

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.

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

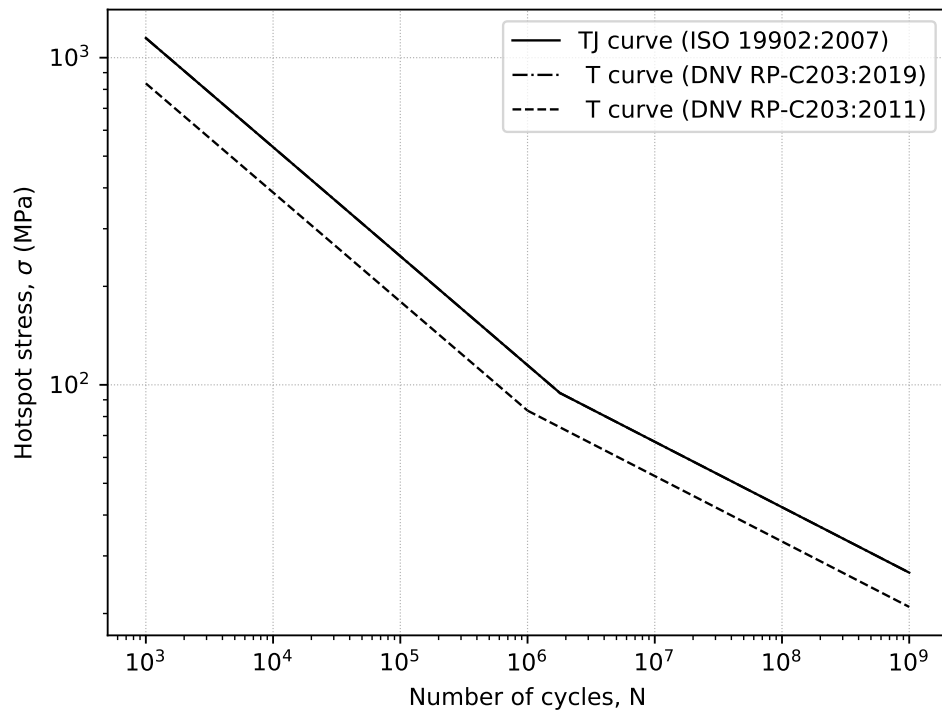


Figure 1: *T* curves

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

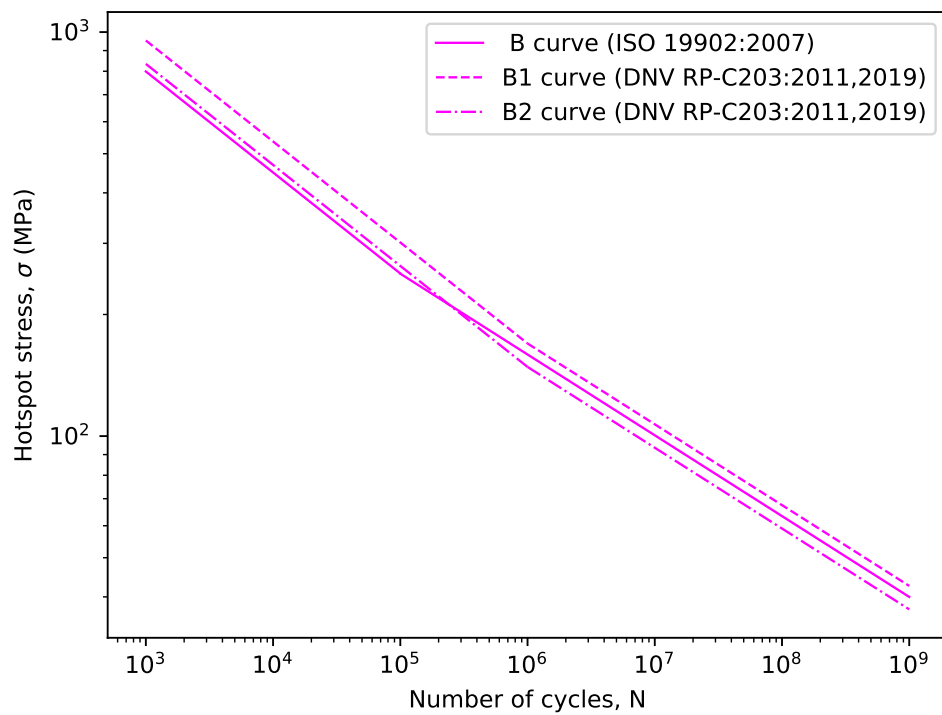


Figure 2: *B* curves

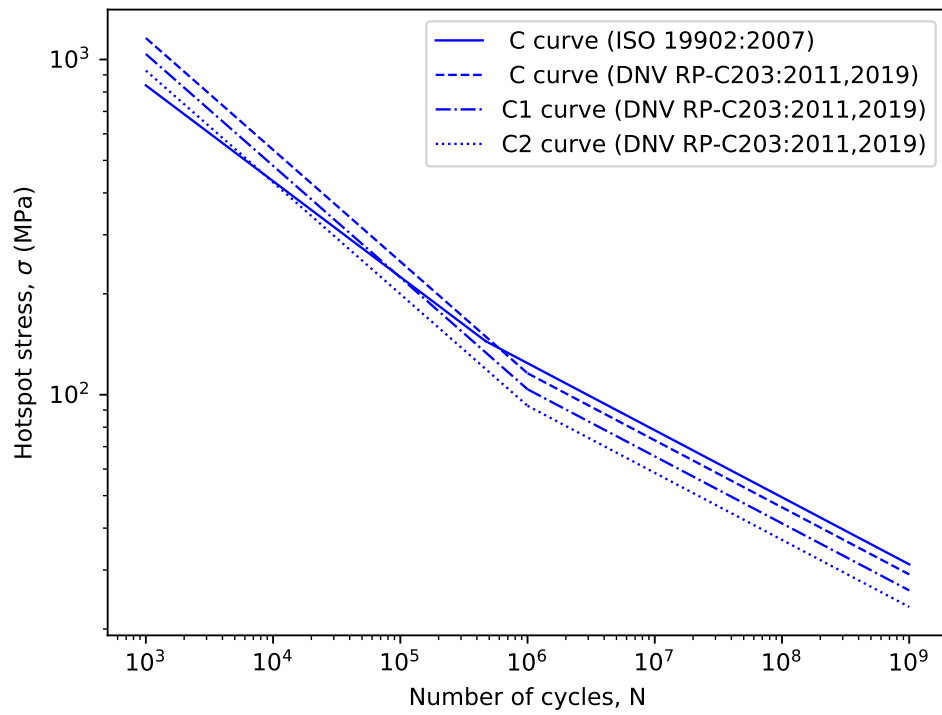


Figure 3: C curves

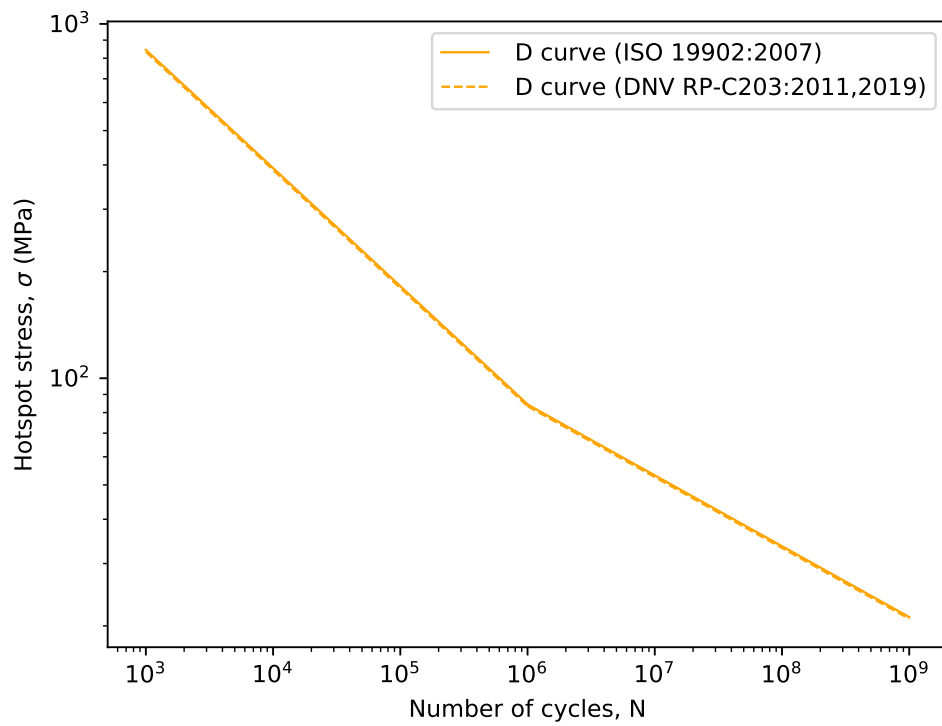


Figure 4: D curves

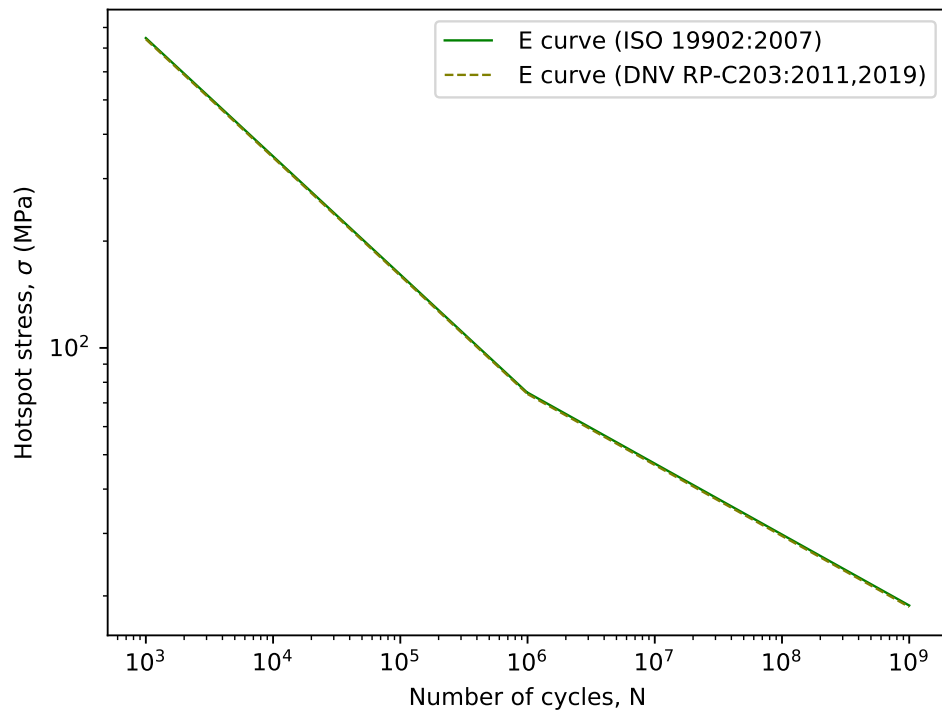


Figure 5: *E* curves

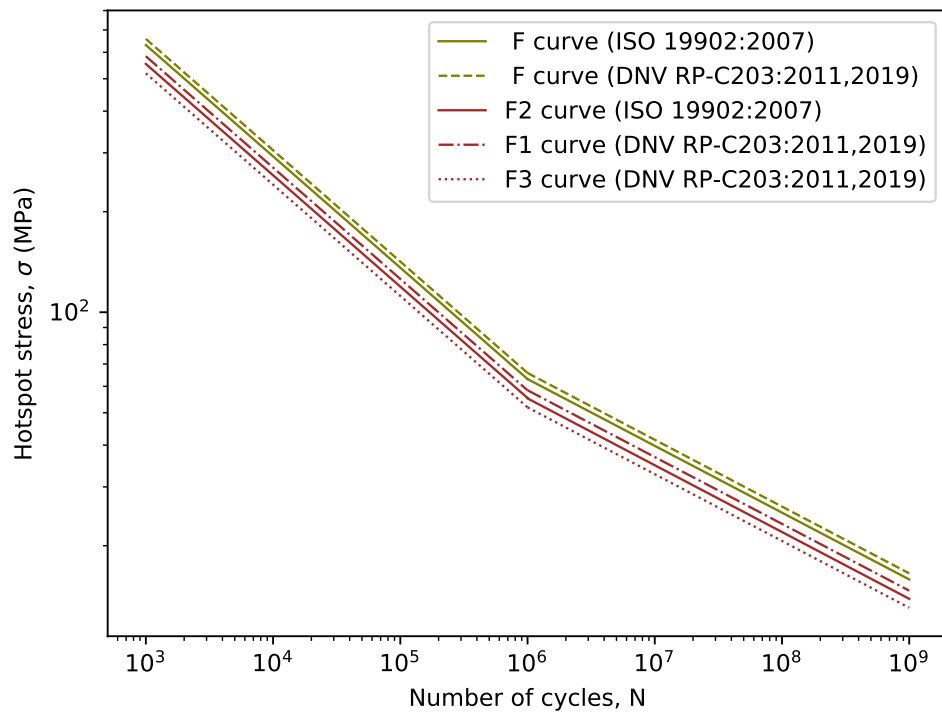


Figure 6: *F* curves

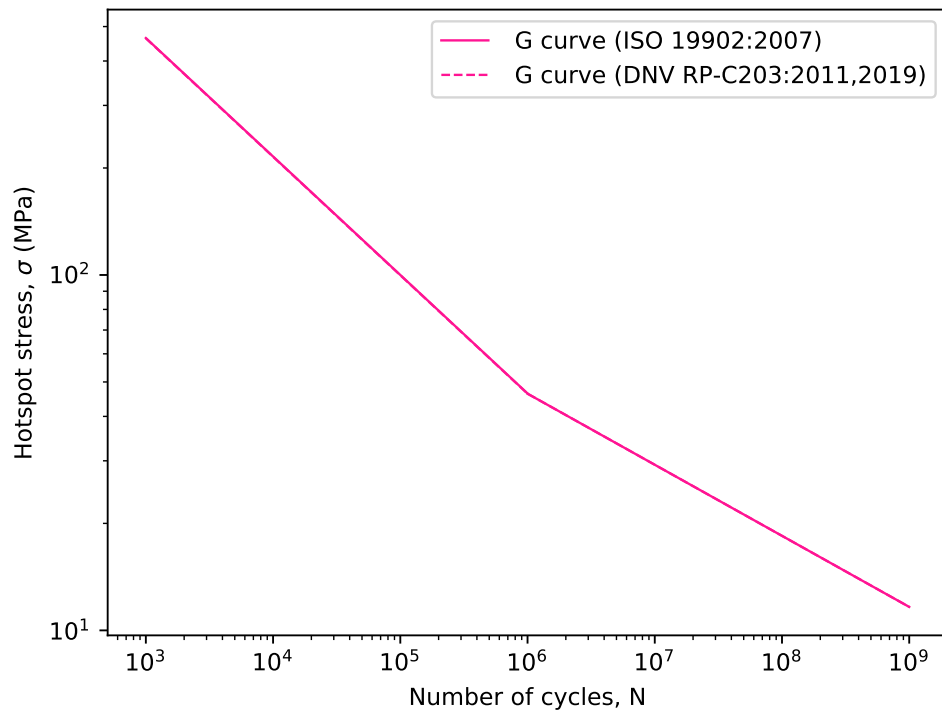


Figure 7: *G curves*

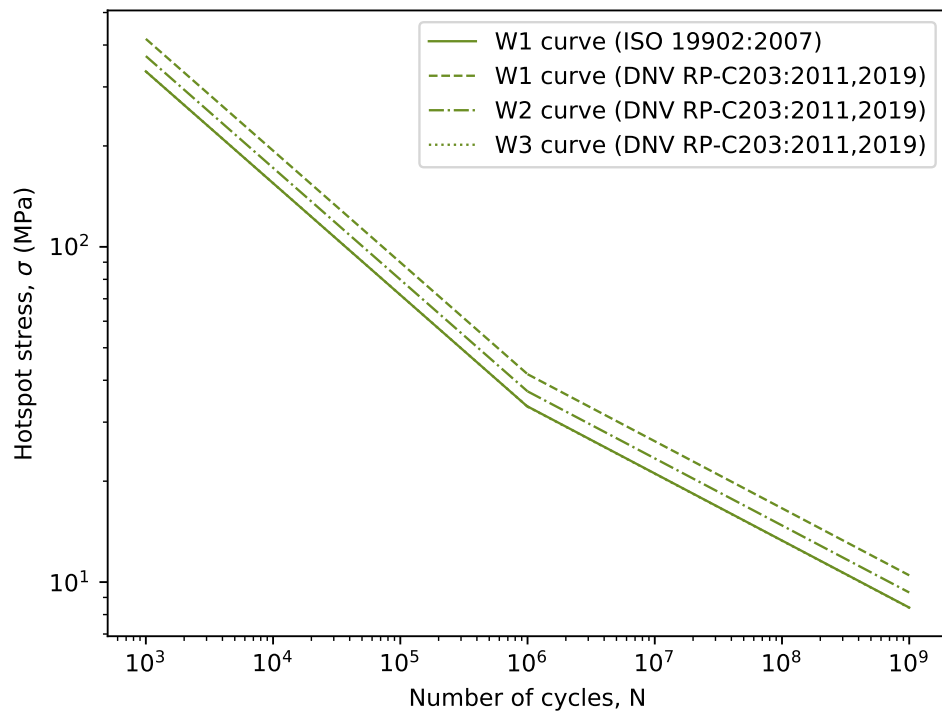


Figure 8: *W curves*

Appendix

A Plot code

```
1  #!/usr/bin/env python
2  # encoding: utf-8
3  """
