

- 1. Introduction**
- 2. Historical Perspective**
- 3. Facility for Continuous Manufacturing**
- 4. Technology and Engineering Manufacturing Readiness Levels**

Section 1

INTRODUCTION

Introduction to Roxel Technology (70 mm)

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- **Roxel has extensive experience working with 70 mm (2.75") rocket motor and propellant grains**
- **Manufacturer of several types of EDB grain**
 - **Europe's major 70 mm 1.3 minimum smoke manufacturer**
 - **Owens the most advanced manufacturing facility and processes**
 - Shear Roll Milling (SRM) + TSE (Twin Screw Extrusion)
 - Automated finishing line
 - **Roxel is producing grains for 68 and 70 mm motors today**

Section 2

HISTORICAL PERSPECTIVE

- **1960-1980's** **Qual + Mfg of grains for Mighty Mouse (Mk 43) and 68 mm**
 - More than 3,000,000 grains manufactured
- **1970-1990's** **Continuous manufacturing developed and implemented**
- **1980-1990's** **Development, Qual & manufacture of Speed Grain**
 - “Improved” Mk 90 type
 - Reduced instability
- **1996-1997** **Attempt to supply Mk 90 grains to USA**
 - Self funded development of Mk 90 Grain (with AA2)
 - Unsolicited bid to AMC for 2nd source
- **2005** **Re-established continuous manufacturing facility**
 - Improvements implemented

Continuous Processing in SNPE Group

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Year	Equipment used	Energetic Material
1970	First TSE (Creusot Loire)	EDB
1973	Single screw + TSE process	EDB <ul style="list-style-type: none">• 60,000 Durandal grains for US Air Force• Represents 210 tons of propellant
1990	Study on SRM + TSE (120 kg/h)	EDB
1992	Double stage unit, Bergerac plant	Single base
1995	Start of Production of first CEP unit	Composite for airbag market
1997	Start of Production of Pont de Buis unit	Single base for hunting powder
2000	Start of Production of second CEP unit	Composite for airbag market
2003	Start of Production of third CEP unit	Composite for airbag market
2005	Re-start 'Improved' TSE/SRM	EDB
2005	Starting of CPA unit	Advanced studies (1.1 class materials)

SNPE Group Current Experience: Air Bags

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- **Three TSE in mass production**
 - **Each with same 85 mm TSE as used on Roxel EDB facility**
- **Ten years of mass production**
 - **Three shift operation**
 - **1995 to date**
- **250 million extruded grains (1.9 to 34 grams)**
- **2500 tons of extruded propellant**
- **Air Bag market is price critical, same for 70 mm grains**



