industrial scale in Angoulême with TSE 120 mm,
- Research scale in Le Bouchet with TSE 45 mm,
- Compositions with solvent: double base GB and multibase like M30 type, HUX.

Also during the 90's feasibility tests were performed with composite HTPB gun propellants for MURAT.

Due to the high qualification cost of existing propellants, many of these projects were canceled. It will not be the case for new propellants, and our new investments today are often related to continuous process, like in Saint Médard in 1996 for production of composite grains with 3 TSE in three shifts for automotive safety.

EURENCO
GROUPE SNPE

Main products and production lines in the field of gun propellants

The merger between SME Explosives and Propellants and NEXPLO lead to the creation in the field of gun propellant of the strongest industrial tool, in spite of Angoulême closure.

Products	Groupe SNPE	NEXPLO
Blasting oils	Angoulême + Karlskoga	Karlskoga+Vihtavuori
Nitrocellulose	Bergerac + Vihtavuori	Vihtavuori
Wet paste	Angoulême + Karlskoga	Karlskoga + Vihtavuori
Single base propellant	Bergerac + Karlskoga + Vihtavuori	Karlskoga + Vihtavuori
Solvent multibase propellant	Angoulême	
Solventless multibase propellant	Saint Médard + Karlskoga (continuous)	Karlskoga (continuous)
Spherical propellant	PB Clermont	PB Clermont
Extruded impregnated propellant	Vihtavuori	Vihtavuori
Composite propellant (LOVA)	Karlskoga (continuous)	Karlskoga (continuous)
Combustible cartridge	Bergerac	Bergerac

EURENCO
GROUPE SNPE

New production line for solvent multibase continuous process

Only one solvent multibase propellant line was needed, in order to be in position to carry on with manufacture of:

- particular high energy double base for French tank gun cartridges,
- additional standardized gun propellants like M26, M30, M31...

Experience from NEXPLO and SME in the field of gun propellant production and continuous process lead to the choice and design of a new continuous line with an innovative process chosen for:

- high safety level,
- low production cost level,
- High reproducibility.

EURENCO
GROUPE SNPE

New production line for solvent multibase continuous process

SME experience in Angoulême corresponds with four NC/NG mixing process ways and two solvent composition adjustment, mixing, extrusion ways:

Production scale	(up to 1998)	spherical grains process → kneader → press (chosen first for safety)
Production scale	(1998 to 2003)	premixed paste process → kneader → press (no more spherical in the plant)
Feasibility	(1993)	solventless granules process → TSE
Feasibility	(1999, 2000)	direct feeding process → TSE

EURENCO
GROUPE SNPE

New production line for solvent multibase continuous process

Double base mixing comparison for first step with existing process

Process	NC	Final Product	Batch quantity	Gelatinized NC	Homogen mix	Safety	Process
Premixed paste	Dry	Solvent paste	Small	Yes & no	No	-	Easy
Spherical grains	Water wet	Dry grains	Large	Yes	Yes	++	Done twice
Solventless granules	Water wet	Dry granules	Small	Yes	Yes	+	Easy
Direct feeding	Dry	Solvent paste	Continuous	Continuous	Yes	+	Lack in flexibility

And for innovative process based on EURENCO experience

Process	NC	Final Product	Batch quantity	Gelatinized NC	Homogen mix	Safety	Process
Direct way by impregnation	Water wet	Granulates in water tank	≈ 20 tons	Partly	Yes	+++	Easy

EURENCO
GROUPE SNPE

New production line for solvent multibase continuous process

Solvent multibase innovative process

Composition adjustment, mixing and extrusion can be made by twin screw and automatic feeders because:

- New investment need gives opportunity for free choice,
- New qualification must be done in any case
- This solution provides advantages:
  - Lower investment and production costs
  - Smaller variations in production quality
  - Smaller quantities inside the machine reducing the risk zones
  - Better logistics and additional possibilities for new propellants