4  sncurves.py -- 2016-21 ckunte
5
6  May 7: Initial commit.
7  Apr 29, 2020: Code simplified
8  Dec 27, 2020: basex is now base (since matplotlib V3.3)
9  Jan 30, 2021: DNV RP-C203:2011,2019 curves added
10 Feb 17, 2021: A practical S-N range is set for structural steel
11 """
12 import numpy as np
13 import matplotlib.pyplot as plt
14
15
16 def style():
17     plt.rcParams["grid.linestyle"] = ":"
18     plt.rcParams["grid.linewidth"] = 0.5
19     plt.grid(True)
20
21
22 def lbls():
23     plt.legend(loc=0)
24     plt.xlabel("Number of cycles, N")
25     plt.ylabel("Hotspot stress,  $\sigma$  (MPa)")
26     pass
27
28
29 def sncurve(
30     curve, r_start, r_mid, r_end, a1, m1, a2, m2, graphcolor, lsty
31 ):
32     # For slope 1 (m1)
33     n = np.arange(r_start, r_mid, 1.0e3)
34     s = (n / 10 ** a1) ** (-1 / m1)
35     plt.loglog(
36         n,
37         s,
38         base=10,
39         color=graphcolor,
40         ls=lsty,
41         linewidth=1.0,
42         label=curve,
43     )
44     # For slope 2 (m2)
45     n = np.arange(r_mid, r_end, 1.0e3)
46     s = (n / 10 ** a2) ** (-1 / m2)
47     plt.loglog(n, s, base=10, color=graphcolor, ls=lsty, linewidth=1.0)
48     pass
49
50
51 def main():
52     # Plot all
53     style()
54     # TJ curve(s)
55     sncurve(
56         "TJ curve (ISO 19902:2007)",
57         1.00e3,
58         1.80e6,
```

```

59         1.00e9,
60         12.18,
61         3.0,
62         16.13,
63         5.0,
64         "black",
65         "_",
66     )
67     sncurve(
68         " T curve (DNV RP-C203:2019)",
