DIE BLOCKS
The origin of Terni's metallurgical industry dates back to 1884, in connection with the spread of the Italian steel making industry. This large metallurgical works, named "Terni" until 1989, was founded in response to a strategic need. The heavy demand for products from the newly-born Italian Navy imposed the establishment of a big factory in a geographically strategic area, which in the following years was to become a key factor for its continued development into an integrated and diversified plant. At the end of World War II the Italian metallurgical industry was thoroughly reorganized on a completely new basis and converted into the production of special products for power generation and industrial applications. In this framework, Terni plant was given the role which was most appropriate to its experience and facilities: the manufacture and conversion of high quality steels. Such activity placed whole "Terni" site, including Società delle Fucine, among the major producers worldwide of heavy and medium-sized forgings in a large variety of products using advanced manufacturing techniques. Società delle Fucine still has the expertise and innovative approach that was characteristic of the 19th century steel plant "Terni". Its plants include the old headquarters and factory located in Terni (100 Km north-east of Rome), with efficient road and railway connections to domestic outlets and close-by Rome and Perugia airports and Civitavecchia and Livorno ports for international outlets. Its productive unit covers a 120,000 sq/m area, where a wide range of forgings from carbon, high-and medium-alloyed and stainless steels are manufacture. Società delle Fucine products are directed to primary economy sectors, such as power generation and industry where reliability is a must to assure working safety and operation efficiency. All grades of steel, whose development stems from a century-old metallurgical experience, comply with the latest steelmaking techniques.

Products

Società delle Fucine forgings are mainly used for power generation, mechanical, chemical, petrochemical, offshore and aerospace applications: all sectors where dependability of machinery and plant components is essential for safety and continual operation. All these requirements are guaranteed by a strict application of manufacturing procedures and severe quality checks.
Facilities

Società delle Fucine is equipped with the most updated facilities for:
- Steelmaking / Ingot Pouring
- Heating for forging
- Forging
- Machining
- Heat Treatment
- Final Machining
- Destructive and Non Destructive testing

Steelmaking
Società delle Fucine equipment includes:
- Two Electric Arc Furnaces up 180 tons
- One ASEA-SKF refining plant up to 180 tons ladle
- Two 140 tons, fully automatized Argo-Oxygen-Decarburization (AOD), converters
- One VD/VOD plant up to 140 tons capacity
- Stream Degassing vacuum tanks for pouring up to 530 tons ingots
- Bottom pouring pits for solid and hollow ingots up to 450 tons

Heating for forging
Società delle Fucine forging heating is developed by means of:
- Four natural gas heating furnaces up to 1000 t capacity, with centralized remote temperature control

Forging
The forging workshop of Società delle Fucine includes:
- One 12.600 tons capacity hydraulic press equipped with an integrated 700 tons*meter manipulator
- One 5.000 tons hydraulic press equipped with an integrated manipulator
- Oxygen cutting machine up to 3000 mm in diameter.

Machining
The machining shop of Società delle Fucine is equipped with:
- Thirteen horizontal numerical control lathes up to 300 tons capacity
- Five vertical numerical control lathes up to 250 tons capacity
- Four milling machines
- Two grinding machines up to 300 tons capacity
- Two boring and honing machines up to 300 tons capacity

Heat treatment
The heat treatment shop of Società delle Fucine includes:
- Vertical and horizontal furnaces
- Vertical and horizontal water quenching tanks
- Two rotating furnaces with quenching machine
- One vertical oil quenching tank

Final Machining
- Final machining of SdF is performed on dedicated vertical and horizontal lathes and two grinding machines up to 300 ton capacity
- UT examinations are performed according to specific standards and procedures using manual and automatic facilities
Research & Development

The forging business has always been accorded particular consideration because of the size and complexity of the metallurgical issues involved and the need to produce highly dependable materials meeting the most challenging and sophisticated requirements. At Società delle Fucine research is a daily job, aiming to the enhancement and rationalization of a well-established technology including the optimization of forging and heat-treating cycles or the study of heavy ingot solidification using mathematical models. Great attention is paid to the application on industrial scale of new technologies such as extruded nodes for off-shore platforms and monobloc channel heads with integral extruded nozzles. High quality level at Società delle Fucine is obtained thanks to technologically advanced facilities, laboratories and equipment and the work of specialized engineering teams, highly qualified for the very complex and delicate job of analyzing materials during the development of the manufacturing process.

