Comparison of S-N curves in seawater with cathodic protection between ISO 19902:2007 and DNV-RP-C203:2011,2019 standards

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February 17, 2021

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Revision history

Feb 17, 2021 A practical stress range is set.[1] Figures (and code) updated to reflect.

Jan 31, 2021 First release.

[1] In other words, $\sigma > 10^3$ MPa is not relevant for structural steel whose yield strength is less than 10^3 MPa.

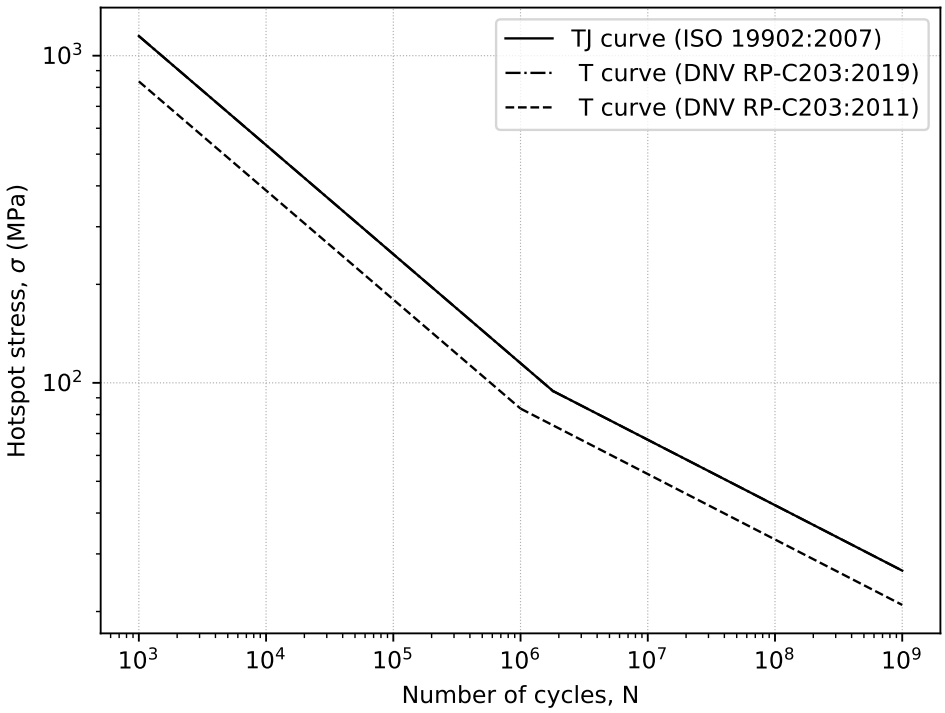

Figure 1: T curves

Note: The T-curve in DNV RP-C203:2019 (amended 2020) is identical to that of ISO 19902:2007.