69         1.00e3,
70         1.80e6,
71         1.00e9,
72         12.18,
73         3.0,
74         16.13,
75         5.0,
76         "black",
77         "-.",
78     )
79     sncurve(
80         " T curve (DNV RP-C203:2011)",
81         1.00e3,
82         1.00e6,
83         1.00e9,
84         11.764,
85         3.0,
86         15.606,
87         5.0,
88         "black",
89         "--",
90     )
91     lbls()
92     plt.savefig("sncurves-tj.pdf")
93     plt.close()
94     # B curve(s)
95     sncurve(
96         " B curve (ISO 19902:2007)",
97         1.00e3,
98         1.00e5,
99         1.00e9,
100        14.61,
101        4.0,
102        17.01,
103        5.0,
104        "magenta",
105        "_",
106    )
107    sncurve(
108        "B1 curve (DNV RP-C203:2011,2019)",
109        1.00e3,
110        1.00e6,
111        1.00e9,
112        14.917,
113        4.0,
114        17.146,
115        5.0,
116        "magenta",
117        "--",
118    )
119    sncurve(
120        "B2 curve (DNV RP-C203:2011,2019)",
121        1.00e3,

```

```

122         1.00e6,
123         1.00e9,
124         14.685,
125         4.0,
126         16.856,
127         5.0,
128         "magenta",
129         "-.",
130     )
131     lbls()
132     plt.savefig("sncurves-b.pdf")
133     plt.close()
134     # C curve(s)
135     sncurve(
136         " C curve (ISO 19902:2007)",
137         1.00e3,
138         4.68e5,
139         1.00e9,
140         13.23,
141         3.5,
142         16.47,
143         5.0,
144         "blue",
145         "-",
146     )
147     sncurve(
148         " C curve (DNV RP-C203:2011,2019)",
149         1.00e3,
150         1.00e6,
151         1.00e9,
152         12.192,
153         3.0,
154         16.320,
155         5.0,
156         "blue",
157         "--",
158     )
159     sncurve(
160         "C1 curve (DNV RP-C203:2011,2019)",
161         1.00e3,
162         1.00e6,
163         1.00e9,
164         12.049,
165         3.0,
166         16.081,
167         5.0,
168         "blue",
169         "-.",
170     )
171     sncurve(
172         "C2 curve (DNV RP-C203:2011,2019)",
173         1.00e3,
174         1.00e6,
175         1.00e9,
176         11.901,
177         3.0,
178         15.835,
179         5.0,
180         "blue",
181         ":",
182     )
183     lbls()
184     plt.savefig("sncurves-c.pdf")

