



SLOVENSKI STANDARD
oSIST prEN IEC 60676:2023
01-junij-2023

Oprema za industrijsko električno ogrevanje - Preskusne metode za peči z odkritim oblokom

Industrial electroheating equipment - Test methods for direct arc furnaces

Industrielle Elektrowärmeanlagen - Prüfverfahren für Lichtbogen-Schmelzöfen

Chauffage électrique industriel - Méthodes d'essai des fours à arc direct

Ta slovenski standard je istoveten z: prEN IEC 60676:2023

ICS:

25.180.10 Električne peči Electric furnaces

oSIST prEN IEC 60676:2023 **en**



27/1163/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

PROJECT NUMBER:

IEC 60676 ED4

DATE OF CIRCULATION:

2023-04-28

CLOSING DATE FOR VOTING:

2023-07-21

SUPERSEDES DOCUMENTS:

27/1152/CD, 27/1160/CC

IEC TC 27 : INDUSTRIAL ELECTROHEATING AND ELECTROMAGNETIC PROCESSING	
SECRETARIAT: Poland	SECRETARY: Mrs Mariola Nowecka
OF INTEREST TO THE FOLLOWING COMMITTEES:	PROPOSED HORIZONTAL STANDARD: <input type="checkbox"/> Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.
FUNCTIONS CONCERNED: <input type="checkbox"/> EMC <input type="checkbox"/> ENVIRONMENT <input type="checkbox"/> QUALITY ASSURANCE <input type="checkbox"/> SAFETY	
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TITLE:

Industrial electroheating equipment - Test methods for direct arc furnaces

PROPOSED STABILITY DATE: 2029

NOTE FROM TC/SC OFFICERS:

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87 INTERNATIONAL ELECTROTECHNICAL COMMISSION

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**INDUSTRIAL ELECTROHEATING EQUIPMENT –
TEST METHODS FOR DIRECT ARC FURNACES****FOREWORD**

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125 International Standard IEC 60676 has been prepared by IEC technical committee 27: Industrial
126 electroheating.

127 This fourth edition cancels and replaces the third edition published in 2011. It constitutes a
128 technical edition.

129 Significant technical changes with respect to the previous edition are as follows:

130 – The structure has been redrafted according to IEC 60398: 2015

131 – The scope has been redrafted

132 – The terms/definitions, normative references and bibliography have been updated and
133 completed

134 – The test methods and content from IEC 60398:2015 have been confirmed, replaced, or
135 complimented with regards to direct arc furnaces (EAF, LF)

136 – The annexes from IEC 60398:2015 have been confirmed, replaced, or complimented with
137 regards to direct arc furnaces (EAF, LF).

138 The text of this standard is based on the following documents:

FDIS	Report on voting
27/xxx/FDIS	27/xxx/RVD

139

140 Full information on the voting for the approval of this standard can be found in the report on
141 voting indicated in the above table.

142 This standard is to be read in conjunction with IEC 60398:2015. It supplements or replaces the
143 corresponding clauses of IEC 60398:2015. Where the text indicates a “modification” of,
144 “addition” to or a “replacement” of the relevant provision of IEC 60398:2015, these changes are
145 made to the relevant text of IEC 60398:2015. Where no change is necessary, the words “This
146 clause of IEC 60398:2015 is applicable” are used. When a particular subclause of IEC
147 60398:2015 is not mentioned in this standard, that subclause applies as far as it is reasonable.
148 When a particular subclause of IEC 60398:2015 is not applicable, the word “Void” is used.

149 This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

150 The committee has decided that the contents of this publication will remain unchanged until the
151 stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to
152 the specific publication. At this date, the publication will be

- 153 • reconfirmed,
- 154 • withdrawn,
- 155 • replaced by a revised edition, or
- 156 • amended.

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INDUSTRIAL ELECTROHEATING EQUIPMENT – TEST METHODS FOR DIRECT ARC FURNACES

INTRODUCTION

Direct electrical arc furnaces are very important applications for steel scrap melting, melting of direct reduced iron (DRI), hot bricked iron (HBI) or hot metal. While ladle furnaces are mainly used for providing the required quality and final adjustment of temperature of molten steel before send to casting machine or to vacuum treatment stations.