Section 3

FACILITY FOR CONTINUOUS MANUFACTURING

Advantages of Continuous Processing

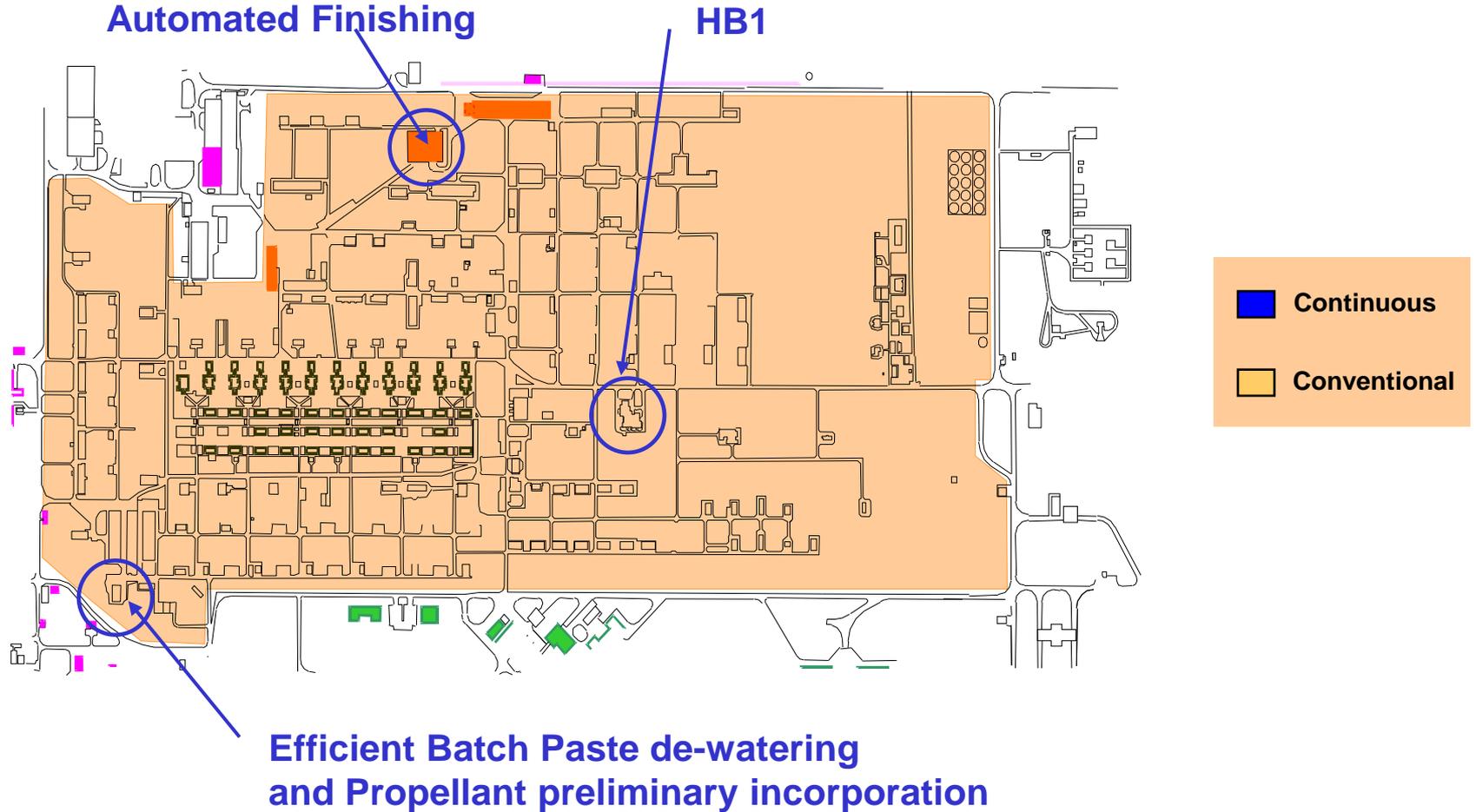
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- **Improved quality**
 - Optimum consolidation
 - Improved consistency
- **Reduced man-hours, capital investment and footprint**
 - Continuous production of “EDB Blank” : 3 x less touch time
 - Two SRM’s equivalent to 24 conventional rolling mills
 - Automated Grain “finishing” : 4 x less touch time
- **Surge capability**
 - Significantly less skilled labour
 - Much reduced footprint
- **Improved Safety**
 - Less than 5 kg of propellant resident in process
- **More environmentally friendly**

Relative Footprints

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Roxel improved process uses < 1/50 footprint of traditional batch manufacture

Continuous Production of “EDB Blank”

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1. Incorporation

- 1500 kg scale (more efficient incorporator, but this stage still batch operation)
- Initial mixing of paste, ballistic modifier, stabiliser, etc

2. Shear Roll Milling (SRM)

- 2 machines, each manufacturing 50 kg/hr
- Each diameter 500 mm
- Produces 8 mm pellets
- Water content reduced from 21 % to < 1.5 % moisture

