

# Open die steel forgings for general engineering purposes —

## Part 1: General requirements

The European Standard EN 10250-1:1999 has the status of a  
British Standard

ICS 77.140.85

## National foreword

This British Standard is the English language version of EN 10250-1:1999.

The UK participation in its preparation was entrusted to Technical Committee ISE/31, Wrought steels, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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### Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 17 and a back cover.

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## Open die steel forgings for general engineering purposes - Part 1: General requirements

Pièces forgées en acier pour usage général - Partie 1:  
Exigences générales

Freiformschmiedestücke aus Stahl für allgemeine  
Verwendung - Teil 1: Allgemeine Anforderungen

This European Standard was approved by CEN on 16 July 1999.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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EUROPEAN COMMITTEE FOR STANDARDIZATION  
COMITÉ EUROPÉEN DE NORMALISATION  
EUROPÄISCHES KOMITEE FÜR NORMUNG

Central Secretariat: rue de Stassart, 36 B-1050 Brussels

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## Foreword

This European Standard has been prepared by Technical Committee ECISS/TC 28, Steel forgings, the Secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2000, and conflicting national standards shall be withdrawn at the latest by February 2000.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association. This European Standard is considered to be a supporting standard to those application and product standards which in themselves support an essential safety requirement of a New Approach Directive and which make reference to this European Standard.

The titles of the other Parts of this European Standard are:

Part 2 : Non-alloy quality and special steels

Part 3 : Alloy special steels

Part 4 : Stainless steels

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

## 1 Scope

This part of this European Standard specifies the general technical delivery conditions for open die forgings, forged bars, and products pre-forged and finished in ring rolling mills, for general engineering purposes.

General information on technical delivery conditions is given in EN 10021.

## 2 Normative references

This part of EN 10250 incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to, or revisions of, any of these publications apply to this European Standard, only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 287-1	Approval testing of welders. Fusion welding - Part 1: Steels
EN 288-1	Specification and qualification of welding procedures for metallic materials - Part 1: General rules for fusion welding
EN 288-2	Specification and qualification of welding procedures for metallic materials - Part 2: Welding procedure specification for arc welding
EN 288-3	Specification and qualification of welding procedures for metallic materials - Part 3: Welding procedure tests for the arc welding of steels
EN 10002-1	Metallic materials - Tensile testing - Part 1: Method of test
EN 10003-1	Metallic materials - Brinell hardness test - Part 1: Test method
EN 10020	Definition and classification of grades of steel
EN 10021	General technical delivery requirements for steel and iron products
EN 10027-1	Designation systems for steels - Part 1: Steel names, principal symbols
EN 10027-2	Designation systems for steels - Part 2: Numerical system
EN 10045-1	Metallic materials - Charpy impact test - Part 1: Test method
EN 10052	Vocabulary of heat treatment terms for ferrous products
EN 10079	Definition of steel products.

EN 10204	Metallic products - types of inspection documents
EN 10228-1	Non-destructive testing of steel forgings - Part 1: Magnetic particle inspection
EN 10228-2	Non-destructive testing of steel forgings - Part 2: Penetrant testing
EN 10228-3	Non-destructive testing of steel forgings - Part 3: Ultrasonic testing of ferritic or martensitic steel forgings
EN 10228-4	Non-destructive testing of steel forgings - Part 4: Ultrasonic testing of austenitic and austenitic-ferritic stainless steel forgings
EN ISO 377	Steel and steel products - Location and preparation of samples and test pieces for mechanical testing (ISO 377:1997)
CR 10260	Designation systems for steels - Additional symbols
EN ISO 3651-2	Determination of resistance to intergranular corrosion of stainless steels - Part 2: Ferritic, austenitic and ferritic-austenitic (duplex) stainless steels - Corrosion test in media containing sulfuric acid (ISO 3651-2:1998)
CR 10261	ECISS Information Circular 11 - Iron and steel - Review of available methods of chemical analysis
prEN 10168	Iron and steel documents - Inspection documents - Contents

### 3 Definitions

For the purposes of this part of this European Standard, the following definition applies in addition to the definitions in EN 10020, EN 10021, EN 10052, EN 10079 and EN ISO 377.

