

# ThyssenKrupp VDM Products and Capabilities

## Meeting Topic:

## Alloys 690/52/152 PWSCC test materials

Meeting at  
Legacy Hotel and Meeting Center,  
1775 Rockville Pike, Rockville, MD  
July 17-18, 2008



# ThyssenKrupp

## Business Units and Subsidiary Companies

### ThyssenKrupp AG

TK Steel

TK Stainless

TK Elevator

TK Technologies

TK Services

#### ThyssenKrupp Stainless AG

ThyssenKrupp  
NirostaThyssenKrupp  
Acciai Speciali TerniThyssenKrupp  
MexinoxThyssenKrupp  
Stainless InternationalShanghai  
Krupp StainlessThyssenKrupp  
VDMThyssenKrupp  
Nirosta  
(GER)ThyssenKrupp  
Acciai Speciali Terni  
(I)ThyssenKrupp  
Mexinox  
(MEX)ThyssenKrupp  
Stainless International  
(D)Shanghai Krupp  
Stainless  
(CN)ThyssenKrupp VDM  
(GER)ThyssenKrupp Nirosta  
Präzisionsband (GER)

Terninox (I)

ThyssenKrupp Trading  
(MEX)ThyssenKrupp  
Silco Inox (HU)Subsidiaries  
worldwide  
including

EBOR Edelstahl (GER)

Tubificio di Terni (I)

ThyssenKrupp Mexinox  
USA (USA)ThyssenKrupp  
Stainless UK (GB)ThyssenKrupp  
VDM USA

Smb Chromstahl (GER)

ThyssenKrupp Titanium  
(I / GER)ThyssenKrupp  
Stainless France (F)ThyssenKrupp Nirosta  
North America (USA)

Società delle Fucine (I)

ThyssenKrupp  
Stainless DVP (E)ThyssenKrupp AST  
USA (USA)ThyssenKrupp  
Eurinox (TR)ThyssenKrupp  
Stainless Guangzhou (CN)ThyssenKrupp  
Stainless Polska (PL)ThyssenKrupp  
Stainless Benelux (NL)

Group Holding

Segments

Segment Holding

Business Units

Business Unit Holding

Subsidiaries



# ThyssenKrupp VDM

## Company Profile



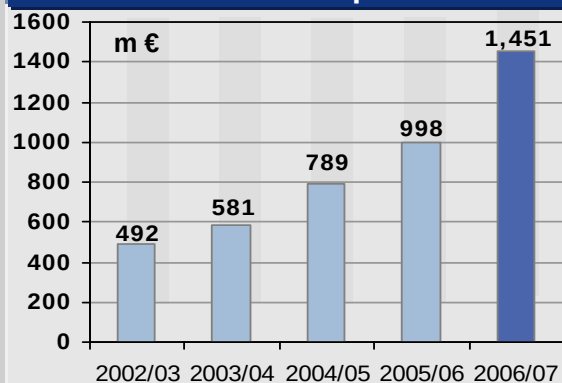
### ThyssenKrupp VDM

58791 Werdohl

Germany

[www.thyssenkruppvdm.com](http://www.thyssenkruppvdm.com)

### Sales Development



### Company Production Sites

#### ThyssenKrupp VDM

- 1 Unna Plant (Melting & Casting)
- 2 Siegen Plant (Hot Rolling)
- 3 Altena Plant (Rod & Bar / Sheet & Plate)
- 4 Werdohl Plant (Strip / Wire)
- 5 Florham Park & Reno Plant (USA)

### Employees

**1,772**

by 09.30.2007

### Production

#### Nickel Alloys

Strip, Sheet, Wire, Bars  
Others

### Production Sites



### Shipments

| Product Group | [1,000 t] | 2002/03     | 2003/04     | 2004/05     | 2005/06     | 2006/07     |
|---------------|-----------|-------------|-------------|-------------|-------------|-------------|
| Strip         |           | 17.5        | 16.8        | 15.5        | 12.6        | 13.5        |
| Sheet         |           | 8.0         | 9.4         | 10.6        | 12.6        | 12.6        |
| Wire          |           | 5.5         | 5.8         | 6.6         | 6.1         | 6.5         |
| Bars          |           | 5.5         | 6.8         | 8.5         | 8.2         | 9.1         |
| Others        |           | 5.0         | 6.9         | 5.4         | 5.1         | 5.5         |
| <b>Total</b>  |           | <b>41.5</b> | <b>45.8</b> | <b>46.7</b> | <b>44.5</b> | <b>47.1</b> |

