



## **KraussMaffei Berstorff Pipe Extrusion**

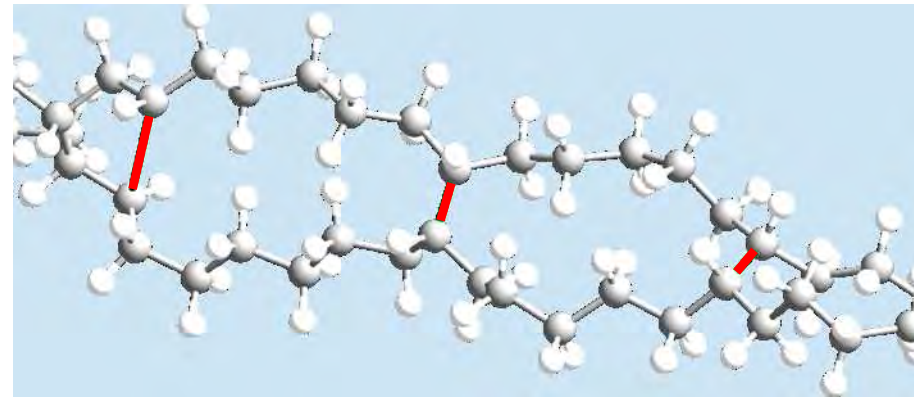
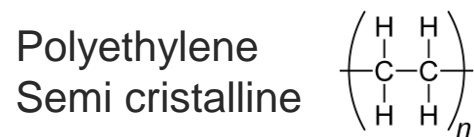
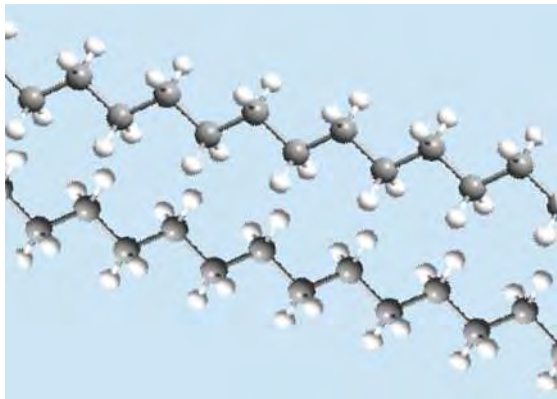
PE-Xa Pipe Extrusion on a fully-operational line

October 2011

**PEX is one of the most versatile, high performance and cost effective polymers in the market.**

## Crosslinking

### Principle



Crosslinked Polyethylene

3-dimensionally cross linking leads to C-C bridges between various molecular chains

## Crosslinking Technologies

### **Peroxide crosslinking (PE-Xa)**

- Chemical Crosslinking by peroxide radicals
- Crosslinking in an amorphous state, inline
- Minimum required degree of crosslinking is 70%

### **Silane crosslinking (PE-Xb)**

- Chemical Crosslinking by reaction of bifunctional groups
- Crosslinking in a semi-crystalline state, offline in a steam chamber in a second process step
- Minimum required degree of crosslinking is 65%

### **Irradiation crosslinking (PE-Xc)**

- Physical Crosslinking by high energy radiation
- Crosslinking in a semi-crystalline state, offline in an irradiation chamber in a second process step
- Minimum required degree of crosslinking is 60%



## **Crosslinking** Technologies

### **Advantages PE-Xa versus PE-Xb & PE-Xc**

PE-Xa pipe production is a 1-step-process.

PE-Xb and PE-Xc pipes have to be crosslinked separately after the pipe extrusion process. PE-Xb pipes have to be crosslinked in water steam chambers or by hot water. PE-Xc pipes need high energy radiation chambers for crosslinking. For that PE-Xc pipes have to be transported to companies which are specialized in this kind of crosslinking.

PE-Xa pipes are crosslinked during production. At the end of the production line the pipes are cross linked and ready for sale. This means huge savings in terms of time, man power, cost, transport, storage capacity and energy.

## **Crosslinking** Technologies

### **Advantages PE-Xa versus PE-Xb & PE-Xc**

Raw material costs for the production of PE-Xa pipes are lower than raw material costs for the production of PE-Xb and PE-Xc pipes.

A rough comparison shows that e.g. PE-Xb raw material is approximately 10% more expensive than PE-Xa. \*

\* depending on 1-step-process or 2-step-process

## **Crosslinking** Technologies

### **Advantages PE-Xa versus PE-Xb & PE-Xc**

PE-Xa pipes are more flexible than PE-Xb and PE-Xc pipes.

This means advantages for the installation (narrow bending radii, installation at low temperatures, ...).

At the same time PE-Xa pipes reach very good values at the internal pressure creep rupture test.

