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HOW TO FILL ARTILLERY SHELLS AT THE LOWEST COST WITH THE HIGHEST IMNESS USING CAST CURED PBX

Their IM properties allow to produce under 1.3 HD rules !!!

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INTRODUCTION ₁

- **Cast Cured Plastic Bonded Explosives enable to reach the IM / MURAT signature requirements while preserving high performances.**
- **At first, only large munitions were concerned but now this improvement is possible for all munitions, including tank, artillery and mortar shells.**
- **Today it is desirable for customers to obtain Insensitive Munitions filled with Cast Cured PBXs at a price as close as possible to usual munitions with melt cast or pressed compositions.**
- **This challenge has been taken up using a continuous process for shell filling.**
- **This is achieved by using an innovative bi-component technology applied to Cast Cured PBX shell filling (EURENCO's Patent / FRANCE #0201213 / USA #6916390 / JAPAN #3740128 / ISRAEL #153983 / SINGAPORE #105568 / TAIWAN #206228 / SOUTH AFRICA #2003/0557... European and others countries patents pending).**
- **The new integrated workshop is already commissioned and the mass production for Rheinmetall will start in June 06.**

INTRODUCTION ₂



EURENCO Integrated Workshop in Sorgues Plant

INTRODUCTION ₃

- The insensitiveness properties of the Cast Cured PBXs allowed an integrated workshop design.
 - Indeed, it has been established that no stimulus in process phases can outcome any detonation neither by SDT (shock-to-detonation transition) nor through DDT (deflagration-to-detonation transition).
 - The maximum risk considered is the Cast Cured PBX combustion with some moderate thermal flux effects.
- *Sufficiently convincing demonstrations were given to the French Authorities in order to classify the manufacturing process in 1.3 HD (Hazard Division)*
- This classification has allowed to reduce significantly the capital expenditure devoted to the new workshop.

INTEGRATED WORKSHOP FOR SHELL FILLING ₁

- The integrated workshop has 1200 meter square area.
- The production line is fully automated from shell body washing-up to final X-Ray control.
- This integrated workshop is operated usually by five people team.
- It allows filling of 50,000 155 mm shells per year or 100,000 120 mm shells per year.
- At each step, the process is controlled and traceability is insured through bare code system.



Handling Robot



INTEGRATED WORKSHOP FOR SHELL FILLING ₂

- This technique enables to achieve the PBX preparation and to fill the shells preserving the quality of the material: charge homogeneity, absence of porosity...
- At each step, this process design insures the integrity of the explosive charge and avoids any source of "properties" degradation (shocks, drops, foreign material ...).
- Worker operations are strongly limited: these are essentially the feeding of production line and the process control.