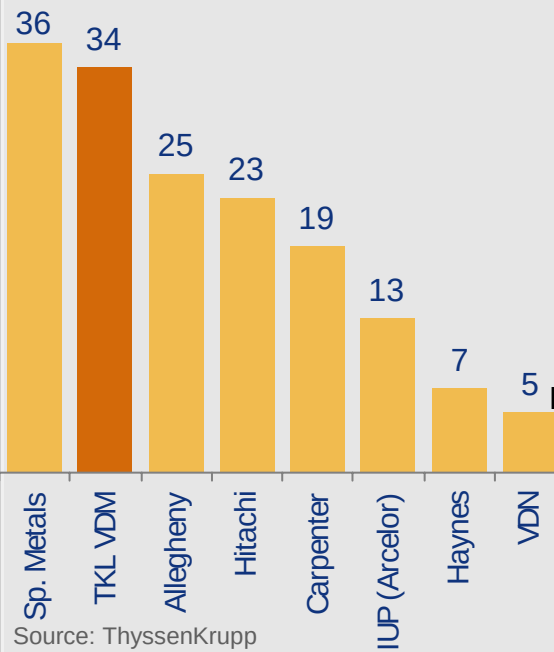


# Market Environment

## Leading Position in Nickel Alloys

### Nickel Alloys, World Market

Shipment in 2006  
1,000 tons

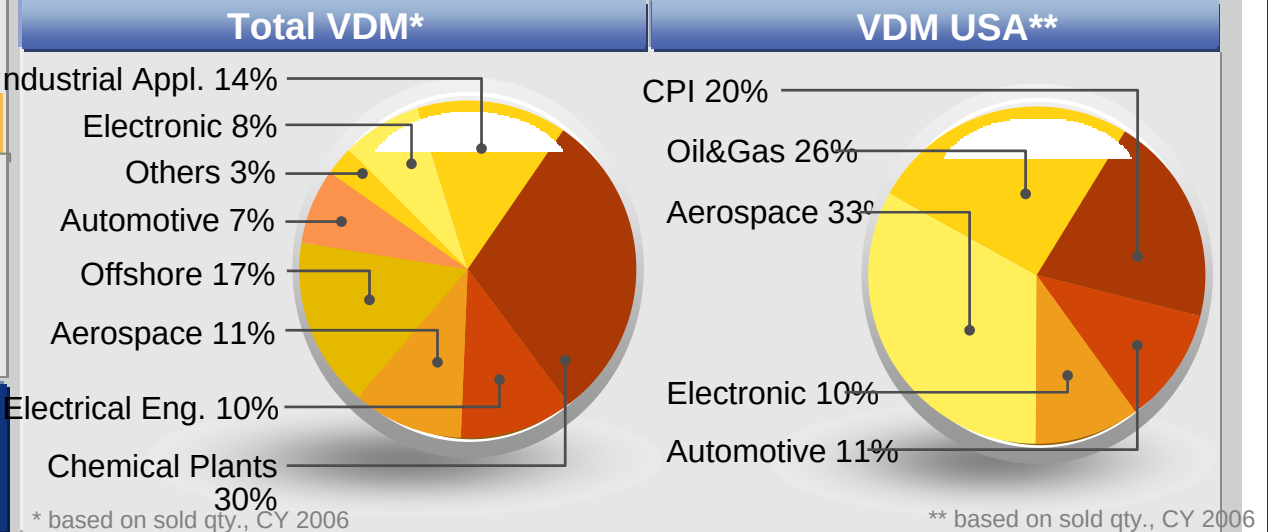


The 6 largest producers  
comprise 67% of all worldwide  
shipments

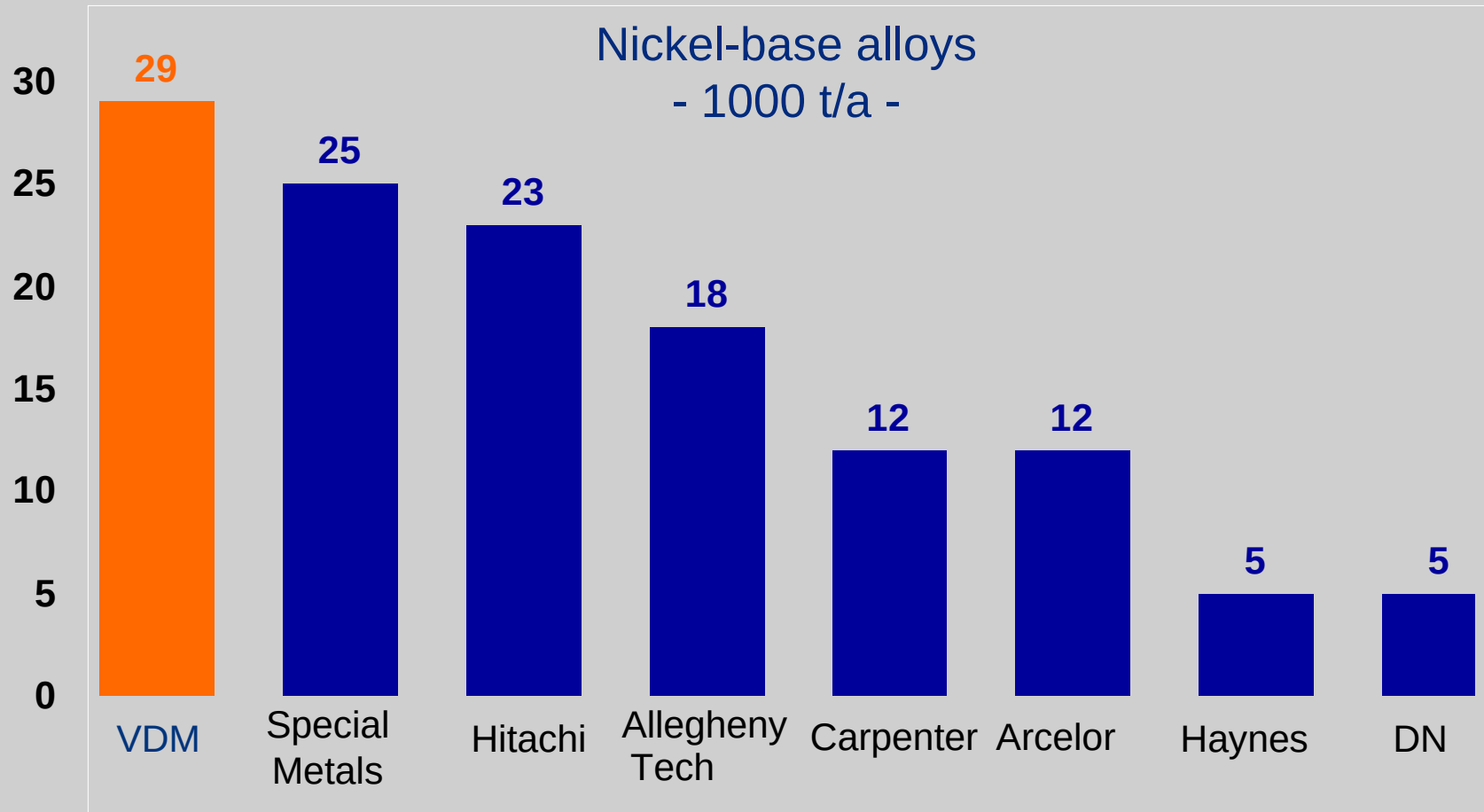
### Nickel Alloys, World Market Development