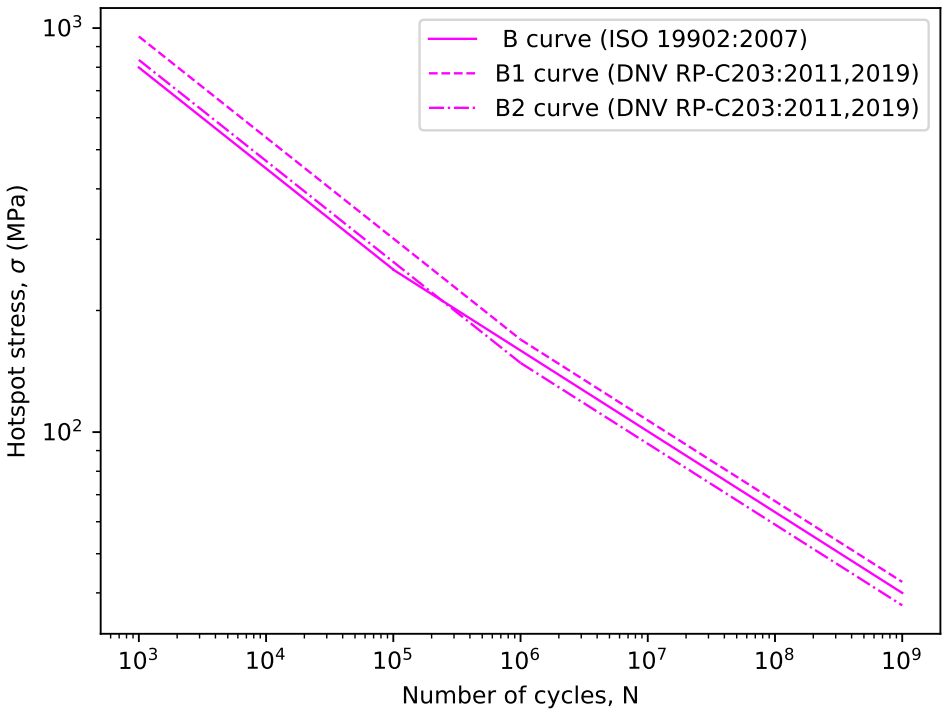

Figure 2: B curves

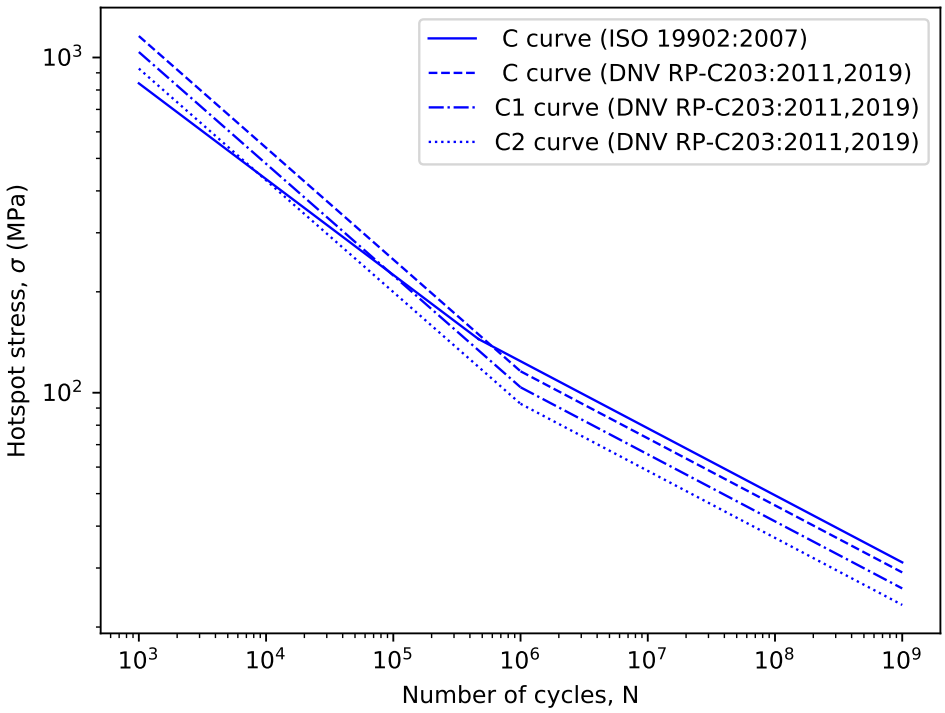

Figure 3: C curves

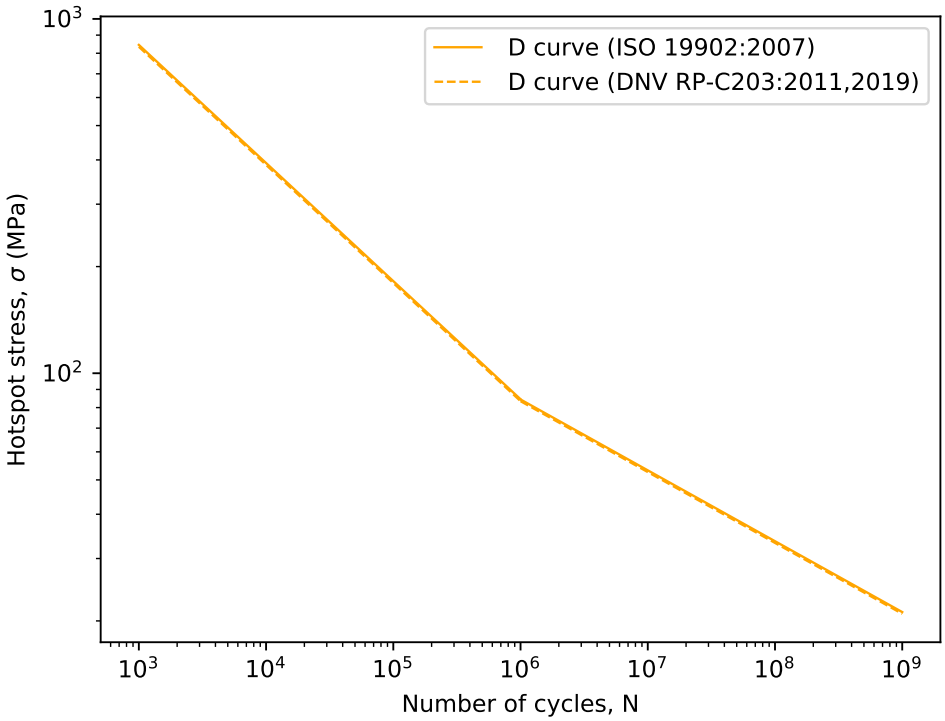

Figure 4: D curves

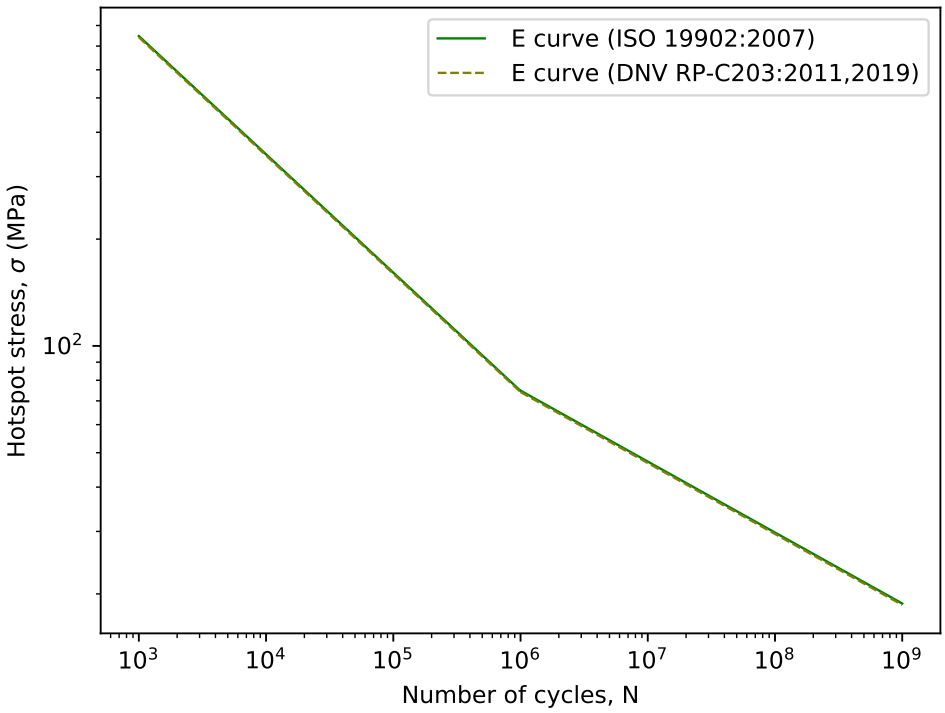

Figure 5: E curves

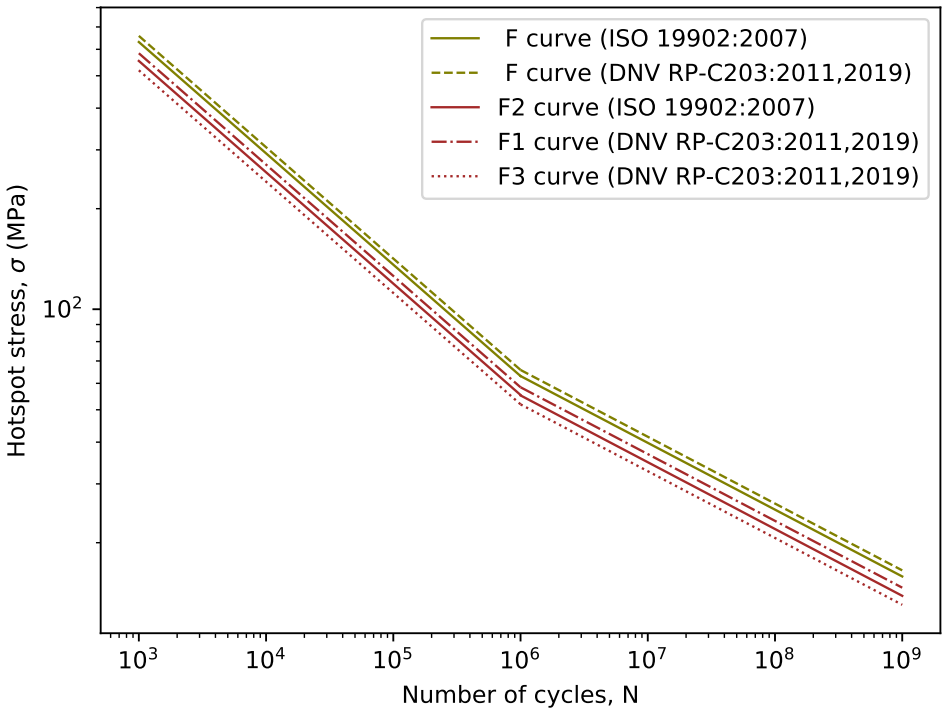

Figure 6: F curves

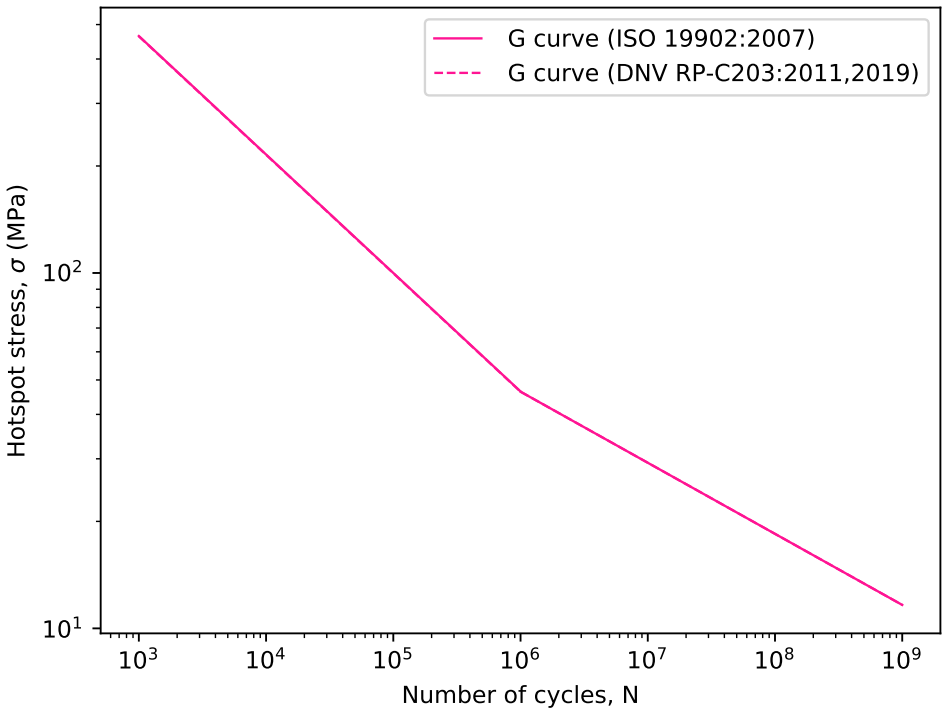

Figure 7: G curves

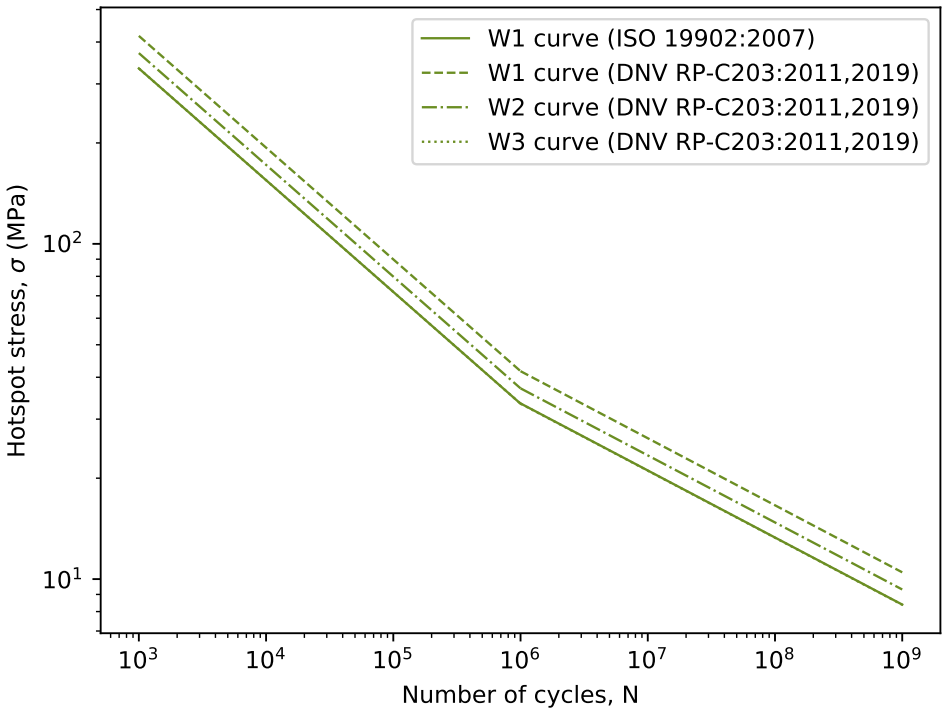

Figure 8: W curves

Appendix

A Plot code

```python
#!/usr/bin/env python
# encoding: utf-8
"""
sncurves.py -- 2016-21 ckunte

May 7: Initial commit.
Apr 29, 2020: Code simplified
Dec 27, 2020: basex is now base (since matplotlib V3.3)
Jan 30, 2021: DNV RP-C203:2011,2019 curves added
Feb 17, 2021: A practical S-N range is set for structural steel
"""
import numpy as np
import matplotlib.pyplot as plt


def style():
    plt.rcParams["grid.linestyle"] = ":"
    plt.rcParams["grid.linewidth"] = 0.5
    plt.grid(True)


def lbls():
    plt.legend(loc=0)
    plt.xlabel("Number of cycles, N")
    plt.ylabel("Hotspot stress, $\sigma$ (MPa)")
    pass


def sncurve(
    curve, r_start, r_mid, r_end, a1, m1, a2, m2, graphcolor, lsty
):
    # For slope 1 (m1)
    n = np.arange(r_start, r_mid, 1.0e3)
    s = (n / 10 ** a1) ** (-1 / m1)
    plt.loglog(
        n,
        s,
        base=10,
        color=graphcolor,
        ls=lsty,
        linewidth=1.0,
        label=curve,
    )
    # For slope 2 (m2)
    n = np.arange(r_mid, r_end, 1.0e3)
