Adding Boron to a Heat of Steel

Illustration

- Here is a (slightly modified) quote from the "Key to Metals" Internet source; the article is "Boron in Steel: Part One":
  - "Boron optimum quantity which has to be added in the steel to achieve maximum hardenability, based on experience is about 0.0003 to 0.0030% B (*or 3 ppm - 30 ppm*). Boron addition beyond the mentioned values deteriorates hardenability because the excess of boron atoms precipitate as cubic $Fe_{23}(CB)_6$ borocarbide, and that is not good.

    Available Forms
    Boron is supplied to steelmakers as ferroboron or as one of several *proprietary* alloys. The choice of what one uses depends, as always, on steelmaking practice, product mix and volume, individual operators' experience and preference, and price. A steelmaker should choose that addition agent giving the highest and most reliable recovery consistent with his overall melt shop economics.
    Ferroboron is addition agent with the lowest cost. Boron content is relatively high: standard grades are sold with boron levels between 12% and 24%. Major impurities are carbon (0.10-1.5%), silicon (0.30-4.0%) and aluminum (0.5-8.0%). A typical analysis will include 18.0% B, 0.50% C, 0.50% Si, 0.2% Al, 0.03% P, and 0.01% S. All except boron are maximum values. The product is supplied in lump form, 2 in. or 1 in., packaged in 250 kg or 500 lb steel drums, or supersacks (bulk bags) of up to 3000 lb (1360 kg) capacity. Many customers apply a minimum size limit, such as 5 mm (0.2 in.), in order to minimize the amount of fine material, which can give poor recoveries in less well-controlled melting practices. Ferroboron is also available as cored wire.
    Because ferroboron does not contain appreciable concentrations of protective elements, it requires greater care than the proprietary alloys in order to give adequate and consistent results. It is normally added after other oxygen/nitrogen scavengers (= "killers" of oxygen), such as ferrotitanium.
    The proprietary boron addition agents are more expensive than ferroboron on an initial cost basis but are often preferred for their greater efficiency, ease of application and more consistent results. All will contain varying proportions of oxygen and/or nitrogen scavengers such as titanium, aluminum, silicon and zirconium. These elements generally have an even greater affinity for oxygen and nitrogen than boron.
    The most common proprietary addition agent typically contains 2.0% B, 15% Al, 30% Ti, 10% Si, bal. Fe. This product's high scavenger/boron ratio ensures its effectiveness for all boron steels, provided they have been adequately deoxidized first.
    A variety of other composition proprietary boron addition alloys are available, with boron contents varying between 0.5% and 4%. Generally, the higher the ratio of boron to scavenger elements, the greater the care required to ensure adequate recovery of the boron in the steel.
    Proprietary boron addition agents are sold in lump form 1-1/4 in. and 2 in. packaged in bags, cans or large drums."
- See what I mean? Obviously, you do not just throw some elemental boron in the cauldron. Thre must be some very good reasons for this. These reasons do not become all that clear, however.
  This can be generalized. The best way of adding an alloying element is a science in itself.
  Take note that the author of that article does not really address the "why" questions that unavoidably come up reading his text. It's not important to him. All that counts is that some procedure works for what is intended.