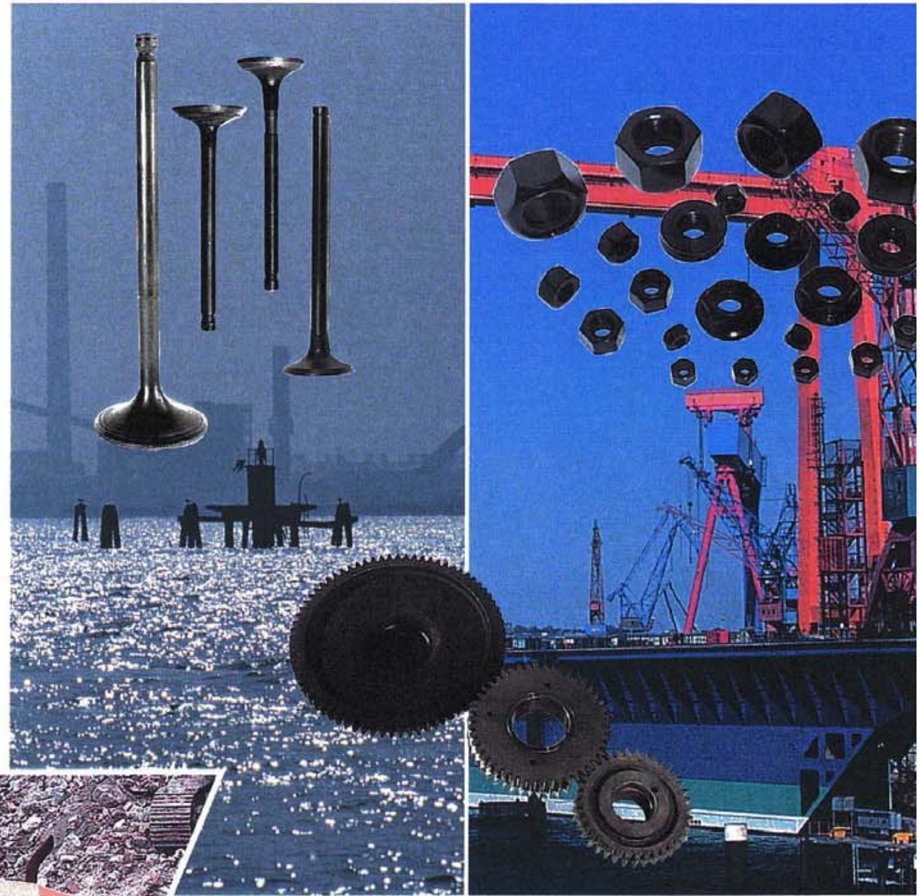
TUFFTRIDE® TF 1 - Process

What is Nitrocarburizing?

A thermochemical treatment which enriches the surface of ferrous materials primarily with nitrogen and, at the same time with small amount of carbon.

TUFFTRIDE® QPQ



improves

- wear resistance
- corrosion resistance
- fatigue strength
- appearance

and is a

- economical
- environmentally friendly
- multi-purpose

process

TUFFTRIDE® TF 1 - Process

Media for Nitrocarburizing

- Salt bath
- Gas
- Plasma
- Powder

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Medium

Molten salt consisting of alkali cyanate and alkali carbonate

Basic Reaction in the Molten Salt

Nitrocarburizing Process

Cyanate (CNO^-) → Nitrogen (N) + Carbonate (CO_3^{2-})

Nitrogen (N) + Iron (Fe) → Iron nitride (Fe_xN)

Regenerating with REG 1

Carbonate (CO_3^{2-}) + REG 1 → Cyanate (CNO^-)

Side Reaction

Cyanate (CNO^-) ↔ Cyanide (CN^-) + Oxygen (O_2)

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Structure of a TUFFTRIDE® treated surface

Compound Layer (CL)

- on the surface of a work piece
- consists of ε - iron nitride

  (in the case of alloyed steels, also of special nitrides)

Diffusion Layer (DL)

- area below the compound layer
- nitrogen is solved atomically in the iron lattice

  (with unalloyed steels and slow cooling also in the form of iron nitride needles)

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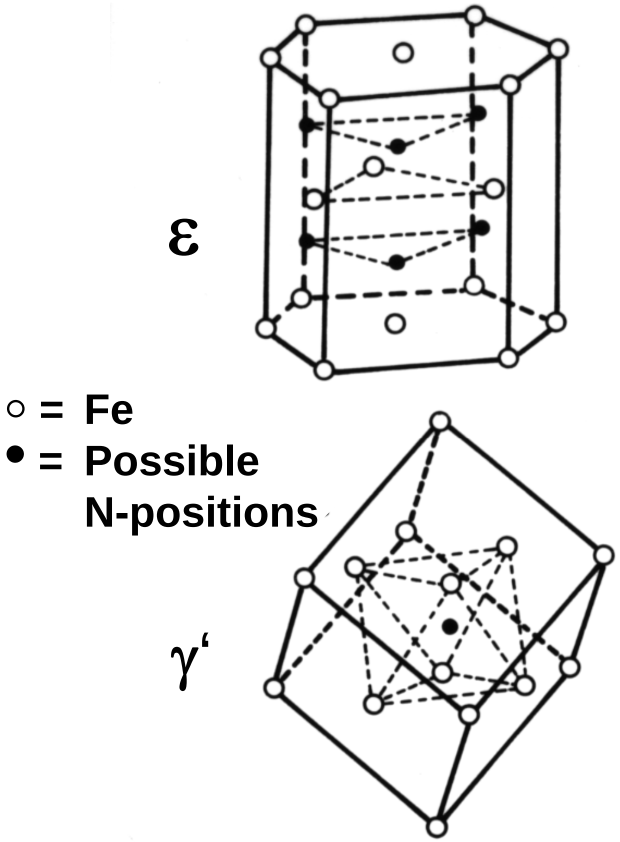