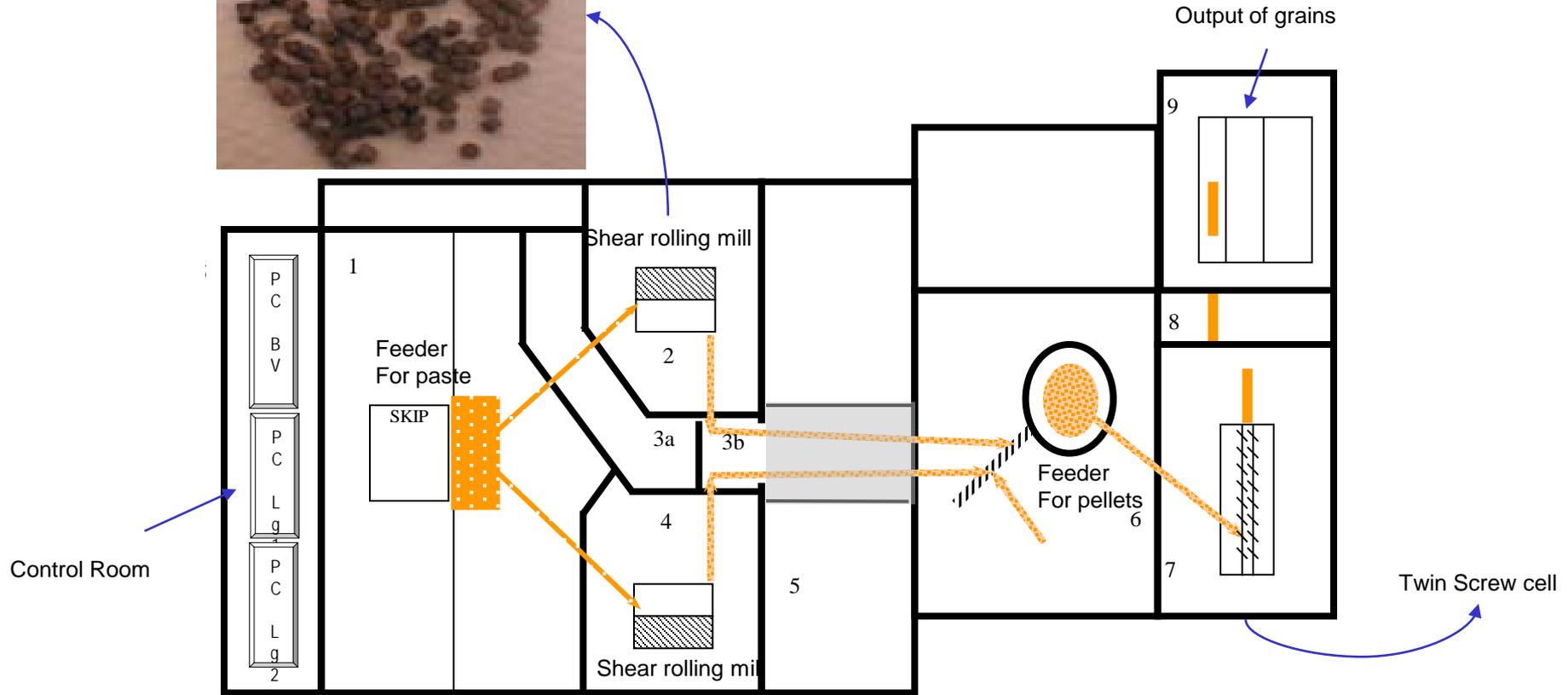
3. Twin Screw Extrusion (TSE)

- 84 mm
- 100 kg/hr (200 grains per shift of 8 hrs)
 - With cleaning, if operated on 3-shift, 5 day operation gives > 100,000/year