## Crosslinked PE-X Pipes

### Types of PE-X Pipes

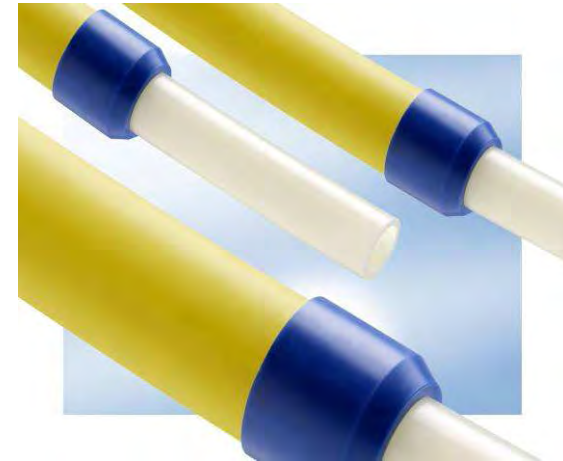
- 1-layer pipes: PE-X
  - 3-layer pipes: PE-X – Adhesive – EVOH
  - 5-layer pipes: PE-X – Adhesive – EVOH – Adhesive – PE/PE-X  
PE-X – Adhesive – Aluminum – Adhesive – PE/PE-X
- 
- PE-X pipes with corrugated cover pipes
  - Insulated PE-X pipes



## Crosslinked PE-X Pipes

### Applications

- Floor-, wall- and ceiling-heating/cooling
- Plumbing (hot and cold domestic water)
- Radiators
- District heating
- Geothermal Energy
- Compressed air and fluids
- Surface heating for outdoor applic. (e.g. airports)
- Lawn heating
- Swimming pools
- Air conditioning networks
- Automotive applications
- Pipe installation at low temperatures
- Alternative pipe laying methods (sandless, ...)



## **Crosslinked PE-X Pipes**

### Advantages vs. metal pipes

- Corrosion resistance
- No incrustation
- Longer lifetime
- Low weight
- High flexibility
- Fast and easy installation
- No leach of metal ions into the water (water quality, purification)
- Manufacturing process more environmental friendly (energy consumption, air/water pollution)