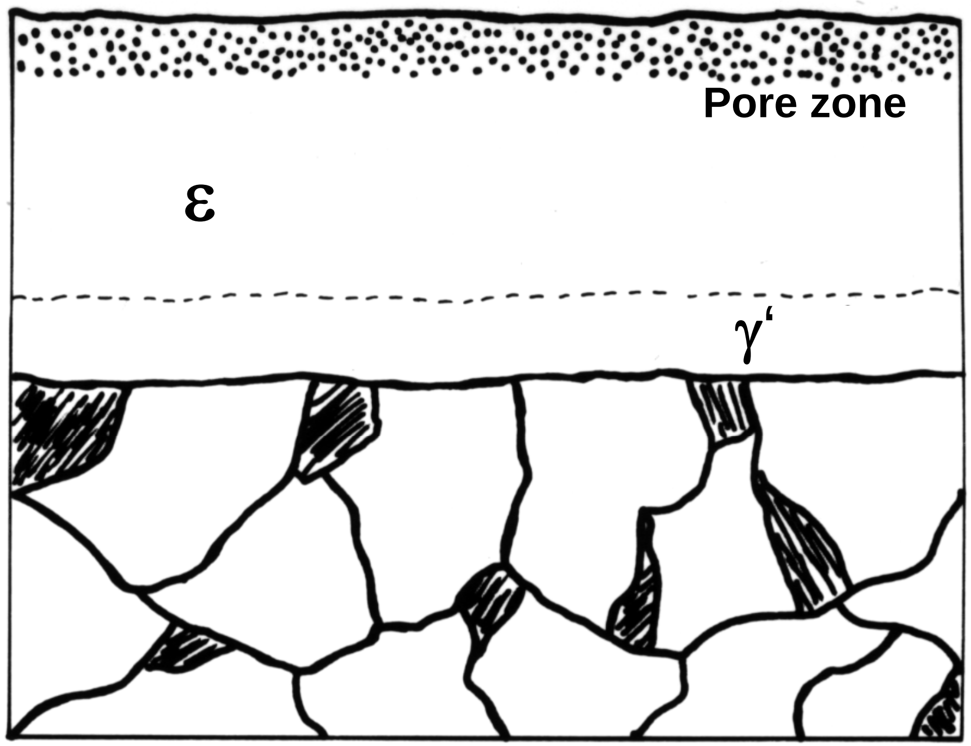

Systematic Structure of the Compound Layer

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Compound Layer

The most important influences on the thickness of the compound layer are:

- **Material**
- **Treating temperature**
- **Bath chemistry (e.g. cyanate content)**
- **Treating time**

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Effects of Composition of Material

An increasing content of alloying elements with constant treatment parameters causes:

- Decrease in thickness of the compound layer
- Decrease in total nitration depth
- Increase in surface hardness