### Nickel Alloys, VDM Sales by Industry



## ThyssenKrupp VDM Market position in 2003



# TK VDM: Portfolio

Alloys, Production Germany and USA

## Nickel- and cobalt alloys

### Standard alloys

#### Wet corrosion-resistant alloys

- Ni
- NiCu
- NiCrFe
- NiCrMoFe
- CrNiMoFe

#### High temperature-resistant alloys

- NiCrFe

### Superalloys

#### High corrosion-resistant alloys

- NiCrMo
- NiMo
- NiCrFeMo

#### High temperature strength alloys

- NiCrMoCo
- CoCrNiW
- Age hardenable
- Non age hardenable

### Physical property alloys

#### Electrical resistance alloys

- NiCr
- NiCrFe
- FeCrAl\*
- FeCr\*

#### Soft magnetic alloys

- NiFe
- NiFeMo

#### Expansion alloys

- NiFe
- NiFeCo

\*Fe-base alloy



# TK VDM: Portfolio

Alloys, Production Germany and USA

|                           |     |                           |     |                  |       |
|---------------------------|-----|---------------------------|-----|------------------|-------|
| Nicrofer 3033             | 33  | Nicrofer 5923 hMo         | 59  | Nicorros         | 400   |
| Nicrofer 3127 hMo         | 31  | Nicrofer 6023             | 601 | Nicorros AL      | K-500 |
| Nicrofer 3220             | 800 | Nicrofer 6030             | 690 | NI99.2           | 200   |
| Nicrofer 3620 Nb          | 20  | Nicrofer 6020 hMo         | 625 | LC-NI99.2        | 201   |
| Nicrofer 4221             | 825 | Nicrofer 7016 Ti Nb X-750 |     | LC-NI99.6        | 205   |
| Nicrofer 4722 Co          | X   | Nicrofer 7216             | 600 | NI99.6 K         | 233   |
| Nicrofer 5120 Co Ti C-263 |     | Nicrofer 7216 LC 600 LC   |     | Cronifer II      | C     |
| Nicrofer 5219 Nb          | 718 | Nimofer 6928              | B-2 | Cronifer 40 A    |       |
| Nicrofer 5520 Co          | 617 | NICR2MN                   | 522 | Cronifer 1525 Ti | A-286 |
| Nicrofer 5621 hMo C-22    |     | Conicro 4023 W            | 188 | Cronix 80        | A     |
| Nicrofer 5716 hMo C-276   |     | Conicro 5010 W            | 25  | NiFe 43 Mn       |       |

# TK VDM: Portfolio

Alloys, Production Germany and USA

|                          |       |                 |        |                     |      |
|--------------------------|-------|-----------------|--------|---------------------|------|
| Pernifer 2918            | F-15  | Nicrofer S 5621 | FM 22  | HN                  |      |
| Pernifer 36              | 36    | Nicrofer S 5923 | FM 59  | 31Ni-5Co            |      |
| Pernifer 40              | 42    | Nicrofer S 6030 | FM 690 | PRP MP 35N          |      |
| Pernifer 50              | 52    | Nicrofer S 6020 | FM 625 | GSA                 | F-15 |
| Magnifer 50              |       | Nicrofer S 7020 | FM 82  | René® 41            |      |
| Magnifer 7904            |       | PRP 188         | 188    | Waspaloy®           |      |
| Pernifer 4205 Ti         | 902   | L-605           | 25     | CP-Ti (Grade 2 & 4) |      |
| Konstantan               | 401   | 901             |        | Ti-6Al-4V           |      |
| Aluchrom (0, Y, Y Hf, W) |       | Alloy S         |        | Ti-6Al-4V ELI       |      |
| Crofer 22 APU            |       | 722             |        | Ti-6Al-6V-2Sn       |      |
| Nicrofer 7020            | WS 82 | HB              |        | Ti-6Al-2Sn-4Zr-2Mo  |      |