Quality control

Full high-level quality control of Società delle Fucine products is based on the proficiency of personnel and the variety and reliability of equipment. The non-destructive test laboratory includes:

- Automatic ultrasound test equipment for shafts up to 150 ton;
- 12 portable US test units;
- 8 units 6000-10000 A for colored or fluorescent magnetic particle tests;
- Endoscopes for axial hole testing;
- Penetrants and visual test units;
- All non-destructive test personnel are qualified and certified for Level II tests, according to ASNT SNT-TC-1A and EN-473. The correctness and completeness of testing procedures and their conformity with the most important national and international standards (EN, ISO, ASME, RCCM, etc.) as well as with customer specifications are guaranteed by the long, proven experience of Level III test operators.

The destructive test laboratory is equipped with:

- Furnaces for Simulated Post Weld Heat Treatment of samples;
- Machines for room temperature, cold and hot tensile testing;
- Pendulums for room temperature, cold and hot impact testing;
- Fixed and portable Brinell, Rockwell and Shore hardness meters;
- Creep testing machines;
- Fatigue testing machine;
- Drop-weight testing machine;
- Portable quantometer for PMI.

Quality control includes a Dimensional Inspection and Calibration Laboratory equipped with the most updated metering equipment to guarantee the reliability, repeatability and reproducibility of measurements and Chemical and Metallographic Examination Laboratories that are located inside Terni’s industrial site.

Quality Assurance

The approach to quality at Società delle Fucine is founded on a simple principle: to identify and meet customer requirements. Based on that, the company has for decades applied a severe Quality System that regulates all product fabrication and inspection steps. This system has been assessed and accepted by all major customers and leading certification bodies such as: the Italian IGQ – Istituto di Garanzia Qualità, a member of IQ-Net, the German TÜV SÜD and the British Lloyd’s Register. The Quality System of Società delle Fucine has been one of the first Italian QA systems accredited by the ASME for the manufacture of forged products for nuclear applications, according to Section III, NCA-3800. The Quality System at Società delle Fucine is kept steadily conforming to the ever stricter specifications of reference standards and customer requirements.

Health & Safety

Health and Safety practices have been introduced at Società delle Fucine, in conformance with Italian laws, with the application of the OHSAS 18001 model. The company has designed and applied several specific measures to ensure an ever increasing level of Safety on the workplace.

Investments on new and safely performing machines have been put in place in order to satisfy all mandatory requirements related to workers Health & Safety and improve the overall company quality level. The integrated Quality Health & Safety System has been assessed and accepted according to OHSAS 18001 standards by the IGQ – Istituto di Garanzia Qualità, the Italian certification body.
Società delle Fucine is equipped with the most updated machinery and its process is kept under steady review, in order to be ready to market changes.

**Steel Manufacturing and Steel Quality:**
Selected scraps are melted in the electric-arc furnace and then refined in a ladle furnace equipped with heating, and vacuum devices, electromagnetic stirring and argon bubbling through a porous plug, in order to obtain low impurity contents. Chemical composition is further optimized to guarantee high performance. Over 80-ton ingots are poured under vacuum with a method called stream degassing. Smaller ingots are normally bottom poured.

**Forging:**
Bars from forging ingots present a fine grain microstructure. In addition, absolute compactness through the cross section of bars is obtained with optimized heating and plastic conditions.

**Heat treatment:**
Bar quenching and tempering remove any risk of die-block breakout or deformation. Heat treatment parameters for every steel grade are selected in order to balance the various characteristics that will determine final product success.

**Machining:**
Die blocks are delivered according to the customers requests, starting from the "as forged" condition to the fully machined one.