    s = (n / 10 ** a2) ** (-1 / m2)
    plt.loglog(n, s, base=10, color=graphcolor, ls=lsty, linewidth=1.0)
    pass


def main():
    # Plot all
    style()
    # TJ curve(s)
    sncurve(
        "TJ curve (ISO 19902:2007)",
        1.00e3,
        1.80e6,
```

```
        1.00e9,
        12.18,
        3.0,
        16.13,
        5.0,
        "black",
        "-",
    )
    sncurve(
        " T curve (DNV RP-C203:2019)",
        1.00e3,
        1.80e6,
        1.00e9,
        12.18,
        3.0,
        16.13,
        5.0,
        "black",
        "-.",
    )
    sncurve(
        " T curve (DNV RP-C203:2011)",
        1.00e3,
        1.00e6,
        1.00e9,
        11.764,
        3.0,
        15.606,
        5.0,
        "black",
        "--",
    )
    lbls()
    plt.savefig("sncurves-tj.pdf")
    plt.close()
    # B curve(s)
    sncurve(
        " B curve (ISO 19902:2007)",
        1.00e3,
        1.00e5,
        1.00e9,
        14.61,
        4.0,
        17.01,
        5.0,
        "magenta",
        "-",
    )
    sncurve(
        "B1 curve (DNV RP-C203:2011,2019)",
        1.00e3,
        1.00e6,
        1.00e9,
        14.917,
        4.0,
        17.146,
        5.0,
        "magenta",
        "--",
    )
    sncurve(
        "B2 curve (DNV RP-C203:2011,2019)",
        1.00e3,
```

```
        1.00e6,
        1.00e9,
        14.685,
        4.0,
        16.856,
        5.0,
        "magenta",
        "-.",
    )
