

# ISO 24251-1:2025-08 (E)

## Prevention of hydrogen assisted brittle fracture of high-strength steel components - Part 1: Fundamentals and measures

---

| <b>Contents</b>   |   | <b>Page</b> |
|---|---|-------------|
| Foreword .....  |   | iv          |
| Introduction .....  |   | v           |
| 1   | Scope .....   | 1           |
| 2   | Normative references .....  | 1           |
| 3   | Terms and definitions .....   | 1           |
| 4   | Abbreviated terms .....   | 4           |
| 5   | Fundamentals .....  | 5           |
| 5.1   | General description of hydrogen embrittlement .....                             | 5           |
| 5.2   | Conditions for hydrogen embrittlement failure .....                             | 5           |
| 5.2.1   | General .....   | 5           |
| 5.2.2   | Material susceptibility .....   | 6           |
| 5.2.3   | Tensile stress .....  | 7           |
| 5.2.4   | Sources of atomic hydrogen .....  | 7           |
| 5.3   | Mechanism of hydrogen embrittlement of high strength steel .....                | 8           |
| 5.4   | Fundamentals of metallic coatings regarding hydrogen uptake and diffusion ..... | 9           |
| 5.4.1   | General aspects of metallic electroplated protection layers .....               | 9           |
| 5.4.2   | Hydrogen generation during coating process .....                                | 9           |
| 5.4.3   | Corrosion protection mechanisms by metallic layers .....                        | 9           |
| 6   | Preventive measures with regard to hydrogen embrittlement .....                 | 12          |
| 6.1   | General .....   | 12          |
| 6.2   | Part design and manufacturing .....   | 13          |
| 6.3   | Material related measures and heat treatment .....                              | 13          |
| 6.4   | Reduction of residual tensile stress (stress relief) .....                      | 14          |
| 6.5   | Measures related to coating processes .....                                     | 14          |
| 6.5.1   | General .....   | 14          |
| 6.5.2   | Pre-treatment -- Cleaning processes .....                                       | 15          |
| 6.5.3   | Electroplating coating processes .....  | 15          |
| 6.5.4   | Stripping of coatings .....   | 15          |
| 6.5.5   | Corrective actions - Baking .....   | 16          |
| 6.6   | Prevention of environmental hydrogen uptake .....                               | 17          |
| 6.6.1   | General .....   | 17          |
| 6.6.2   | Environmentally appropriate design .....  | 17          |
| Annex A (informative) Electroplating processes .....                |   | 18          |
| Annex B (informative) Principles of electrochemical corrosion ..... |   | 20          |
| Bibliography .....  |   | 23          |