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**Die Blocks Manufacturing Cycle (Flow Chart)**
PLAST-40 1.2738

Steel description
Excellent hardenability and uniform hardness
Good machinability
Excellent polishing
Excellent photo-etching
Good toughness
Suitable for chrome plating
Nitridable

Application
Large-size plastic moulds
Die holders for hammer, presses and screw presses and for die casting
Structural components, shafts
Blow moulds

Reference standards

<table>
<thead>
<tr>
<th>UNI</th>
<th>Wnr.</th>
<th>DIN</th>
<th>AFNOR</th>
<th>AISI/SAE</th>
<th>GB</th>
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<td>AISI P20+Ni</td>
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Chemical composition

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<th>Mo</th>
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Physical properties
Density at 20°C 7.85Kg/dm³
Thermal conductivity at 20°C 35 W/(m*K)

Thermal expansion coefficient 10^−6 m/(mK)

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CCT

SdF - DIE BLOCKS
Heat treatment

**Soft annealing**
Heating to 840-860°C for 1 hour every 50mm of thickness, furnace cooling and tempering at 620-660°C for 1 hour every 25mm of thickness and cooling in air.

**Quality heat treatment**
Austenitization at 830-850°C for 1 hour every 50 mm of thickness, quenching in oil or water and polymers. Tempering (2 Cycles) at 520-600°C according to the desired hardness (see tempering diagram).

**Cleanliness**
ASTM E45-Method A B C D ≤ 2.0
DIN 50602-K4 ≤ 20

**Ultrasonic**
SEP 1921-test group 3 - class D/d

**Hardness**
Standard 290 - 330 HB on surface.
Other hardness requirements can be discussed on demand of the customer.
PLAST-30  1.2738 MOD. (HH)

Steel description
Excellent hardenability and uniform hardness
Good machinability
Excellent polishing
Excellent photo-etching
Good toughness
Suitable for chrome plating
Nitridable

Application
Large-size plastic moulds
Die holders for hammer, presses and screw presses and for die casting

Reference standards

<table>
<thead>
<tr>
<th>UNI</th>
<th>Wnr.</th>
<th>DIN</th>
<th>AFNOR</th>
<th>AISI/SAE</th>
<th>GB</th>
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<td>-</td>
<td>40CMND8</td>
<td>AISI P20+Ni HH</td>
<td>3Cr2MnNiMo</td>
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Chemical composition

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<th>Cr</th>
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Physical properties

Density at 20°C 7,83Kg/dm³
Thermal conductivity at 20°C 37,2 W/(m*K)

Thermal expansion coefficient 10⁻⁶m/(mK)

<table>
<thead>
<tr>
<th>20-100°C</th>
<th>20-200°C</th>
<th>20-300°C</th>
<th>20-400°C</th>
<th>20-500°C</th>
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</table>

CCT
Heat treatment

**Soft annealing**
Heating to 840-860°C for 1 hour every 50mm of thickness, furnace cooling.

**Quality heat treatment**
Austenitization at 840-880°C for 1 hour every 50 mm of thickness, quenching in oil or water and polymers. Tempering (2 Cycles) at 520-600°C according to the desired hardness (see tempering diagram).

### Tempering Curve

<table>
<thead>
<tr>
<th>Temperature [°C]</th>
<th>Hardness [HB]</th>
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</thead>
<tbody>
<tr>
<td>293</td>
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<td>332</td>
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<table>
<thead>
<tr>
<th>Temperature [°C]</th>
<th>Hardness [HRC]</th>
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</thead>
<tbody>
<tr>
<td>293</td>
<td>60</td>
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<tr>
<td>332</td>
<td>55</td>
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<tr>
<td>371</td>
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<tr>
<td>490</td>
<td>35</td>
</tr>
<tr>
<td>530</td>
<td>30</td>
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</tbody>
</table>

### Cleanliness
ASTM E45-Method A B C D ≤ 2.0  
DIN 50602-K4 ≤ 20

### Ultrasonic
SEP 1921-test group 3 - class D/d

### Hardness
Standard 310 - 355 HB on surface.  
Other hardness requirements can be discussed on demand of the customer.
**PLASTER 1.2311**

**Steel description**
- Good hardenability with slight decrease of hardness
- Good machinability
- Excellent polishing
- Good suitability to photo-etching

**Application**
- Medium-size plastic moulds up to 500 mm
- Die holders for hammers, presses and screw presses and for die casting

**Reference standards**

<table>
<thead>
<tr>
<th>UNI</th>
<th>Wnr.</th>
<th>DIN</th>
<th>AFNOR</th>
<th>AISI/SAE</th>
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</table>