    lbls()
    plt.savefig("sncurves-b.pdf")
    plt.close()
    # C curve(s)
    sncurve(
        " C curve (ISO 19902:2007)",
        1.00e3,
        4.68e5,
        1.00e9,
        13.23,
        3.5,
        16.47,
        5.0,
        "blue",
        "-",
    )
    sncurve(
        " C curve (DNV RP-C203:2011,2019)",
        1.00e3,
        1.00e6,
        1.00e9,
        12.192,
        3.0,
        16.320,
        5.0,
        "blue",
        "--",
    )
    sncurve(
        "C1 curve (DNV RP-C203:2011,2019)",
        1.00e3,
        1.00e6,
        1.00e9,
        12.049,
        3.0,
        16.081,
        5.0,
        "blue",
        "-.",
    )
    sncurve(
        "C2 curve (DNV RP-C203:2011,2019)",
        1.00e3,
        1.00e6,
        1.00e9,
        11.901,
        3.0,
        15.835,
        5.0,
        "blue",
        ":",
    )
    lbls()
    plt.savefig("sncurves-c.pdf")
```

```
    plt.close()
    # D curve(s)
    sncurve(
        " D curve (ISO 19902:2007)",
        1.00e3,
        1.00e6,
        1.00e9,
        11.78,
        3.0,
        15.63,
        5.0,
        "orange",
        "-",
    )
    sncurve(
        " D curve (DNV RP-C203:2011,2019)",
        1.00e3,
        1.00e6,
        1.00e9,
        11.764,
        3.0,
        15.606,
        5.0,
        "orange",
        "--",
    )
    lbls()
    plt.savefig("sncurves-d.pdf")
    plt.close()
    # E curve(s)
    sncurve(
        " E curve (ISO 19902:2007)",