# TK VDM Germany: Production capabilities Werdohl, Altena & Bielefeld



Forgings  
& Billets



Plate  
& Sheet



Strip



Rod & Bar



Wire

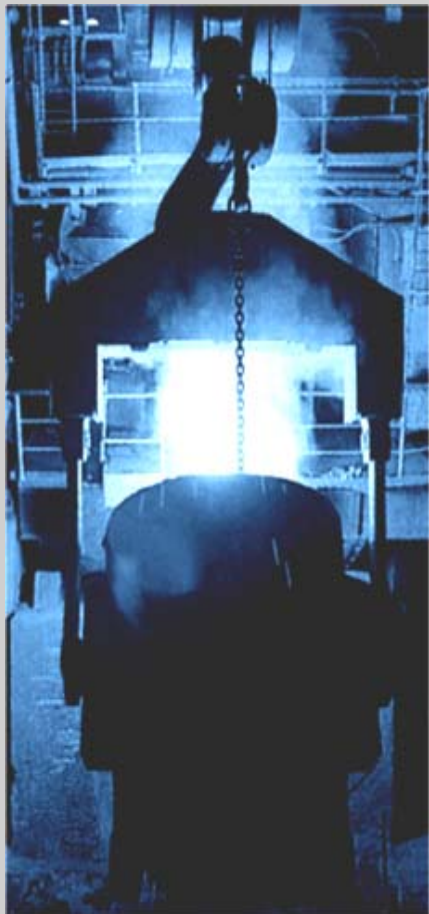


Welding  
consumables

For additional information please  
see our brochures and material  
data sheets or visit our website  
**[www.ThyssenKruppVDM.com](http://www.ThyssenKruppVDM.com)**

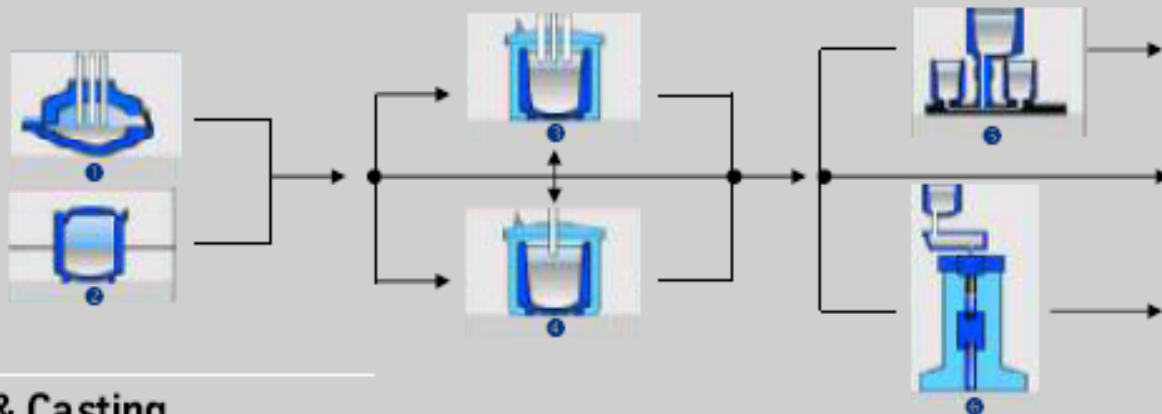
# ThyssenKrupp VDM - Unna

## Division Melting & Casting



# Division Melting & Casting

## Process flow

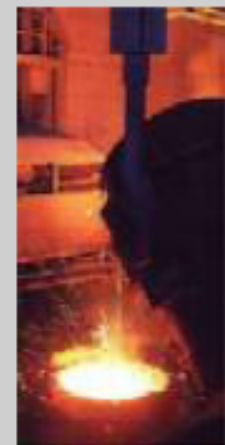


### Melting & Casting

- ① 30 t EAF
- ② 3 x 16 t induction furnaces
- ③ Vacuum ladle furnace
- ④ VOD unit
- ⑤ Ingot casting
- ⑥ Continuous caster

**EAF** = Electric Arc Furnace  
**VOD** = Vacuum Oxygen Decarburization  
**VLF** = Vacuum Ladle Furnace

View of the Unna  
melting shop





## Division Melting & Casting VIDP furnace in Unna



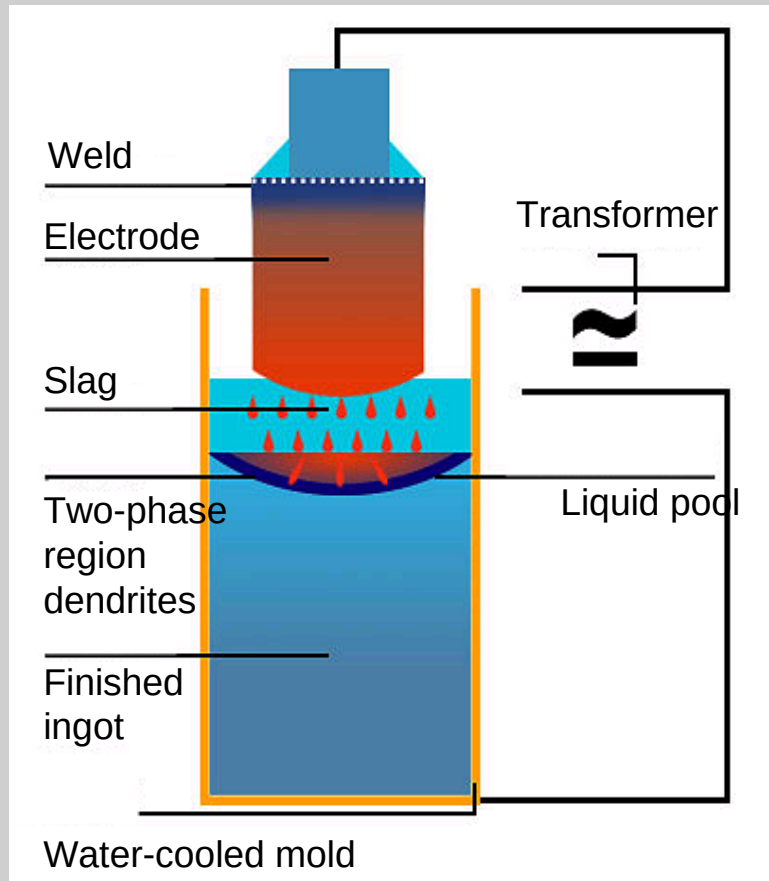
VIDP: Vacuum Induction Degassing and  
Pouring