**Physical properties**
- Density at 20°C 7.83 Kg/dm³
- Thermal conductivity at 20°C 33 W/(m*K)

**Chemical composition**

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Cr</th>
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<th>Ni</th>
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<td>0.50</td>
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**Thermal expansion coefficient 10⁻⁶ m/(m*K)**

<table>
<thead>
<tr>
<th>Temperature [°C]</th>
<th>20-100°C</th>
<th>20-200°C</th>
<th>20-300°C</th>
<th>20-400°C</th>
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<td>13.9</td>
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</table>

**CCT**

![CCT Diagram]

SdF - DIE BLOCKS
Heat treatment

**Soft annealing**
Heating to 840-860°C for 1 hour every 50mm of thickness, furnace cooling and tempering at 620-660°C for 1 hour every 25mm of thickness and cooling in air.

**Quality heat treatment**
Austenitization at 830-850°C for 1 hour every 50 mm of thickness, quenching in oil or water and polymers. Tempering (2 Cycles) at 500-600°C according to the desired hardness (see tempering diagram).

---

**Cleanliness**
ASTM E45-Method A B C D ≤ 2.0
DIN 50602-K4 ≤ 20

**Ultrasonic**
SEP 1921-test group 3 - class D/d

**Hardness**
Standard 280 - 320 HB on surface.
Other hardness requirements can be discussed on demand of the customer.
Steel description
Good machinability
High toughness mainly due to high nickel content
High hardenability and uniform hardness also in large-size bars
Good suitability to photo-etching
High wear resistance due to high carbon content and the presence of suitable ferro alloy elements

Application
Drop-forging dies of any size for ferrous metals, subjected to high dynamic mechanical stress and thermal shocks
Plastic moulds
Die supports for extrusion

Reference standards

<table>
<thead>
<tr>
<th>UNI</th>
<th>Wnr.</th>
<th>DIN</th>
<th>AFNOR</th>
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Chemical composition

<table>
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Physical properties
Density at 20°C 7.84Kg/dm³
Thermal conductivity at 20°C 36 W/(m*K)

Thermal expansion coefficient 10⁻⁶/m/(mK)

<table>
<thead>
<tr>
<th>20-100°C</th>
<th>20-200°C</th>
<th>20-300°C</th>
<th>20-400°C</th>
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<td>13.9</td>
<td>14.2</td>
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</table>

CCT

SdF - DIE BLOCKS
Heat treatment

**Soft annealing**
Heating to 840-860°C for 1 hour every 50mm of thickness, air cooling and tempering at 620-660°C for 1 hour every 25mm of thickness and cooling.

**Quality heat treatment**
Austenitization at 830-850°C for 1 hour every 50 mm of thickness, quenching in oil or water and polymers. Tempering (2 Cycles) at 580-620°C according to the desired hardness (see tempering diagram).

![Tempering Curve](image)

**Cleanliness**
ASTM E45-Method A B C D ≤ 2.0
DIN 50602-K4 ≤ 20

**Ultrasonic**
SEP 1921-test group 3 - class D/d

**Hardness**
Standard 360 - 400 HB on surface.
Other hardness requirements can be discussed on demand of the customer.
**Steel description**
High resistance to thermal cracks
High hot-wear resistance due to large amounts of carbides dispersed in a martensitic matrix
High hardness in quenched and tempered condition also at high temperature
Excellent machinability in annealed condition
Excellent polishing
High Hardenability

**Application**
Dies for light alloy die-casting
Dies for drop forging of presses and screw presses
Dies for aluminum for hot extrusion
Mandrels

**Reference standards**

<table>
<thead>
<tr>
<th>UNI</th>
<th>Wnr.</th>
<th>DIN</th>
<th>AFNOR</th>
<th>AISI/SAE</th>
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**Physical properties**
Density at 20°C 7.83Kg/dm³

**Chemical composition**

<table>
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<th>C</th>
<th>Si</th>
<th>Mn</th>
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**CCT**

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Heat treatment

Annealing (standard delivery condition)
Heating to 1030-1060°C for 1 hour every 50mm of thickness, slow furnace cooling and tempering at 620-780°C.

Technical suggestions for hardening
Austenitization at 1020-1040°C for 1 hour every 50 mm of thickness, quenching in oil or vacuum. Tempering (2 Cycles recommended) at 560-620°C according to the desired hardness (see tempering diagram).