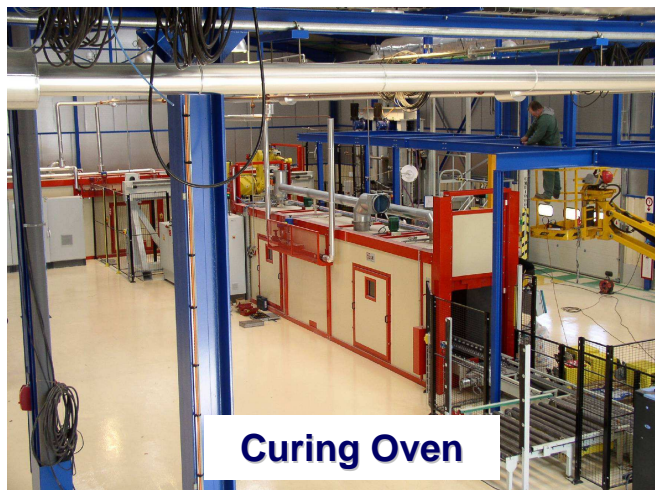
INTEGRATED WORKSHOP FOR SHELL FILLING ₃



Anti-SD Pallet



Anti-SD Pallet



Curing Oven



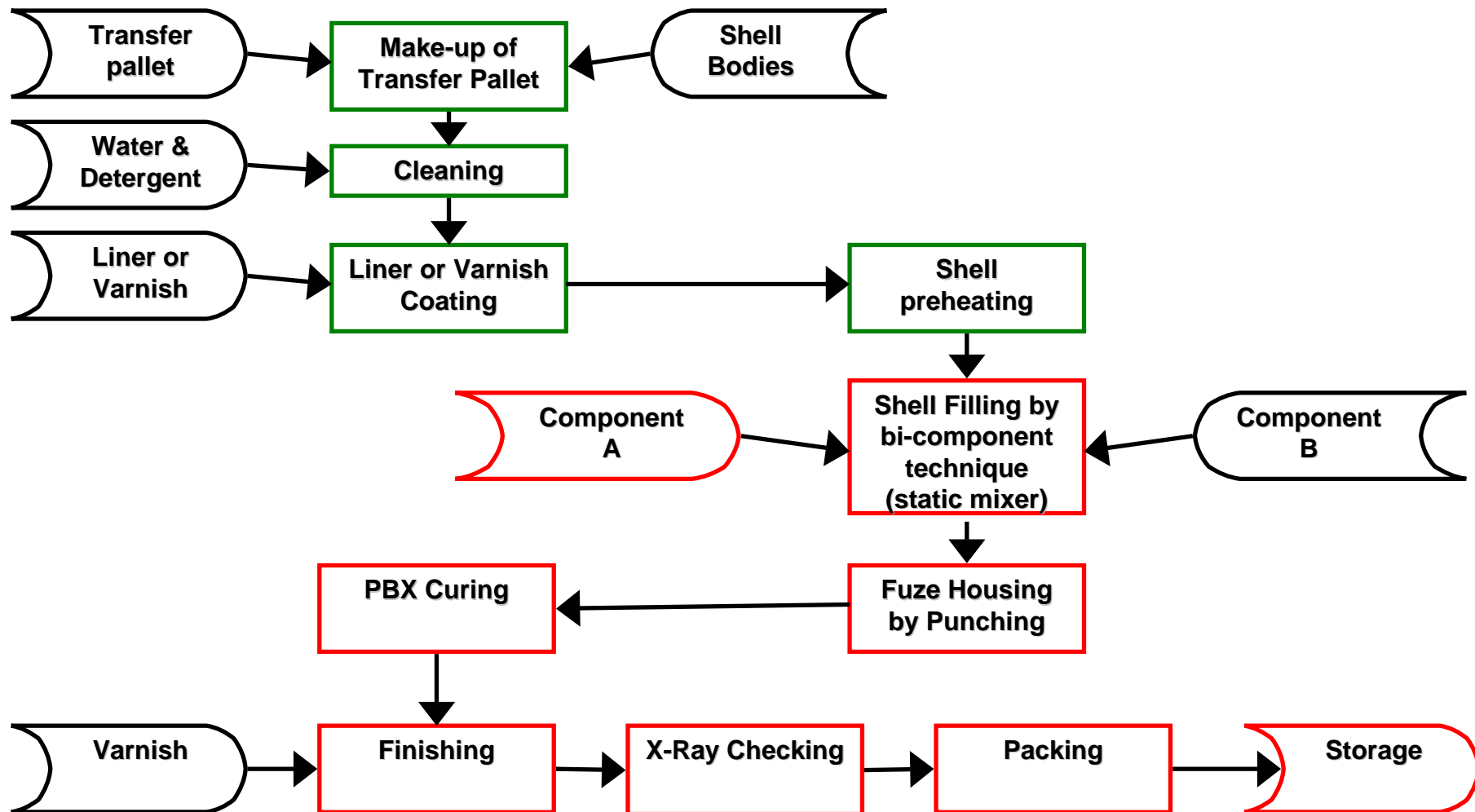
Curing Oven



Bi-Component filling system

INTEGRATED WORKSHOP FOR SHELL FILLING 4

- The various process phases are summarized on this flowchart :



CAST CURED PBX PROPERTIES ₁

- The Cast Cured PBXs used in this workshop are classic compositions :
 - Based on inert binder (HTPB, PU ...) and solid fillers (RDX, HMX, AP, Aluminum...).
- In the workshop, explosives are present under various forms:
 - pasty in containers,
 - cured in shells,
 - mitigated scraps in bins.
- Some minimum safety requirements for pasty and cured explosive compositions must be taken in account.

CAST CURED PBX PROPERTIES ₂

LIST OF TESTS	MINIMUM SAFETY REQUIREMENTS
Combustion Propagation in Gutter Test (AFNOR Standard NF T70-507 or AOP7 302.02.001)	Lower than 50 mm/s
Large Card Gap Test (40 mm) (AFNOR Standard NF T70-502 or STANAG 4488)	Lower than 240 cards
Friction Sensitivity Test (BAM apparatus) (AFNOR Standard NF T70-503 or STANAG 4487)	Higher than 50 Newton
Large Scale Electrostatic Discharge Sensitivity Test (AFNOR Standard NF T70-527 or STANAG 4490)	Not Sensitive
Friability Test (AFNOR Standard NF T70-524 or UN 7c) ii))	Lower than 18 MPa/ms at 150 m/s
Critical Pressure of Combustion under Parallel Layers (SNPE N° 108)	Higher than 600 MPa
External Fire Test (AFNOR Standard NF T70-525 or UN 7e))	No more than burning

CAST CURED PBX PROPERTIES ₃

- These minimum requirements were set-up to eliminate any risk of accidental transition-to-detonation :
 - SDT (shock-to-detonation transition) through sensitivity to low shocks,
 - DDT (Deflagration-to-Detonation transition) due to catastrophic combustion reactivity after an accidental ignition.
- These safety parameters are maintained all along the manufacturing cycle.
- The substance characterizations are completed by full scale trials (UN tests listed in series 6). The various items have passed these tests.