**3.1 batch:** forgings of similar dimensions from the same cast, made by the same forging procedure and from the same heat treatment charge. "Similar dimensions" are to be taken as forgings having dimensions within  $\pm 10\%$  of the equivalent thickness

### 4 Classification and designation

#### 4.1 Classification

The steels covered by this European Standard are classified as follows:

- Part 2: Non-alloy quality and special steels;
- Part 3: Alloy special steels;
- Part 4: Stainless steels.

## 4.2 Designation

The steels in parts 2 to 4 of this European Standard shall be designated in accordance with the requirements of EN 10027-1 and EN 10027-2, and CEN CR 10260.

## 5 Information to be supplied by the purchaser

### 5.1 Mandatory information

The purchaser shall select the steel type, the shape and dimensions of the forgings taking the intended use into account.

The purchaser shall provide in the order all the information necessary for describing the forging and its characteristics and details concerning delivery including the following:

- a) the quantity of forgings required;
- b) the forging dimensions, or the drawing number(s) containing the dimensions, tolerances and surface finish, with which the forging shall conform;
- c) the steel designation (name or number) of the material of which the forgings are made (see 4.2);
- d) whether the purchaser has any specific requirements on the hot working process or needs to be informed of the forging procedure (see A.2 and A.3);
- e) whether production and testing of the forgings is to be witnessed by the purchaser's representative, and if so, the particular stages in production and testing at which the purchaser's representative may require to be present (see clause 14);
- f) any required options (see 5.2 and annex A);
- g) if required, the type of inspection document in accordance with EN 10204.

### 5.2 Options

A number of options are available and these are detailed in annex A. Where any of the options given are specified at the time of the order, the forgings shall conform to the requirements of any such option, in addition to the mandatory requirements of this European Standard.

If the purchaser does not specify any options at the time of enquiry and order, the manufacturer shall supply in accordance with the basic specification.

## 6 Manufacture of the steel

### 6.1 Steelmaking process

The steel shall be produced by an electric process or one of the basic oxygen processes (see A.1).



## **6.2 Deoxidation**

The steel shall be fully killed.

## **7 Manufacture of the product**

### **7.1 Hot working**

The choice of hot working process shall be at the discretion of the manufacturer (see **A.2**).

### **7.2 Forging reduction**

The forging shall receive a sufficient forging reduction to completely consolidate the forging and remove the cast structure (see **A.3**).

### **7.3 Heat treatment**

The forgings shall be delivered in a heat treated condition as specified in the relevant part of EN 10250, unless otherwise agreed at the time of enquiry and order.

### **7.4 Weldability**

The steels in this European Standard are generally regarded as being weldable. Welding shall be carried out in accordance with EN 287 and EN 288.

## **8 Surface condition and internal soundness**

### **8.1 General**

The forgings shall be sound and free from such segregation, cracks, laminations or defects that preclude their intended use (see **A.4**, **A.5** and **A.6**).

### **8.2 Removal or surface defects**

#### **8.2.1 Conformity to 8.1**

Before forgings are despatched or presented for acceptance, surface defects shall be removed in order to conform to **8.1**.

#### **8.2.2 Chipping and/or grinding**

Surface defects shall be removed by chipping and/or grinding providing the residual thickness meets the minimum tolerance and that the resulting depression does not undercut the rest of the surface. If the thickness is to be reduced to below the minimum tolerance, the repair shall only be carried out following agreement with the purchaser.

### 8.2.3 Chipping and/or grinding and resurfacing by welding

If resurfacing by welding is agreed by the purchaser, prior to the repair being carried out, surface defects exceeding the acceptance criteria shall be removed by chipping and/or grinding followed by resurfacing by welding and levelling the weld. Any welding operations shall be in accordance with EN 287-1 and EN 288-1, EN 288-2 and EN 288-3.