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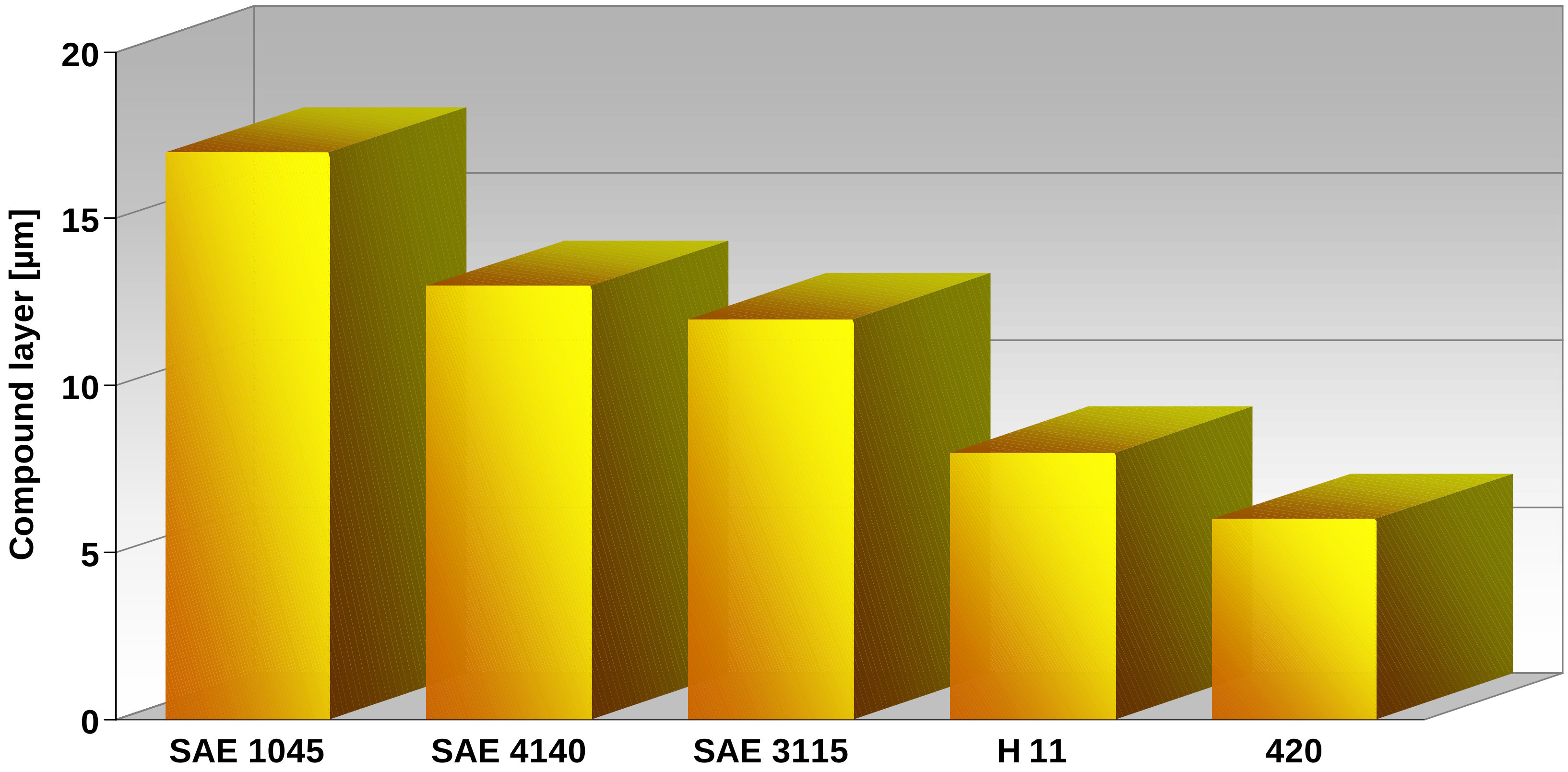
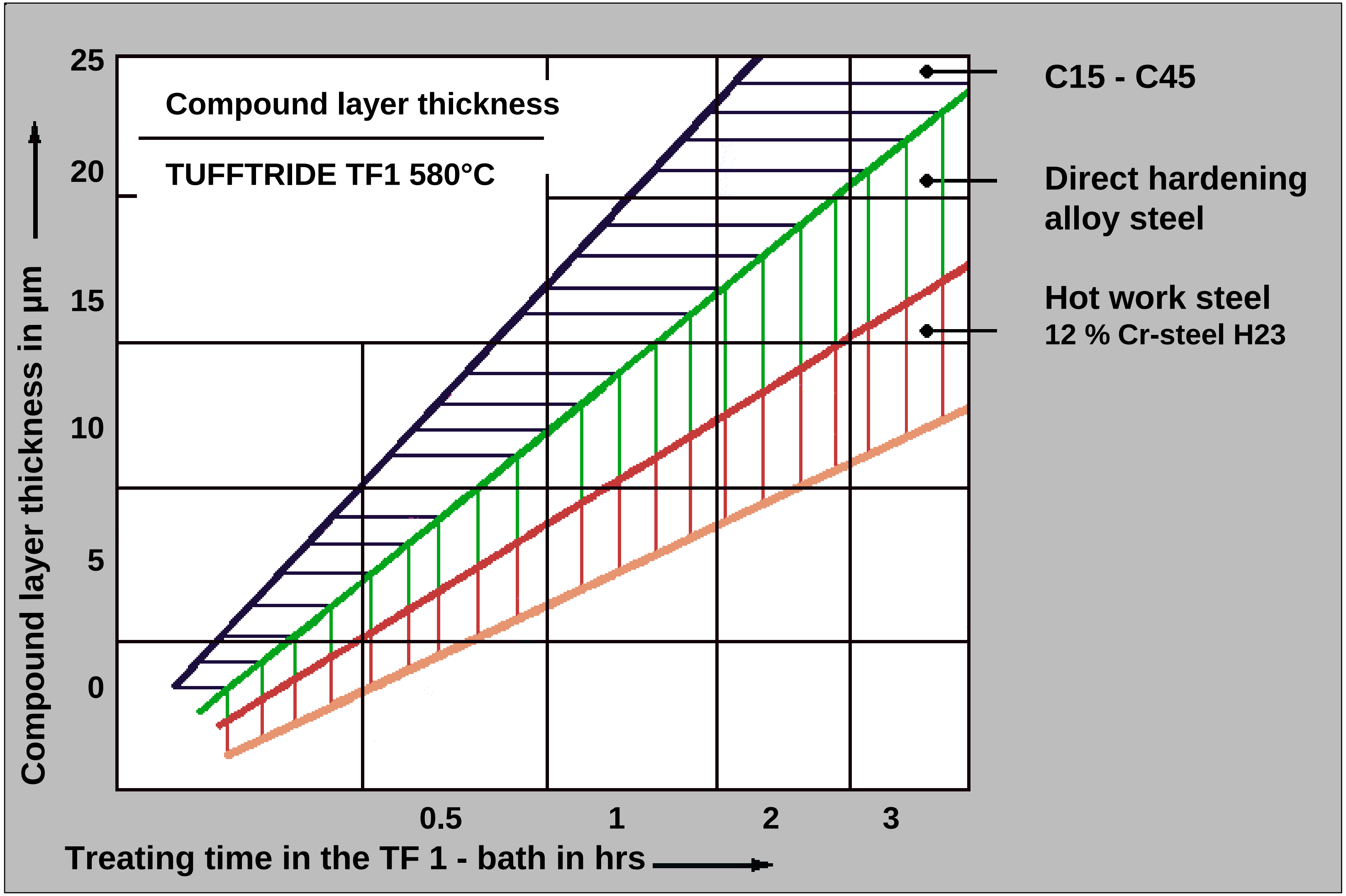
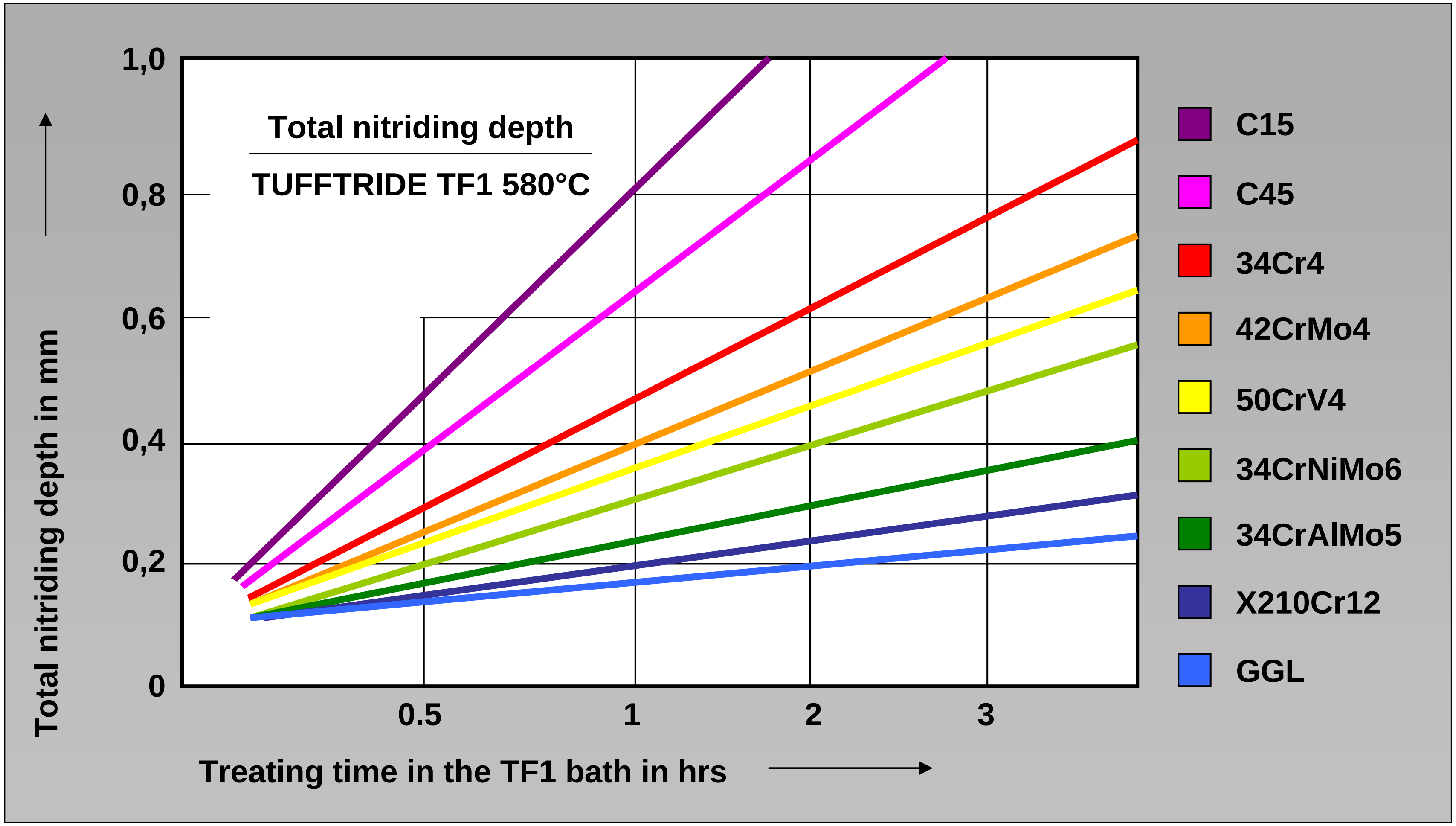
Influence of various materials on the thickness of the compound layer