Located
together in
“HB1” unit

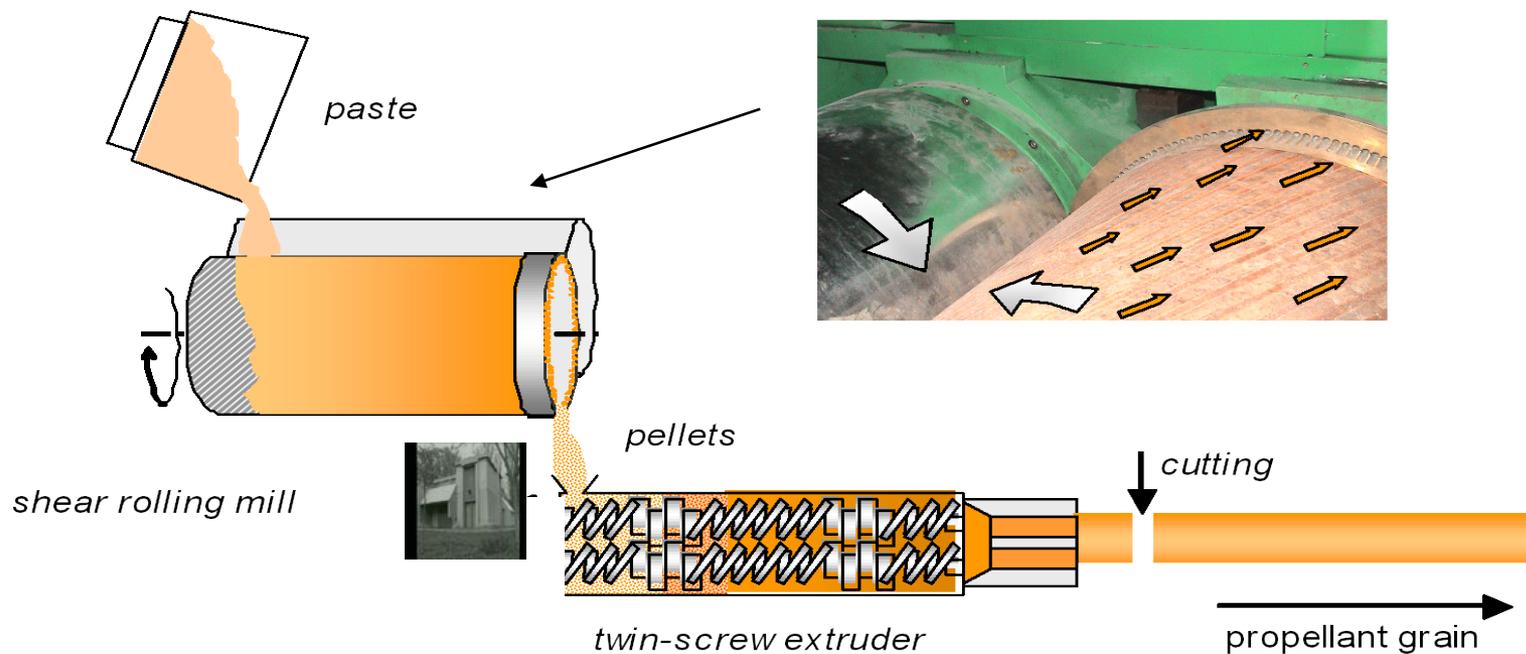
HB1 Unit: Top View

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HB1 Unit: Continuous Process Principle