        1.00e3,
        1.00e6,
        1.00e9,
        11.62,
        3.0,
        15.37,
        5.0,
        "green",
        "-",
    )
    sncurve(
        " E curve (DNV RP-C203:2011,2019)",
        1.00e3,
        1.00e6,
        1.00e9,
        11.610,
        3.0,
        15.350,
        5.0,
        "olive",
        "--",
    )
    lbls()
    plt.savefig("sncurves-e.pdf")
    plt.close()
    # F curve(s)
    sncurve(
        " F curve (ISO 19902:2007)",
        1.00e3,
        1.00e6,
        1.00e9,
```

```
        11.40,
        3.0,
        15.00,
        5.0,
        "olive",
        "-",
    )
    sncurve(
        " F curve (DNV RP-C203:2011,2019)",
        1.00e3,
        1.00e6,
        1.00e9,
        11.455,
        3.0,
        15.091,
        5.0,
        "olive",
        "--",
    )
    sncurve(
        "F2 curve (ISO 19902:2007)",
        1.00e3,
        1.00e6,
        1.00e9,
        11.23,
        3.0,
        14.71,
        5.0,
        "brown",
        "-",
    )
    sncurve(
        "F1 curve (DNV RP-C203:2011,2019)",
        1.00e3,
        1.00e6,
        1.00e9,
        11.299,
        3.0,
        14.832,
        5.0,
        "brown",
        "-.",
    )
    sncurve(
        "F3 curve (DNV RP-C203:2011,2019)",
        1.00e3,
        1.00e6,
        1.00e9,
        11.146,
        3.0,
        14.576,
        5.0,
        "brown",
        ":",
    )
    lbls()
    plt.savefig("sncurves-f.pdf")