Obtainable compound layer thickness in relation to the treating time



Total nitriding depth of various steels in relation to the treating time



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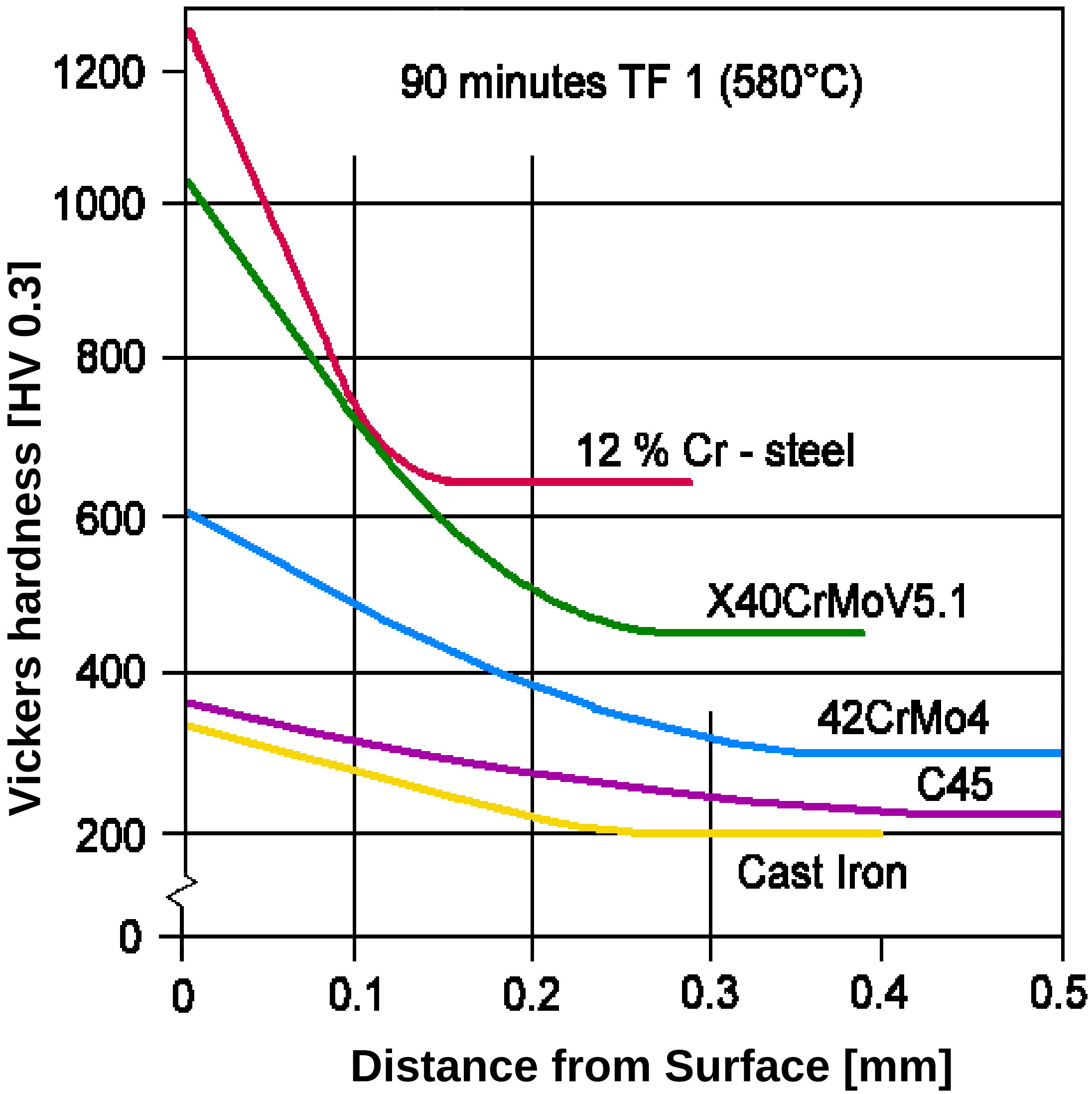