Cleanliness
ASTM E45-Method A B C D ≤ 2.0
DIN 50602-K4 ≤ 20

Ultrasonic
SEP 1921-test group 3 - class D/d

Hardness
Standard < 230 HB on surface. Other hardness requirements can be discussed on demand of the customer.
Steel description
High resistance to thermal cracks due to Cr, Mo and V additions
High hot-wear resistance due to large amounts of carbides dispersed in a martensitic matrix
High hardness in quenched and tempered condition also at high temperature
Excellent machinability in annealed condition
Excellent polishing
High Hardenability

Application
Dies for light alloy die-casting
Dies for drop forging of presses and screw presses
Dies for aluminum for hot extrusion
Mandrels

Reference standards

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<th>UNI</th>
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Physical properties
Density at 20°C 7,83Kg/dm³

Chemical composition

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CCT
Heat treatment

**Annealing (standard delivery condition)**
Heating to 1030-1060°C for 1 hour every 50mm of thickness, slow furnace cooling and tempering at 620-780°C.

**Technical suggestions for hardening**
Austenitization at 1020-1050°C for 1 hour every 50 mm of thickness, quenching in oil or vacuum.
Tempering (2 Cycles recommended) at 560-620°C according to the desired hardness (see tempering diagram).

**Cleanliness**
ASTM E45-Method A B C D ≤ 2.0
DIN 50602-K4 ≤ 20

**Ultrasonic**
SEP 1921-test group 3 - class D/d

**Hardness**
Standard < 230 HB on surface.
Other hardness requirements can be discussed on demand of the customer.
CHARACTERISTIC

To ensure fitness of die blocks to their applications, steels are selected based on their general characteristics, i.e. taking account of their physical, mechanical and technological features. The following table reports the characteristics required for each application.

**MACHINABILITY**
Machinability is improved by approx. 30% by means of micro additions during steel refining process. Non-metallic elements are added to generate complex micro inclusions, whose task is to break down chips during chip removal.

**HARDNESS**
The optimal hardness for each steel is a balance between wear resistance, machinability and toughness. Hardness is required to be uniform also at the core of large cross-size bars. This can be facilitated through an adequate chemical composition that confers the desired hardenability onto steel.

**POLISHING**
The excellent polishing of Società delle Fucine steels is mainly due to a fine and compact microstructure that is acquired at the end of heat treatment, and to the absence of porosity and micro inclusions. Adequate hardness and steel chrome contents are additional factors that improve polishing.

**TOUGHNESS**
Toughness depends on various factors, including steel chemical composition, microstructure, austenitic grain diameter and inclusion contents.

**RESISTANCE TO FIRE CRACKS**
When the die-block surface is subject to alternating heating and cooling, it may develop cracks (also called fire cracks or thermal-fatigue cracks). Laboratory tests are carried out to check resistance to fire cracks and results are applied to the development and optimization of manufacturing processes. Among the metallurgical parameters that will determine the behavior of steel to the cracks, toughness plays the main role, followed by micro-cleanliness, microstructure and hardness.

**PHOTO-ETCHING**
Steel behavior to photo-etching is basically affected by operating process conditions and steel metallurgical properties. Among metallurgical properties, the absence of areas showing segregation of carbides and micro inclusions plays a major role.

**WEAR RESISTANCE**
Resistance to wear depends on operating conditions (i.e. temperature, materials at contact with die-blocks, relative speed, specific loads, etc.), mechanical characteristics (e.g. hardness) and metallurgical properties (e.g. microstructure) of steel. Additional surface treatments such as nitriding and chromium plating can improve wear resistance further.

**CORROSION RESISTANCE**
Exposure to the environment can attack the surface of die-blocks. Sometimes the attack is so strong that die-blocks must be repolished in order to recover efficiency.

**SURFACE TREATMENTS**
The purpose of surface treatments is mainly to increase local hardness of die-blocks or improve corrosion resistance. For local hardenability, recourse is made to nitriding (gaseous, saline or ionic) and more rarely to surface quenching, as it can cause die deformation. Chromium or nickel plating is applied to improve corrosion resistance. Thanks to their good cleanliness, proper chemical composition and microstructure, all die-blocks steels by Società delle Fucine can be subject to further surface treatments.