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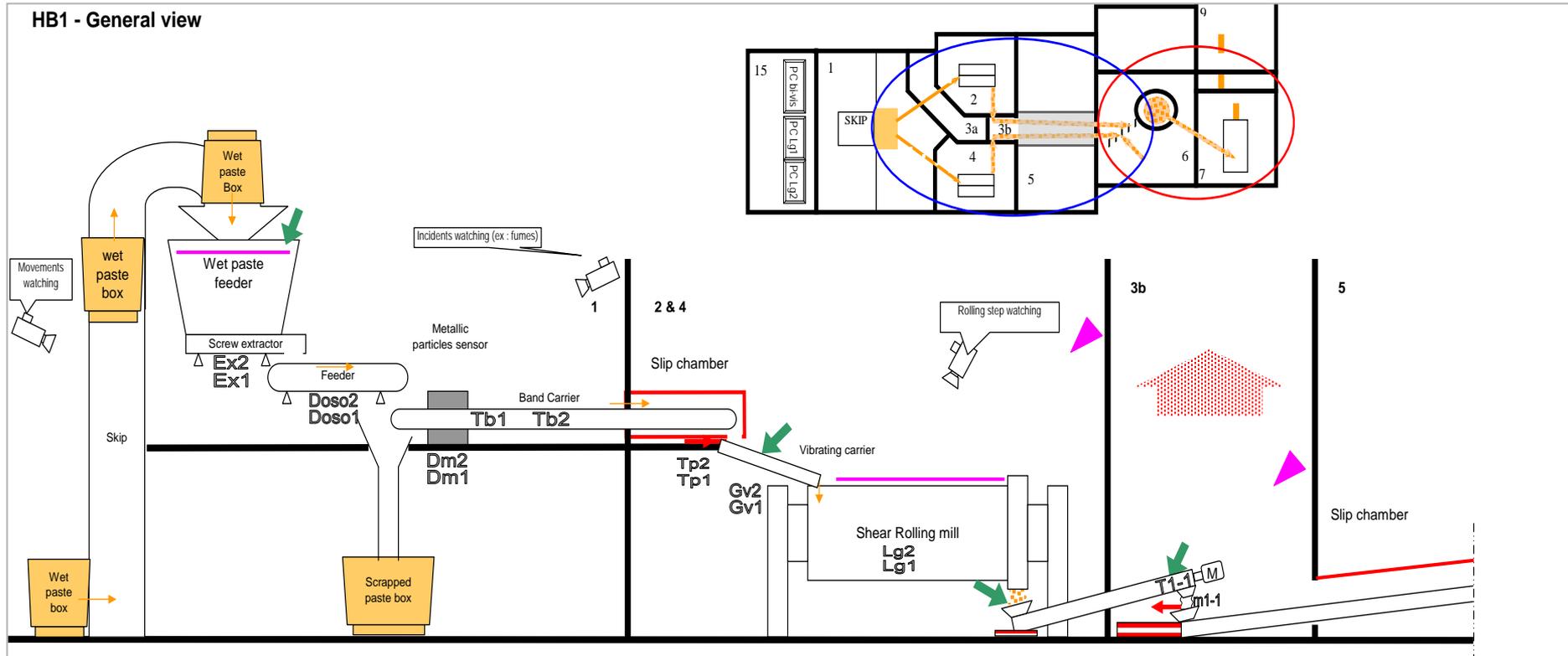
The twin screw :