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Hardness Behaviour of Different Materials

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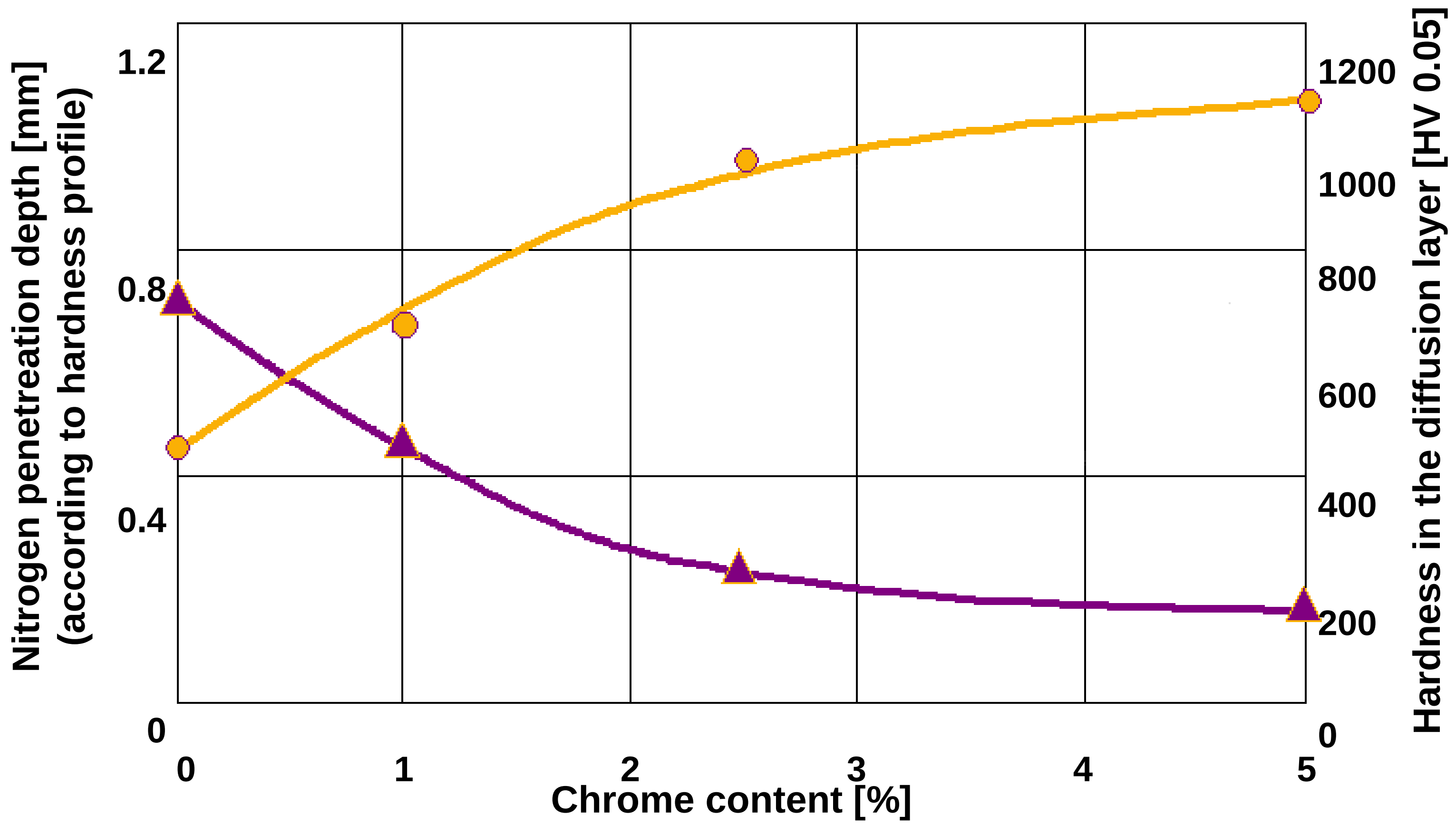
Surface hardness and case depth in relation to the chrome content



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Treating Cycle

- Preheating on air (350 - 400°C)
- Nitrocarburizing in a TUFFTRIDE TF1 bath (usually at 580°C)
- Cooling
- Cleaning in a heated and agitated rinsing cascade
- (Short immersion in dewatering fluid)

Preheating

Reason

- Only completely dry components should be put into the bath !
- Temperature in TF 1 bath should not drop below 1000°F (540°C) or the formation of the compound layer will be negatively impacted.

Influencing Factors

- Temperature (normally 660-750°F) (350-400°C)
- Duration (usually 30-90 minutes, min. 30 minutes)

Important!