The manufacturer of the installation or equipment usually needs to fulfil the following requirements, which come from different sources and are quite often in this order of priorities:

- a) to enable the intended process and make the installation to work properly
- b) to be cost effective during design and manufacturing
- c) to ensure that the equipment is safe to use in the sense of providing freedom from unacceptable risk of physical injury or damage to the health of the operator (safety in the narrower sense of ISO 12100:2010)
- d) to prove that the equipment is cost effective to operate and uses sufficiently small amounts of energy, material and other resources
- e) to ensure that the equipment is safe to use in the sense of providing freedom from unacceptable risk or physical injury or damage to the health of people, or damage to property or the environment (adding other safety aims to c) and in the much broader definition of safety according to ISO/IEC Guide 51)

It is usually part of the proprietary knowledge of the manufacturer or user of the equipment, to make it cost effective or enabling intended processes with a benefit. IEC 60519-1 and IEC 60519-4 assists with achieving safety in the ISO 12100:2010 sense. The focus of this standard is on basic requirements for measuring instrumentation and test methods concerned with energy and resource efficiency, performance of the intended process and assessing cost of ownership for installations and equipment.

This document presumes that the installation or equipment is operated and maintained only by personnel consisting of skilled or instructed persons.

1 Scope

This clause of IEC 60398 is replaced by the following.

Replacement:

This document specifies the basic test procedures, conditions and methods for establishing the main performance parameters and the main operational characteristics of furnaces for direct arc heating, forming arcs between the **electrode** and metal such as the electric arc furnace using alternating current (**EAF AC**) or direct current (**EAF DC**), and ladle furnace (LF).

Measurements and tests that are solely used for the verification of safety requirements of equipment for direct electrical arc furnaces are outside the scope of this document and are covered by IEC 60519-1, IEC 60519-4 and ISO 13578.

This document is applicable for the commissioning, verification of design improvements or for energy related tasks with respect to energy use or energy efficiency, establishing of an energy baseline, and labelling. Some concepts from this document can directly be used as key performance indicators.

Detailed tests for specific types of electric arc furnace equipment and installations are beyond the scope of this document. This document is intended as general reference for all future test standards applicable to particular electric arc furnace equipment or installations.

204 This document includes the concept and material presented in IEC 60398 on energy efficiency
205 dealing with the electrical and processing parts of the equipment, as well as the overall
206 performance.

207 Test methods for some special equipment, e.g., controlled **rectifiers**, are covered by
208 IEC 60146-1-1 and **furnace transformers** are covered by IEC 60076 series.

209 Test methods for submerged arc furnaces (SAF) are covered by IEC 60683.

210 **2 Normative references**

211 This clause of IEC 60398 is replaced by the following.

212 *Replacement:*

213 The following referenced documents are indispensable for the application of this document. For
214 dated references, only the edition cited applies. For undated references, the latest edition of
215 the referenced document (including any amendments) applies.

216 IEC 60398:2015, *Industrial electroheating installations – General test methods*

217 IEC 60519-1, *Safety in electroheating installations – Part 1: General requirements*

218 IEC 60519-4, *Safety in electroheating installations – Part 4: Particular requirements for arc
219 furnace installations*

220 ISO 13578, *Industrial furnaces, and associated processing equipment: Safety requirements for
221 machinery and equipment for production of steel by electric arc furnaces*

222 **3 Terms and definitions and abbreviated terms**

223 **3.1 Terms and definitions**

224 For the purposes of this document the terms and definitions given in IEC 60398:2015 and the
225 following apply.

226 NOTE 1 Refer to International Electrotechnical Vocabulary, IEC 60050, for general definitions. Terms relating to
227 industrial electro heat are defined in IEC 60050-841.

228 NOTE 2 The terms and definitions refer to EAF and/or LF where applicable.

229 **3.1.101**

230 **active power**

231 ***P***

232 under periodic conditions, mean value, taken over one period *T* of the instantaneous power *p*

$$233 \quad P = \frac{1}{T} \int_0^T p \, dt$$

234 Note 1 to entry: Under sinusoidal conditions, the active power is the real part of the complex power \underline{S} ,
235 thus $P = \text{Re}(\underline{S})$.

236 Note 2 to entry: The coherent SI unit for active power is Watt, W.

237 [SOURCE: IEC 60050-131:2002, 131-11-42]

238 **3.1.102**

239 **apparent power**

240 ***S***

241 power rating of the **furnace transformer**, energizing the EAF or LF (in MVA)

$$242 \quad S = \sqrt{3} UI \quad (\text{for three-phase system})$$

243 where

U is the voltage, r.m.s., sinusoidal value [in kV]

I is the current, r.m.s. sinusoidal value [in kA]

244 [SOURCE: IEC 60050-131:2002, 131-11-41, modified – more precise]

245 **3.1.103**

246 **arc furnace**

247 furnace with a vessel, in which metal or other charged conducting material is heated mainly by
248 electric arc or joule effect using alternating current (AC) or direct current (DC)

249 [SOURCE: IEC 60050-841:2004, 841-26-05, modified – more precise]

250 **3.1.104**

251 **arcing time**

252 actual current flow time during power-on time (in min).