- melting and casting nickel base alloys under vacuum for the Aerospace industry
- at 20 to 30-tonne capacity this new VIDP furnace is the largest of its kind
- with target tap-to-tap times cut down to under six hours
- since the plant is being integrated into the existing melting shop, it can also be charged with hot metal
- with the VIDP furnace ThyssenKrupp VDM is operating the world's largest VIM furnace for special alloys

## Division Melting & Casting

### 20 m.t. ESR unit # 1 at Unna melting plant

ESR Unit # 2 = 7 m.t. ingots



Schematic  
diagram  
of the electro  
slag  
remelting  
process

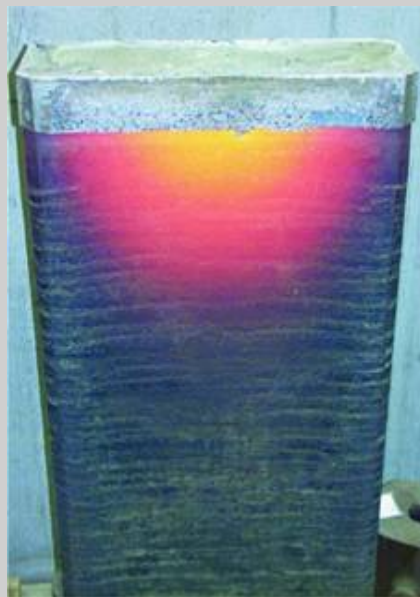
Furnace vessel  
with electrode rod



ESR = Electro Slag Remelting

## Division Melting & Casting

### 20 m.t. ESR unit at Unna melting plant



Cast electrode with furnace hood, for  
remelting  
in a controlled atmosphere



ESR = Electro Slag Remelting



## Division Melting & Casting

### Unit # 1 the world's largest VAR plant in Unna 30 m.t. ingots

VAR Unit # 2 = 7 m.t. ingots

#### Vacuum Arc Remelting

- for traditional VAR applications
- guarantees total reproducibility
- possibility of “triple melting”
- for a variety of alloys
- alloys for applications such as aerospace and sour gas:  
e.g. **Nicrofer 5219 Nb - alloy 718**

...designed for ingot diameters  
up to 1275 mm and a  
total weight of 30 m.t.



Forge Shop TXL-VDM\_HPJaeger\_2007\_12\_18

# The new Forge Shop at ThyssenKrupp VDM Unna plant



A company  
of ThyssenKrupp  
Stainless

**ThyssenKrupp VDM**



ThyssenKrupp



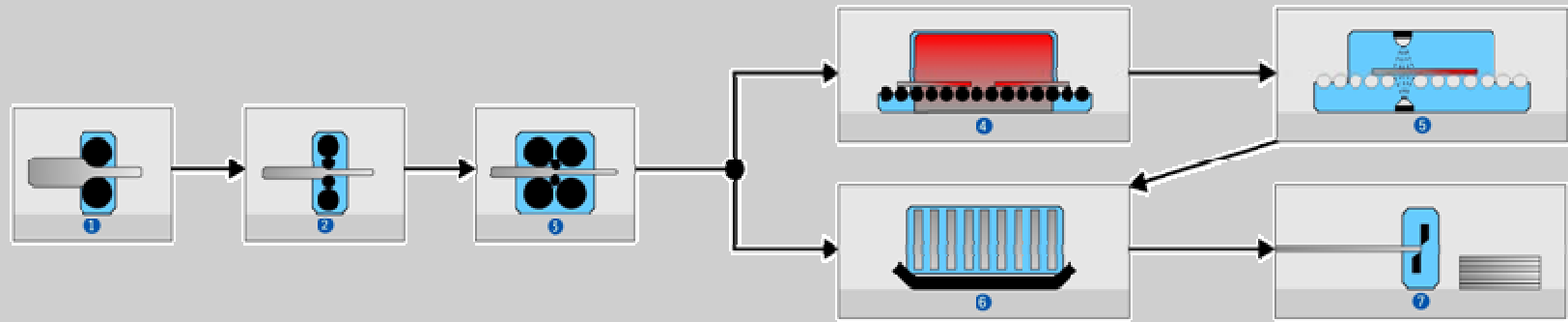
# ThyssenKrupp VDM - Altena

## Division Sheet & Plate / Division Bar & Billet



## Division Sheet & Plate

### Process flow



### Sheet & Plate

- ① Ingot to slab
- ② Slab to plate
- ③ Plate to sheet
- ④ Annealing
- ⑤ Blasting
- ⑥ Pickling
- ⑦ Shearing