Too high a temperature, or too long a time, can lead to scaling.

(⇒ Poorer nitriding quality, high sludge formation)

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Influencing Factors in Bath Performance

- Temperature
- Treating time
- Bath chemistry

CNO^-	35-38%
CN^-	$\leq$ 5%
Fe	$\leq$ 0.02%

- Aeration

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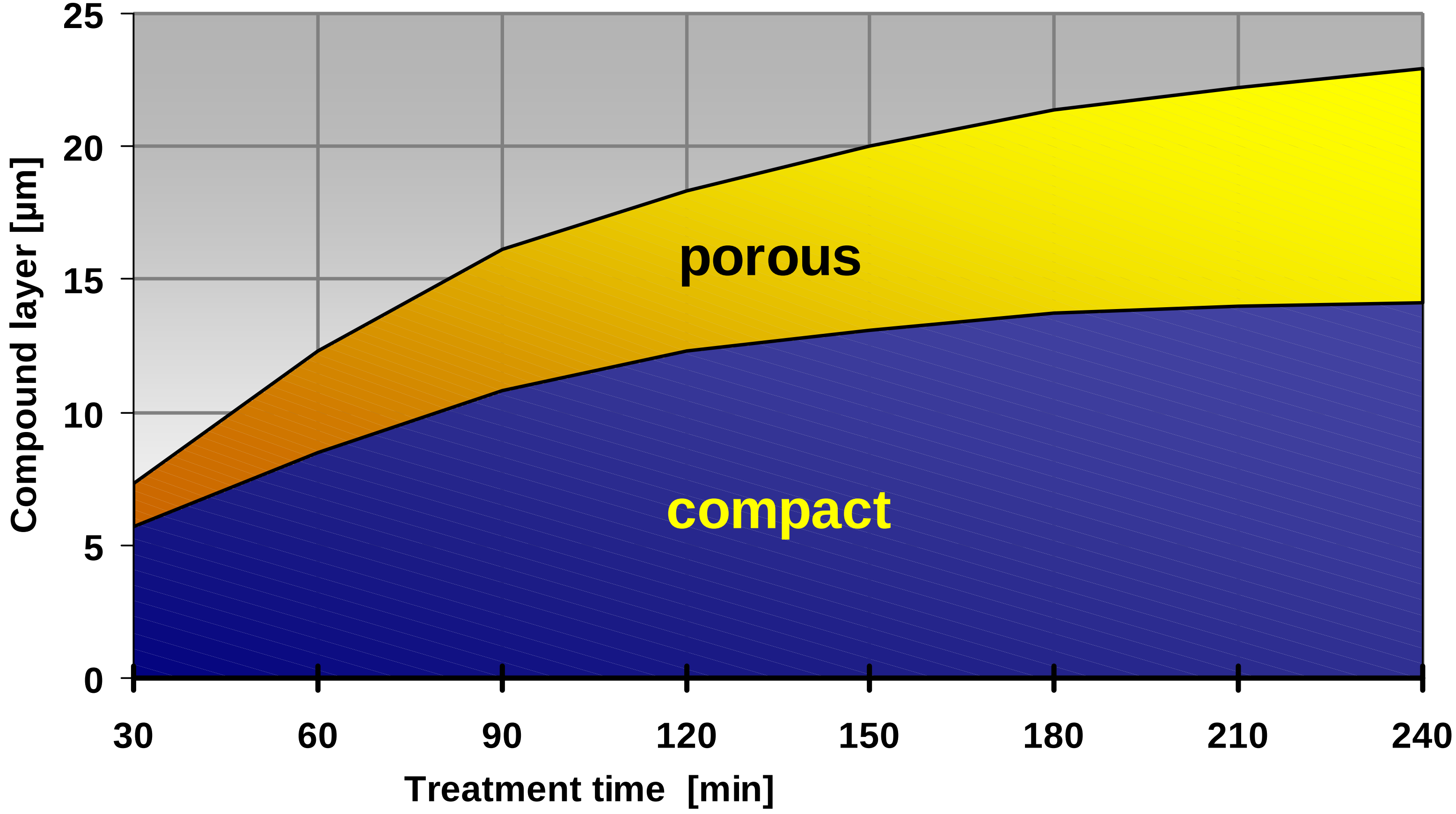
Influence of treatment time on the compound layer



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Highly flexible because

- components requiring various treating times can be treated together in the salt bath
- various materials can be nitrocarburized in one charge
- the treating / processing time is very short
- the plants are of modular design so that fluctuations in throughput can be accommodated
- cooling mediums with different cooling rates (water, AB1 bath, forced air, nitrogen or vacuum) can be used
- TUFFTRIDE treatment is possible within a temperature range of 480°C - 630°C

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Bath Chemistry

CN^- Content (≤ 5%)

- Dependent on throughput and sludge content
- Too much reduces the lifetime of the pot and affects the regeneration reaction
- Is influenced by the aeration

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Regenerating with REG1

1. Determine the required amount of regenerator from tables in the operating instructions

2. Measure exactly the amount of regenerator required to 100 g

3. Using a shovel, carefully add the regenerator in small portions to the aerated bath

Bath Chemistry

CNO^- Content (35-38%)

- Maintained through addition of REG 1
- Too much causes thick compound layers with too much porosity
  (⇒ Lowering of wear and corrosion resistance)
- Too little reduces nitriding activity and leads to thinner compound layers
  (⇒ Lowering of wear and corrosion resistance)