    plt.close()
    # G curve(s)
    sncurve(
        " G curve (ISO 19902:2007)",
        1.00e3,
        1.00e6,
```

```
        1.00e9,
        11.00,
        3.0,
        14.33,
        5.0,
        "deeppink",
        "-",
    )
    sncurve(
        " G curve (DNV RP-C203:2011,2019)",
        1.00e3,
        1.00e6,
        1.00e9,
        10.998,
        3.0,
        14.330,
        5.0,
        "deeppink",
        "--",
    )
    lbls()
    plt.savefig("sncurves-g.pdf")
    plt.close()
    # W curve(s)
    sncurve(
        "W1 curve (ISO 19902:2007)",
        1.00e3,
        1.00e6,
        1.00e9,
        10.57,
        3.0,
        13.62,
        5.0,
        "olivedrab",
        "-",
    )
    sncurve(
        "W1 curve (DNV RP-C203:2011,2019)",
        1.00e3,
        1.00e6,
        1.00e9,
        10.861,
        3.0,
        14.101,
        5.0,
        "olivedrab",
        "--",
    )
    sncurve(
        "W2 curve (DNV RP-C203:2011,2019)",
        1.00e3,
        1.00e6,
        1.00e9,
        10.707,
        3.0,
        13.845,
        5.0,
        "olivedrab",
        "-.",
    )
    sncurve(
        "W3 curve (DNV RP-C203:2011,2019)",
        1.00e3,
```

```
        1.00e6,
        1.00e9,
        10.570,
        3.0,
        13.617,
        5.0,
        "olivedrab",
        ":",
    )
    lbls()
    plt.savefig("sncurves-w.pdf")
    plt.close()
    pass


if __name__ == "__main__":
    main()
```