### 8.3 Dimensions, shape and tolerances and nominal mass

The dimensions and shape of the product shall conform to the tolerances stated in the order.

Any calculation of the nominal mass of the product shall be based on the following density values:

- |   |                         |
|---|-------------------------|
| – non-alloy and alloyed steels in EN 10250-2 and EN 10250-3 | 7,85 kg/dm <sup>3</sup> |
| – austenitic stainless CrNi steels in EN 10250-4            | 7,9 kg/dm <sup>3</sup>  |
| – austenitic stainless CrNiMo steels in EN 10250-4          | 8,0 kg/dm <sup>3</sup>  |

### 8.4 Compatibility with non-destructive testing NDT

The agreed requirements for surface finish shall be compatible with the requirements of the reference to NDT standards (EN 10228).

## 9 Chemical composition

### 9.1 Cast analysis

The chemical composition of the steel, determined by cast analysis, shall conform to the requirements specified in the relevant parts of EN 10250.

Elements not listed in the composition tables in the relevant parts of EN 10250 shall not be intentionally added without the agreement of the purchaser except for finishing the cast (see options **A.7** and **A.8**).

### 9.2 Product analysis (optional requirement)

If required and specified by the purchaser a product analysis shall be carried out and reported instead of a cast analysis (see **A.9**). The results of a product analysis on samples taken and prepared in accordance with clause 11 shall not deviate from the specified limits for the cast analysis by more than the values given in the tables of permissible deviations of product analysis in the relevant parts of EN 10250 (see options **A.9** to **A.11**).

## 10 Mechanical properties

The mechanical properties obtained from the test pieces, selected, prepared and tested in accordance with the requirements of clauses 11 and 12, shall comply with the values specified in the relevant parts of EN 10250.

Details of the assessment of impact tests based on the sequential method are given in **8.3** of EN 10021. The average value for the Charpy impact strength obtained in three tests at room temperature shall not be less than the value specified in the relevant part of EN 10250 for the appropriate limiting ruling section (see annex B) of the steel concerned. One individual value may be below the specified value, but no individual value shall be less than 70 % of the specified value.

Impact tests at temperatures below room temperature may be specified (see **A.12**).

## 11 Sampling and preparation of test pieces

### 11.1 General

The minimum number of samples shall be in accordance with the requirements of **11.2** and **11.3**, according to the mass and/or size of the forging.

For the provision of pieces, forgings up to the unit mass given in Table 1 may be batched to the maximum batch masses given in Table 1.

**Table 1: Unit mass and batch mass limit**

Maximum mass of final individual product, kg	10 000
Maximum batch mass limit, kg	35 000
Maximum number of pieces	50

### 11.2 Methods used for the provision of samples

#### 11.2.1 General

Samples shall be provided by one of the following methods:

- a) for small forgings up to 1000 kg - if agreed with the purchaser, as separately forged samples from the bars, billets or ingots from which the forgings have been made. The samples shall receive nominally the same hot working reduction and have nominally the same equivalent thickness as the ruling section of the forgings they represent, as defined in annex B;

- b) from prolongations of the forgings having a diameter or section approximately equal to the ruling section of the forging at the time of heat treatment (see annex B). Integral samples shall not be parted from the forging until all heat treatment is completed;
- c) from additional forgings.

### **11.2.2 Separate samples or additional forgings**

Separate samples or additional forgings shall be heat treated with the forging or batch they represent.

### **11.2.3 Forgings up to and including 1000 kg mass ( $\leq 5$ m in length)**

Samples shall be provided in accordance with **11.2.1a**, **11.2.1b** or **11.2.1c**.

### **11.2.4 Forgings from 1000 kg up to and including 4000 kg ( $\leq 5$ m in length)**

Samples shall be provided in accordance with **11.2.1b** or **11.2.1c**. A sample shall be taken from one end of each sample forging.

### **11.2.5 Forgings over 4000 kg or greater than 5 m in length (any mass)**

Samples shall be provided in accordance with **11.2.1b** or **11.2.1c**. A sample shall be taken from each end of each sample forging.