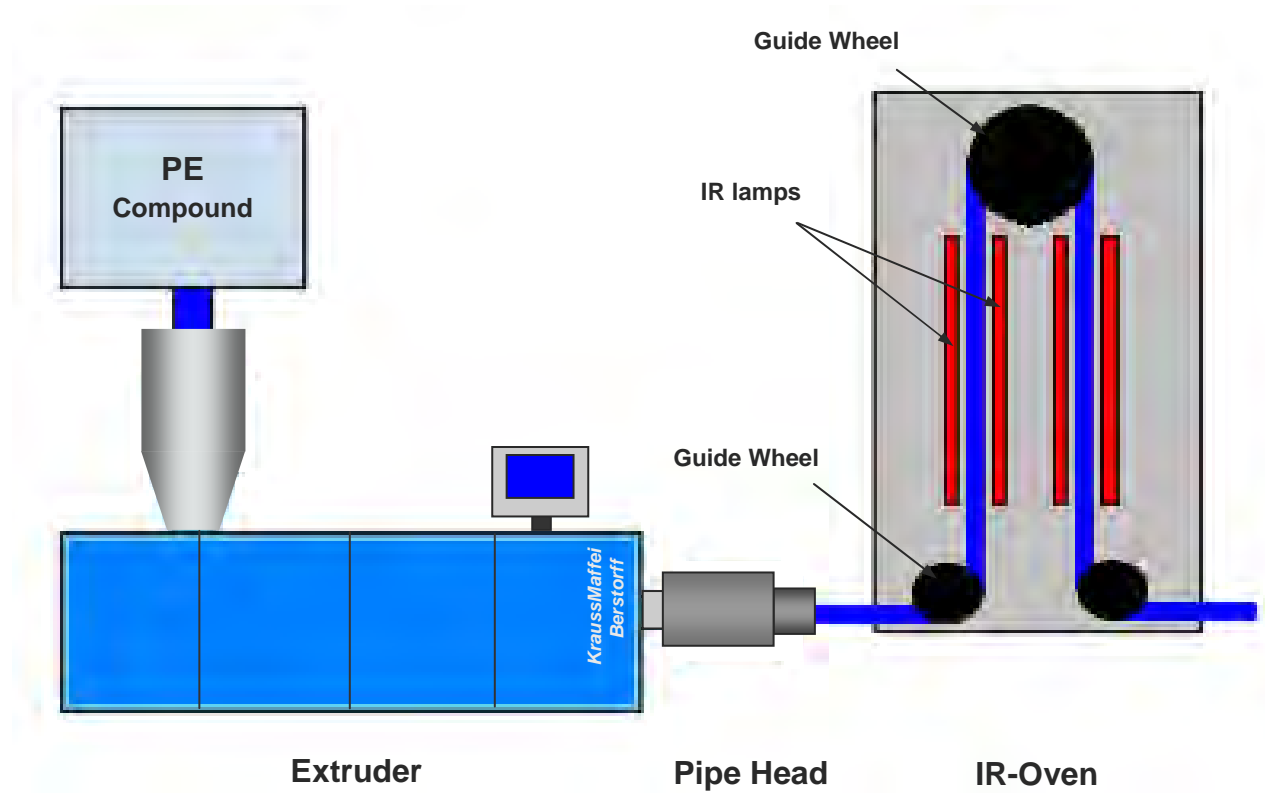
## **Crosslinked PE-X Pipes**

### Advantages vs. thermoplastic PE or PP

- High temperature resistance
  - application temperature up to 95 °C
  - maximum temperature peaks up to 120 °C
- Better chemical resistance even under high temperatures conditions
- Higher pressure resistance at high temperatures
- Increased resistance against abrasion
- High flexibility even at low temperatures
- Improved impact strength
- Improved aging resistance
- Improved resistance against rapid crack growth (RCP) and slow crack growth (SCG)
- Less creep

## PE-Xa Extrusion Process

### Key Components



## PE-Xa Extrusion Process

### Key Components

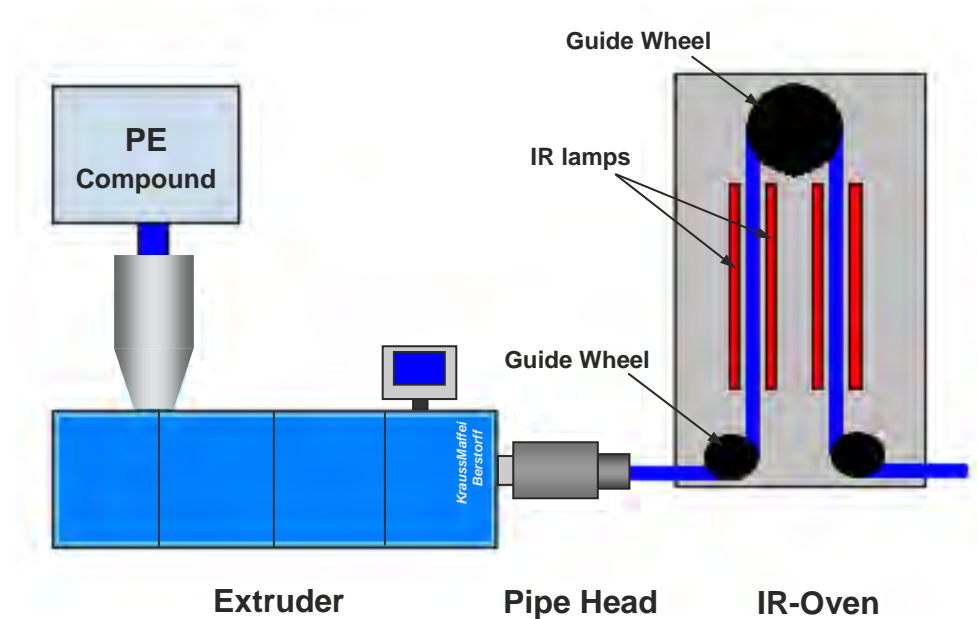
#### Extruder

High demand on homogenization at

- low melt temperature
- gentle processing
- consistent shear rates
- no shearing peaks
- exact temperature control

To avoid premature crosslinking

=> Counter rotating twin screw



Source: Borealis

## **PE-Xa Extrusion Process**

### Key Components

#### **Pipe Head**

High demands on

- flowing channel geometry, volume & surface
- pressure resistance
- shear deformation

To avoid

- material deposits
- premature crosslinking
- memory marks due to extreme visco elastic properties of melt

#### **IR-Oven**

High demands on

- temperature control
- pipe guidance

to ensure uniform energy input for uniform & consistent crosslinking

## PE-Xa Extrusion Process

### Material

#### Batch wise mixing recommended

- pre mixed compound
  - ~ 99 % Polyethylene (semolina), bulk density 410 g/l
  - 0,4 - 0,5 % Stabilizer (powder)
  - 0,4 - 0,5 % Peroxide (liquid)
- after mixing soaking in containers
- typical soaking time 24 h

#### Benefits

- ensures uniform soaking of PE with Peroxide & uniform distribution of stabilizer
- leads to a constant process
- consistent and uniform crosslinking
- longer production cycles, reduced risk of premature crosslinking



