

# DIN EN 13445-6:2021-12 (E)

## Unfired pressure vessels - Part 6: Requirements for the design and fabrication of pressure vessels and pressure parts constructed from spheroidal graphite cast iron

| <b>Contents</b>         |  | <b>Page</b> |
|-------------------------|--|-------------|
| European foreword ..... |  | 5           |
| 1                       | Scope .....  | 6           |
| 2                       | Normative references .....                                 | 6           |
| 3                       | Terms, definitions units and symbols .....                 | 7           |
| 3.1                     | Terms and definitions .....                                | 7           |
| 3.2                     | Units .....  | 9           |
| 3.3                     | Symbols .....  | 9           |
| 3.4                     | Inter-relation of thicknesses definitions .....            | 11          |
| 4                       | Service conditions .....                                   | 11          |
| 4.1                     | Cyclic loading .....                                       | 11          |
| 4.2                     | Limitations on temperature and energy content .....        | 12          |
| 5                       | Requirements .....   | 12          |
| 5.1                     | Materials .....  | 12          |
| 5.2                     | Design .....   | 14          |
| 5.2.1                   | Technical documentation .....                              | 14          |
| 5.2.2                   | Design methods .....                                       | 14          |
| 5.3                     | Founding .....   | 21          |
| 5.3.1                   | General .....  | 21          |
| 5.3.2                   | Welding .....  | 21          |
| 6                       | Material testing .....                                     | 21          |
| 6.1                     | General .....  | 21          |
| 6.2                     | Frequency and number of tests .....                        | 21          |
| 6.3                     | Chemical analysis .....                                    | 22          |
| 6.4                     | Graphite structure .....                                   | 22          |
| 6.5                     | Inspection documents .....                                 | 22          |
| 7                       | Testing and final assessment .....                         | 22          |
| 7.1                     | Testing .....  | 22          |
| 7.1.1                   | General .....  | 22          |
| 7.1.2                   | Testing requirements for CQ = 0,8 .....                    | 23          |
| 7.1.3                   | Testing requirements for CQ = 0,9 .....                    | 23          |
| 7.1.4                   | Surface imperfections .....                                | 24          |
| 7.1.5                   | Cracks, laps, cold shut and non-fused chaplets .....       | 24          |
| 7.1.6                   | Ultrasonic testing and/or sectioning .....                 | 24          |
| 7.1.7                   | Magnetic particle testing (only for ferritic grades) ..... | 24          |
| 7.1.8                   | Penetrant testing .....                                    | 25          |
| 7.1.9                   | Radiographic testing .....                                 | 25          |
| 7.1.10                  | Surface roughness .....                                    | 25          |
| 7.1.11                  | Minimum wall thickness .....                               | 25          |
| 7.1.12                  | Wall thickness tolerances .....                            | 25          |
| 7.1.13                  | Other dimensions .....                                     | 25          |
| 7.1.14                  | Qualification of testing personnel .....                   | 26          |
| 7.2                     | Final assessment .....                                     | 26          |
| 7.2.1                   | General .....  | 26          |
| 7.2.2                   | Hydraulic test pressure .....                              | 26          |