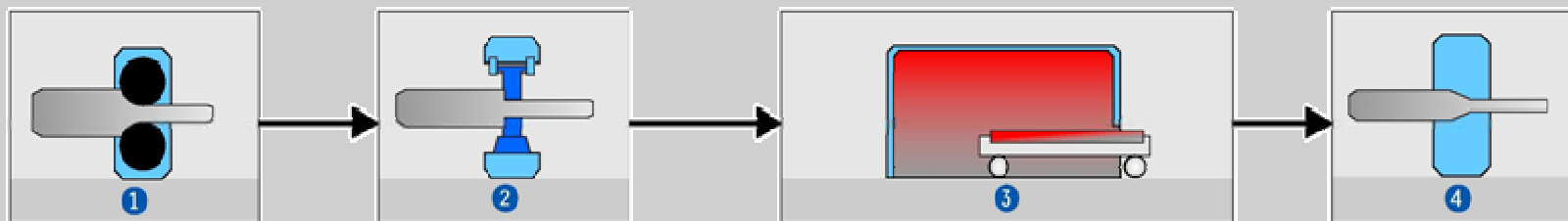
Continuous annealing furnace at the Siegen plant



Cold rolling mill at the Altena plant

## Division Rod & Bar

### Process flow



### Rod & Bar

- 1** Ingot to billet
- 2** Forging and Rolling
- 3** Annealing
- 4** Dry drawing



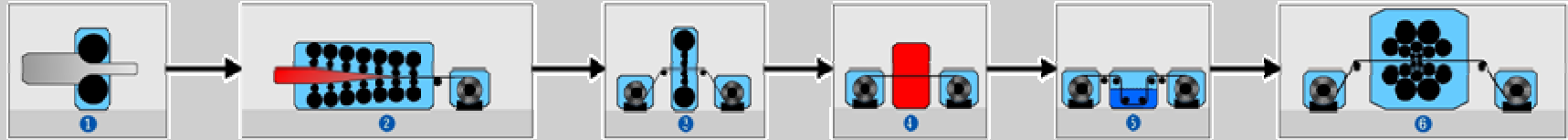
Bars undergoing heat treatment at the Altena plant



## ThyssenKrupp VDM - Werdohl Head Office & Division Strip/ Division Wire



## Division Strip Process flow



### Strip

- ① Ingot to slab
- ② Slab to hot strip
- ③ Cold rolling
- ④ Annealing
- ⑤ Pickling
- ⑥ Finish rolling

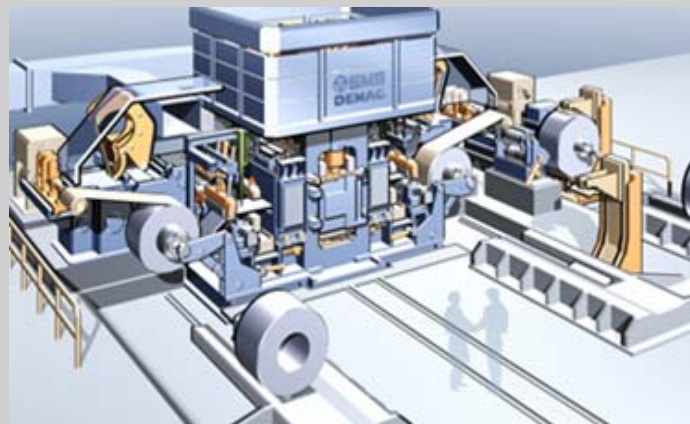


Strip annealing line at the Werderhohl plant



## Division Strip

### New modern split block 20-roll foil mill



Strip width: 350 - 750 mm  
Strip thickness: 0.02 - 1.00 mm  
Coil weight: up to 9000 kg  
Main application:  
Aluminium-chromium alloy foils,  
for use  
in metallic catalytic converter  
substrates

## Division Strip

### New precision foil splitter



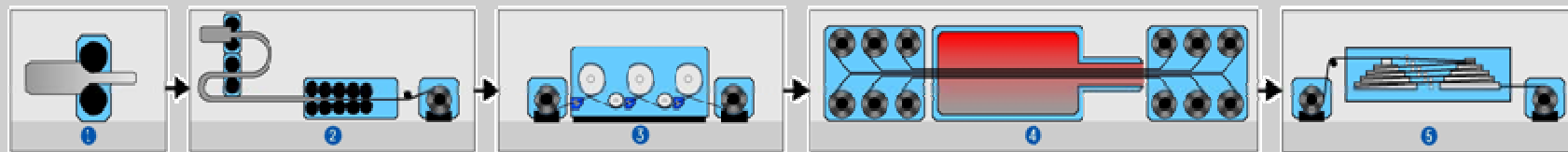
Precision foil splitter



|                      |                              |
|----------------------|------------------------------|
| Strip speed:         | 460 m/min.                   |
| Strip width:         | 150 - 800 mm                 |
| Max. number of cuts: | max. 45                      |
| Slitting width:      | min. 18 mm                   |
| Strip thickness:     | 0.02 - 0.5 mm                |
| Strip thickness:     | 0.05 - 0.2 mm                |
| Width tolerance:     | max. 9 t                     |
| Coil weight:         | 300 - 1700 N/mm <sup>2</sup> |

Tensile strength:

## Division Wire Process flow



### Wire

- 1 Ingot to billet
- 2 Billet to wire rod
- 3 Cold drawing (cast or rolled rod)
- 5 Intermediate or final annealing
- 6 Wet drawing