HAZARD DIVISION CLASSIFICATION₁

- The various manufacturing operations conducted in the integrated workshop have been classified under 1.3 Hazard Division by the French Authorities.
- The approval document has been issued by DGA / IPE (French Procurement Agency / Inspectorate for Powders and Explosives) by end of 2005.
- The 1.3 QDs are drawn for the whole quantity of explosive inside this workshop (3 tons).

HAZARD DIVISION CLASSIFICATION₂

- The justification is that no aggression is able to provoke any transition-to-detonation, because:
 - the Fault Tree Analysis has demonstrated that all possible accidental events generate some no-dangerous shocks (many times) in comparison with PBX shock sensitivity,
 - the preventive measures defined from Fault Tree Analysis are checked according to defined procedures all along manufacturing cycle,
 - the possible ignition of explosive cannot generate any violent reaction even for shells, so no DDT is possible and no dangerous fragment can provoke any SDT of neighbouring items.
 - Obviously, the fuses are never present in the workshop and even in the whole factory, so, the delivered products are not able to detonate at any time.

HAZARD DIVISION CLASSIFICATION₃

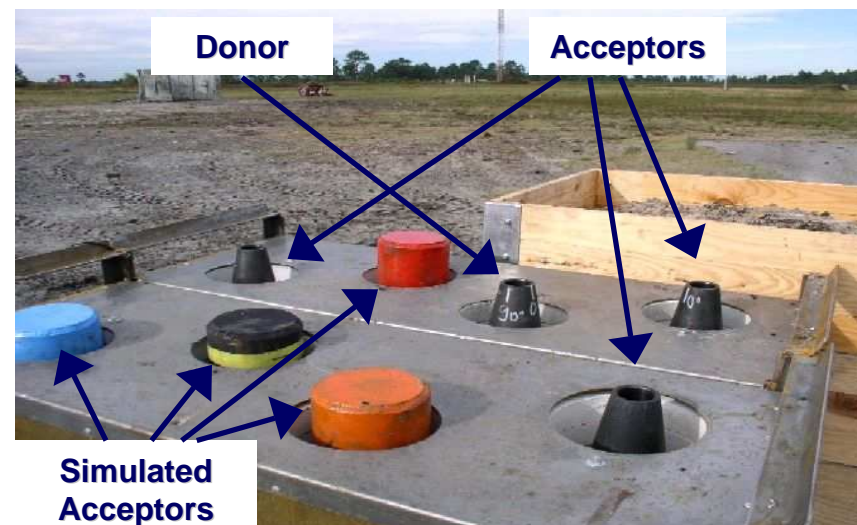
- Some complementary trials were requested even if the Fault Tree Analysis had demonstrated that all detonations can be eliminated regarding the listed Cast Cured PBX properties.
- The DGA/IPE request was to demonstrate the absence of sympathetic detonation between shells on pallets all along the production line.

SYMPATHETIC REACTION TRIAL₁

- A specific pallet has been designed using:
 - SDT threshold for each studied Cast Cured PBX,
 - Numerical simulations though LS-DYNA with specific behavior laws,
 - Preliminary tests in laboratory,
 - Full scale tests in standard & hardened conditions to evaluate a safety margin,
 - The reference charge is the 155 mm artillery shell.

SYMPATHETIC REACTION TRIAL₂

- The first assessment has shown the necessity to set-up some specific screens between shells within each pallet and between pallets.
- These screens are made of pressure attenuator materials; the pallet framework is made of steel.



SYMPATHETIC REACTION TRIAL₃

- The results have shown the absence of sympathetic detonation inside each pallet and between pallets.
- The nearest acceptor is partially torn, the two others are intact.



CONCLUSIONS

- **Cast Cured PBXs enables to reach the Insensitive Munitions signatures compliant with STANAG 4439 while preserving high performances.**
- **This advantage can be used also during manufacturing phase of medium and large caliber artillery shells.**
- **The integrated workshop can be operated under 1.3 HD due to the demonstrated absence of all detonation risks during the manufacturing phases.**