For forgings whose diameter exceeds the length of the axis, such as discs or rings, samples shall be provided by increasing the outside diameter, length or thickness of the forgings or by reducing the inside diameter of the forgings, as applicable.

## **11.3 Preparation of test pieces**

All samples shall be taken at a distance of  $t/4$  below the heat treated surface (with a minimum of 20 mm and a maximum of 80 mm), and  $t/2$  from the end (where  $t$  is the equivalent thickness ( $t_{eq}$ ) or the thickness of the ruling section ( $t_R$ ) of the forging at the time of heat treatment, see annex B).

For integral samples, the end of the forging shall be projected by means of a thermal buffer, the height of which shall be at least equal to  $t/2$  (maximum 90 mm). This thermal buffer, the width of which shall be at least equal to  $t$ , shall be welded to the part before heat treatment.

The direction of test pieces shall be:

- transverse to the grain flow, for hollow cylindrical forgings and forged bars  $\geq 160$  mm in diameter;
- parallel to the grain flow for forgings  $< 160$  mm diameter;
- transverse to the grain flow for other products, grain flow to be determined by etching or consideration of the forging procedure.

If requested by the purchaser at the time of enquiry and order, additional tests shall be carried out in different directions and positions.

From each sample the following test pieces shall be prepared:

- a) one tensile test piece which shall be of type and dimensions conforming to the requirements of EN 10002-1;
- b) when required by the specification, three impact test pieces as specified in EN 10045-1. The axis of the notch shall be perpendicular to the nearest surface of the forging.

## **12 Mechanical test methods**

### **12.1 General**

When required by EN 10250-2, EN 10250-3 and EN 10250-4, mechanical tests shall be carried out by the following methods.

### **12.2 Hardness tests**

Hardness tests shall be carried out in accordance with EN 10003-1.

### **12.3 Tensile tests**

Tensile tests at room temperature shall be carried out in accordance with the requirements of EN 10002-1.

### **12.4 Impact tests**

Impact tests shall be carried out, at the specified temperature, in accordance with EN 10045-1 (see A.13).

### **12.5 Intergranular corrosion test**

See A.14.

## **13 Retests and re-heat treatment**

### **13.1 Retests**

Retests shall be carried out in accordance with EN 10021.

### 13.2 Re-heat treatment

The manufacturer shall have the right to repeat the heat treatment of any material, including material already found not to fulfil the test requirements, and resubmit it for testing. No forging shall have more than two full re-heat treatments.

## 14 Inspection

Inspection shall be carried out in accordance with the procedures in EN 10021.

An inspection document to EN 10204 covering specific inspection shall be supplied to the purchaser. An inspection certificate type 3.1B shall be provided unless another is requested at the time of enquiry and order such as 3.1A, 3.1C or 3.2. The content of the inspection document shall conform to prEN 10168 and shall contain the following information:

- a) the number of the relevant part of this European Standard and the steel designation (name or number);
- b) the reference number of each forging;
- c) the steelmaking process;
- d) the cast analysis in respect of all specified elements;
- e) the residual element content, if required;
- f) details of the heat treatment given to the forgings;
- g) the room temperature mechanical properties determined in accordance with this European Standard and the results of any optional tests;
- h) the results of any non-destructive tests;
- i) details of any agreed additional tests and results;
- j) whether any repairs have been carried out (see **8.2**). The location of any such repairs shall be marked clearly on the drawings and/or the forgings.

## 15 Marking

**15.1** Each forging or batch or forgings, as appropriate, shall be legibly marked to show:

- a) the manufacturer's name or trade mark;
- b) the reference numbers or other identification marks by which the forgings can be related to the manufacturer's certificate;
- c) the mark of the inspecting representative, if required (see clause 14).

NOTE Marking EN 10250 on or in relation to a product is a claim by the manufacturer that the product has been manufactured in accordance with the requirements of the standard. The accuracy of such a claim is therefore the manufacturer's sole responsibility.

**15.2** The mark shall be placed in the area indicated on the forging drawing, or at the discretion of the supplier, if not shown on the forging drawing.