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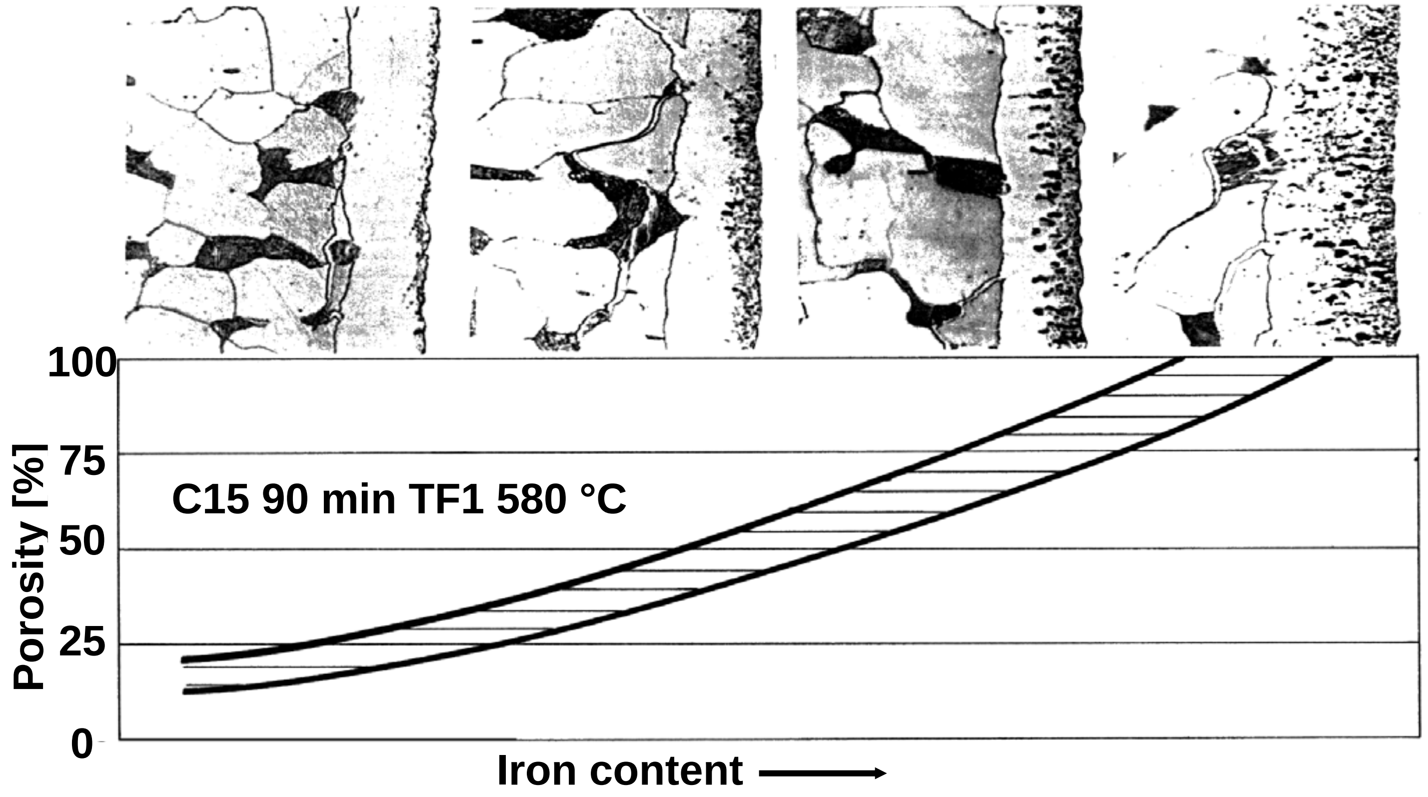
Influence of Sludge Content on the Compound Layer



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Cooling Media

- Water
- Oxidative cooling bath (AB1 bath)
- Forced air
- Nitrogen
- Vacuum
- (Oil)

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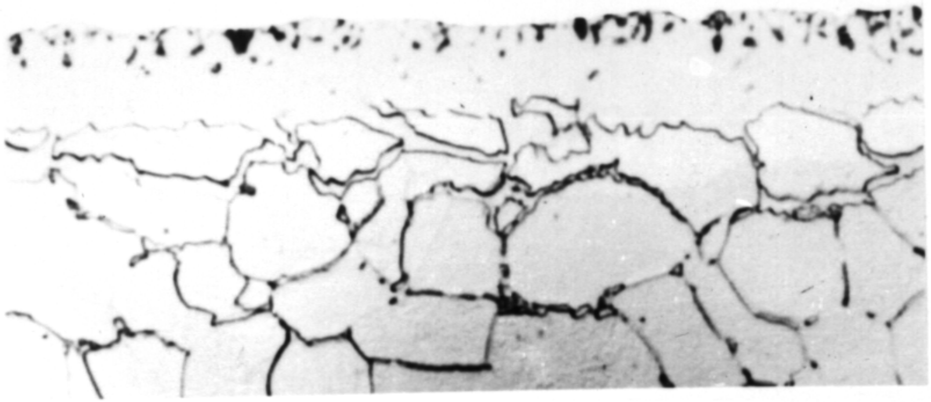

90’ TF1 (580°C) ☑ SW

90’ TF1 (580°C) ☑ 10’ AB1 (350 °C) ☑ SW

Formation of the diffusion layer at different cooling rates
Material: 1015

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TUFFTRIDE® - Process

Advantages of an AB1 Bath

- Significant increase in corrosion resistance
- Oxidation of salt residue from TF1 bath to carbonate
- Less distortion because of gradual cooling
- Better running properties

Oxidation in AB1

Medium

Molten salt consisting of alkali nitrate, alkali hydroxide and alkali carbonate

Basic Reactions in the Molten Salt

Detoxification Reaction

Cyanide (CN^-) + Nitrate (NO_3^-) → Carbonate (CO_3^{2-}) + Nitrite (NO_2^-)

Cyanate (CNO^-) + Nitrate (NO_3^-) → Carbonate (CO_3^{2-}) + Nitrite (NO_2^-)

Oxidation of the Compound Layer

Iron nitride (Fe_xN) + Nitrate (NO_3^-) → Magnetite (Fe_3O_4) + Nitrite (NO_2^-)