Heating element and stainless fine-gauge continuous wire production at the Bärenstein plant





# ThyssenKrupp VDM USA

## Company Profile



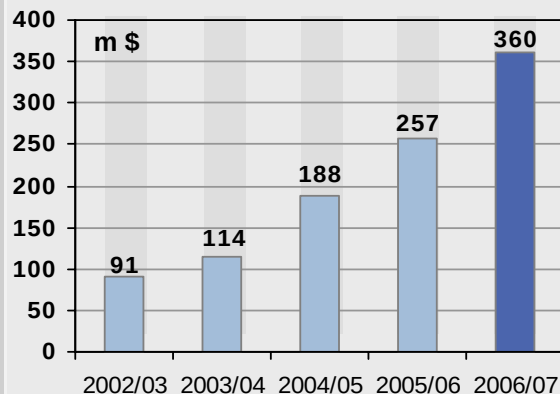
**ThyssenKrupp VDM USA**  
306 Columbia Turnpike,  
Florham Park, NJ 07932  
USA

### Employees

**222**

by 09.30.2007

### Sales Development \*



### Company Production Sites

#### ThyssenKrupp VDM USA, Inc.

- 1** Florham Park Plant (Melting & Blooming)
- 2** Reno Plant (Rolling)

### Production

**Nickel & Cobalt Alloys, Titanium**  
Ingots, Billets, Bars, Flats & Shapes

### Portfolio / Warehouse

**Nickel Alloys**  
Strip, Sheet, Wire, Bars, Others

### Production Sites & Sales Offices



### NAFTA Sales Office

### Shipments \*

| Product Group [m lbs]       | 2002/03     | 2003/04     | 2004/05     | 2005/06     | 2006/07     |
|-----------------------------|-------------|-------------|-------------|-------------|-------------|
| Strip                       | 3.3         | 4.1         | 4.2         | 4.5         | 4.0         |
| Sheet                       | 2.0         | 2.9         | 3.4         | 4.1         | 4.7         |
| Wire                        | 2.0         | 2.3         | 3.2         | 3.4         | 4.1         |
| Bars total                  | 5.4         | 6.3         | 8.6         | 8.4         | 8.7         |
| Including US bar production | 4.3         | 4.7         | 6.8         | 6.7         | 7.6         |
| <b>Total</b>                | <b>12.7</b> | <b>15.6</b> | <b>19.4</b> | <b>20.4</b> | <b>21.5</b> |

\* including former Precision Rolled Products, Inc.





# TK VDM USA: Primary Melting Equipment

## Florham Park NJ Plant

### Vacuum Induction Melting (VIM)



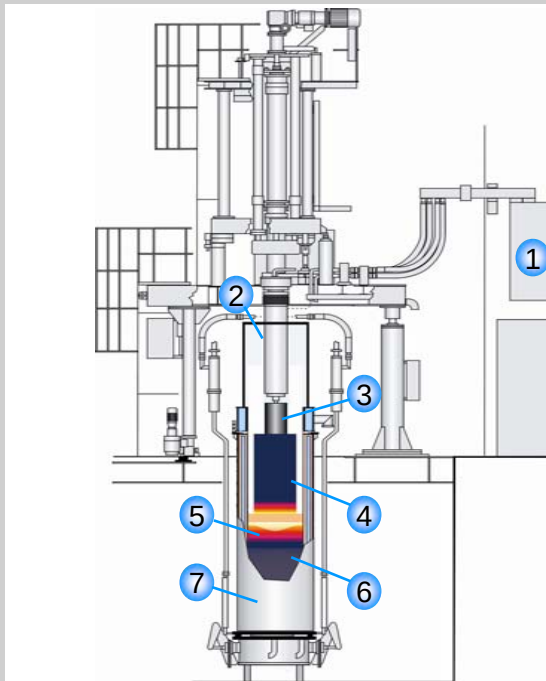
Pennwalt Stokes 6000 pound unit with 1000 KW power supply with four two stage Stokes mechanical vacuum pumps and blowers and 6 oil- booster pumps.

Vacuum Induction Melting is preferred for applications requiring minimal gas and inclusion content, low levels of residual elements and close control of reactive elements.

# TK VDM USA: Secondary Metallurgy Equipment

## Florham Park NJ Plant

### Electro Slag Remelting (ESR)



- 1 Power supply
- 2 Ram
- 3 Stub (welded on to the electrode)
- 4 Electrode
- 5 Slag (ESR-only)
- 6 Ingot
- 7 Water cooled crucible

Three Consarc Units with three 15,000 Amp power supplies capable of remelting 13 inch (330 mm), 16 inch (406 mm) and 20 inch (508 mm) round ingots.

Critical parameters of the remelt process are computer controlled to ensure optimum ingot structure, chemical composition and micro-cleanliness.



# TK VDM USA: Rolling Equipment

## Florham Park NJ Plant

### Blooming Mill



Birdsboro 2/high/19 inch (483mm) "Single Stand Mill" powered by a 750 horsepower reversing DC motor with computerized Screw Down (Pass) Control.

This mill is capable of accepting ingot and/or billet up to 16 in (406 mm) diameter. It has the capability to produce 2 inch (51 mm), 3 inch (76mm) and 4 inch (102 mm) round cornered square (RCS) billet, and slabs up to 17 inches (432 mm) wide. This mill can also produce flats and narrow plate.

