

# ISO/TR 9839:2023-08 (E)

## Road vehicles - Application of predictive maintenance to hardware with ISO 26262-5

---

<b>Contents</b>		<b>Page</b>
Foreword .....		iv
Introduction .....		v
<b>1</b>	<b>Scope .....</b>	<b>1</b>
<b>2</b>	<b>Normative references .....</b>	<b>1</b>
<b>3</b>	<b>Terms and definitions .....</b>	<b>1</b>
<b>4</b>	<b>Abbreviated terms .....</b>	<b>2</b>
<b>5</b>	<b>Literature survey of degrading faults .....</b>	<b>4</b>
5.1	General .....	4
5.2	Degrading faults in industry standards .....	4
5.2.1	JEDEC JEP122H[4] .....	4
5.3	Degrading faults in technical publications .....	5
5.3.1	Advanced CMOS Reliability Update: Sub 20 nm FinFET Assessment[5] .....	5
5.3.2	Circuit-Based Reliability Consideration in FinFET Technology[6] .....	6
5.3.3	Intermittent Faults and Effects on Reliability of Integrated Circuits[7] .....	6
<b>6</b>	<b>Literature survey on predictive maintenance .....</b>	<b>6</b>
6.1	General .....	6
6.2	Predictive maintenance in industry standards .....	6
6.2.1	IEC 61508[9] .....	6
6.2.2	IEEE Std 1856[3] .....	6
6.3	Predictive maintenance in technical publications .....	7
6.3.1	A Survey of Online Failure Prediction Methods[10] .....	7
6.3.2	An Odometer for CPUs[11] .....	7
6.3.3	Circuit Failure Prediction for Robust System Design in Scaled CMOS [12] .....	8
6.3.4	A Circuit Failure Prediction Mechanism (DART) for High Field Reliability [13] .....	8
6.3.5	Predicting Remediations for Hardware Failures in Large-Scale Datacenters[14] .....	8
6.3.6	Improving Analog Functional Safety Using Data-Driven Anomaly Detection [15] .....	8
<b>7</b>	<b>Degrading faults and the ISO 26262 series .....</b>	<b>8</b>
7.1	Understanding the lifecycle of degrading faults .....	8
7.2	Classification of degrading faults .....	12
7.3	Quantifying degrading fault base failure rate .....	12
7.3.1	Industry standards and models .....	12
7.3.2	Field data .....	13
7.3.3	Expert judgement .....	13
<b>8</b>	<b>Applying predictive maintenance .....</b>	<b>13</b>
8.1	Diagnostic coverage (DC) evaluation for predictive mechanisms .....	13
8.2	Considering random hardware metrics .....	13
8.2.1	Impacting the SPFM and LFM .....	13
8.2.2	Application as a dedicated measure .....	14
8.3	Considering RUL prediction .....	14
<b>Annex A (informative)</b>	<b>An approach to handling degrading faults .....</b>	<b>16</b>
<b>Bibliography</b> .....		<b>18</b>