|       |  |    |
|-------|--|----|
| 8     | Pressure vessels constructed of a combination of parts in different materials .....                            | 26 |
| 9     | Marking and documentation .....  | 26 |
| 9.1   | Marking of castings .....  | 26 |
| 9.2   | Name plate for the complete pressure vessel .....  | 27 |
| 9.3   | Documentation .....  | 27 |
|       | (normative) Technical data for the design calculations .....   | 28 |
| A.1   | Purpose .....  | 28 |
| A.2   | Technical data .....   | 28 |
| A.2.1 | Ferritic spheroidal graphite cast iron according to EN 1563:2018 .....   | 28 |
| A.2.2 | Austenitic spheroidal graphite cast iron according to EN 13835:2012 .....                                      | 29 |
|       | (informative) Ductility .....  | 30 |
|       | (informative) Determination of the minimum local wall thickness and minimum required burst test pressure ..... | 32 |
|       | (normative) Assessment of fatigue life .....   | 34 |
| D.1   | Purpose .....  | 34 |
| D.2   | Specific definitions .....   | 34 |
| D.3   | Specific symbols and abbreviations .....   | 34 |
| D.4   | Limitations .....  | 35 |
| D.5   | General .....  | 35 |
| D.6   | Simplified fatigue assessment .....  | 35 |
| D.6.1 | Pseudo-elastic stress range .....  | 35 |
| D.6.2 | Correction factors .....   | 36 |
| D.6.3 | Fatigue design curves .....  | 37 |
| D.6.4 | Allowable number of cycles .....   | 43 |
| D.6.5 | Allowable stress range .....   | 43 |
| D.7   | Detailed fatigue assessment .....  | 43 |
| D.7.1 | Pseudo-elastic stress ranges .....   | 43 |
| D.7.2 | Corrections to stress range .....  | 44 |
| D.7.3 | Fatigue design curves .....  | 45 |
| D.7.4 | Allowable number of cycles .....   | 46 |
| D.7.5 | Allowable stress range .....   | 47 |
| D.8   | Assessment rule for total fatigue damage .....   | 47 |
| D.9   | Repairs of surface imperfections .....   | 47 |
|       | (normative) Design by analysis for castings .....  | 48 |
| E.1   | Introduction .....   | 48 |
| E.2   | Special requirements to EN 13445-3:2021, Annex B .....   | 48 |
| E.2.1 | Addition to B.8.2.3: Design checks for normal operating load cases .....                                       | 48 |
| E.2.2 | Addition to B.8.2.4: Design checks for testing load cases .....  | 48 |
| E.3   | Additions to EN 13445-3:2021, Annex C .....  | 48 |
| E.4   | Requirements .....   | 49 |
|       | (informative) Recommendations for in-service validation and inspection .....                                   | 50 |
| F.1   | Purpose .....  | 50 |
| F.2   | Tests during operation .....   | 50 |
| F.3   | Measures to be taken when the calculated allowable fatigue lifetime has been reached.51                        |    |
|       | F.3.1 General .....  | 51 |
| F.3.2 | Testing of vessels and pressure parts at end of life without indicated damages .....                           | 51 |
| F.3.3 | Hydraulic testing of vessels and vessel parts with indicated damages .....                                     | 51 |
|       | (normative) Specific design requirements .....   | 52 |

|   |           |
|---|-----------|
| <b>Issue 1 (2021-05) G.1 Scope .....</b>  | <b>52</b> |
| <b>G.2 Design .....</b>   | <b>52</b> |
| <b>G.2.1 General .....</b>  | <b>52</b> |
| <b>G.2.2 Cover crown thickness, pressure to convex side .....</b>   | <b>53</b> |
| <b>G.2.3 Cover crown thickness, pressure to concave side .....</b>  | <b>53</b> |
| <b>G.2.4 Flange thickness .....</b>   | <b>53</b> |
| <b>(normative) Experimental cyclic pressure testing procedure .....</b>   | <b>54</b> |
| <b>H.1 Purpose .....</b>  | <b>54</b> |
| <b>H.1.1 General .....</b>  | <b>54</b> |
| <b>H.1.2 Experimental methods and other design methods .....</b>  | <b>54</b> |
| <b>H.2 Validity .....</b>   | <b>54</b> |
| <b>H.3 Tests requirements .....</b>   | <b>54</b> |
| <b>H.3.1 General .....</b>  | <b>54</b> |
| <b>H.3.2 Number of parts .....</b>  | <b>54</b> |
| <b>H.3.3 Procedure .....</b>  | <b>55</b> |
| <b>H.3.4 Material tests .....</b>   | <b>57</b> |
| <b>H.4 Allowable number of cycles .....</b>   | <b>57</b> |
| <b>Annex ZA (informative) Relationship between this European Standard and the essential requirements of Directive 2014/68/EU (Pressure equipment Directive) aimed to be covered .....</b> | <b>61</b> |
| <b>Bibliography .....</b>   | <b>63</b> |