1. Weldability of Metals
DIN 8580 and DIN 8595 classify welding into production technique main group 4 "Joining", group 3.6 "Joining by welding", Figure 1.1.

**Figure 1.1**

**Weldability** of a component is determined by three outer features according to DIN 8528, Part 1. This also indicates whether a given joining job can be done by welding, Figure 1.2.

**Figure 1.2**
Material influence on weldability, i.e. **welding suitability**, can be detailed for a better understanding in three subdefinitions, Figure 1.3.

The chemical composition of a material and also its metallurgical properties are mainly set during its production, Figure 1.4. They have a very strong influence on the **physical characteristics of the material**.

Process steps on steel manufacturing, shown in Figure 1.4, are the essential steps on the way to a processible and usable material. During manufacture, the requested chemical composition (e.g. by alloying) and metallurgical properties (e.g. type of teeming) of the steel are obtained.

Another modification of the material behaviour takes place during subsequent treatment, where the raw material is rolled to processible semi-finished goods, e.g. like strips, plates, bars, profiles, etc.. With the rolling process, material-typical transformation processes, hardening and precipitation processes are used to adjust an optimised material characteristics (see chapter 2).
A survey from quality point of view about the influence of the most important alloy elements to some mechanical and metallurgical properties is shown in Figure 1.5.

Figure 1.5

![Table showing influence of alloy elements on some steel properties](image)

Figure 1.6 depicts the decisive importance of the carbon content to suitability of fusion welding of mild steels. A guide number of flawless fusion weldability is a carbon content of $C < 0.22\%$. With higher C contents, there is a danger of hardening, and welding becomes only possible by observing special precautions (e.g. pre- and post-weld heat treatment).

### Table: Influence of Alloy Elements on Some Steel Properties

- **Material**
- **C-content (%)** (Melt analysis)
- **Fusion weldability**

<table>
<thead>
<tr>
<th>Material</th>
<th>C-content (%)</th>
<th>Fusion weldability</th>
</tr>
</thead>
<tbody>
<tr>
<td>S185 (St 33) [EN 10 025]</td>
<td>unlimited (up to 0.30)</td>
<td>Not guaranteed, however mostly no problem with low C-content</td>
</tr>
<tr>
<td>S235JR (St 37), S275JR (St 42) [EN 10 025], L235G (St 35), L275G (St 45) [Steels for tubing EN 10 208], P220GH (H 1), P230GH (H 1), P280NH (H 3)</td>
<td>up to 0.21</td>
<td>up to 0.22% C; good weldability (exception: plate thickness &gt;0.3 mm, special order conditions), as long as content of impurities (P, S etc.) not too high</td>
</tr>
<tr>
<td>C10 (C 10), C15 (C 15), C22 (C 22) [Class hardening and tempering steels EN 10 083]</td>
<td>up to 0.22 (up to 0.24)</td>
<td>Not guaranteed, however mostly no problem with low C-content</td>
</tr>
<tr>
<td>S355J0 (St 52)</td>
<td>up to 0.22 and higher contents of Mn and Si</td>
<td>Weldable</td>
</tr>
<tr>
<td>E200 (St 50) Steel for mechanical engineering</td>
<td>unlimited, about 0.30</td>
<td>Weldable with electric arc methods, no gas welding of thin plates</td>
</tr>
<tr>
<td>E355 (St 60), C35 (C 35)</td>
<td>about 0.40</td>
<td>Weldable with special electrodes and mostly pre- and post-welding heat treatment</td>
</tr>
<tr>
<td>E360 (St 70), C45 (C 45)</td>
<td>about 0.60</td>
<td>Very restricted weldability in spite of special measures</td>
</tr>
</tbody>
</table>

Figure 1.6

![Fusion Weldability of Unalloyed Quality Steels](image)
In addition to material behaviour, weldability is also essentially determined through the design of a component. The influence of the design is designated as **welding safety**, Figure 1.7.

![Welding Safety Diagram](image)

**Figure 1.7**

The influence of the manufacturing process to weldability is called **welding possibility**, Figure 1.8. For example, a pre- and post-weld heat treatment is not always possible, or grinding the weld surface before welding the subsequent pass cannot be carried out (narrow gap welding).

![Welding Possibility Diagram](image)

**Figure 1.8**