**15.3** If stamping is not permissible, the mark shall be made with paint (see **A.15**).

**15.4** For small forgings that are boxed, the information required in **15.1** may be marked on the box, or on a tag securely attached to the box, in which the forgings are shipped.

## **Annex A (normative)**

### **Options**

#### **A.1 Steelmaking process**

Any specific requirements for the steelmaking process or information required by the purchaser concerning the manufacturing process shall be indicated at the time of enquiry and order.

#### **A.2 Hot working**

The hot working process and, if so agreed, the degree of hot working, shall be in compliance with any special agreements made at the time of enquiry and order.

#### **A.3 Forging reduction**

The purchaser may request that information shall be provided concerning the forging procedure and the calculated forging reduction.

#### **A.4 Ultrasonic testing**

Ultrasonic testing shall be carried out in accordance with EN 10228-3 or EN 10228-4. The acceptance criteria shall be agreed at the time of enquiry and order. The quantity of forgings tested shall be a statistically controlled sample or 100 % as agreed between purchaser and supplier.

#### **A.5 Magnetic particle inspection**

Magnetic particle inspection shall be carried out in accordance with EN 10228-1. The acceptance criteria shall be agreed at the time of enquiry and order. The quantity of forgings inspected shall be a statistically controlled sample or 100 % as agreed between purchaser and supplier.

#### **A.6 Penetrant testing**

Penetrant testing shall be carried out in accordance with EN 10228-2. The acceptance criteria shall be agreed at the time of the enquiry and order. The quantity of forgings tested shall be a statistically controlled sample or 100 % as agreed between purchaser and supplier.

#### **A.7 Declaration of residual elements**

The residual elements specified in the order shall be declared on the manufacturer's certificate.

#### **A.8 Limits on residual elements**

On residual elements other than those specified, a limit shall be agreed between purchaser and manufacturer.



### **A.9 Product analysis**

A product analysis, where the number of samples is specified by the purchaser, shall be carried out. The samples shall be taken either from the test pieces used for the verification of the mechanical properties or from drillings from the same location (see also **A.10** and **A.11**).

### **A.10 Product analysis from a different location**

The location, if different from that in **A.9**, shall be agreed between purchaser and manufacturer, as shall also the permissible deviations in analyses, taking into account the heterogeneity of the product (see also **A.11**).

### **A.11 Product analysis dispute**

In case of dispute, product analyses shall be carried out in accordance with the methods in the relevant European Standards listed in CR 10261.

### **A.12 Impact testing at temperatures below room temperature**

For impact testing specified below room temperature (see clause 10), the actual temperatures of testing and the values to be obtained shall be agreed at the time of enquiry and order. The Charpy V-notch impact tests shall be carried out in accordance with the requirements of EN 10045-1.

### **A.13 Charpy U-notch impact tests**

For austenitic stainless steels, Charpy U-notch impact tests are to be carried out in accordance with EN 10045-1. The required levels shall be specified at the time of enquiry and order.

### **A.14 Intergranular corrosion test**

An intergranular corrosion bend test shall be carried out as specified in ISO 3651-2 (unless otherwise specified in the order). One test shall be made on each cast or heat treatment batch on the forging having the largest equivalent thickness in the batch.

### **A.15 Marking by use of paint**

Where stamping is not permissible, marking shall be by use of a permanent paint, neutral with regard to the steel to which it is applied. Any restriction regarding the composition shall be specified by the purchaser at the time of enquiry and order.

NOTE In the choice of paints, legal requirements of CEC or national countries should be taken into account.

## **Annex B (informative)**

### **Ruling section and equivalent thickness**

#### **B.1 General**

This annex covers definitions for the terms “ruling section”, “thickness of ruling section ( $t_R$ )” and “equivalent thickness ( $t_{eq}$ )” and methods for the determination of  $t_{eq}$ .

#### **B.2 Definitions**

##### **B.2.1 Ruling section**

That section for which the mechanical properties are specified.