253 Note 1 to entry: Arcing time represents a high percentage of power on time

254 **3.1.105**

255 **asymmetry factor**

256 K

257 difference between maximum and minimum impedance of any phase, divided by the mean
258 impedance of all three phases (in %)

259 Note 1 to entry: Not applicable for **EAF DC**.

260 Note 2 to entry: The reactance's are decisive for the unsymmetry for **EAF AC**

261 **3.1.106**

262 **furnace transformer**

263 transformer changing high voltage electrical supply to a lower voltage and higher current
264 for an arc furnace process

265 [SOURCE: IEC 60050-841:2004, 841-26-55, modified – more precise]

266 **3.1.107**

267 **capacity (of EAF)**

268 volume of liquid material, which can be produced in the EAF during one heat (in t)⁶⁻

269 Note 1 to entry: Whether metric or short tons according to pre-requisites.

270 [SOURCE: IEC 60050-841:2004, 841-21-40, modified – more precise]

271 **3.1.108**

272 **cold state (of EAF)**

273 thermal state of EAF installation when the temperature of all parts equals the ambient
274 temperature

275 **3.1.109**

276 **clean bus**

277 high voltage bus system which supplies the auxiliary equipment (e.g., motor control center,
278 control system) where the network distortions are considered to be lower than in the dirty bus
279 system

280 **3.1.110**

281 **DC reactor (smoothing choke)**

282 inductor smoothing electrical high frequency fluctuations in **EAF DC**, due to changes in arc
283 conditions

284 Note 1 to entry: In case multiple **rectifiers** are coupled in the system, inductors can decrease the fluctuations as
285 well.

286 **3.1.111**

287 **dirty bus**

288 high voltage bus system which supplies the **furnace transformer** and contains the network
289 distortions from the process (e.g., flicker, harmonics)

290 Note 1 to entry: Distortion values on the dirty bus can exceed the limits of power quality of the grid.

- 291 **3.1.112**
292 **disconnector**
293 **grounding switch**
294 motor operated non load switch providing visible safety distance and connection to ground
295 installed between the furnace switchgear and the furnace transformer
- 296 **3.1.113**
297 **electric arc furnace using alternating current EAF AC**
298 furnace, in which electric arcs between the electrodes and conducting material are formed,
299 using alternating current
300 [SOURCE: IEC 60050-841:2004, 841-26-07 modified – more precise]
- 301 **3.1.114**
302 **electric arc furnace using direct current EAF DC**
303 furnace, in which the direct current is conducted via bottom electrode(s) (anode) to the
304 material to be processed, forming arcs between the material and the electrode(s) from top
305 (cathode)
306 [SOURCE: IEC 60050-841:2004, 841-26-06, modified – more precise]
- 307 **3.1.115**
308 **electrode (EAF)**
309 part produced from high density graphite to transfer the electrical energy forming arcs between
310 tip and charge material
311 Note 1 to entry: *In EAF DC, a bottom electrode (anode) is metallic or conductive material in the bottom of an EAF*
312 *and arcs are formed between the charge material and the graphite electrode from top (cathode).*
313 Note 2 to entry: *In EAF AC electrodes are typically named as electrode A, electrode B, electrode C or electrode 1,*
314 *electrode 2, electrode 3.*
315 [SOURCE: IEC 60050-841:2004, 841-26-38, modified – more precise]
- 316 **3.1.116**
317 **furnace shell**
318 vessel of **arc furnace** made from metal (currently: steel) and covered by a roof
319 [SOURCE: IEC 60050-841:2004, 841-26-20, modified – more precise]
- 320 **3.1.117**
321 **furnace switchgear**
322 high-voltage switchgear connecting the **furnace transformer** to the electrical supply providing
323 switching on/off under load
- 324 **3.1.118**
325 **heat melt**
326 liquid material which is tapped after one process batch from an EAF into a ladle
327 Note 1 to entry One heat produced during one process cycle.
- 328 **3.1.119**
329 **high current system**
330 assembly of conductors to carry the high current between **furnace transformer** secondary
331 bushings and **electrode(s)** of an EAF
332 Note 1 to entry: It consists of the bus bar system, cables and either a current tube system or current conducting
333 **electrode** arm to the electrodes.
334 [SOURCE: IEC 60050-841:2004, 841-26-54, modified – more precise]
- 335 **3.1.120**
336 **hot state (of EAF)**
337 thermal state of an EAF in which the lining temperature is above 600 °C and a steady-state
338 temperature of the components is reached