Regeneration

Nitrite (NO_2^-) + Oxygen (O_2) → Nitrate (NO_3^-)

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Influencing Factors in AB 1® Bath

Temperature 660-750ºF (350-400ºC)

- Influences the oxidation potential
- Determines the solubility of the carbonate

Sodium Nitrate Content ($NaNO_3$: 8-15%)

- Influences the oxidation potential
- Is partially reduced to sodium nitrite during the bath reaction

Sodium Carbonate Content (Na_2CO_3 : approx.. 30%)

- Formed by the oxidation of cyanide and cyanate
- Too much:
  - ☑ Makes cleaning of parts more difficult
  - ☑ Leads to formation of a bath crust and building of sludge on bottom of pot

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Influencing Factors in AB 1® Bath

Agitation

- Necessary for an even temperature and homogeneous bath composition
- Ensures heat dissipation when load is brought in

Aeration

- Oxygen in the air oxidizes sodium nitrite ($NaNO_2$) back to sodium nitrate ($NaNO_3$)

Important !

- Too much oxidation potential ⇒ reddish colored parts
- Too little oxidation potential ⇒ reduced corrosion resistance
  ⇒ inconsistent dark coloring

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AB 1 Bath

Warning signs that something is wrong !

- **Bath is not liquid at 750°F (400°C).**
- **No foaming, no reaction when load is brought in.**
- **(Brown-coloured salt melt)**

Influencing Factors in the Quenching Tank

Temperature < 104ºF (< 40ºC)

- Higher temperatures cause reddish coloration

Salt Content

- Too high AB 1® salt content
  - ⇒ Can lead to talc on parts
  - ⇒ Makes cleaning more difficult (especially in hard water)
- Fresh rinse water must contain some AB 1 salt (< 1%) to reduce the high surface tension
  (⇒ Building of gas bubbles; discoloration of the parts)

Agitation

- Avoids localized hot areas
- Improves cleaning effectiveness

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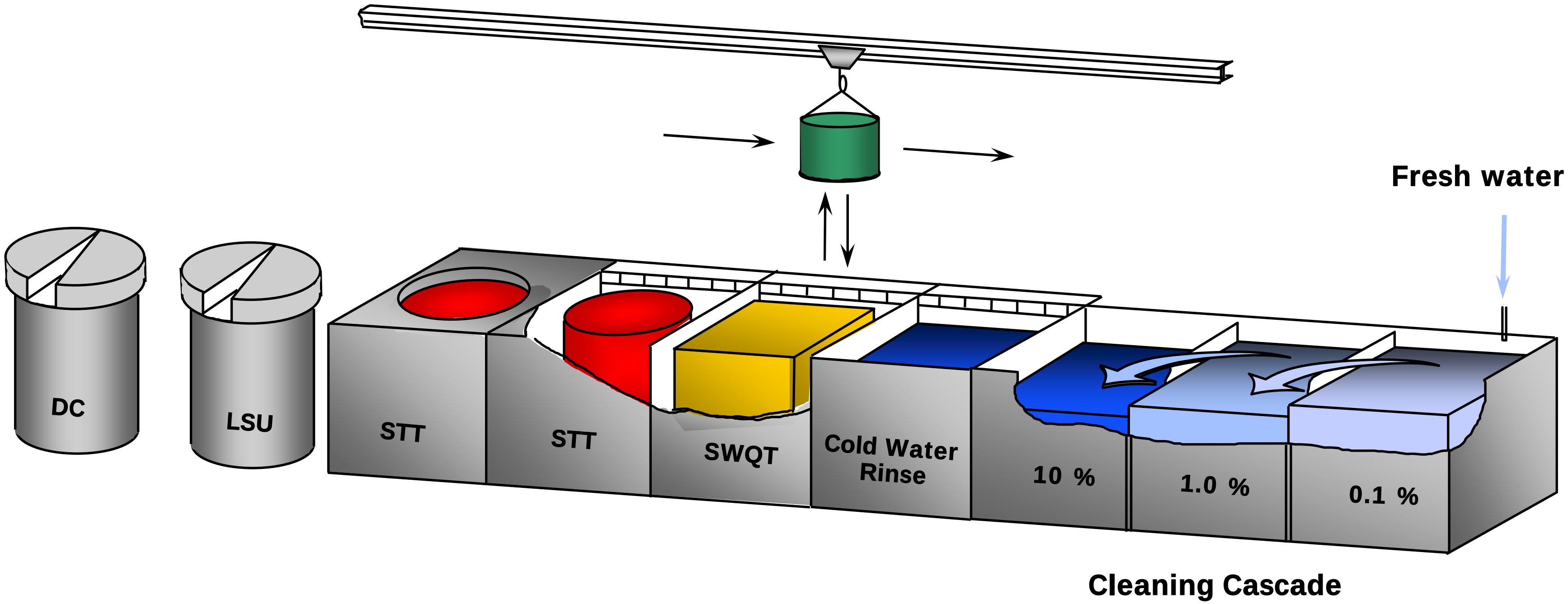
Diagram of a TUFFTRIDE® - plant



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Rinsing technology	Amount of waste water %	litres
Rinsing tank	100	2000
2 rinsing tanks	20	400
2-step washing cascade	2.25	45
3- step washing cascade	0.65	13
4- step washing cascade	0.33	6.5

Requirement of Washing Water for Different Rinsing Techniques

Source: Dr. Rolf Stiefel
Institute for Industrial Hydroeconomy and Aircleaning, Cologne

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Influencing Factors in the Rinse Cascade

Temperature 140-175º F (60-80ºC)

- Heat increases the dissolving of salt residues

Salt Content

- The lower the salt content, the more effective the cleaning

Agitation

- Fast water flow speeds up the dissolving of salt residues
- Improves the cleaning effectiveness

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