PE

Source: Borealis

## **PE-Xa Extrusion Line by KMB**

Complete integrated extrusion line

**Extrusion line for the production of PE-Xa pipes**

**Diameter range 16 to 63 mm**

**Mono layer pipes & 3-layer pipes**



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## PE-Xa Extrusion Line by KMB Extruder

### Twin Screw Extruder KMD 63 K/R

- Single-conical screws in special PE-Xa execution
- Internal screw tempering, air cooled barrel
- No degassing necessary
- Max. throughput 110 kg/h
- Melt temperature 160 to 165°C
- Special execution of intake throat
- Gravimetric System recommended
- Moveable C5 control panel
- Synchronization with IR-oven and haul-off



## PE-Xa Extrusion Line by KMB

### Pipe Head

#### Pipe Head KM-RKW 30-25 PE-Xa

- Pipe diameter range 16 to 25 mm

#### Pipe Head KM-RKW 30-63 PE-Xa

- Pipe diameter range 32 to 63 mm

- Quick coupling flange to extruder
- Horizontal or vertical extrusion
- Flow and pressure optimized
- Easy and quick assembly and dismantling
- Special coating on die sets



## PE-Xa Extrusion Line by KMB

### Crosslinking Unit

#### Infrared-Ovens IRPEX-V-8-32-V / IRPEX-V-8-63-V

- vertical model for vertical extrusion
- for pipes up to OD 32 mm / 63 mm
- crosslinking capacity up to 24 m/min / 12 m/min
- height about 5.000 mm
- 8 IR units each having 4 monocassettes
- one central cooling blower for all 32 monocassettes
- total IR power at 100% load 96 kW
- adjustable pipe surface cooling in both sides
- speed and temperature controlled pulling wheel on the top
- dancer for pipe tension control => minimum length shrinkage rates of the pipes
- electrical and control cabinets



Picture shows IR-Oven IRPEX-V-4+1-63-H  
(very special execution!)  
Source: Crosslink Finland Oy

## PE-Xa Extrusion Line by KMB Calibration & Cooling

### Vacuum Tank

- Special calibration sleeves with wet inlet
- Segmented spraying cycles, to be switched on/off independently
- Pipe supporting discs
- Ultrasonic measuring
- Air shower



## PE-Xa Extrusion Line by KMB

### Post Co-Extrusion of Barrier Layer

**Coating Pipe Head incl. 2 Co-Extruders  
KME 30-25 D/C**

- Adhesive and oxygen barrier
- Vacuum application

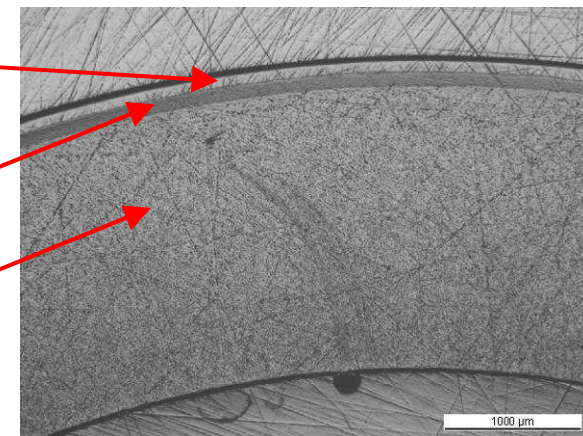


Focus on minimized tolerance of layer thickness distribution

Oxygen barrier layer

Adhesive layer

PE-Xa basic pipe



## PE-Xa Extrusion Line by KMB

### Cooling

#### Spray Bath

- Intensive cooling
- Moveable version
- Pipe supporting rollers adjustable from outside
- Special water film ring nozzle and water lock at the inlet for a perfect pipe surface



## PE-Xa Extrusion Line by KMB Haul-Off

### Belt Haul-Off

- Synchronization with IR-oven and €
- Haul-off force 2500 N



## PE-Xa Extrusion Line by KMB Coiler

### Double Winder

- Dancer controlled
- Length measuring unit
- Guillotine



## PE-Xa Extrusion Line by KMB

### Customer Benefits

- Reproducible excellent pipe quality @ highest production speeds
- Reliable turn key solutions
- Stable and consistent process, uniform crosslinking
- Long production runs without cleaning stops
- Fast & easy disassembly and cleaning of processing unit and pipe head
- Complete single-vendor solutions: Extrusion lines for PE-Xa pipes and injection moulding machine for PPSU fittings



## PE-Xa Extrusion Line by KMB

### Next steps

- Increase of diameter up to 110 mm
- Increase of output / line speed
- Increase no. of pipe layers



**Thank you for your attention**

For further questions please contact



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