EURENCO
GROUPE SNPE

New production line for solvent multibase continuous process

SOLVENT MULTIBASE PROPELLANT PLANT

EURENCO
GROUPE SNPE

New production line for solvent multibase continuous process

The main part of investment will be the twin screw extruder, our proposal is strenghened by the experience we have together in three different knowledge areas:

Technology

- Feeding equipment
  - Material extraction from the hopers,
  - Flow rate control (stability, accuracy),
  - Feeders calibration (LT2B equipment).
- Twin screw machine
  - Safety concerns,
  - Screw designs, ie kneading,
  - Process control,
  - Barrel design.
- Die design

Mathematical modeling

- Twin screw flow (LUDOVIC, Code),
- Residence time distribution (ECLIPSE),
- Die flow (poly. 3D).

Instrumentation

- Infra red temperature control,
- Paste rheological behavior
- Computor controlled process

EURENCO
GROUPE SNPE

Small scale validation achieved for new production process phase

Preliminary process validation was done last year:

At Karlskoga plant for:

- Pellets and granulate production with the same composition as the candidate propellant:
  - NG: 29,9% ; NC: 68,3% ; stabilizer: 1% ; plasticizer: 0,6%, with addition of Mg- stearate for the single screw extrusion,
  - Geometrie, D: 5mm, thickness: 3mm, density: 0,7 kg/m^3,
  - Continuous drying in oven.

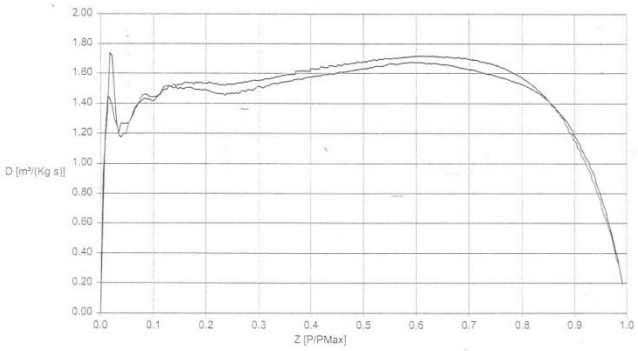
At Le Bouchet Research Center for:

- Granulates and solvent paste safety test,
- Propellant grains by continuous process with BC 45 TSE.

and Angoulême for:

- Propellant grains by batch process with Werner kneader and press (industrial scale).

We have made one lot with same composition, same geometry and same mechanical properties level at shot gun test: impact+CV.



RQ = 0,97 RI = 1,01

EURENCO
GROUPE SNPE

Twin screw comparison for large scale solvent multibase production

Parameter	BC 45 CRB	APV 65	BC72	APV65	BC72
Screw diameter (mm)	55	65	95	65	95
L/D	21	25	28	25	28
Granulates type	D: ≈ 5mm, thickness: ≈ 3mm			D: ≈ 5mm, Thickness: ≈ 1mm	
Dwell time	24 min			12 min	
Q: quantity of paste inside the barrel (1.3)	1.5 kg	5 kg	7 kg	5 kg	7 kg
Production flow (kg/h)	4	≈ 15	≈ 20	≈ 25 - 30	≈ 35 - 50

EURENCO
GROUPE SNPE

Equipments for large scale solvent multibase production

TSE machine BC72 CLEXTRAL type is able to reach the requirements

- sliding barrel with 8 modules,
- pressure release nozzle for safety,
- addition of feeders for solid fillers (modified multibase composition).

EURENCO
GROUPE SNPE

Conclusions

- The new line use the experience of continuous process production for solventless and composite (LOVA) gun propellant and the experience on solvent double base compositions,
- The new line use an innovative process with two continuous stages using one single screw and one twin screw,
- The main phases of this new process were checked by using three production equipments in Karlskoga, Angoulême and Le Bouchet,
- The new line will be use for production of multibase gun propellant also with solid filler.