- Compacts,
- Gelatinizes,
- Extrudes at the final shape the propellant

HB1 Unit: detailed view

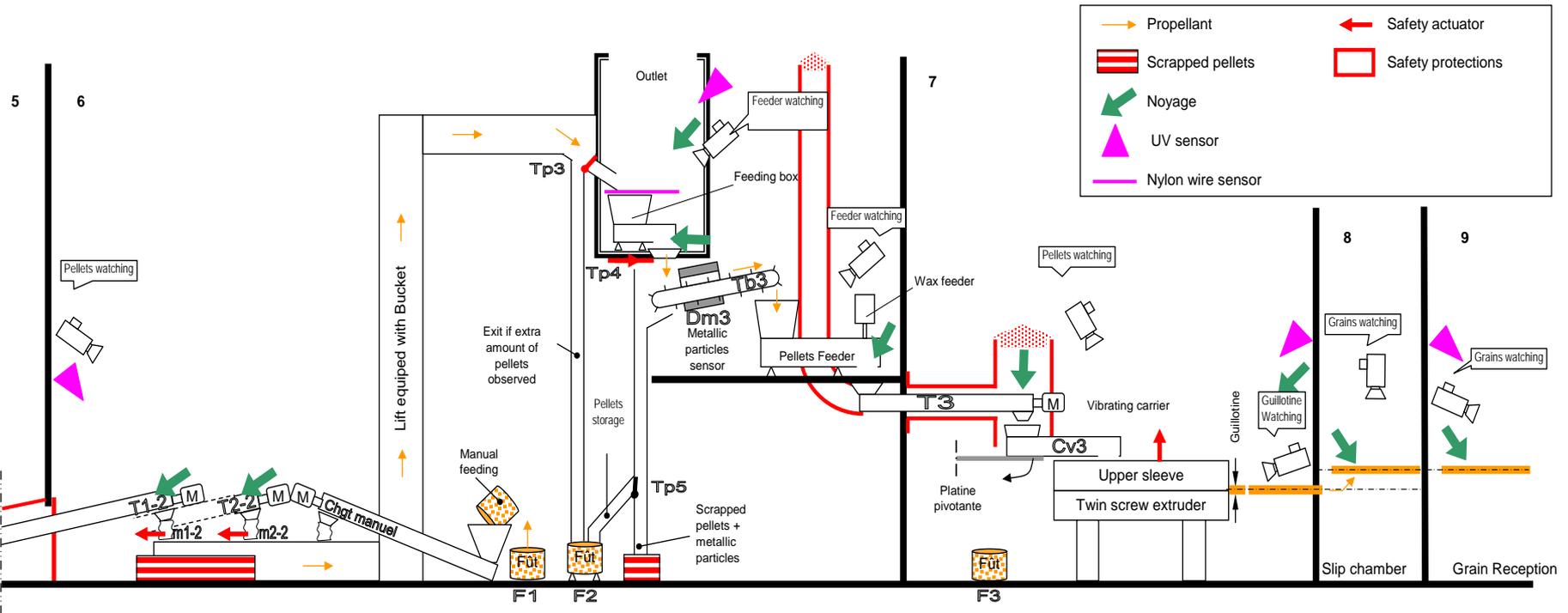
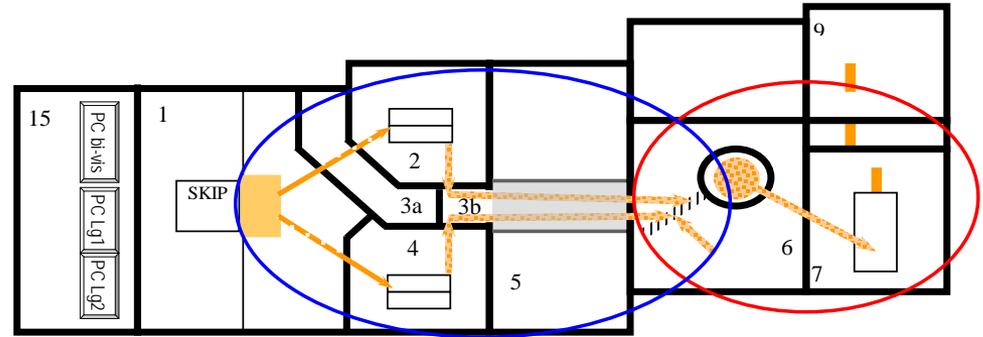
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HB1 - General view



HB1 Unit: detailed view

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Continuous Production of "EDB Blank"

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- **Has been used since mid 1990's for all grains (68/70 mm motors)**
- **400 grains per shift (8hrs)**
 - If operated on 3-shift, 5 day operation gives > 200,000/year
- **Sequence of operations**
 1. Ultrasonic inspection
 - Shown to be more discerning than X-Ray
 2. Removal of reject grains
 - The overall finished reject rate is now < 5 % (originally 25%)
 3. Cut to length
 4. Bond Ethyl Cellulose (EC) Washers
 5. Machine external diameter
 6. Tape Wrap (EC)
 7. Bond End Sleeve
 8. Pack