##### **B.2.2 Thickness of ruling section ( $t_R$ )**

That thickness of a rectangular cross section with a width to thickness of  $\geq 2$  and a length to thickness ratio of  $\geq 4$ , these two values to be used together.

##### **B.2.3 Equivalent thickness ( $t_{eq}$ )**

That thickness of a section of a shape X for which the same properties as for the thickness  $t_R$  of the ruling section can be expected when the same heat treatment, sampling and testing conditions are applied.

#### **B.3 Determination of the equivalent thickness**

##### **B.3.1 Normalized and normalized and tempered condition**

In the normalized and tempered condition, the equivalent thickness ( $t_{eq}$ ) will be equal to the thickness of the ruling section ( $t_R$ ).

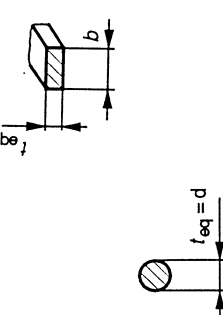
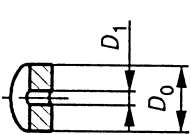
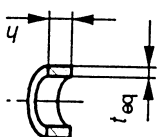
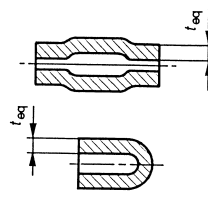
##### **B.3.2 Quenched and tempered condition**

Thicknesses equivalent to the thickness given in the tables for the mechanical properties of parts 2 and 3 of this European Standard for forgings in the quenched and tempered condition shall, unless otherwise agreed at the time of enquiry and order, be read off from Table B.1 (see **B.3.3**).

##### **B.3.3 Complex forgings in the quenched and tempered conditions**

If for the shape of the section of the ordered product no equivalent thicknesses are given in Table B.1, the thickness range of Table 1, parts 2 or 3 of this European Standard which is applicable for the relevant section, shall be agreed at the time of enquiry and order (see also **5.1b**).

**Table B.1 Equivalent thickness for sections of shapes different from the ruling sections<sup>1)</sup>**

Thickness of the ruling section <sup>1)</sup>		Equivalent thickness $t_{eq}$ in mm for					Cylindrical hollow section both ends open		Cylindrical hollow section one end/both ends closed		Other sections
$t_R$		Bars with round/rectangular cross section	Discs	Rings	Cylindrical hollow section both ends open		Cylindrical hollow section one end/both ends closed		Other sections		
$\frac{b}{t_R} \geq 2, \frac{l}{t_R} \geq 4$	mm				$D_0 - D_1 \geq 2 t_{eq}$ $D_1 \leq 200 \text{ mm}$ $t_{eq} = t_R$	$h > t_{eq}$ $D_1 > 200 \text{ mm}$ $t_{eq} = t_R$	$D_1 > 200 \text{ mm}$ $t_{eq} = t_R$	$80 \leq D_1 \leq 200 \text{ mm}$ $t_{eq} \sim 0,85$	$D_1 < 80 \text{ mm}$ $t_{eq} \sim 0,75 t_R$		By agreement (see B.3.2)
16	35	25	16	16	16	16	15	12	10		
50	40	35	35	35	35	35	30	25	20		
75	60	50	50	50	50	50	40	35	30		
100	80	70	70	70	70	70	55	50	40		
150	120	100	100	100	100	100	85	75	60		
200	160	130	130	130	130	130	115	100	80		
250	200	160	160	160	160	160	140	125	100		
300	250	200	200	200	200	200	170	150	120		
375	300	250	250	250	250	250	210	180	150		
500	400	330	330	330	330	330	280	250	200		
600	480	400	400	400	400	400	340	300	240		
750	600	500	500	500	500	500	425	375	300		

<sup>1)</sup> Indicated are the thickness values given in the tables for the mechanical properties in EN 10250-2 and EN 10250-3 for the ruling section, i.e. rectangular cross-section with a width to thickness ratio of  $\geq 2$  and a length to thickness ratio of  $\geq 4$ , these two values to be used together.

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