# TK VDM USA: Rolling Equipment

## Reno NV Plant

### 14" Bar Mills



Five "Three High Stands" and one "Two High Stand" powered by a 1500 horsepower DC motor with SCR control unit. The maximum input billet size for this mill is 6 inch (152 mm) cross-section.

### 10" Bar Mills



Six "Three High Stands" and one "Two High Stand" powered by a 1500 horsepower DC motor. The maximum input billet size for this mill is 2.75 inches (70 mm) cross-section.



# TK VDM USA: Thermal Treating Equipment

Florham Park NJ

Plant

Reno

Plant

## Batch Furnace for homogenization



|                    |                                  |
|--------------------|----------------------------------|
| Temperature Range: | 1300°F to 2200°F                 |
| Fuel:              | Natural Gas                      |
| Length/Width:      | 21 feet/5 feet                   |
| Height:            | 32 inches to the top of the arch |

## Car Bottom Furnace



|                    |                               |
|--------------------|-------------------------------|
| Temperature Range: | 1100°F to 2200°F              |
| Fuel:              | Natural Gas                   |
| Length:            | 19 feet 6 inches              |
| Width:             | 5 feet 10 inches              |
| Height:            | 4 feet to the top of the arch |

# TK VDM USA: Bar Finishing Equipment 1/2

## Reno Plant

### Quench Tank



Length/Width: 25 feet/4 feet  
Depth: 38 inches  
Quench media: Air or circulating water

### Centerless Grinding



0.250 inch to 4.500 inch rounds



# TK VDM USA: Bar Finishing Equipment 2/2

## Reno Plant

### Peeling

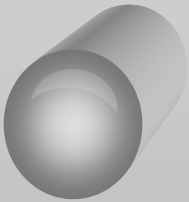
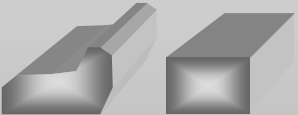


Fully automated peeling machine, capable of peeling bars and billets from 2.5 inch (63,5 mm) up to 12 inch (304,8 mm).



# TK VDM USA: Production capabilities Florham Park & Reno

## Products and dimensions

|                                                                                                                   |              |                           |           |               |         |
|-------------------------------------------------------------------------------------------------------------------|--------------|---------------------------|-----------|---------------|---------|
|                                  | Hot Working  | Width<br>Diameter (Round) |           | Thickness     |         |
|                                                                                                                   |              | inches                    | mm        | inches        | mm      |
| <br><i>Round</i>                 | Rolled       | 0.75 – 4.0                | 19 – 102  | /             | /       |
|                                                                                                                   | GFM          | 4.0 – 6.0                 | 102 – 152 | /             | /       |
|                                                                                                                   | Press Forged | 6.0 – 12.0                | 152 – 305 | /             | /       |
| <br><i>Plate</i>                 | Rolled       | 4.0 – 14.0                | 102 – 356 | 0.400 – 2.500 | 10 – 64 |
| <br><i>Shape / Rectangular</i> | Rolled       | 0.50 – 6.50               | 13 – 165  | 0.281 – 2.625 | 7 – 67  |

Please note: Product forms are thermal treated to meet temper requirements specified by the customer

- **Alloy 600 - Beginning 1980' s**  
**first observation of Stress Corrosion Cracking**
- **General Electric, Westinghouse and others**  
**identified carbide morphology and carbon**  
**depletion on the the grain boundaries as the cause**  
**of this severe problem**
- **Further research work approved Alloy 690 is the**  
**ideal material**
- **In the late 1990' s, the overhaul of existing nuclear**  
**power stations sarterd using Alloy 690**
- **New power plants are designed with Alloy 690**  
**only**



## VDM Nicrofer 6030 – alloy 690

|             | <u>Ni</u>   | <u>Cr</u>   | <u>Fe</u>   | <u>C</u>    | <u>Mn</u>  | <u>Si</u>  | <u>Cu</u>  | <u>S</u>     |
|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|--------------|
| <b>Min.</b> | <b>58.0</b> | <b>27.0</b> | <b>7.0</b>  |             |            |            |            |              |
| <b>Max.</b> |             | <b>31.0</b> | <b>11.0</b> | <b>0.05</b> | <b>0.5</b> | <b>0.5</b> | <b>0.5</b> | <b>0.015</b> |

Chemical composition (wt.-%) according to ASTM





## Supply Record

|       | Plate/Sheet<br>(Tons) | Rod/Bar<br>(Tons) |
|-------|-----------------------|-------------------|
| 2002  | 45                    | 17                |
| 2003  | 24                    | 6                 |
| 2004  | 22                    | 3                 |
| 2005  | 23                    | 21                |
| 2006  | 15                    | 65                |
| 2007  | 30                    | 116               |
| 2008  | 55                    | 30                |
| Total | 184                   | 258               |

Qualified per ASME Sect. III NCA 3800  
10 CFR 50 App. B and 10 CFR 21



## Supply References

### Doosan Heavy Industry, Korea

- Qinshan Nuclear Power II
- Shinkori 1 & 2 and 3 & 4
- Shinwolson 1 & 2
- KEDO 1 & 2

### ENSA, Spain

### PCC, USA

### Ansaldo Camozzi, Italy

### Areva (former Framatome), France

### Valinox, France (under qualification)



# Thank you very much!



October  
2007