Automated Finishing Facility

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Section 4

TECHNOLOGY and ENGINEERING MANUFACTURING READINESS LEVELS

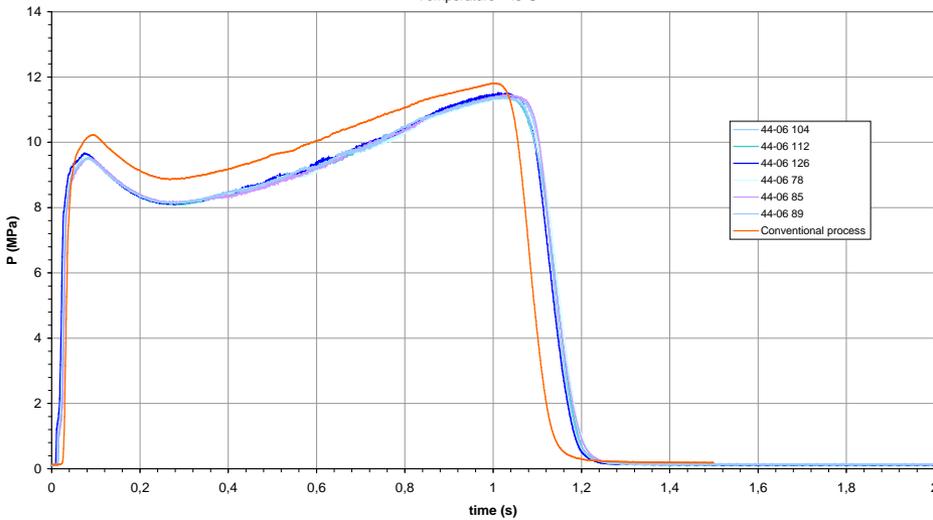
- **Technology Risk Level (TRL)**

- Grain is qualified and is flying on numerous systems in Europe.

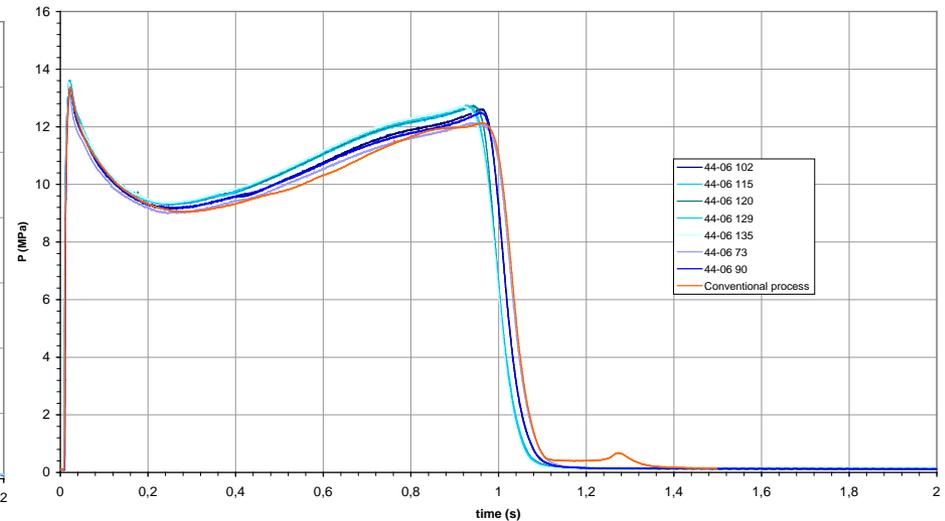
- **Engineering Manufacturing Readiness Level (EMRL)**

- Propellant continuously manufactured shown similar performances compared to the one obtained with conventional process

Speed grain - Pressure versus curves
Conventional versus continuous process
Temperature - 45°C



Speed grain - Pressure versus time curves
Conventional process versus continuous process
Temperature +66°C



Roxel is able to manufacture 1.3 class Min Smoke propellants in 70 mm calibre

- More than 40 years production experience
- More than 3,000,000 manufactured
- Extensive investment and experience in continuous processing
 - 210 Tons of EDB processed by Twin Screw Extrusion
- New mass production is on going
 - 5000 grains to manufacture before the end of 2006
 - 34 000 grains to manufacture in 2007