```



```

185 plt.close()
186 # D curve(s)
187 sncurve(
188     " D curve (ISO 19902:2007)",
189     1.00e3,
190     1.00e6,
191     1.00e9,
192     11.78,
193     3.0,
194     15.63,
195     5.0,
196     "orange",
197     "_",
198 )
199 sncurve(
200     " D curve (DNV RP-C203:2011,2019)",
201     1.00e3,
202     1.00e6,
203     1.00e9,
204     11.764,
205     3.0,
206     15.606,
207     5.0,
208     "orange",
209     "--",
210 )
211 lbls()
212 plt.savefig("sncurves-d.pdf")
213 plt.close()
214 # E curve(s)
215 sncurve(
216     " E curve (ISO 19902:2007)",
217     1.00e3,
218     1.00e6,
219     1.00e9,
220     11.62,
221     3.0,
222     15.37,
223     5.0,
224     "green",
225     "_",
226 )
227 sncurve(
228     " E curve (DNV RP-C203:2011,2019)",
229     1.00e3,
230     1.00e6,
231     1.00e9,
232     11.610,
233     3.0,
234     15.350,
235     5.0,
236     "olive",
237     "--",
238 )
239 lbls()
240 plt.savefig("sncurves-e.pdf")
241 plt.close()
242 # F curve(s)
243 sncurve(
244     " F curve (ISO 19902:2007)",
245     1.00e3,
246     1.00e6,
247     1.00e9,

```

```

248         11.40,
249         3.0,
250         15.00,
251         5.0,
252         "olive",
253         "--",
254     )
255     sncurve(
256         " F curve (DNV RP-C203:2011,2019)",
257         1.00e3,
258         1.00e6,
259         1.00e9,
260         11.455,
261         3.0,
262         15.091,
263         5.0,
264         "olive",
265         "--",
266     )
267     sncurve(
268         "F2 curve (ISO 19902:2007)",
269         1.00e3,
270         1.00e6,
271         1.00e9,
272         11.23,
273         3.0,
274         14.71,
275         5.0,
276         "brown",
277         "-",
278     )
279     sncurve(
280         "F1 curve (DNV RP-C203:2011,2019)",
281         1.00e3,
282         1.00e6,
283         1.00e9,
284         11.299,
285         3.0,
286         14.832,
287         5.0,
288         "brown",
289         "-.",
290     )
291     sncurve(
292         "F3 curve (DNV RP-C203:2011,2019)",
293         1.00e3,
294         1.00e6,
295         1.00e9,
296         11.146,
297         3.0,
298         14.576,
299         5.0,
300         "brown",
301         ":",
302     )
303     lbls()
304     plt.savefig("sncurves-f.pdf")
305     plt.close()
306     # G curve(s)
307     sncurve(
308         " G curve (ISO 19902:2007)",
309         1.00e3,
310         1.00e6,

```

```

311         1.00e9,
312         11.00,
313         3.0,
314         14.33,
315         5.0,
316         "deeppink",
317         "_",
318     )
319     sncurve(
320         " G curve (DNV RP-C203:2011,2019)",
321         1.00e3,
322         1.00e6,
323         1.00e9,
324         10.998,
325         3.0,
326         14.330,
327         5.0,
328         "deeppink",
329         "--",
330     )
331     lbls()
332     plt.savefig("sncurves-g.pdf")
333     plt.close()
334     # W curve(s)
335     sncurve(
336         "W1 curve (ISO 19902:2007)",
337         1.00e3,
338         1.00e6,
339         1.00e9,
340         10.57,
341         3.0,
342         13.62,
343         5.0,
344         "olivedrab",
345         "_",
346     )
347     sncurve(
348         "W1 curve (DNV RP-C203:2011,2019)",
349         1.00e3,
350         1.00e6,
351         1.00e9,
352         10.861,
353         3.0,
354         14.101,
355         5.0,
356         "olivedrab",
357         "--",
358     )
359     sncurve(
360         "W2 curve (DNV RP-C203:2011,2019)",
361         1.00e3,
362         1.00e6,
363         1.00e9,
364         10.707,
365         3.0,
366         13.845,
367         5.0,
368         "olivedrab",
369         "-.",
370     )
371     sncurve(
372         "W3 curve (DNV RP-C203:2011,2019)",
373         1.00e3,

```

```

374         1.00e6,
375         1.00e9,
376         10.570,
377         3.0,
378         13.617,
379         5.0,
380         "olivedrab",
381         ":",
382     )
383     lbls()
384     plt.savefig("sncurves-w.pdf")
385     plt.close()
386     pass
387
388
389 if __name__ == "__main__":
390     main()

```